COPY

Final

environmental statement

related to operation of

VERMONT YANKEE NUCLEAR POWER STATION

VERMONT YANKEE NUCLEAR POWER CORPORATION

DOCKET NO. 50-271

JULY 1972

UNITED STATES ATOMIC ENERGY COMMISSION

DIRECTORATE OF LICENSING

SUMMARY AND CONCLUSIONS

This Final Environmental Statement was prepared by the U.S. Atomic Energy Commission, Directorate of Licensing.

1. This action is administrative.

2. The proposed action is the issuance of an operating license to the Vermont Yankee Nuclear Power Corporation (applicant) for the Vermont Yankee Nuclear Power Station (plant) located on the Connecticut River in the State of Vermont, County of Windham, in the Village of Vernon (Docket No. 50-271).

   The Vermont Yankee Nuclear Power Station will use a single-unit boiling-water reactor with an initial power rating of 1593 thermal megawatts (MWt) to provide a net power output of 513 electrical megawatts (MWe). The reactor will be cooled by a once-through flow of water pumped from and returned to Vernon Pond, an existing impoundment of the Connecticut River (built to serve the Vernon Hydroelectric Station) and also by means of mechanical draft cooling towers.

3. Summary of environmental impact including beneficial and adverse effects follows:

   a. Cooling water heated to about 20°F above inlet temperature will be discharged to Vernon Pond at a rate of 840 cfs when the plant operates on a total open-cycle basis. Mechanical-draft cooling towers are provided to protect Vernon Pond during low flow and critical temperature periods in the Connecticut River.

   b. About 150 acres of Vernon Pond in the vicinity of the station may be subjected to some thermal and biological stress from discharge of the station's condenser cooling water. This impact will be kept below significant levels by the limits described in Conclusion 7a.

   c. A possible impact on aquatic resources may occur in the cooling water intake structure through entrainment of plankton and small fish. While limited pre-operational experience with the circulating water pumps has revealed no fish mortalities, close surveillance of this aspect of plant operation will be required.

   d. Chemical effluents from the station should cause only mimimal impact on Vernon Pond. The total residual chlorine concentration will be limited to 0.1 mg/liter in the immediate vicinity of the plant discharge, and no significant impact on the aquatic biota in the pond is expected.

e. The program for construction and maintenance of transmission lines has been designed to reduce environmental impact. Herbicides are applied in accordance with suggested precautions and labeled registration with the Environmental Protection Agency and the U. S. Department of Agriculture and are regulated by the Vermont Department of Agriculture in order to protect aquatic biota in nearby watercourses and also to avoid roadways or areas which have been selectively cut to reduce visual impact.

f. Operation of the cooling towers will result in a small increase in local fogging. This impact is considered minimal in comparison with shutting down the station or allowing full or partial operation of the plant with once-through river cooling.

g. Approximately 60 acres of 125 acres of land formerly used for pasture and agricultural habitat have been occupied by the plant facilities.

h. Noise from operation of the mechanical draft cooling towers may be a source of irritation to the populace in offsite residential areas. At present there is no scientific evidence that such levels of ambient noise cause any long- or short-term health effects. Quantitative assessment of the nuisance effects of this noise source can be determined only after the towers have operated for sustained periods of time.

i. No significant environmental impacts are anticipated from normal operational releases of radioactive materials.

j. A very low probability risk of accidental radiation to the population will be created.

k. A local historic site is the Governor Jonathan Hunt house located on the western boundary of the site; the building which was built in the 1780's has been acquired by the applicant and will be maintained as a public museum.

l. Operation of the station will add about 3.6 billion kilowatt hours of electricity per year for use by residents, communities, and industries in the State of Vermont and in the New England region as a whole. The local economy will be aided by an increased operating payroll and locally purchased goods and services, as well as additional property taxes.

4. Principal alternatives considered:

a. Purchase of power from outside sources

b. Use of fossil fuels or hydroelectric sources

c. Construction of an equivalent plant at some other site

d. Use of alternative cooling systems

e. Use of alternative modes of cooling system operation (open, closed or helper-cycle)

f. Use of other biocides than chlorine in cooling system

g. Use of alternative radwaste systems

h. Use of alternative transmission lines

5. Comments on the Draft Environmental Statement were received from the agencies and organizations listed below and have been considered in the preparation of the Final Environmental Statement. Copies of these comments are included as Appendix XII-A and discussed in Section XII.

Department of Agriculture
Department of Army (Corps of Engineers)
Department of Commerce
Environmental Protection Agency
Federal Power Commission
Department of Interior
Department of Transportation
Advisory Council on Historic Preservation
State of Vermont Agency of Environmental Conservation
State of Vermont Agency of Development and Community Affairs
State of New Hampshire Fish and Game Department
State of New Hampshire Water Supply and Pollution Control Commission
Commonwealth of Massachusetts Department of the Attorney General
Vermont Yankee Nuclear Power Corporation
New England Coalition on Nuclear Pollution

6. This Final Environmental Statement has considered the above mentioned comments and is being made available to the public, to the Council on Environmental Quality, and to other agencies in July 1972.

7. On the basis of the analysis and evaluation set forth in this statement, after weighing the environmental, economic, technical and other benefits of the Vermont Yankee Nuclear Power Station against the environmental costs and considering available alternatives, it is concluded that the action called for is the issuance of an operating license for the facility subject to the following conditions for protection of the environment:

a. In consideration of potential ecological damage to approximately 150 acres of Vernon Pond, the staff has established a requirement that except in a 10 acre exempt area, resulting river temperatures shall

not exceed 45°F when the unheated river water is less than 40°F or increase more than 5°F when the unheated river is above 40°F. Because the location of the thermal plume from the plant's discharge is dependent on fluctuating river flows, no location for this exempt area has been specified. Rather the location of this area will be allowed to fluctuate and to occupy any 10 acre area in Vernon Pond at any given instant. In consideration of this fluctuation and because the ecological basis for setting a 10 acre exempt area is admittedly uncertain, the staff believes a mobile 50 acre area can be made available for study purposes during the first year of station operation. That area would be used in accordance with the comprehensive monitoring program detailed in the plant Technical Specifications. If the results from the 1-year study program indicate that an area larger than 10 acres could be permanently established without a significant or irreversible effect on Vernon Pond, an appropriate permanent enlargement of the 10 acre limit would be considered.

b. The total residual chlorine concentration will be limited to 0.1 mg/liter in the immediate vicinity of the plant discharge. It is not planned to use any other chemicals besides sodium hypochlorite and sulfuric acid in the plant cooling system. The environmental impact of any proposed new chemicals shall be assessed and their use approved by the AEC.

c. The applicant will define a comprehensive environmental (chemical, biological, and thermal) monitoring program for inclusion in the Technical Specifications for the Station which is acceptable to the regulatory staff for determining changes which may occur in land and water ecosystems as a result of plant operation.

d. If harmful effects or evidence of irreversible damage are detected by the monitoring program, the applicant will provide an analysis of the problem and will provide a course of action to be taken immediately to alleviate the problem.

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FOREWORD

This Final Environmental Statement evaluates the anticipated impact of the proposed operation of the Station on the environment for the purpose of determining whether the action called for issuance of an operating license to the applicant for the operation of the Vermont Yankee Nuclear Power Station (Docket No. 50-271). The document has been prepared by the Directorate of Licensing (the staff) of the U.S. Atomic Energy Commission (Commission or AEC) with assistance from Oak Ridge National Laboratory and in accordance with the requirements of the National Environmental Policy Act of 1969 (NEPA) and the provisions of Appendix D to Part 50 of the Commission's Regulations.[1]

The applicant submitted an Environmental Report - Vermont Yankee Nuclear Power Station, on August 26, 1970.[2] The Commission forwarded copies of this report to the following Federal, State, and local agencies[3] requesting their review and comment:

Department of Agriculture
Department of Commerce
Department of Defense
Federal Power Commission
Department of Health, Education, and Welfare
Department of Housing and Urban Development
Department of the Interior
Department of Transportation
State of Vermont Agency of Environmental Conservation

Subsequently, copies of the Environmental Report were provided to the appropriate New Hampshire and Massachusetts agencies and to the Vernon, Vermont, Board of Selectmen. A copy of the report was also placed in the Commission's Public Document Room at 1717 H Street, N.W., Washington, D. C., and the local Public Document Room (Brooks Memorial Library), 224 Main Street, Brattleboro, Vermont.

Notice of the availability of the report, together with a request for comments, was published in the Federal Register.[4] Members of the public and Federal and State agencies responded to this request, and the regulatory staff considered these comments in their preparation of a detailed environmental statement, which was published on June 1, 1971.[5] Copies of this report were provided to appropriate Federal and State agencies and a notice of availability of the document was published in the Federal Register on June 9, 1971.[6]

In accordance with the requirements of Appendix D to 10 CFR 50, as revised following the "Calvert Cliffs" decision,[7] the applicant, on December 21, 1971, supplemented its environmental report.[8]

The Directorate of Licensing, on April 7, 1972, issued a Draft Detailed Statement. Notice of availability of that Draft Detailed Statement, with a request for comments, was also published in the Federal Register,[9] and copies thereof, with requests for comments, were also sent to appropriate Federal, State and local agencies.

This Final Environmental Statement takes into account the applicant's and agencies' comments on the Draft Detailed Statement issued April 7, 1972, the applicant's reply to the Federal and State agency comments, as well as the applicant's Final Safety Analysis Report and amendments thereto,[10] the Commission's Safety Evaluation,[11] the report of the Advisory Committee on Reactor Safeguards (ACRS), the applicant's Environmental Report and supplements thereto, and the AEC Detailed Environmental Statement issued June 1, 1971.[5] Copies of all the aforementioned documents are available for inspection by members of the public in the Commission's Public Document Room, 1717 H Street, N. W., Washington, D. C., and the Brooks Memorial Library, 224 Main Street, Brattleboro, Vermont.

Independent calculations and sources of information were also utilized as a basis for the Commission's assessment of environmental impact. In addition, some of the information was gained from a visit to the Vermont Yankee plant site and surrounding areas on September 2 and 3, 1971, by the staff.

As a part of its safety evaluation leading to the issuance of construction permits and operating licenses, the Commission staff makes a detailed evaluation of (1) the applicant's plans and facilities for minimizing and controlling the release of radioactive materials under both normal operating and potential accident conditions, (2) the adequacy of the applicant's effluent and environmental monitoring programs, and (3) the potential radiation exposure of plant workers and members of the public. Because of the fuller consideration given to those questions in other Commission documents, only the salient points that bear directly on the anticipated doses to the public are repeated here. Similarly, more detailed descriptions of the plant and its effluent control systems and the environmental characteristics of the site, such as meteorology, geology, and hydrology are provided in the applicant's preliminary and final safety analysis reports and amendments thereto and are not repeated in detail in this report.

The applicant is required to comply with Section 21(b) of the Federal Water Pollution Control Act, as amended by the Water Quality Improvement Act of 1970.

A license authorizing initial fuel loading and 1% startup and plant testing was issued by the AEC on March 21, 1972.

Mr. Walter G. Belter (Telephone: (301) 973-7370) is the AEC Environmental Manager for this Final Environmental Statement.

References for Foreword

1. 10 CFR Chapter 1.

2. "Vermont Yankee Nuclear Power Station Environmental Report, Vermont Yankee Power Corporation, August 26, 1970.

3. Letters from the Director, Division of Reactor Licensing, to Federal, State, and Local Agencies Transmitting the Applicant's Environmental Report, September 23, 1970.

4. Notice of Availability of Environmental Report and Request for Comments from State and Local Agencies, 35 Federal Register 15026 (September 26, 1970).

5. Detailed Statement on the Environmental Considerations by the Division of Reactor Licensing, AEC, Related to the Proposed Issuance of an Operating License to the Vermont Yankee Power Corporation for the Vermont Yankee Nuclear Power Station, Docket No. 50-271, June 1, 1971.

6. Notice of Availability of the Detailed Statement, 36 Fed. Reg. 11122 (June 9, 1971).

7. U. S. Court of Appeals for the District of Columbia Circuit Opinions, Numbers 24,839 and 24,871, Calvert Cliffs decision, July 23, 1971.

8. Vermont Yankee Nuclear Power Corporation, Supplement to Environmental Report, December 21, 1971.

9. Notice of Availability of AEC Draft Detailed Statement, 37 Federal Register 7423 (April 14, 1972).

10. Vermont Yankee Nuclear Power Corporation, Final Safety Analysis Report (Submitted December 31, 1969) and Subsequent Amendments, Vermont Yankee Nuclear Power Station, Docket No. 50-271.

11. Safety Evaluation by the Division of Reactor Licensing, AEC in the Matter of the Vermont Yankee Nuclear Power Station, Docket No. 50-271, June 1, 1971.

I. INTRODUCTION

The Vermont Yankee Nuclear Power Station is located on a 125-acre site on the west shore of the Connecticut River, in the town of Vernon, Vermont, which is approximately four miles north of the Massachusetts state line. The site is bounded on the north, south, and west by privately owned land and on the east by the Connecticut River. About 30% of the area within a 1-mile radius of the site consists of the Vernon Pond, Connecticut River, and undeveloped land adjacent to the river. The remainder of the land within this area is predominantly used for dairy feed products and pasture.

The plant will generate 540 megawatts of electricity for distribution to other utilities in the New England area. The station will use a boiling water nuclear reactor system with condenser cooling water being obtained from the Connecticut River. Two mechanical draft cooling towers will be used in conjunction with a once-through cooling water system. The heat dissipation system is flexible in that either or both cooling systems can be used to minimize the environmental effects of heated water discharge to the river or to the surrounding atmosphere.

The Vermont Yankee Nuclear Power Cooperation filed with the AEC an application dated November 30, 1966, for a construction permit for the Vernon plant. On December 11, 1967, a provisional construction permit was issued by the AEC. A final safety analysis report was submitted by the applicant on December 31, 1969. A safety evaluation on operation of the Vermont Yankee Nuclear Power Station was issued by the AEC Division of Reactor Licensing on June 1, 1971. Public hearings to consider issuance of an operating license have been held during 1971 and 1972. Further sessions of the hearing will be held before a decision is made on whether or not to issue an operating license.

A. SITE SELECTION

When the process of site selection was initiated, Gibbs & Hill, Inc., consulting engineers of New York, were engaged to study site availability in Vermont. Twenty-three sites were considered: six located along the Connecticut River in Vermont and 17 on the Vermont shore of Lake Champlain.

In 1965, the preliminary appraisal[1] of sites considered requirements such as:

1. Sufficient land area.
2. Adequate supply of cooling water.
3. Accessibility by rail, highway, or navigable waterways.
4. Remoteness from heavily populated areas.

Based on this preliminary appraisal, six sites were chosen for further investigation. Further studies, such as subsurface structure, geology, seismology, hydrology, and meteorology, were then conducted on these six sites. These studies concluded that three sites were suitable: Five Mile Point and the Way Property on Lake Champlain, and the Vernon site on the Connecticut River. Ebasco Services, Inc., another consulting engineering firm, was retained to conduct a study[2] of energy transmission costs from the three recommended sites. Ebasco Services found that the Vernon site required less transmission construction, thereby favoring it as the site for construction of the plant.

Using these site study reports,[1,2] the nearness to population centers was evaluated by the AEC Regulatory Staff for all of the sites under consideration. Five sites had higher population densities than Vernon, and the remainder had lower densities. After further site study of the environmental factors noted above, Five Mile Point and Vernon were considered in the final selection. The Five Mile Point area within a 10-mile radius was mostly rural except for the city of Ticonderoga, New York (4 miles away), which had a population of 3568. For the Vernon site, within a 10-mile radius, the area was predominantly rural with the exception of Brattleboro, Vermont, which at the time of the study had a population of 9315 (5 miles away), and Hinsdale, New Hampshire, which had a population of 2187 (2 miles away). Also, at Vernon, the plant property is adjacent to residential property slightly more than 1000 ft from the reactor. However, the Vernon site met all siting requirements of Commission regulations.

In an evaluation of energy sources, the Gibbs and Hill power study[3] concluded that bituminous coal and petroleum oils are not economically competitive with nuclear fuel in the Vermont area. Subsequent analysis by the Federal Power Commission[4] on the New England fuels situation explain why nuclear fuels are more practical in Vermont. The New England area has a shortage of fossil fuel resources; and since Vermont is far distant from other sources of fossil fuels, electric power costs have always been high.

Another factor which influences choice of fuel in New England is the growing need to improve air quality in conjunction with the shortage of low-sulfur fossil fuels. Three New England states, Connecticut, Massachusetts, and New Hampshire, have already imposed limitations on the sulfur content of fuels which can be burned, and Vermont is considering similar legislation. The Federal Power Commission states further that, under these circumstances, it appears unlikely that a coal- or oil-burning steam-electric plant would be the best source of needed generating capacity in the State of Vermont.[4] In consideration of these factors, it is understandable why the applicant decided that nuclear fuel would be most suitable for the Vernon plant.

The pollution load on the air and water at the Vernon site is quite nominal. The river carries a high silt load, which limits its sport fishing potential, but other factors are reasonable. The air is generally clean, because of the lack of industry or other sources of pollution. More detailed discussion of these factors will be found in later portions of the report, particularly in the discussion on impacts, Section V. Further discussion of site selection will also be found in Section XI, "Alternatives to the Proposed Action and Cost-Benefit Analysis of Their Environmental Effects."

B. APPLICATIONS AND APPROVALS

Permits and approvals from various Federal and State agencies as related to environmental aspects of the Vermont Yankee Nuclear Power Station are detailed in the applicant's Supplement to the Environmental Report, dated December 21, 1971. Appendix I-1 lists chronologically the applications, permits, and environmental actions taken to date.

References

1. Gibbs & Hill, Inc., Site Study, October 1965.

2. Ebasco Services, Inc., Nuclear Plant Site Evaluation for Central Vermont Public Service Corporation and Green Mountain Power Company, undated report received by the USAEC Division of Reactor Licensing in September 1971.

3. Gibbs & Hill, Inc., Consulting Engineers of New York, Power Study, July 1965.

4. Letter from J. N. Nassikas, Chairman of the Federal Power Commission, to H. L. Price, Dec. 8, 1970, with report Federal Power Commission Comments Relative to the Environmental Statement on the Vermont Yankee Nuclear Power Station.

II. THE SITE

A. GENERAL

The Vermont Yankee Plant is on a strip of lowlands and terraces, about one mile wide, that borders the Connecticut River. The impounded section of the river adjacent to the site is known as Vernon Pond, which extends upriver for approximately six miles. The area around the station is level, with uplands rising several hundred feet east and west of the lowlands.

B. LOCATION OF PLANT

The plant site is near the town of Vernon, Windham County, in southeast Vermont (Fig. II-1). The plant is on the west shore of the Connecticut River, 250 ft above mean sea level, approximately two-thirds of a mile upstream of the Vernon Hydroelectric Dam at Connecticut River mile 142. The site (Fig. II-2) is bounded by the Connecticut River (Vernon Pond) on the east, by farm and pasture land mixed with wooded areas on the north and south, and by the town of Vernon on the west. The site coordinates are 42°47' north latitude and 72°31' west longitude.

Warwick and Northfield State Forests (Mass.) (Fig. II-1) are approximately 8 miles southeast of the site, with other sections of Northfield Forest 6 miles southwest. Colrain State Forest (Mass.) is also southwest of Vernon, at a distance of approximately 18 miles. Northeast of the site is the Pisgah Mountain range, rising to 1500 ft. Mountains and hills extend to the west and northwest, some attaining heights of 1800 ft. Green Mountain National Forest covers a large area approximately 30 miles west of Vernon.

Most of the land around the site is undeveloped (75 to 80% within five miles is wooded). The developed land is used for agriculture and dairying, and for residential areas of small villages. The plant site includes about 125 acres owned by the Vermont Yankee Nuclear Power Corporation and an adjoining narrow strip of river bank to which the corporation has perpetual rights and easements from the New England Power Company. The New England Power Company, one of the sponsor corporations of the Vermont Yankee Nuclear Power Corporation, owns the east bank of the Connecticut River opposite the plant site. The nearest site boundary is 910 ft west of the reactor building. The exclusion area, as defined in 10 CFR 100, includes a portion of the Connecticut River above Vernon Dam (Fig. II-2). Approximately 60 acres of the site is taken up by the reactor building and associated structures. Some of the remaining acreage is used for parking, storage, and underground construction, so that almost the entire site has been modified during plant construction.

Interstate Highway 91 passes approximately 2 miles west of the site; -mont State Route 142 parallels the west bank of the Connecticut River

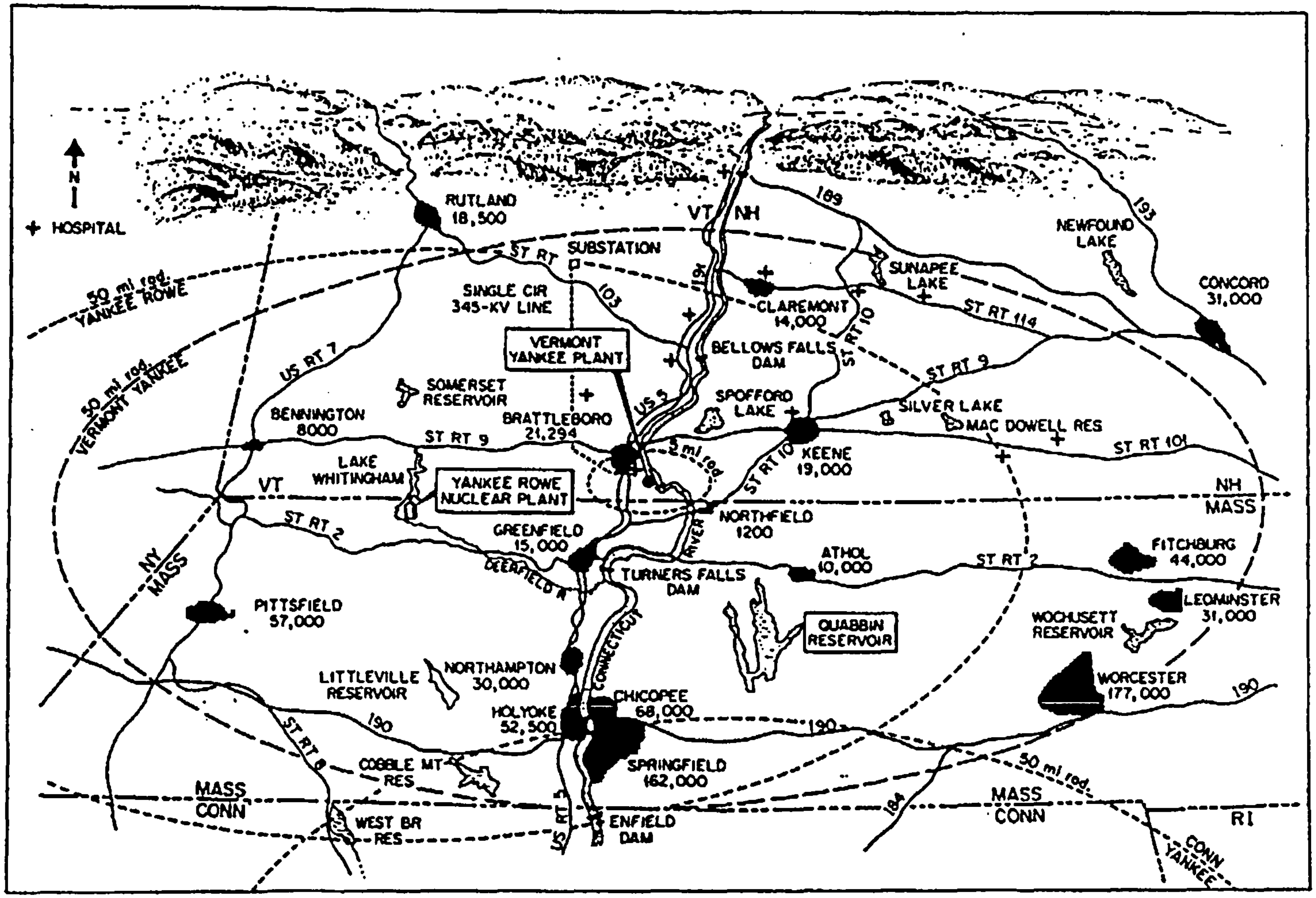


Fig. II-1. 50-Mile Radius - Vermont Yankee Nuclear Power Station.

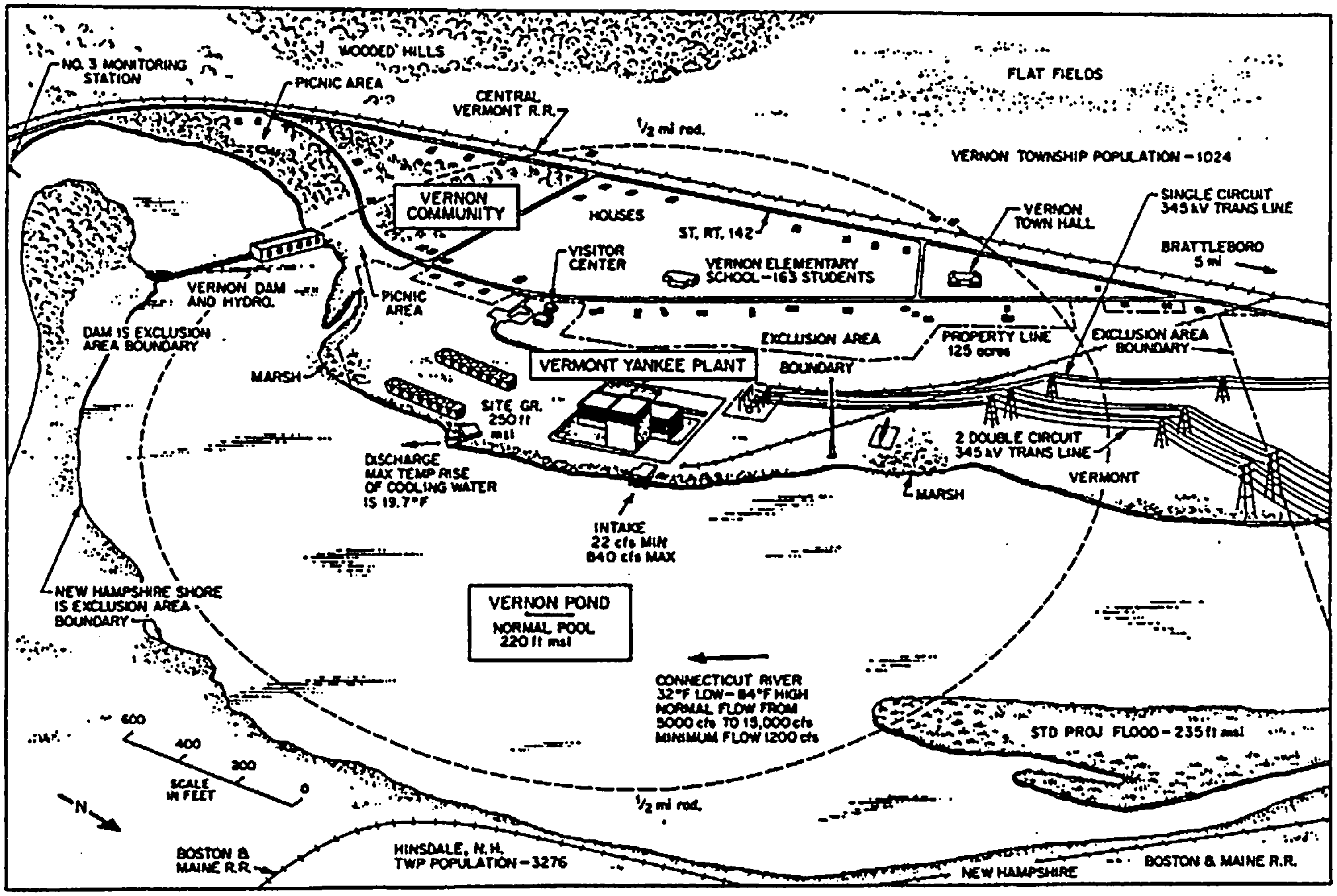


Fig. II-2. Vermont Yankee Nuclear Power Station.

and passes 2,000 ft west of the reactor building. Access to the site is provided by Governor Hunt Road (local) or by a spur of the Central Vermont Railroad, which also parallels the west bank.

C. REGIONAL DEMOGRAPHY AND LAND USE

In a staff visit to the site in September 1971, it was observed that the nearest settlements are: a small cluster of homes (pop. about 50) approximately one fourth mile from the reactor; a group of about 30 homes 0.7 mile across the river; the villages of Vernon, North Vernon, and South Vernon (1970 township population 1024) extending for about 4 miles along Route 142; Hinsdale, New Hampshire (1970 township pop. 3276), 2 miles across the river to the east. Brattleboro (1970 urban area pop. 21,294) is 5 miles upstream. Other populated areas include Turners Falls (pop. 4400), 12 miles south; Greenfield, Mass. (pop. 15,000), 14 miles southwest; Keene, N. H. (pop. 19,000), 17 miles northeast; Athol, Mass. (pop. 10,000), 20 miles southeast; and Northampton, Mass. (pop. 30,000), 32 miles south.

The area within 5 miles of the site is rural and sparsely settled (Fig. II-3), containing 6,583 people (1970 pop.). Small towns in the area have populations ranging between 1,000 and 3,000. The 1970 population density was 87 people per square mile within a 5-mile radius of the plant. The density in this area is expected to be 115 per square mile in 1980 and 160 per square mile in 2000.[1] The 1970 population distribution within a 5-mile and a 50-mile radius is shown in Table II-1 and in Fig. II-4.[2] The projected distribution of population in the area within a 50-mile radius for year 2010 is also shown in Fig. II-4.

The nearest house is 1300 ft from the reactor building and is one of several just west of the site (Fig. II-5). The Vernon Elementary School (enrollment 163) is about 1500 ft from the reactor building (Fig. II-6). The Vernon Library and City Hall are approximately 2300 ft away.

The largest sports facility in the immediate vicinity is a horse racetrack at Hinsdale (average attendance approx. 4000). A nursing home with a resident population of about 35 (planned expansion to 54) has been completed south of Vernon, 2 miles downriver. The nearest hospital is in Brattleboro (103 beds, 269 working staff). Camping facilities along the river are limited to a small family-picnic type maintained by the New England Power Company. Approximately 3 miles across the river in New Hampshire is a large (115 unit) trailer park. The resident population of this trailer park is expected to remain at 80 to 100 units after completion of the reactor.

Land within 25 miles of the site is approximately 80% undeveloped; and most of the developed land is used for agriculture and dairying. The nearest dairy farm is approximately one-half mile northwest of the reactor,

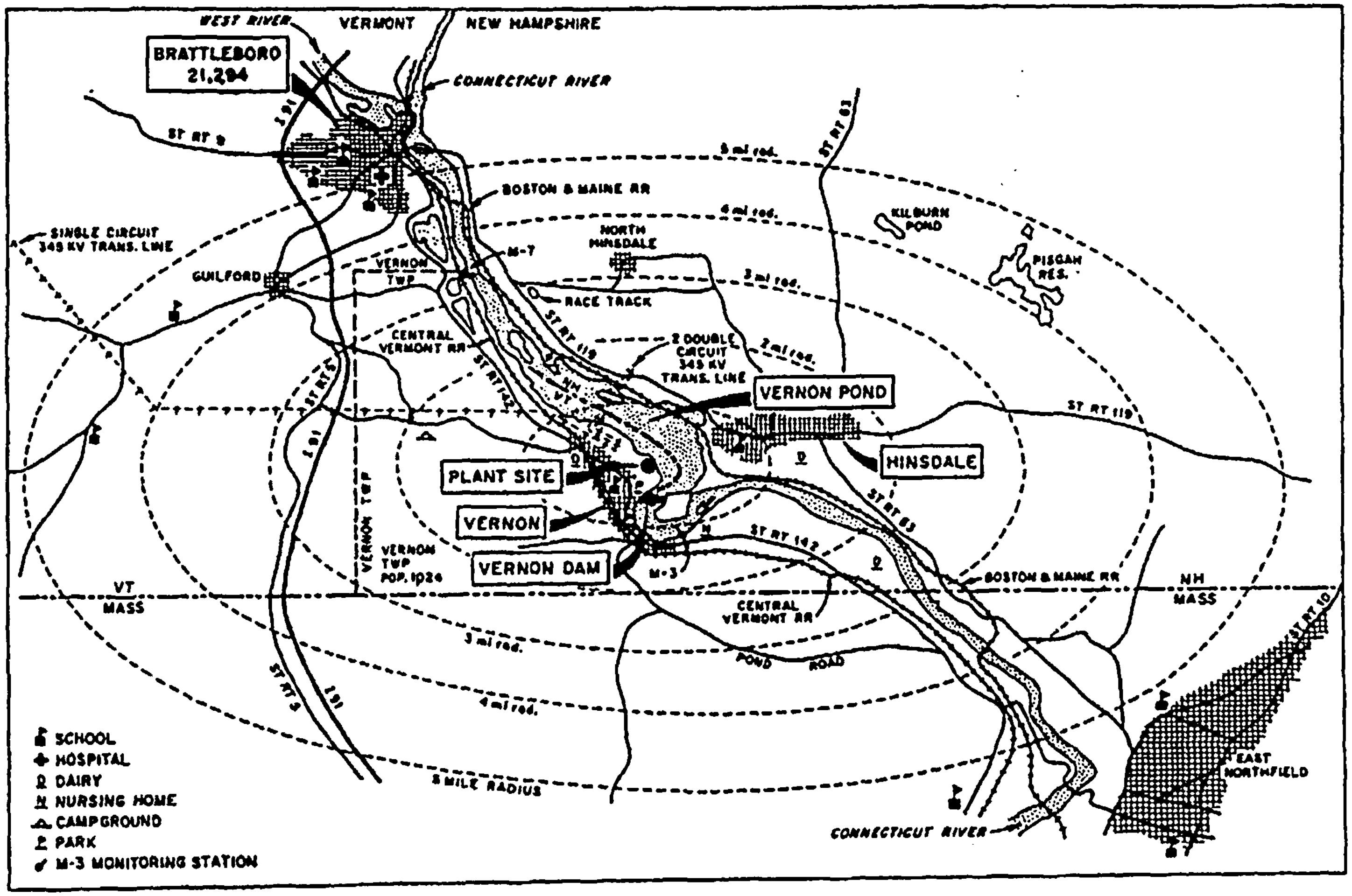
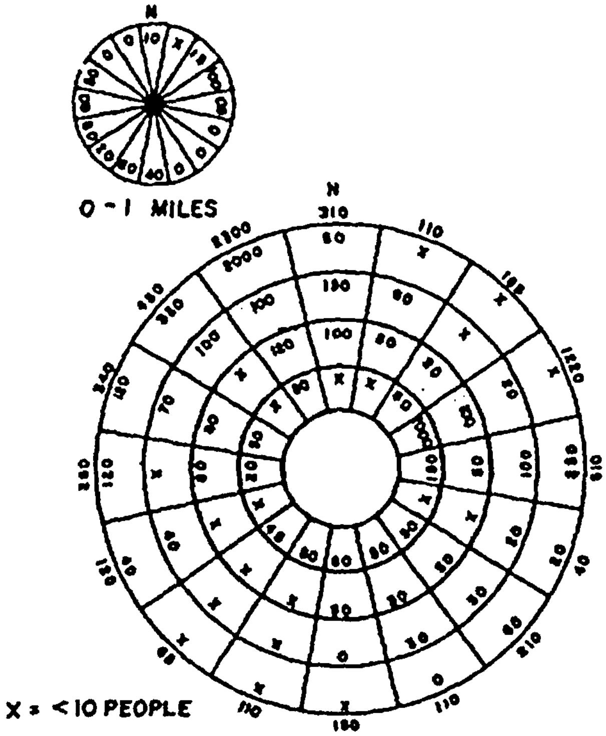


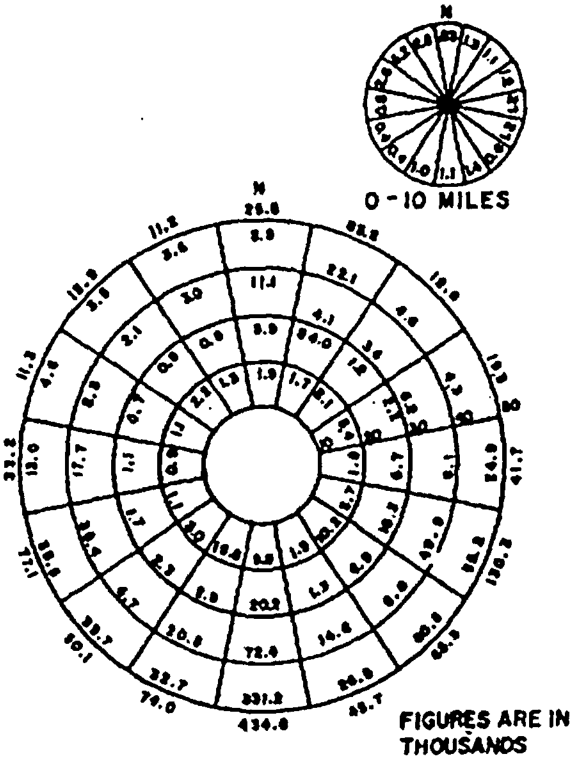
Fig. II-3. 5-Mile Radius - Vermont Yankee Nuclear Power Station.

Table II-1. Population totals, Vermont Yankee (1970)

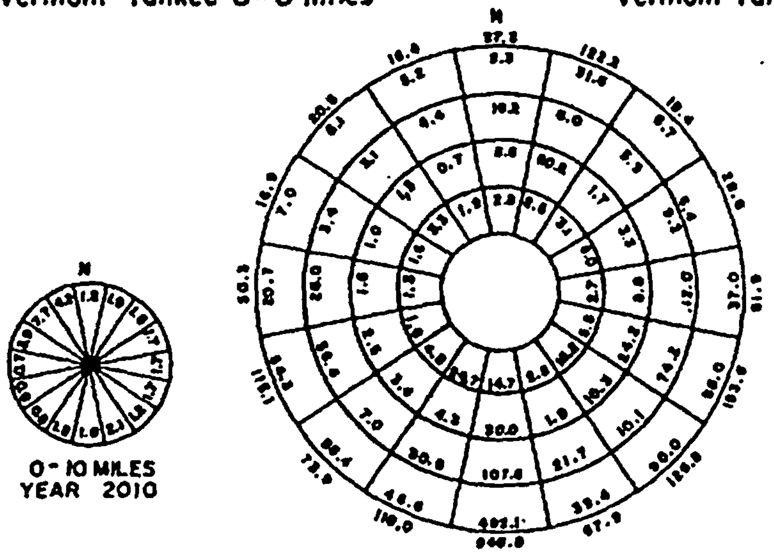
Ring miles	Population	Cumulative miles	Population
		0–5 Miles	
0–1	455	0–1	455
1–2	1,605	0–2	2,060
2–3	780	0–3	2,840
3–4	740	0–4	3,580
4–5	3,010	0–5	6,590
		0–50 Miles	
0–10	23,030	0–10	23,030
10–20	64,800	0–20	87,830
20–30	123,800	0–30	211,630
30–40	265,800	0–40	477,430
40–50	671,800	0–50	1,149,200



Population Distribution 1970
Vermont Yankee 0 - 5 Miles



Population Distribution 1970
Vermont Yankee 0 - 50 Miles.



FIGURES IN THOUSANDS

RING MILES	POPULATION 1970	POPULATION 2010
0-10	23.0	33.9
10-20	64.8	96.2
20-30	123.8	183.7
30-40	265.8	393.5
40-50	671.8	998.8
0-50	1149.2	1706.1

Vermont Yankee
Population Distribution
Year 2010 Projection
0 - 50 Miles

Fig. II-4. Population Distribution.

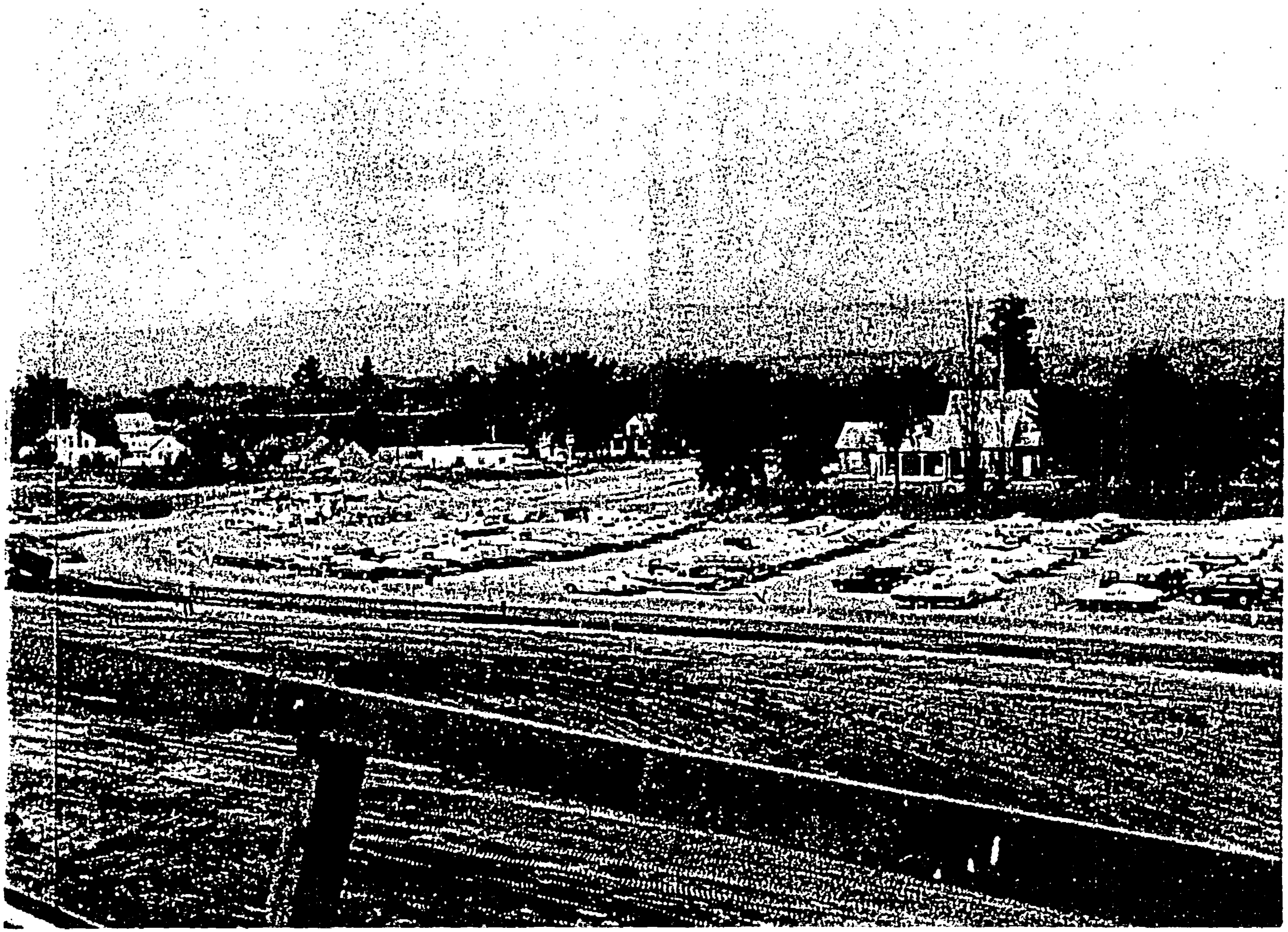


Fig. II-5. Nearest Residence (to the left of Gov. Hunt Museum and Information Center, the most prominent building), viewed from atop the cooling tower.

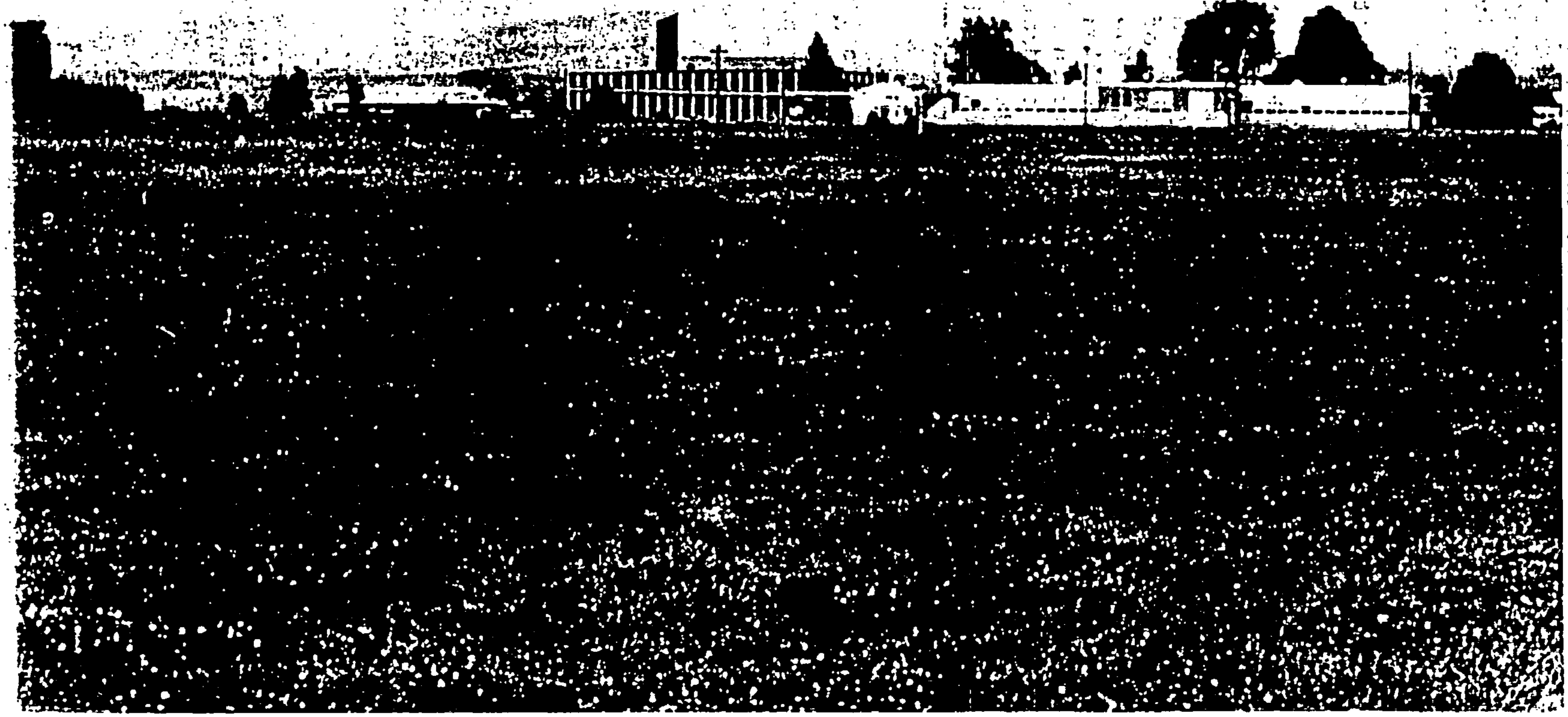


Fig. II-6. [illegible] Elementary School, 1500 S[illegible]

and there are two others within a 5-mile radius (Fig. II-3). There are no large industries within 25 miles of the site, but several small industries are located in nearby towns and along the river between Vernon and Brattleboro. The only major industries in the immediate vicinity are a paper processing plant 9 miles upriver and a large lumbering operation 3 miles north of the site. The sewage treatment plant for the city of Brattleboro is upriver approximately 2.5 miles.

Sand and gravel mining operations are common in the area, particularly in former floodplain areas of the river.

The Vernon Pond and river areas above and below the plant are used to some extent for canoeing, and for a limited amount of sport fishing. The countryside surrounding the site is used for seasonal hunting of small game. The New England Power Company is developing a series of small recreation areas along the Connecticut River; one of these has been constructed on the pond south of the reactor site. The land bordering Vernon Pond has the potential for more extensive recreation development, as does most undeveloped land bordering a waterway. The Bureau of Outdoor Recreation has identified Vernon Pond as having moderate outdoor recreation potential for use as a natural area. The Connecticut River Comprehensive Report states that Vernon Pond has regional recreation significance.[3] These judgments were published in 1968, after construction of the Vermont Yankee Plant had begun.

No commercial fishing is practiced on this section of the Connecticut River,[4] and the river is not utilized for municipal or industrial water supplies, with the exception of the upstream paper processor and the Northfield-Quabbin Reservoir Project described in Section II.E.2. The predominant crops in the area are used for dairy feed in the immediate vicinity. The milk products from these dairies are consumed principally within a 25-mile radius of Vernon.[5] Within a 5-mile radius of the plant site, water for private use is supplied by wells and springs and there appears to be no extensive use of river water for irrigation purposes. As noted before, transportation on the river is limited to small sporting groups. The series of dams (4 below reactor site, 9 above; Fig. II-7) developed by the New England Power Company precludes any industrial navigation, since there are no locks. At present, the only other nuclear facility within a 50-mile radius is the 175 MW(e) Yankee Nuclear Power Station at Rowe, Mass., approximately 22 miles from the Vermont Yankee site. The 50-mile radius circle overlaps that of the Connecticut Yankee Power Station at Haddam Neck, Conn.

D. HISTORIC SIGNIFICANCE

The Vermont Archaeological Society has been contacted concerning the possibility of archaeological materials being found in this section of the Connecticut River Valley. The past secretary (H. N. Muller who is

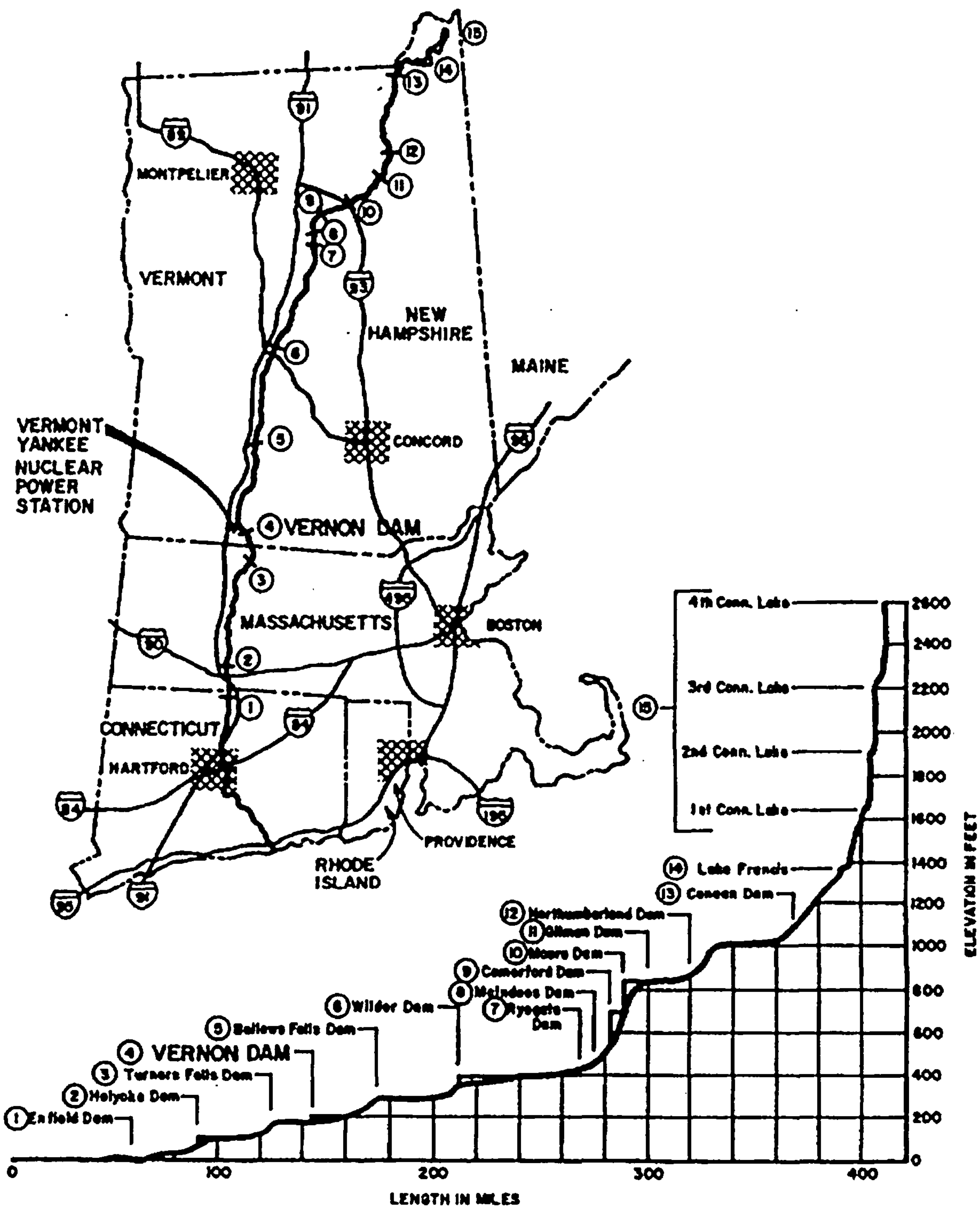


Fig.II-7
Connecticut River Dams-Location Map and Profile.

also Assistant Dean of Arts and Sciences at the University of Vermont) of the society is not aware of any significant fossil deposits in the Vernon area; however, it appears that archaeological surveys of the area are incomplete and no survey was made before site preparation began. Extensive subsurface exploration followed by excavation was done before construction began at the site. Neither of these activities revealed any fossil deposits or archaeological materials of significance; and since construction is essentially complete none can be expected in the future.

The National Register of Historic Places does not list any sites in the immediate vicinity of the reactor. The Vermont Board of Historic Sites lists a historic "site marker" for the location of an old fort 3 miles west of the reactor, and there is a state-owned historic covered bridge 20 miles northwest of the station (Scott Covered Bridge in Townshend).

A site that is locally historic is the Governor Jonathan Hunt house on the western boundary of the plant site; it was acquired by the applicant and efforts are underway to maintain the building as a public museum. Additions have been made to the building for use as a visitors' center for the plant (Fig. II-8). Jonathan Hunt was born in Northfield, Massachusetts, in 1738 and elected Lieutenant Governor of Vermont in 1794. The Hunt mansion was built in the early 1780's near the river for his bride, and it was she who suggested the name Vernon for a new town organized near her home.

Discussion by the staff with the Vernon Historians, Inc., a local organization active in preserving the historical heritage of the community, has established the fact that no other historical sites exist in the immediate vicinity of the reactor. The staff contacted the State Liaison Officer, Board of Historic Sites, who also stated that there are no nationally registered historic sites in the vicinity of the Vernon Plant (Appendix XII-A).

E. ENVIRONMENTAL FEATURES

1. Climate

The climate of the Vermont Yankee site is of a continental type, with some influence from the maritime climate of the Atlantic Coast. Temperature records indicate a range from -33° to 100°F. Annual snowfall has varied from 30 to 118 in. Extremes of temperature, precipitation, snowfall, and wind for Brattleboro, Vernon, and Westover AFB (Mass.) have been reported by the U. S. Weather Bureau for a 20-year period.[6] The site has been monitored for over 5 years by the applicant; monitoring will continue when the plant becomes operational. The Air Resources Environmental Lab, National Oceanic and Atmospheric Administration, as part of the staff safety review, analyzed the data provided by the applicant.

Fig. II-8. Gov. Hunt Home and Reactor Visitors' Center.

Data collected at the on-site station in the meteorological site monitoring program[7] from August 1967 through July 1968 indicate that the most frequent wind direction is from the north-northwest (downriver) at an average speed of 7 to 8 miles per hour. Inversion frequency varies from 36% in the fall to 42% in the spring (av 39%). Rainfall as heavy as 2.7 in./hr has been recorded in the area. Freezing rain or drizzle is common in the Vernon area during the winter months. As many as 10 ice storms per year have been recorded, with ice thickness up to 0.75 in. Severe storms such as tornadoes do occur in the vicinity of the plant. In a 50-year period (1916-1965), two tornadoes have been reported in Bennington, Vermont, eight in Cheshire County, New Hampshire, and nine in Franklin County, Massachusetts;[7] however, property damage reported has been small. Information on occurrence of fogging conditions near this section of the Connecticut River is not tabulated in any of the weather summaries. However, according to a recent study[8] of potential seasonal effects that might result from the cooling tower plumes at the Vermont Yankee Plant, natural fog frequency occurs about 140 hr/year.

2. Surface Water Hydrology

There are three dams downstream of the Vernon Dam and nine upstream. These dams are largely used for hydroelectric power production, although they do provide some measure of flood control.

The Vernon hydroelectric plant and most of the other hydroelectric plants on the Connecticut River are used to produce power at times of peak demand. When the demand is low, as late at night or on weekends, the plants produce little power and the river flow is greatly reduced to conserve water. When the demand is high, the river flow is greatly increased. The flow past Vernon Dam varies from a low of about 125 cubic feet per second (cfs) to a high which itself varies from about 5,000 cfs in late summer to 15,000 cfs or more in the spring. Once the nuclear power plant is in operation, the river will be so regulated that the minimum instantaneous flow[9,10] is 1,200 cfs. The low, average, and high mean monthly discharges at Vernon Dam over a 5-year period are shown in Fig. II-9. The highest average monthly flow for the period of record from 1945 to 1965 was 46,000 cfs in April, and the lowest was 1,805 cfs in August.

The river is still subject to floods, despite the many dams. However, the greatest and most destructive flood was on March 19, 1936, when the discharge was 176,000 cfs and the river stage at Vernon was 231.4 ft above mean sea level (MSL). The Corps of Engineers "Standard Project Maximum Probable Flood" would have a flow, with the present 16 flood-control dams in place, of 230,000 cfs and a stage of 235.1 ft MSL. The plant site grade is 250 ft MSL, so that it is in no danger from floods.

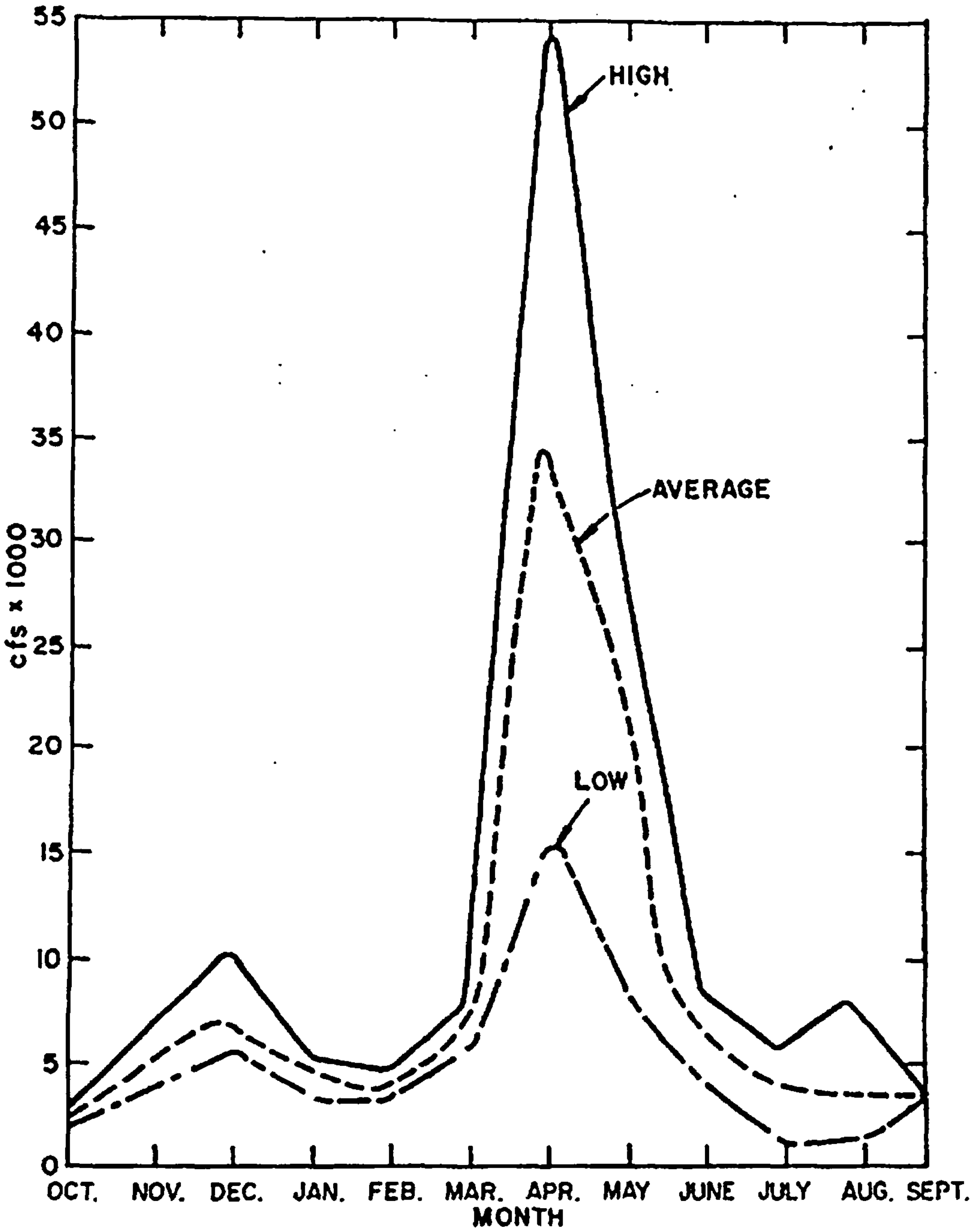


Fig.II-9
Mean Monthly Discharge.
Vernon Dam

In a feasibility study by the Metropolitan District Commission of Massachusetts, Connecticut River water at a point 15 miles downstream from the Vernon plant would be directed, under certain conditions, to Quabbin Reservoir, a domestic water supply for over two million people in Massachusetts.[11] The plan would divert this water via Northfield Mountain Reservoir only when the flow in the Connecticut River exceeds 17,000 cfs. Flow above this figure occurs normally during 70 to 80 days of high freshet flow, which takes place primarily in the spring. When the flow in the Connecticut River is 17,000 cfs (about 7,600,000 gpm) radionuclide and chemical liquid effluents from the Vermont Yankee plant would be greatly diluted; they would be diluted further when they are pumped into Quabbin Reservoir.

During the staff site visit in early September 1971, the water in Vernon Pond near the Vermont Yankee site appeared dirty, in comparison with other bodies of water in the surrounding environment. The water's appearance probably accounts for its limited use for recreation. However, the water quality studies by Webster-Martin, Inc.,[12] showed that the dissolved oxygen concentration was quite good during all the periods sampled (1967-1970). In most cases the water was nearly saturated with oxygen. A heavy silt load is carried by the river, as shown by the Webster-Martin studies. This silt load undoubtedly accounts for much of the appearance of the water.

The river water temperatures as measured near the plant site from January 1968 through December 1970 are plotted in Fig. II-10.[13] The temperature of the river water varies from 32° to 84°F with the daily variations rarely exceeding 2°F. From December through March the water temperature averages below 35°F, and in July, August, and September it averages between 70° and 77°F.

Chemical quality of the river water was also determined in the Webster-Martin study. The pH of the river water varies from 6.40 to 7.82, the total solids from 55 to 142 milligrams per liter (mg/liter) and the dissolved oxygen from 4.8 to 14.6 ppm. Chloride varies from 1.5 to 10.2 mg/liter, sulfate from 5.5 to 13.0 mg/liter, and sodium from 3.5 to 7.0 mg/liter.[14] Maximum concentrations of various elements in the water at stations 3 and 7 (Fig. II-3) above and below the plant site are given in Table II-2 for the period from May 1969 to May 1970. With values in these ranges, the river is not considered seriously polluted.

The river at the plant site, or rather the lake formed behind the dam, Vernon Pond, is a half mile wide and up to 35 ft deep.

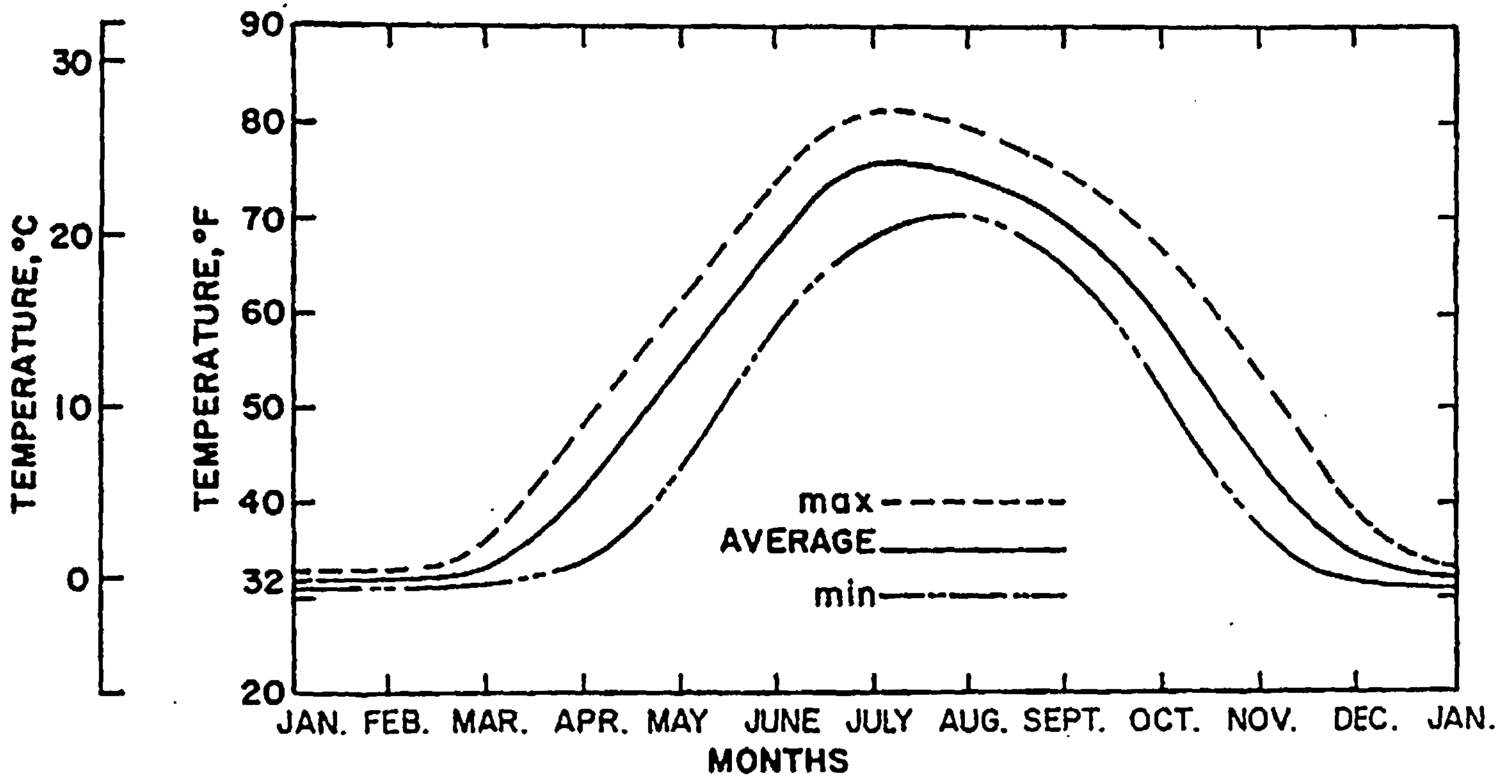


Fig. II-10
Three Year Average Seasonal Temperature Variation of Water Below Vernon Dam.

Table II-2. Summary of water quality data[12]

Elements and parameters	Value measured[a]		
	Minimum	Median	Maximum
pH	6.40	7.30	7.82
Turbidity, A.P.H.A. units	0.2	1.8	16
Concentration, mg/liter			
Chloride	1.5	7.0	10.2
Sulfate	5.0	9.4	13.0
Total solids	55	78	142
Suspended solids	0	5	17
Dissolved oxygen	6.35	9.30	12.6
Cadmium			<0.05
Chromium			0.019
Copper		0.01	0.07
Iron	0.08	0.34	3.4
Nickel		<0.01	0.04
Sodium	3.5	4.3	7.0
Zinc		<0.02	0.25

[a]Value measured, May 1969 to May 1970, at either Station 7 or Station 3 above and below plant (see Fig. II-3).

3. Geology

Extensive geological investigation of the site has been carried out in conjunction with the design and construction of the major structures of the nuclear power station.[15] The subsurface exploration program has included 93 borings at depths up to 100 ft. These borings show that the area is overlaid by glacial deposits from the Pleistocene age, with an average 30 ft of glacial overburden above the bedrock. It is important to consider the geology and groundwater conditions in selection of a reactor site, in order to assess the possibility of flood damage.

The bedrock is composed of quartz diorite gneiss (granite-like rock) and has a long and complex history. The original bedrock in the area was composed of early Paleozoic sedimentary rocks (over 230 million years old). These rocks were strongly folded from east to west to form a structure referred to as a nappe, in which the fold was not only overturned and recumbent but may also have been displaced to the west by faulting.[16]

This recumbent fold was in its turn intruded from below by a number of domes or plutons of quartz diorite. The Vernon dome, the rocks of which actually underlie the site, was 8 miles long and 2 miles wide and is one of a series of similar structures which extend northward into northern New Hampshire and southward into Connecticut. Further down-folding of the rocks on a smaller scale produced a synclinal area between the Vernon and the Westmoreland dome to the north.[17]

Very much later, at the beginning of the Triassic period some 70 million years ago, the area was further deformed by downfaulting. A large block of land extending from Long Island Sound on the south to somewhat north of the plant site was downfaulted. Similar graben areas, many still filled with Triassic red beds and basalts, are found along the eastern coast of the United States.[18] There has been no apparent movement, however, of these structures during the past several million years.

4. Groundwater

The local groundwater level fluctuates depending upon precipitation and water level changes in the Connecticut River. Drainage from precipitation or flooding in the area occurs over a rock surface beneath a thin layer of overburden. Some of the nearby communities rely entirely on stream water, other than the river, and some get their water supply partly from wells. There are many private wells in the area (Fig. II-11).[19] Although some of the wells have yields of several hundred gallons per minute, such yields may be obtained only where the glacial deposits are unusually thick and permeable. Some of the wells go into bedrock, which in this area yields only small flows of water.[20]

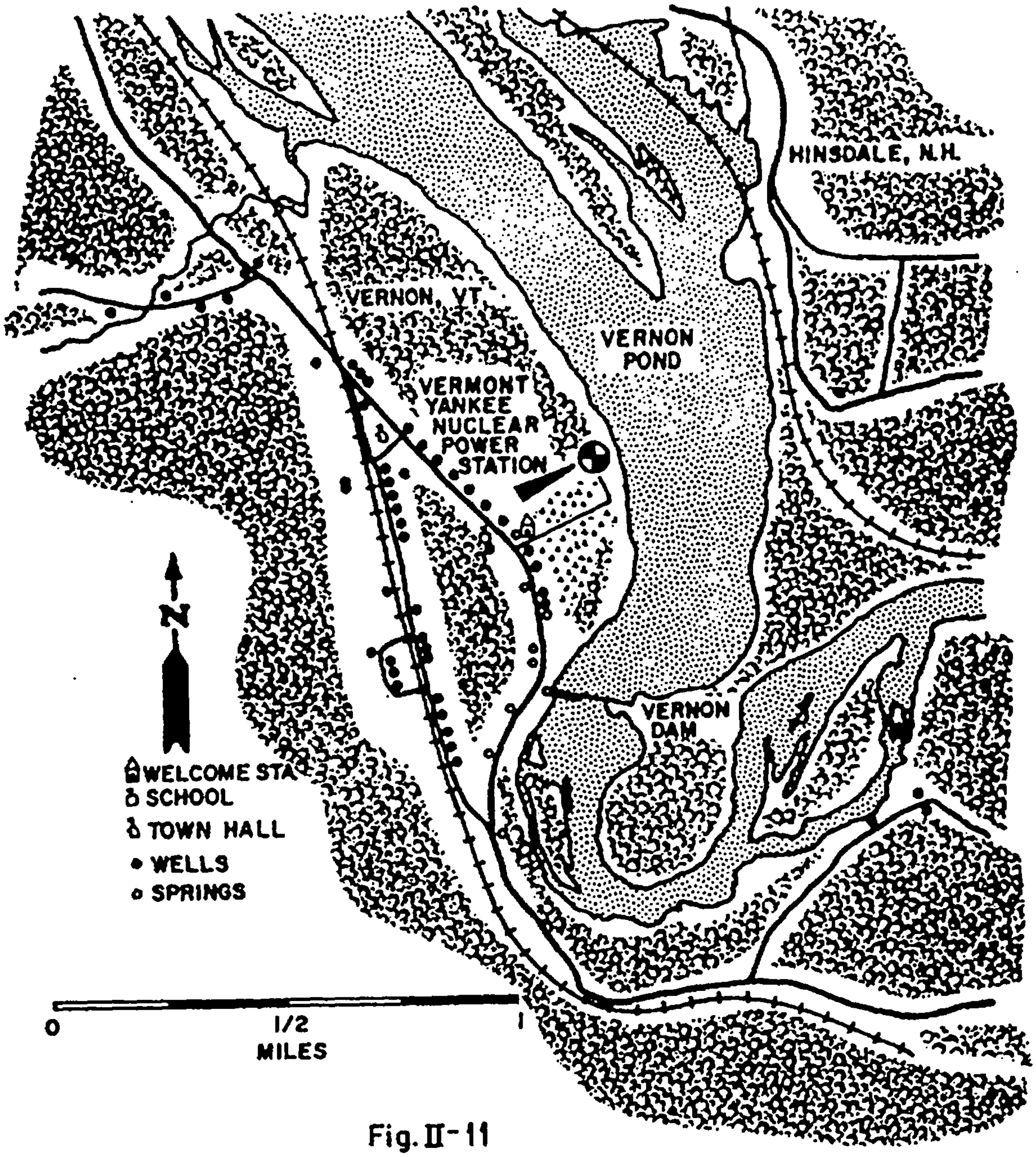


Fig. II-11
Location of Wells and Springs.

There are no deep artesian aquifers (water-permeable rock, sand, or gravel) in the area, and all of the groundwater is contained in the surficial glacial deposits or in the uppermost fractured bedrock. In general, the water table slopes toward the river, into which the groundwater discharges; however, when the river stage is rising rapidly, the slope of the water table adjacent to the river may be reversed, in which case the river will recharge the groundwater.

F. BIOTA

The Vermont Yankee site, which was formerly agricultural and pasture land, is on one of the terraces formed by the Connecticut River. The nearby hills are covered with forest of beech, birch, maple, and white pine. Animals of the area are typical of those associated with pasture land and forest of this type.

Most of the organisms associated with the aquatic ecosystem are those found in Vernon Pond, which is an impoundment of the Connecticut River created when the Vernon Hydroelectric Dam was constructed in 1909. The water impounded by the dam covers an area of approximately 2500 acres and varies in width from 400 to 3000 ft and in depth from 15 to 50 ft.

Except for the applicant's ecological studies,[21] very little information is available on the aquatic biota in this part of the Connecticut River. The Vermont Yankee Nuclear Power Corporation contracted with Webster-Martin, Inc., as an aquatic biological consultant to undertake a water quality and aquatic biota study program. Although the program was initiated in 1967, some of the important studies, such as those on phytoplankton and zooplankton, were not initiated until May of 1970. The biological phase of the program includes phytoplankton, zooplankton, benthic fauna, fish, and vascular plants. These studies are primarily descriptive, with some quantitative data given, especially for fish.

The Ecological Studies of the Connecticut River, Vernon, Vermont,[21] submitted by the applicant, is a preoperational report. This report is not exhaustive but is probably the best source of information on water quality and biota in the Connecticut River in this area. The applicant plans similar postoperational studies for at least 4 years, as discussed in Section V.C.5.

1. Terrestrial and Amphibious Vertebrates

The applicant's ecological studies did not include the terrestrial environment. Population counts of mammals, reptiles, and amphibians in the area are not available; however, Dr. William Countryman, a consultant with Webster-Martin, Inc., and a professor at Norwich University, Northfield, Vermont, supplied the AEC staff with check lists of these animals for the

state.[22] Lists of mammals, reptiles, and amphibians found in Vermont are given in Tables II-3, II-4, and II-5. Not all species and subspecies listed for the state are present on the Vermont Yankee site and immediate environs. It is unlikely that many subspecies will occur together in this general area, and it is considered improbable that mammals such as nutria, gray wolf, wolverine cougar, or moose are ever in the Vermont Yankee area except as "accidentals" or wanderers.

2. Birds

A check list of the birds[23] shows that 258 species representing 45 families are found in Vermont. Of the 258 species, 143 are regular nesting species in the state. Birds associated with the Vermont Yankee site would be those endemic to pasture land and the nearby forest habitat, such as eastern meadowlarks, red-winged blackbirds, song sparrows, starlings, and black-capped chickadees. Since the site is adjacent to Vernon Pond, some water birds would be common to the area; examples are kingfisher, black duck, and wood duck.

3. Vascular Aquatic Plants

The vascular plant communities associated with Vernon Pond were studied for the applicant.[24] Approximately 160 species of marsh and shoreline plants were identified. Collection dates and descriptions of the species are given in the applicant's report.[24]

In addition, two small marshes (Fig. II-2) were studied in detail. One marsh, about an acre in size, is 0.4 mile upstream from the cooling water intake; the other marsh, of similar size, is about the same distance downstream from the cooling water discharge. A species list and the frequency of the more abundant vascular plants was compiled by making transect studies of the two marshes.

These two marshes were studied intensively so that they might serve as sensitive indicators of possible changes in water quality. The more abundant species were Equisetium fluviatile (water-horsetail), Galium palustre (bedstraw), Typha glauca (cattail), Carex crinita (sedge), Scirpus pedicellatus (wool-grass), Polygonum punctatum (water smartweed), and Acorus calamus (sweet flag).

4. Phytoplankton and Periphyton

Microscopic plants which occur as free-living forms carried by the river current (phytoplankton) or as attached forms (periphyton) growing on submerged objects are the primary producers of the aquatic ecosystem. Phytoplankton samples were collected from May 1970 to April 1971 at six

Table II-3. Mammals of Vermont[22]

Species	Common name
Didelphis marsupialis virginiana Kerr	Opossum
Sorex cinereus cinereus Kerr	Masked shrew
Sorex palustris albibarbis (Cope)	White-lipped water shrew
Sorex fumeus fumeus Miller	Smoky shrew
Sorex fumeus umbrosus Jackson	Nova Scotian smoky shrew
Sorex dispar dispar Batchelder	Gray shrew
Microsorex hoyi thompsoni (Baird)	Pigmy shrew
Blarina brevicauda hooperi Bole and Moulthrop	Short-tailed shrew
Blarina brevicauda talpoides (Gapper)	Short-tailed shrew
Parascalops breweri (Bachman)	Hairy-tailed mole
Condylura cristata cristata (Linnaeus)	Star-nosed mole
Myotis lucifugus lucifugus (Le Conte)	Little brown bat
Myotis keenii septentrionalis (Trouessart)	Eastern long-eared brown bat
Myotis soldalis Miller and G. M. Allen	Kentucky brown bat
Myotis subulatus leibii (Audubon and Bachman)	Least brown bat
Lasionycteris noctivagans (Le Conte)	Silver-haired bat
Pipistrellus subflavus obscurus Miller	Pipistrelle
Eptesicus fuscus fuscus (Palisot de Beauvois)	Big brown bat
Lasiurus borealis borealis (Muller)	Red bat
Lasiurus cinereus cinereus (Palisot de Beauvois)	Hoary bat
Sylvilagus transitionalis (Bangs)	Allegheny cottontail
Lepus americanus virginianus Harlan	Virginia varying hare
Tamias striatus lysteri (Richardson)	Northeastern chipmunk
Marmota monax canadensis (Erxleben)	Canada woodchuck
Marmota monax preblorum A. H. Howell	New England woodchuck
Marmota monax rufescens A. H. Howell	Rufescent woodchuck
Sciurus carolinensis pennsylvanicus Ord	Gray squirrel
Tamiasciurus hudsonicus gymnicus (Bangs)	Bangs' red squirrel
Tamiasciurus hudsonicus loquax (Bangs)	Southern red squirrel
Glaucomys volans volans (Linnaeus)	Southern flying squirrel
Glaucomys sabrinus macrotis (Mearns)	Northern flying squirrel
Castor canadensis acadicus V. Bailey and Doutt	New Brunswick beaver
Peromyscus maniculatus gracilis (Le Conte)	Canadian deer mouse
Peromyscus leucopus noveboracensis (Fischer)	Northern white-footed mouse
Clethrionomys gapperi gapperi (Vigors)	Boreal red-backed vole
Clethrionomys gapperi ochraceous (Miller)	White Mt. red-backed mouse
Microtus pennsylvanicus pennsylvanicus (Ord)	Meadow vole
Microtus chrotorrhinus chrotorrhinus (Miller)	Yellow-cheeked vole
Microtus pinetorum scalopsoides (Audubon and Bachman)	Pine vole
Ondatra zibethicu. [illegible]bethicus (Linnaeus)	Muskrat
Synaptomys cooperi cooperi Baird	Southern bog lemming
Rattus rattus rattus (Linnaeus)	Roof rat
Rattus norvegicus norvegicus (Berkenhout)	Norway rat
Mus musculus domesticus Rutty	House mouse
Zapus hudsonius acadicus (Dawson)	Meadow jumping mouse
Napaeozapus insignis insignis (Miller)	Woodland jumping mice
Erethizon dorsatum dorsatum (Linnaeus)	Porcupine
Myocaster coypus bonariensis (E. Geoffroy St.-Hilaire)	Nutria
Canis lupus lycaon Schreber	Gray wolf

Table II-3. Continued

Species	Common name
Vulpes fulva fulva (Desmarest)	Red fox
Urocyon cinereoargenteus borealis Merriam	Northern gray fox
Ursus americanus americanus Pallas	Black bear
Procyon lotor lotor (Linnaeus)	Raccoon
Martes americana americana (Turton)	Marten
Martes pennanti pennanti (Erxleben)	Fisher
Mustela erminea cicognanii Bonaparte	Small brown weasel
Mustela frenata occisor (Bangs)	Northern long-tailed weasel
Mustela vison vison Schreber	Mink
Gulo luscus luteus Elliot	Wolverine
Mephitis mephitis nigra (Peale and Palisot de Beauvois)	Eastern skunk
Lutra canadensis canadensis (Schreber)	River otter
Felis concolor couguar Kerr	Cougar
Lynx canadensis canadensis Kerr	Lynx
Lynx rufus gigas Bangs	Bobcat
Lynx rufus rufus (Schreber)	Bobcat
Dama virginiana borealis (Miller)	White-tail deer
Alces alces americana (Clinton)	Moose

Table II-4. Reptiles of Vermont[22]

Species	Common name
Chelydra serpentina serpentina Linnaeus	Snapping turtle
Sternothaerus odoratus Latreille	Stinkpot
Clemmys insculpta Le Conte	Wood turtle
Chrysemys picta picta Schneider	Painted turtle
Natrix sipedon sipedon Linnaeus	Common water snakes
Storeria dekayi dekayi Holbrook	Brown snake
Thamnophis sauritus sauritus Linnaeus	Ribbon snake
Thamnophis sirtalis sirtalis Linnaeus	Common garter snake
Diadophis punctatus edwardsi Merrem	Northern ringneck snake
Coluber constrictor constrictor Linnaeus	Racer
Opheodrys vernalis vernalis Harlan	Smooth green snake
Elaphe obsoleta obsoleta Say	Rat snake
Lampropeltis doliata triangulum Lacepede	Eastern milk snake
Crotalus horridus horridus Linnaeus	Timber rattlesnake

Table II-5. Amphibians of Vermont[22]

Species	Common name
Necturus maculosus maculosus Rafinesque	Mud puppy
Ambystoma jeffersonianum Green	Jefferson's salamander
Ambystoma maculatum Shaw	Spotted salamander
Notophthalmus viridescens viridescens Rafinesque	Newt
Desmognathus fuscus fuscus Rafinesque	Dusky salamander
Plethodon cinereus cinereus Green	Red-backed salamander
Hemidactylium scutatum Schlegel	Eastern four-toed salamander
Gyrinophilus porphyriticus porphyriticus Green	Purple salamander
Eurycea bislineata bislineata Green	Two-lined salamander
Hyla crucifer crucifer Wied	Spring peeper
Hyla versicolor versicolor Le Conte	Common tree frog
Rana catesbeiana Shaw	Bull frog
Rana clamitans Latreille	Green frog
Rana sylvatica sylvatica Le Conte	Wood frog
Rana pipiens pipiens Schreber	Leopard frog
Rana palustris Le Conte	Pickerel frog

sampling stations. The locations of the sampling stations are shown in Fig. II-12, and a description of each station is given in the applicant's report.[21] Periphyton samples were collected along the shore among vascular plants and in bays and eddies of the Connecticut River. A list of 44 genera and 71 species of phytoplankton and 43 genera and 66 species of periphyton is given.[25]

Phytoplankton were the most abundant in Vernon Pond during August, September, and October. The total number of organisms per liter ranged from 20,000 to 74,000 at sampling stations near the Vermont Yankee Plant. Ten species occurred consistently in the samples, and these species are listed in Table II-6. Microspora stagnorum, a filamentous green algae,[26] was the most abundant species at sampling station 4 during August, September, and October. The number of Microspora stagnorum dropped rapidly from 8000 organisms per liter at the end of October to less than 1000 organisms per liter at the middle of November. One-celled algae with rigid cell walls are referred to as diatoms. Melosira varians, a diatom which is characteristic of organically enriched areas,[27,28] was abundant in September (2000 organisms per liter). Asterionella formosa, a diatom, was the next most abundant species; peak populations of about 1000 organisms per liter occurred in June and October.[25] Asterionella formosa is known as a filter clogging algae, and when it is abundant can produce a fishy taste in water.[27]

Species of Scenedesmus, a green algae characteristic of organically enriched areas,[27] were abundant in July and August at sampling station 4 (approximately 800 organisms per liter). The blue-green algae, Oscillatoria limosa, a pollution algae,[27] along with six other species were collected in Vernon Pond but were not abundant.

5. Zooplankton

The microscopic animals which float in river water and feed primarily on phytoplankton (algae) are known as zooplankton. An annotated list of 42 genera found in the Connecticut River is given in the applicant's report.[21] The most common groups were rotifers (microscopic animals with a wheel-like ring of cilia), daphnia (water-fleas), and nauplii (small crustacea). Seasonal variation in the total number of organisms and the number of genera observed were based on collections started in May 1970 at six sampling stations (Fig. II-12). The greatest number of organisms per sample and the greatest diversity of genera occurred during the months of June through October.[29]

In Vernon Pond at station 4, near the Vermont Yankee Plant, approximately 8000 zooplankton organisms were collected in 10-liter samples during June and July. The number decreased rapidly during the colder months to less than 200 organisms in October and November.

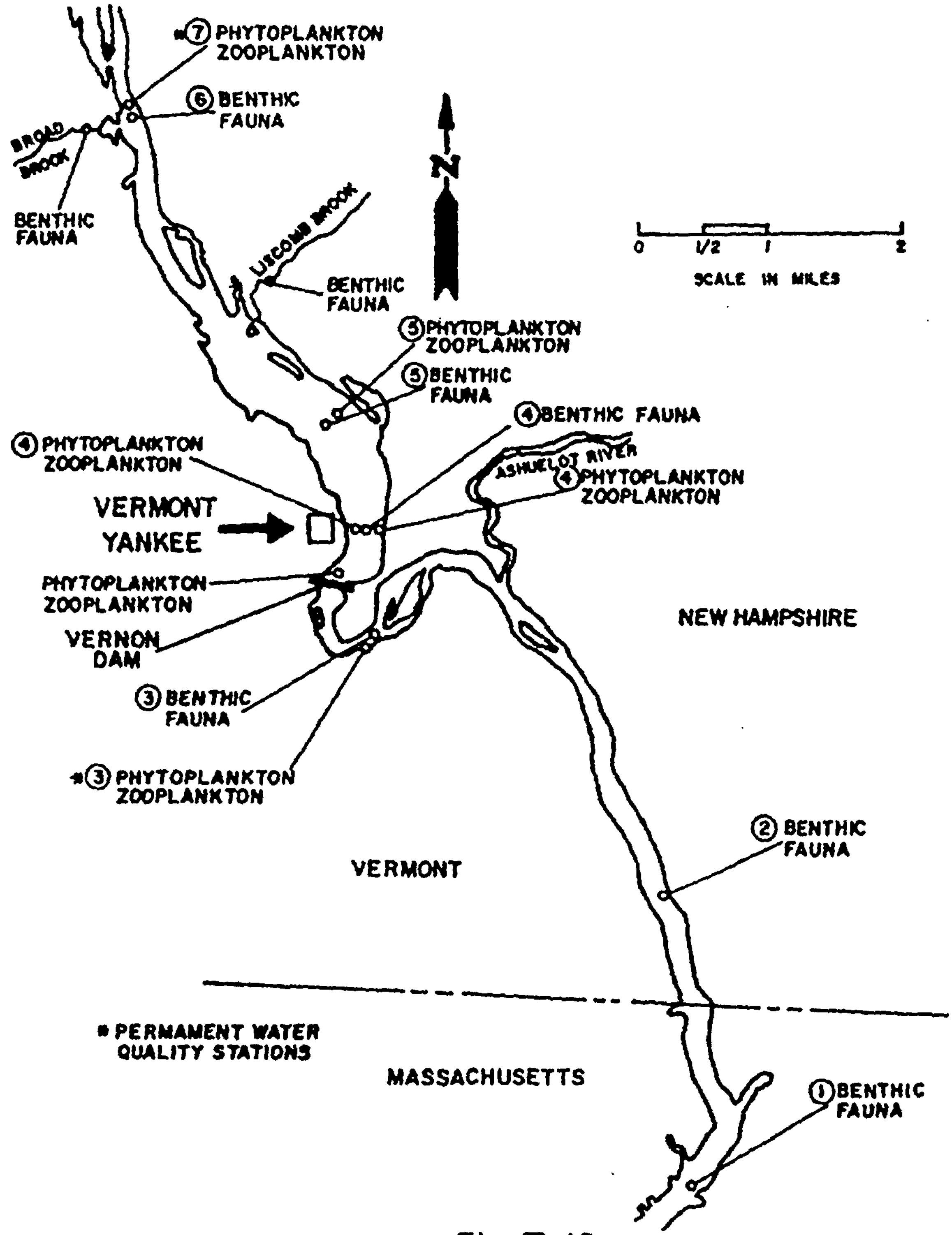


Fig. II-12
Location of Sampling Stations for Benthic Fauna, Phytoplankton Zooplankton and Water Quality.

Table II-6. Ten Phytoplankton Species Common to Vernon Pond

Species	Common name
Microspora stagnorum (Kuetz.) Lagerheim	Green algae-filamentous
Pediastrum spp.	Green algae-nonfilamentous
Scenedesmus spp.	Green algae-nonfilamentous
Tribonema bombycinum (Ag.) Derbes and Solier	Yellow-green algae
Dinobryon cylindricum Imhoff	Yellow-green algae, flagellates
Melosira varians C. A. Agardh	Diatoms
Tabellaria spp.	Diatoms
Fragillaria crotonensis Kitton	Diatoms
Asterionella formosa Hassall	Diatoms
Ceratium hirundinella (DFM) Shrank	Yellow-green algae, flagellates

6. Benthic Fauna

The invertebrate animals which live on the river bottom are known as benthic fauna. Webster-Martin, Inc., conducted studies on the bottom organisms in the Connecticut River near the Vermont Yankee Plant for the applicant. An annotated list of the benthic fauna is provided.[30] The list is based on samples collected from May to October of 1967 to 1970 at eight sampling stations; high flows and icing of the river prevented sampling at other times. The locations of the sampling stations are shown in Fig. II-12.

The most common benthic organisms collected were Tubellaria (flatworm), Oligochates (Tubicifid roundworms), Helobdella glassiphonia (leeches), Asellus (isopods), Sphaerium musculium (small fresh water clams), immature stages of Tendipedidae (two-winged, mosquito-like flies), and nymphs of Odonata (dragonflies). The greatest diversity of species occurred at sampling stations 1, 2, and 3. These stations are below Vernon Dam, and benthic organisms found at these stations are those that are found in flowing streams with rocky bottoms. Such organisms as Ephemeroptera (May flies), Trichoptera (caddis flies), and Plecoptera (stoneflies) were found at these stations. There is less diversity of species in the thick silt found on the bottom of Vernon Pond than in the river below the dam. The benthic fauna found in Vernon Pond are typical of those found in impounded waters.

7. Fish

Studies of the resident fish species in the Connecticut River in the area of Vernon, Vermont, were conducted during 1969-1970 for the applicant.[31] These studies provide an inventory of the species and their relative abundance before the Vermont Yankee Plant becomes operational. Few studies have been made on the fish populations in this part of the Connecticut River. Besides the applicant's study, Morrison[32] made a similar study for the state of New Hampshire in connection with the anadromous fish restoration program.

In general Morrison's results agree with the results of the Webster-Martin study. A species list for fish in Vernon pond was compiled from the applicant's report[31] and from Morrison's study[32] (Table II-7). Of the 31 species listed in the table, 24 species were listed as being captured in the applicant's report and 18 species listed as being captured in Morrison's report. Some of the species listed but which were not captured in either study were the American shad, brown trout, black dace, and long-nose dace. The American shad is discussed in the section on the anadromous fish restoration program (see Chapter V). Some species listed, such as carp, largemouth bass, black crappie, and white perch, are not native to the area.

Table II-7. Fish in Vernon Pond

Species	Common name
Alosa sapidissima	American shad
Ambloplites rupestris	Rock bass
Anguilla rostrata	American eel
Catostomus commersonii	White sucker
Catostomus nannomyzon	Longnose sucker
Cottus cognatus	Slimy sculpin
Cyprinus carpio	Carp
Etheostoma olmstedi	Darter
Esox niger	Chain pickerel
Fundulus diaphanus	Banded killfish
Hybognathus nuchalis	Eastern silver minnow
Icatalurus natalis	Yellow bullhead
Icatalurus nebulosus	Brown bullhead
Lepomis auritus	Redbreast sunfish
Lepomis gibbosus	Pumpkinseed
Lepomis macrochirus	Bluegill
Micropterus dolomieui	Smallmouth bass
Micropterus salmoides	Largemouth bass
Notemigonus crysoleucas	Golden shiner
Notropis hudsonius	Spottail shiner
Notropis umbratilis	Redfin shiner
Perca flavescens	Yellow perch
Pomoxis nigromaculatus	Black crappie
Rhinichthys atratulus	Blacknose dace
Rhinichthys cataractae	Longnose dace
Morone americanus	White perch
Salmo gairdnerii	Rainbow trout
Salmo trutta	Brown trout
Salvelinus fontinalis	Brook trout
Semotilus corporalis	Fall fish
Stizostedion vitreum	Walleye

A comparison of the number and average weight of the fish captured in the two independent studies is shown in Table II-8. The primary difference between the two studies was that smallmouth bass represented a greater percentage of the resident fish population in Morrison's study. About 30% of the fish captured were carp and white sucker; however, they represented about 66% of the total weight.

Morrison[32] concluded from his study that the density of the resident fish population was quite low in this part of the Connecticut River and that there was relatively little fishing. This is not an unusual situation in water where most of the large fish are carp and sucker. Based on the abundance and weight studies, white perch, yellow perch, smallmouth bass, and largemouth bass afford most of the local sport fishing in the river.

Table II-8. Comparison of the Number and Average Weight of Selected Species of Fish Captured[a] by Morrison[32] and Webster-Martin[31]

Species	Morrison (1969) Number of fish	Morrison (1969) Average weight (lb)	Webster-Martin (1970) Number of fish	Webster-Martin (1970) Average weight (lb)
Smallmouth bass	728	0.34	109	0.33
Largemouth bass	5	1.5	177	0.03
Rock bass	373	0.26	282	0.18
Sunfish and bluegill	109	0.22	362	0.04
White perch	93	0.49	311	0.32
Yellow perch	474	0.25	1175	0.27
Walleye	174	0.64	64	0.62
White sucker	722	1.9	847	0.34
Chain pickerel	8	0.6	9	0.8
Carp	122	8.0	158	8.5
Rainbow trout	1	0.6	1	0.23
Other species	73	0.5	2186	0.002

[a]Sampling techniques and equipment differed to some extent.

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III. THE PLANT

A. EXTERNAL APPEARANCE

The reactor building, turbine building, and stack are visible from Vermont State Route 142 (Fig. II-3), which passes by the plant, and also from New Hampshire on State Route 119 (Fig. III-1), on the other side of the river. The cooling towers, although partially visible from Route 142 now, will not be visible when planned landscaping is finished.

The turbine building has a structural steel frame covered with corrugated metal siding. The reactor building has reinforced concrete side walls, with the top 40 ft covered with metal siding (Fig. III-2). The 318-ft-high tapered, reinforced concrete stack is about 650 ft from the end of the turbine building (Figs. III-2 and III-3). The visitors' center serves both to screen the plant from the highway and to provide a view of the buildings (Fig. III-4). After planned landscaping, the cooling towers will not be visible from the visitors' center.

The intake and discharge structures can be seen only from the New Hampshire side of the river; their appearance is not obtrusive.

The plume from the cooling towers will possibly be the most noticeable visual feature of the plant. It will be visible from Vernon and from State Route 119 in New Hampshire. The townspeople of Hinsdale, New Hampshire, will probably notice the plume in the rare cases when the wind blows it in their direction.

B. TRANSMISSION LINES

Transmission lines are needed to transmit power and to tie into the regional transmission network. The Vermont Yankee Station will significantly increase Vermont's power generation when it goes into service; however, about 45% of the plant's output will be delivered to utilities (including Vermont Yankee sponsors) outside the state. The 345-kV New England grid loops from western Massachusetts north to the Vermont Yankee switchyard, where Vermont Yankee is connected to the grid, and then east through New Hampshire. The two 345-kV grid transmission lines built to the Vermont Yankee switchyard would have been required to supply purchased power to the State of Vermont even if the station had not been located at the Vernon site. The only facilities added as a result of the construction of the Vermont Yankee Station are two 115-kV lines that connect the station to the interconnected Vermont-New Hampshire 115-kV grid.

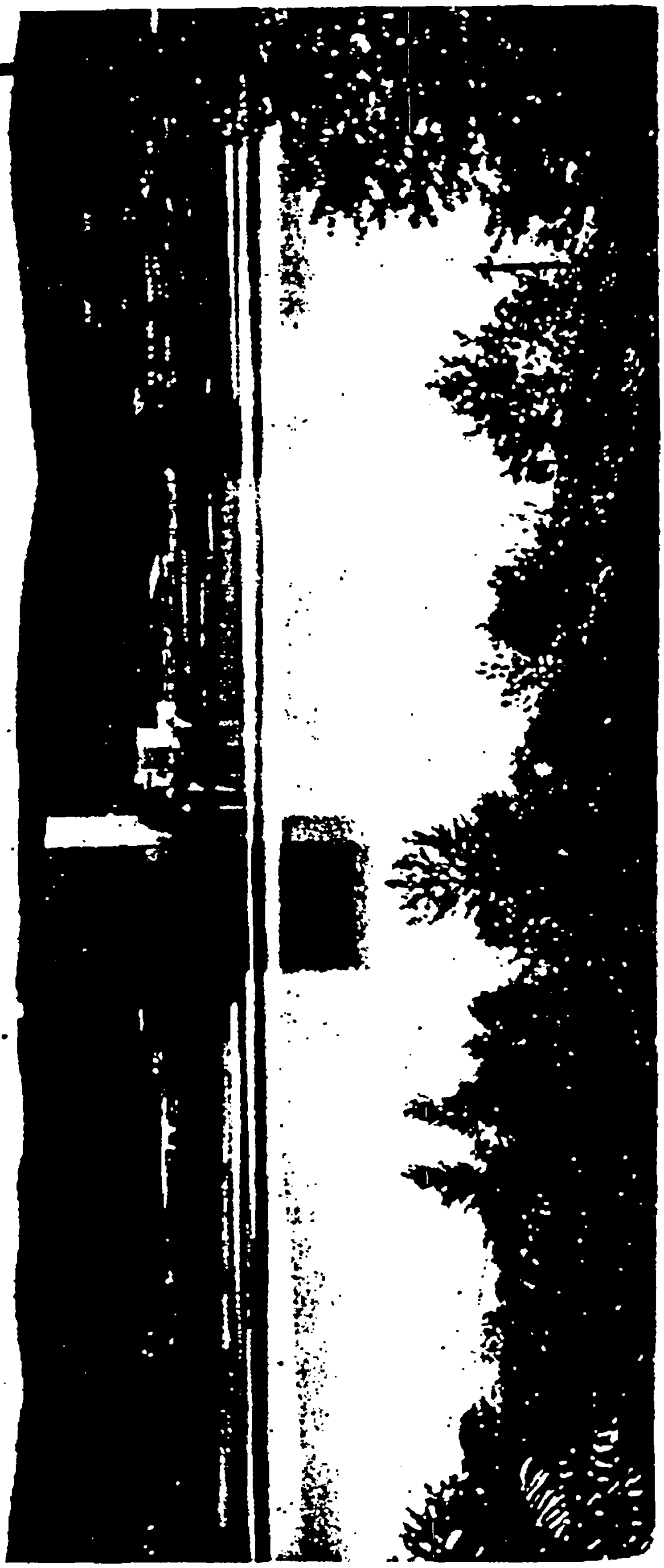

Fig. III-1. Vermont Yankee Plant seen from New Hampshire.

Fig. III-2. Turbine Building and Reactor Building.

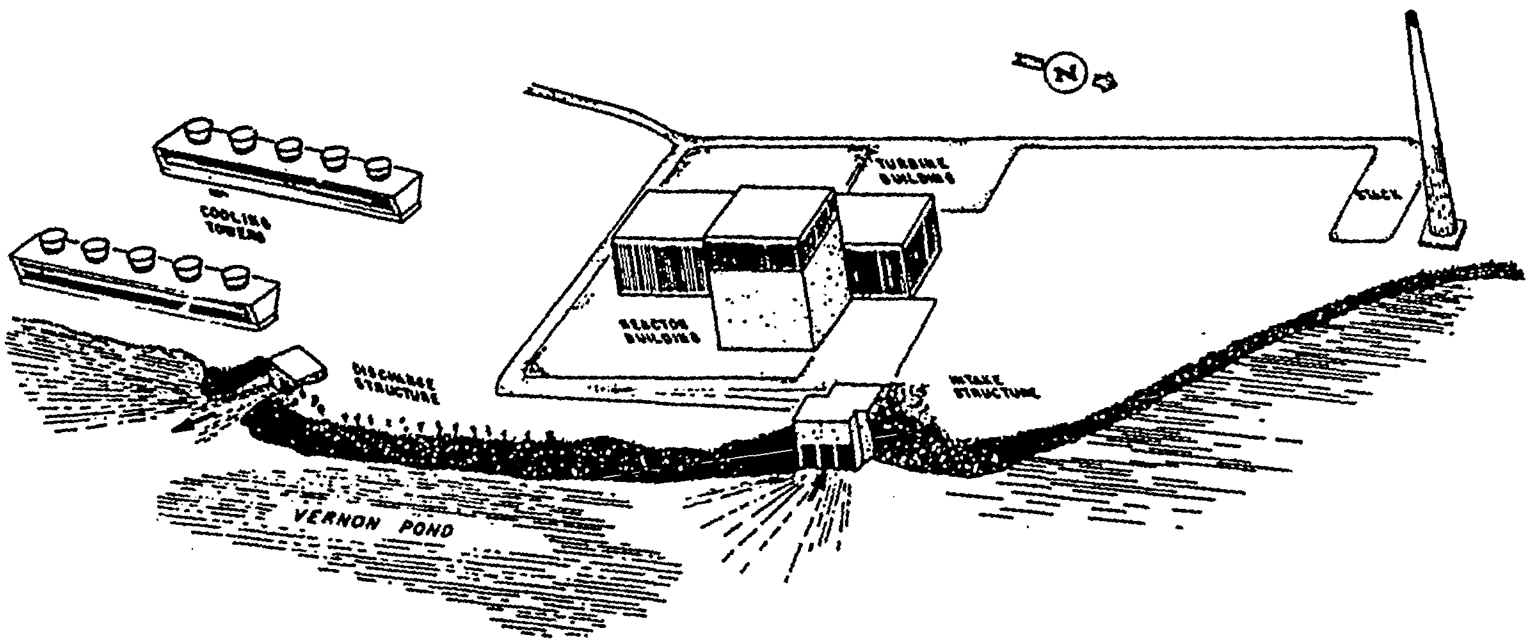

Fig. III-3
Facility Arrangement.
Vermont Yankee Nuclear Power Station

Fig. III-4. Turbine Building and Reactor Building, seen from nearest point accessible by public.

Two double-circuit 345-kV lines have been constructed, which run north from the plant switching station 1400 ft on the plant's property to two towers and then cross Vernon Pond to the New Hampshire side (Fig. III-5). The Public Service Company of New Hampshire is responsible for the tie-in with the transmission grid for the New England area. Two 115-kV lines run from the power plant to the towers on the Vermont side of Vernon Pond. One of them crosses the river and connects with the Brattleboro-to-Keene, New Hampshire, line. The other continues northward along the river.

Transmission line development includes two substations and a 345-kV transmission line requiring a right-of-way 150 ft wide and approximately 51 miles long that runs from the switching station at the Vermont Yankee Plant to a proposed substation 3 miles NE of the village of Ludlow, Vermont. The substation requires an area 600 ft by 585 ft. Vermont Electric Power Company, Inc. (VELCO), an organization established for transmission of electric power in Vermont, has plans for two 345-kV lines and has acquired a 250-ft-wide right-of-way (to accommodate two lines in the future) and ample acreage at the substation sites. Descriptions of these transmission lines and proposed alternates can be found in the State of Vermont Public Service Board's Findings of December 31, 1969,[1] and June 12, 1970.[2]

The VELCO program for maintenance of its transmission lines uses herbicides but also includes erosion control and selective cutting. Herbicides are used to control the growth of vegetation in the rights-of-way. Applications of herbicides are made shortly after clearing and every 2 or 3 years thereafter. The use and application of the herbicides are controlled at the state level by the Pesticide Advisory Council in the Vermont Department of Agriculture and at the federal level by the U. S. Department of Agriculture. The program is designed to reduce the impact of transmission lines on the environment.

Approval of the transmission facilities has been obtained at the local, state, and Federal level. The Vernon Board of Selectmen and Vernon Planning Commission issued statements saying that transmission lines associated with the Vermont Yankee Plant would not influence the orderly development of the town.[1] Approval for the construction of the transmission facilities has been obtained from the State of Vermont.[1,2] On July 31, 1970, the Federal Power Commission approved the use of lands for the transmission of electrical energy associated with the Vermont Yankee Plant.[3]

C. REACTOR AND STEAM-ELECTRIC SYSTEM

The 1593 MW(t) nuclear system uses a single-cycle, forced-circulation, boiling-water reactor, that produces steam for direct use in the steam turbine. Fuel for the reactor core consists of slightly enriched uranium dioxide pellets contained in sealed Zircaloy-2 tubes. Steam produced

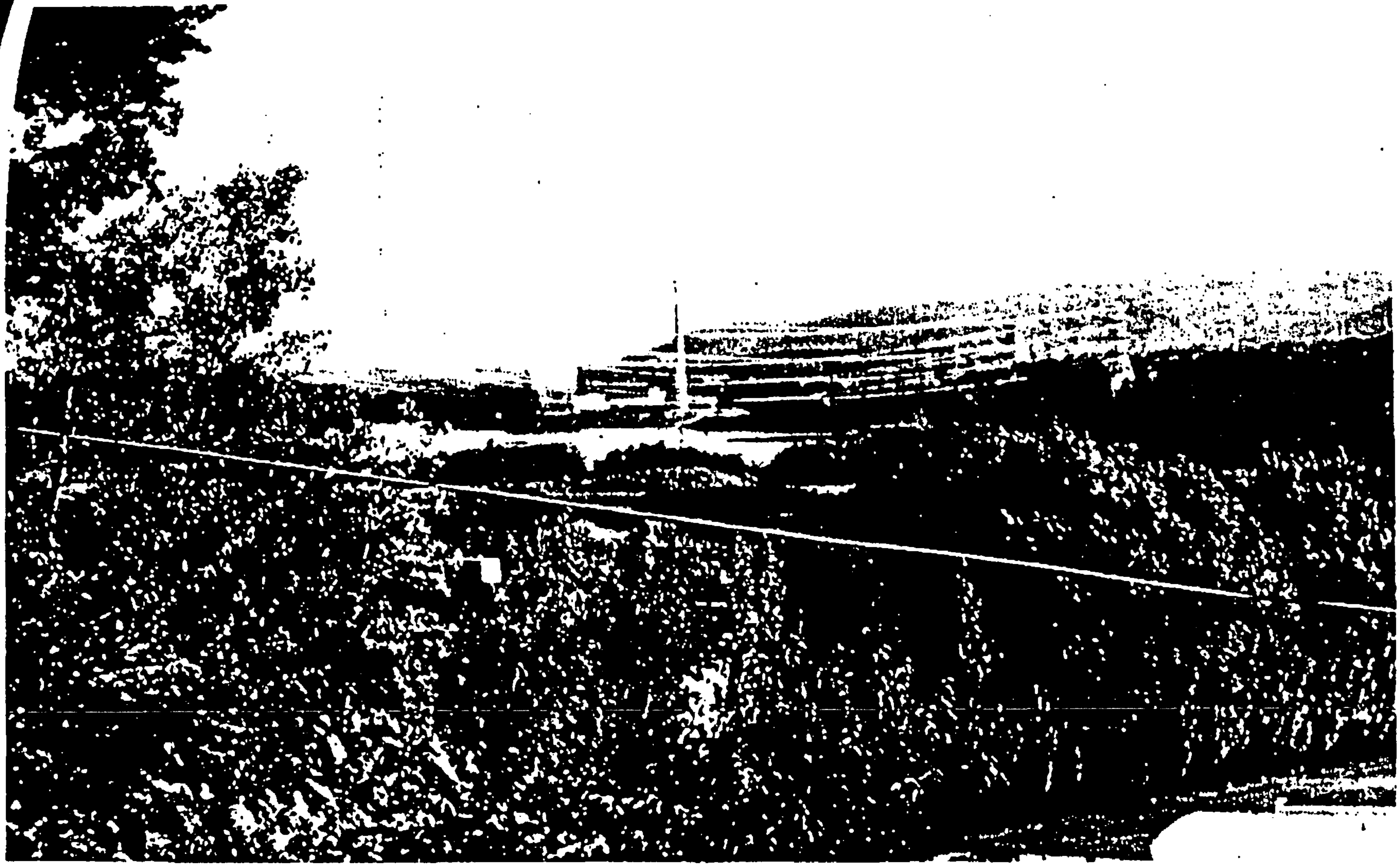

Fig. III-5. Transmission lines crossing Vernon Pond.

in the reactor core drives the turbine-generator, which generates 540 MW(e). Steam is condensed in the single-pass-type main condenser, which will accept normal steam discharge or bypass discharge (up to 105% of the turbine design flow) resulting from a load loss.

A circulating water system cools the main condenser with water pumped from and returned to Vernon Pond. As an alternate operation, cooling water is recirculated through cooling towers which dissipate heat to the atmosphere.

The designer and fabricator of the nuclear steam-supply system was the General Electric Company, which also supplied the turbine. Primary containment for the reactor is a steel vessel surrounded by reinforced concrete. Secondary containment (the reactor building) surrounds the primary containment vessel and serves as another barrier to release of radioactive fission products and activation products.

D. EFFLUENT SYSTEMS

1. Heat

a. Thermal Source Term

Heat is dissipated from the main condenser to the circulating water system (Fig. III-6), which provides a continuous flow of cooling water through the condenser. The circulating water follows one basic flow path for full open cycle and another for closed cycle, In the open cycle, the water is pumped from the river, passed through the condenser, and discharged back into the river. In the closed cycle, water is circulated through the cooling towers to dissipate condenser heat. The only water discharged to the river during closed-cycle operation is the blowdown from the cooling towers. Blowdown refers to the water continuously removed from the cooling tower collection basins to rid the cooling towers of dissolved solids. In a modification of the open cycle described below, both flow paths are used.

Vernon Pond is the source of water for both the circulating water system and the service water system. The service water system supplies cooling water to auxiliary equipment and heat exchangers. Water will be removed from the river at 10,000 gallons per minute (gpm) or 22.2 cubic feet per second (cfs) for the service water system in closed-cycle operation or 376,000 gpm (840 cfs) for both systems in open-cycle operation. Heated service water is discharged into the circulating water being returned to the river during open-cycle operation or is used as makeup water during closed-cycle operation. Maximum consumptive use of water occurs during closed-cycle operation, when about 5000 gpm (11.1 cfs) evaporates and drifts from the cooling towers. Consumptive use refers to water removed from the river and lost (not returned to the river).

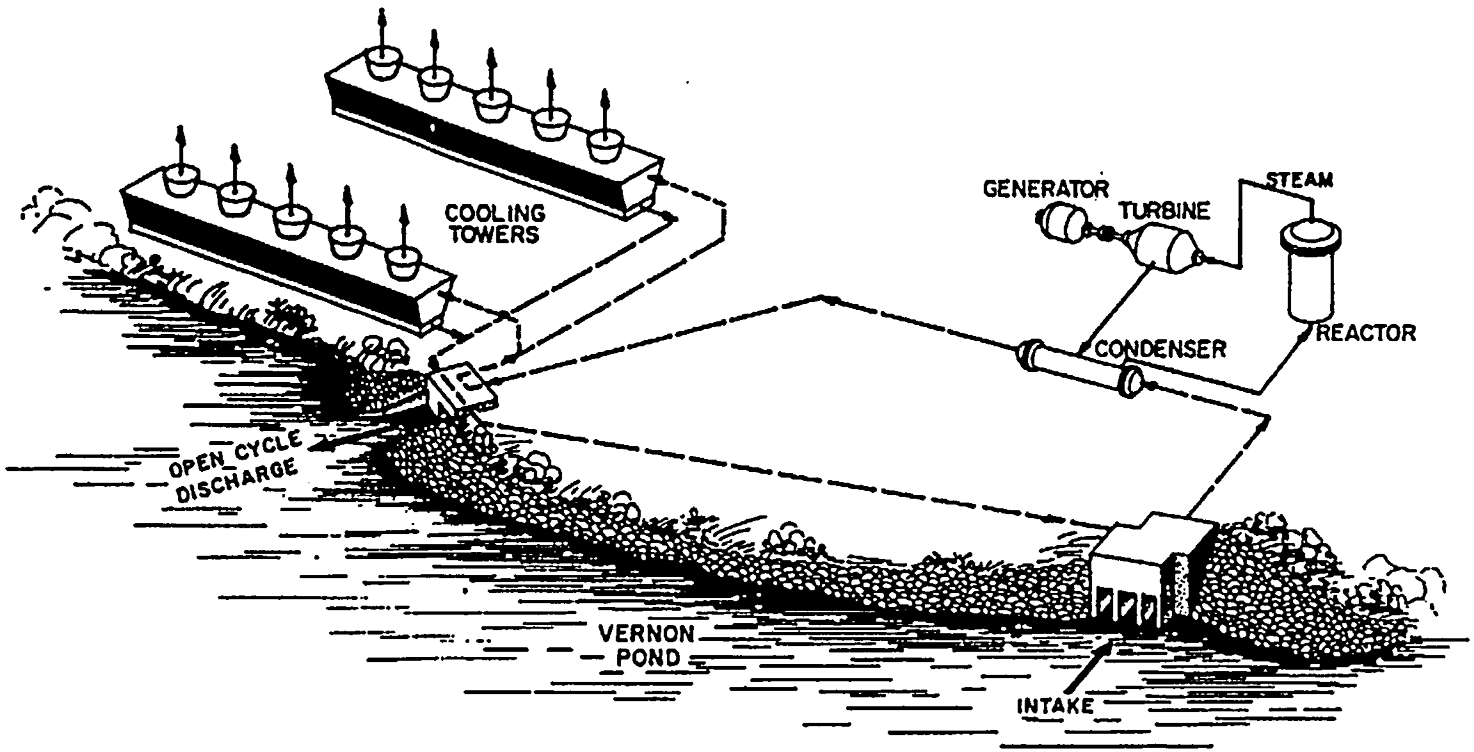

Fig. III-6
Heat Dissipation System.
Vermont Yankee Nuclear Power Station

The intake is a reinforced concrete structure on the river bank NE of the reactor. Openings in the intake are covered by trash racks, which are vertical steel bars 3/8-in. thick by 3-in. deep spaced on 3-in. centers. Inside the intake are traveling screens made of copper wire with 3/8-in. clear openings. Recirculation of warm discharge water is provided when needed to keep the intake bays and service bays free of ice. For normal pool water level, velocity through the trash racks is ~1 ft per second (fps) and velocity through the traveling screens is 1.57 fps. The structure houses intakes and pumps for the circulating water system, the service water system, and the radioactive waste dilution system.

There are two mechanical draft cooling towers, each about 463 ft long, 60 ft wide, and 50 ft high (Fig. III-7). Each tower has 11 induced-draft fans with 14-ft-high fiberglass fanstacks, polyvinyl chloride fill, and drift eliminators. The cooled water is collected in a reinforced concrete basin which also serves as a foundation for the tower. The towers were designed to operate at a noise level less than 88 decibels above the ASA Standard Reference Level when measured 50 ft from the air inlet face and 5 ft above grade. In the residential area 600 ft W of the towers, sound has been measured at 68 dB(C), which is 56 dB(A); the standard A weighting scale is usually considered to approximate the response of the human ear.

The basin for the No. 2 cooling tower is about 15 ft deep and serves as a storage reservoir for 1,500,000 gallons (200,000 ft^3) of water to be used for emergency cooling. A de-icing line supplies warm water to the basin to prevent the emergency cooling water from freezing.

Chlorine (sodium hypochlorite) and sulfuric acid will be added to the condenser cooling water to control biological fouling and scale deposition. This is discussed in more detail in Sect. III.D.3.a.

A concrete discharge-aerating structure on the river bank south of the intake discharges water to the river over 27 concrete deflector blocks (Fig. III-8), which aerate the water. Flow velocity over the aeration spillway is about 5 fps. Compartments and pumps in the discharge structure are arranged so that water can be discharged to the river or pumped through the cooling towers, or both. Water returning to the discharge structure from the towers can be mixed with circulating water and discharged or returned to the intake structure.

Figure III-6 shows the intake, discharge, cooling towers, and condenser. The three operating modes of the circulating water system are shown by flow lines. In each mode, 366,000 gpm (815 cfs) passes through the condenser with a temperature rise of 19.7°F.

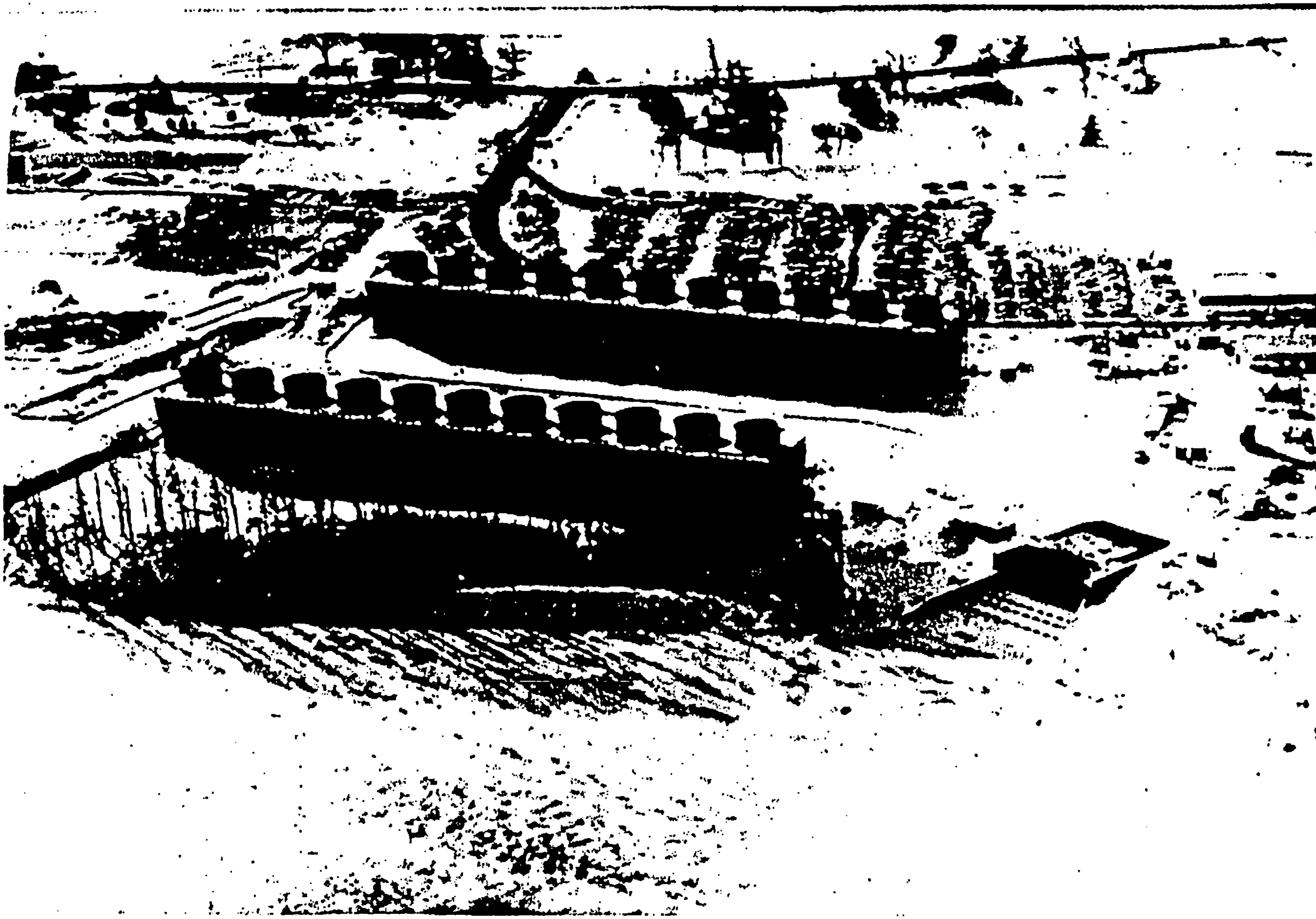

Fig. III-7. Cooling Towers.

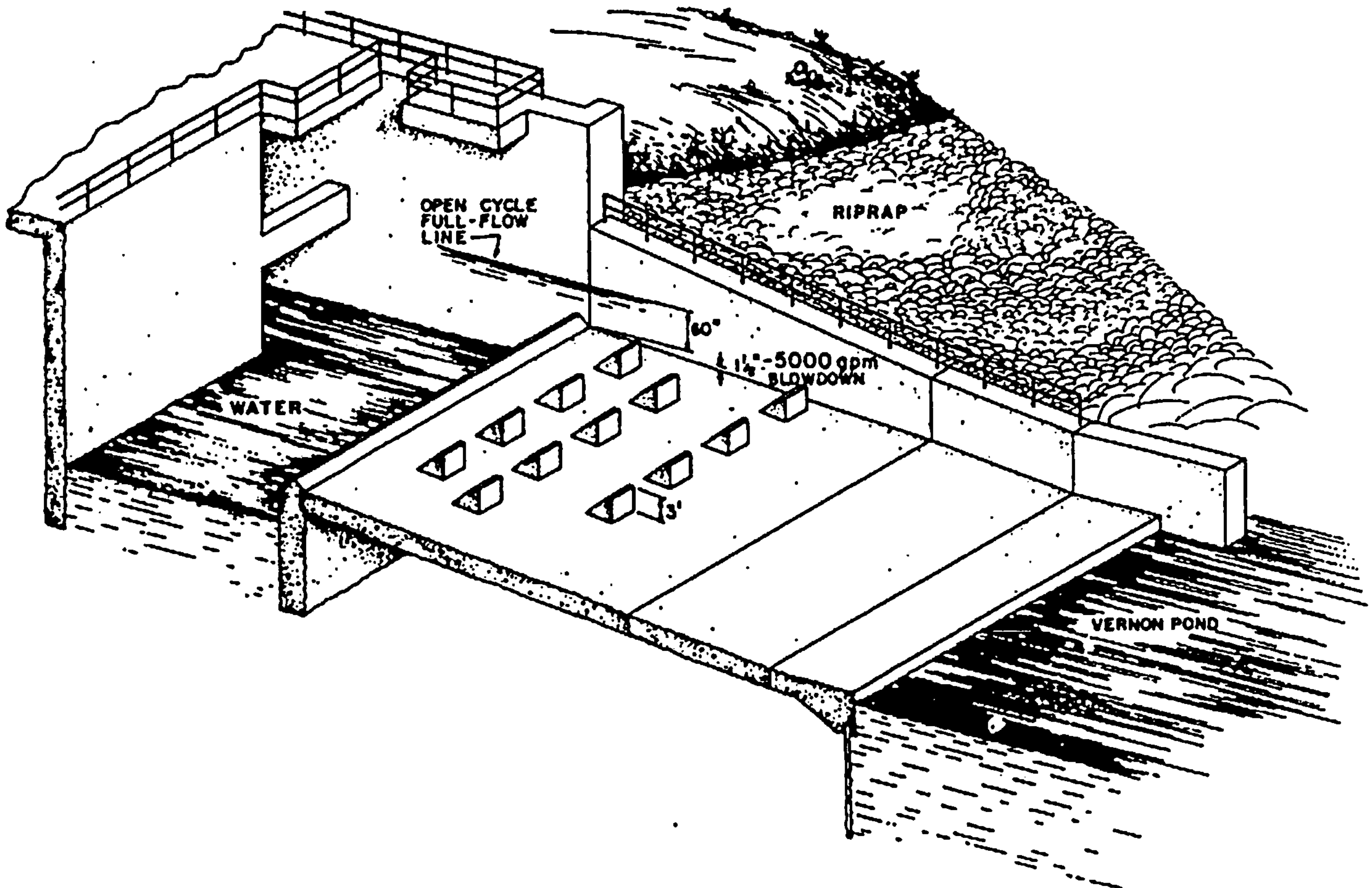

Fig. II-8
Discharge Spillway
with Aeration Blocks.
Vermont Yankee Nuclear Power Station

(1) Open Cycle

In the open-cycle mode of operation, no water is pumped through the cooling towers. The total flow (366,000 gpm cooling water plus ,000 gpm service water) is directed from the discharge structure into the river.

(2) Closed Cycle

In the closed-cycle mode, the total cooling water flow of 376,000 gpm is pumped to the cooling towers, where it is cooled by evaporation. About 5000 gpm is lost through evaporation and drift during full-power closed-cycle operation. The only water discharged to the river is about 5000 gpm of cooling tower blowdown, which is discharged at a maximum temperature of 90°F. The remaining 366,000 gpm of effluent from the cooling towers is returned to the intake structure for recirculation.

(3) Helper Cycle

In the helper-cycle mode, only part of the water is circulated through the cooling towers before being discharged to the river. Cooling tower effluent is mixed with heated water from the condenser to lower the temperature of the water before discharge. There is some loss by evaporation and drift.

The mode of operation of the cooling system can be selected so as to limit the heat load on the river according to administratively chosen criteria. The applicant states that he will conform to requirements of the State of Vermont Water Resources Board in its Final Order of Permit, dated June 10, 1968, and as amended November 26, 1971. These orders establish allowable increases in the river water temperatures that are dependent on ambient river temperature. No discharge of heated condenser water is permitted when the river temperature is 70°F or greater, with the exception that chemical blowdown from the cooling towers may be discharged at a flow not to exceed 15 cfs at a temperature not greater than 90°F. For water temperatures between 67° and 70°F, a 1°F rise in river temperature is permitted; below 55°F, a 5°F rise is allowed; intermediate increases are allowed between 55 and 67°F. The rate of change of temperature is limited to 0.5° to 1°F per hour at different seasons of the year. The temperature changes are to be measured downstream of the mixing zone - that is, at a point below the Vernon Dam (discussed in Section III.D.1.b and Chapter V). Thermal restrictions imposed by the New Hampshire Water Supply and Pollution Control Commission (NHWS&PCC) in its "Final Permit to Discharge Certain Station Wastes," dated March 2, 1972, are similar to the Vermont requirements described above, except that all temperatures are to be measured at points within the State of New Hampshire as later determined by the NHWS&PCC.

b. Dispersion of Heat

The extent and severity of calefaction of Vernon Pond will depend upon factors: (1) the cooling system mode of operation (open, helper, or closed cycle); (2) the design of the discharge opening; (3) the river flow rate; (4) the fraction of flow taken from various depths going through Vernon Dam; (5) the air temperature relative to water temperature; and (6) wind speed and direction.

The cooling mode is a directly controllable factor, because it can be chosen. The design of the discharge opening could be changed by the applicant. The depth from which water enters the dam could be changed through a special agreement with the corporation that operates the dam. The effects of the other factors can be largely compensated for by the applicant's choice of cooling mode. The applicant has proposed to exercise this choice in such a way as to conform to the requirements of the State permits, as discussed above, operating the cooling towers when necessary to limit the temperature of the river as measured at monitoring stations below the Dam.

The temperature of Connecticut River water is recorded continuously at two stations (Fig. II-3). One station, No. 7, is about 4.25 miles upstream from the plant, near the Brattleboro town line; warm water from the discharge plume is unlikely to reach this point. The other, station 3, is about 0.65 mile downstream from Vernon Dam; this location effectively extends the allowable mixing zone to this distant point. These two stations send continuous temperature signals to the plant, and the applicant has proposed that the release of heated water to Vernon Pond be based on these signals. The intake from Vernon Pond to operate the hydroelectric generators in Vernon Dam (Fig. II-2) extends from 5 to 35 ft below the surface of the pond. If cold water is drawn from the lower levels, the temperature recorded below the dam will not reflect the temperature on the surface should thermal stratification occur; in fact, the measured water temperature below the dam could be colder than that at the upstream station, even though heated water is being released by the Vermont Yankee Plant. Thus, the cooling towers might not be used at times when they are needed.

Knowledge of temperature distributions in Vernon Pond is essential for an assessment of environmental impact of plant operation. Presently available physical and mathematical methods of predicting temperature distributions are discussed below. Because these predictions are not sufficiently reliable, the staff has chosen to identify thermal limits derived from consideration of possible damage to the pond and then to require the applicant to adhere to specified thermal limits (Sect. V.C.7).

Two different techniques were employed to predict thermal plume dispersion in the pond. The applicant ran dye dispersion studies, while the staff considered mathematical models of thermal plume dispersion. Another way to determine thermal plume dispersion would be to measure the temperatures and their ecological effects during operation of the plant. However, this

would require a significant period — a year or so — during which inadequately restrained plant operation could possibly result in a significant ecological impact on the pond. Assessment of the restraint that would be provided by the applicant's compliance with Vermont's Final Order of Permit, as amended, and identification of a better alternative, if one is needed, must be based on the best available predictions of thermal plume dispersion.

The applicant sponsored dye dispersion studies in Vernon Pond in August 1971.[5] Figures III-9 and III-10 show isotherm lines derived from dye concentration measurements at river flows of 1270 and 4900 cfs, respectively. However, this study was carried out with unheated water and the dye density and dispersion do not adequately replicate those for heated water. Accordingly, the staff has estimated thermal plume dispersion in Vernon Pond by use of a mathematical model.

The warm water from the discharge structure is expected to form a layer near the surface, flowing out for several hundreds of feet before it disperses. The shape of this plume will depend in part on the quantity of river flow through the dam. At the minimum river flow of 1200 cfs (538,000 gpm), the heated plume will flow across the pond to the New Hampshire shore, where it will be deflected both north and south along the shore line. At high river flow, the plume will curve more toward the dam and probably deflect into the intake of the hydroelectric station.

Several mathematical models were investigated by the staff, although no mathematical model was set up to incorporate all the flow characteristics of Vernon Pond. The Motz-Benedict Model[6] was selected to study thermal plumes from a surface discharge into a flowing water body. The model conservatively assumes entrainment only at the sides of the discharge plume. Values for the drag coefficient and for the entrainment coefficient must be obtained by empirical methods. The entrainment coefficient is the most uncertain value in the model. Several calculations were carried out to determine the sensitivity of the discharge plume to the coefficient value. The results shown include what is believed to be a realistic value of 0.1 for the entrainment coefficient for the hydraulic conditions in Vernon Pond below the Vermont Yankee discharge. Isotherm lines were computed and plotted to predict how the heated water will disperse. The cases covered the following river flows:

River flow (cfs)	River condition	Area within 5°F isotherm (acres)	Area within 10°F isotherm (acres)
1,270	Low flow	150	5.5
4,900	Prevailing average flow	29	3
10,000	Approximate yearly average flow	26	2.5
15,000	Approximate average flow during spring months	22.5	2.5

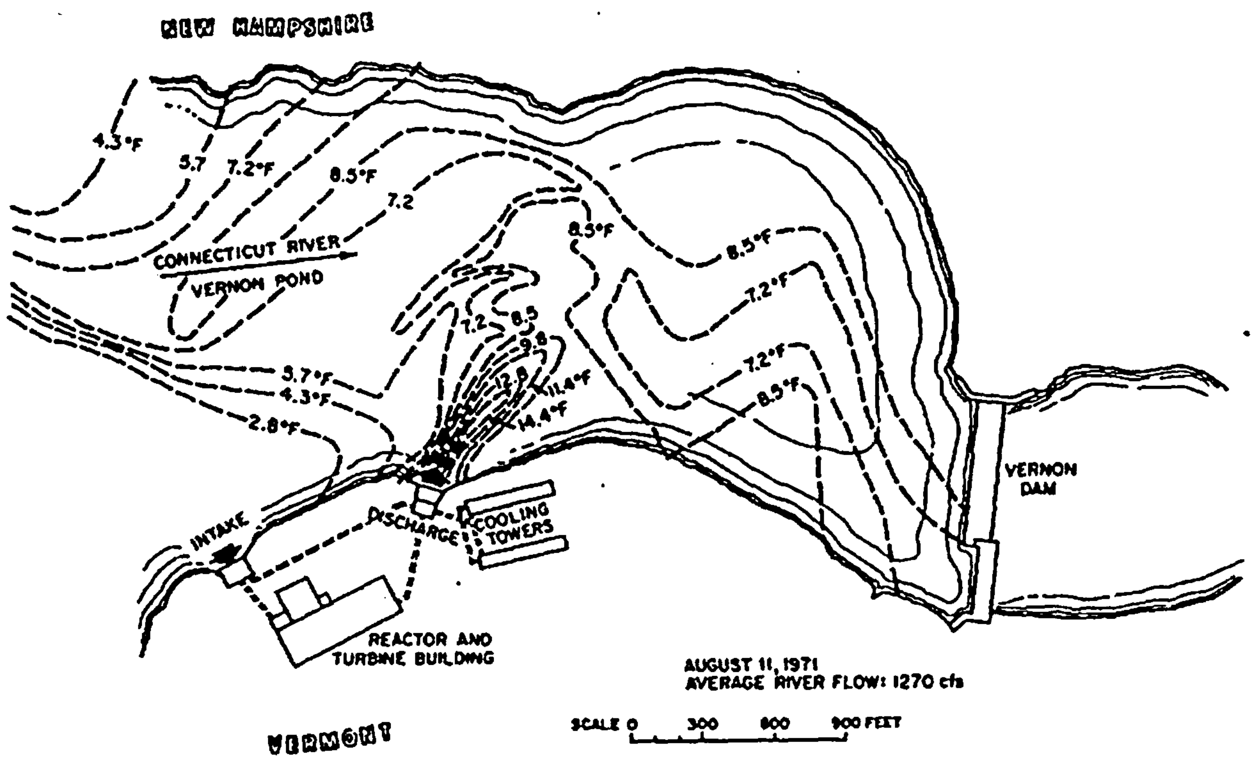

Fig. III-9. Temperature Increases in Vernon Pond as Calculated from Dye Concentrations at a River Flow of 1270 cfs.

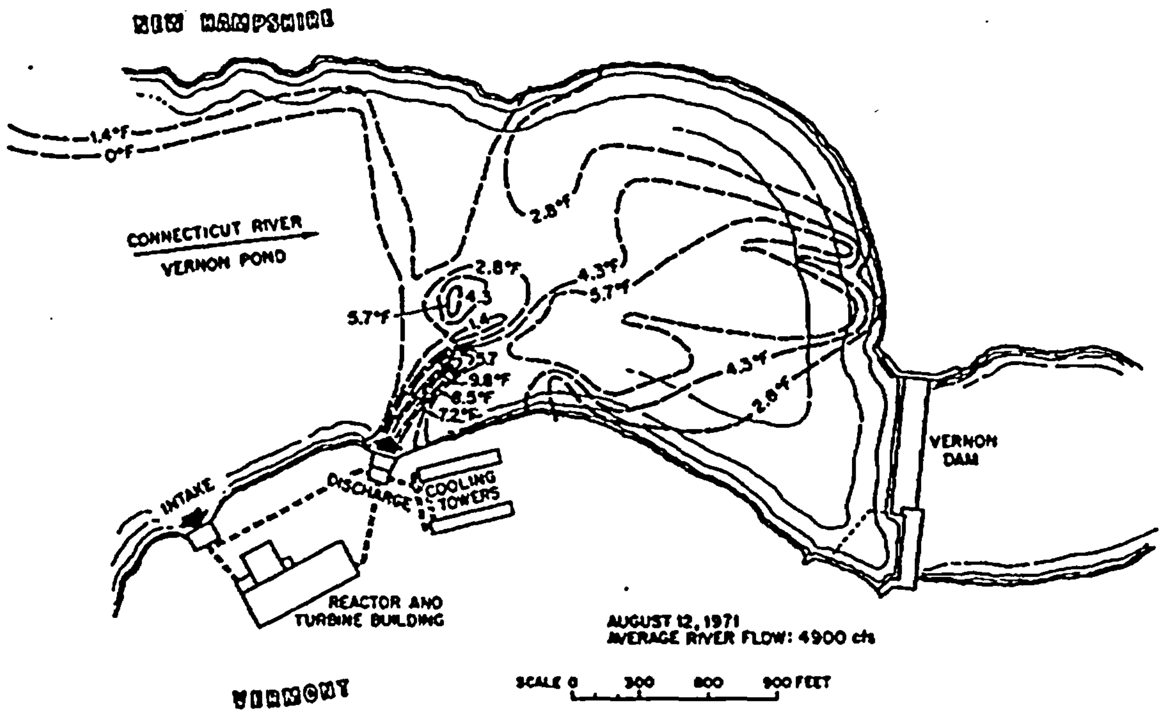

Fig. III-10. Temperature Increases in Vernon Pond as Calculated from Dye Concentrations at a River Flow of 4900 cfs.

The thermal plumes are plotted with the plume center line and isotherm lines for 5°, 10°, and 15°F above the ambient water temperature (see Figs. III-11-III-14). Isotherms, plotted from the computer output, are drawn as solid lines until the heated effluent begins to strike the New Hampshire shore line. Dotted lines show a prediction of how the remainder of the heated effluent will be deflected. The area within the dotted lines is equal to the area that the plume would have covered in a large body of water where it would not be deflected by land.

As the rate of flow of the river increases, the thermal plume is bent more toward the dam. However, our predictions are that the temperature of water in the plume will not decrease below 5°F before reaching the New Hampshire shore. In fact, at low flows much of Vernon Pond between the discharge structure and the dam will contain water 5°F above ambient river temperature; the temperature will be even higher near the center of the plume. For the lowest flow (1270 cfs), the computer output indicates that about 150 acres — or a part of Vernon Pond extending beyond the intake structure — would contain water 5°F or more above ambient river temperature.

The dispersion data from the dye studies appear to be in approximate agreement with the surface temperatures predicted by the mathematical model at both low-flow conditions. However, there is still uncertainty about the accuracy of the mathematical model and about the sufficiency with which the dye study simulates heated water discharge. Moreover, the mathematical model fails to predict the vertical extent of the thermal plume. For these reasons, the staff has chosen field temperature monitoring as the controlling factor in thermal plume management.

In Sect. V.B.2, the need for temperature monitoring stations will be discussed, and in Sect. V.C.7, temperatures and locations of isotherms will be developed to serve as alternative criteria for restrained operation while thermal plume and ecological impact studies are being made to support the development of better criteria. During this interim period, the applicant could operate at full power, satisfying the alternative thermal criteria by running the cooling system in closed-cycle mode when necessary.

Adoption of these thermal criteria would allow the applicant to operate the plant initially without gross damage to the environment while affording the applicant an opportunity to gather data on thermal and ecological effects caused by plant operation with the ultimate aim of producing data which would support more refined and possibly less restrictive criteria for thermal discharges.

2. <u>Radioactive Waste</u>

In the operation of nuclear power reactors, radioactive material is produced by fission and by neutron activation reactions of metals and material in the reactor system. Small amounts of gaseous and liquid radioactive wastes enter the effluent streams, which are monitored and processed

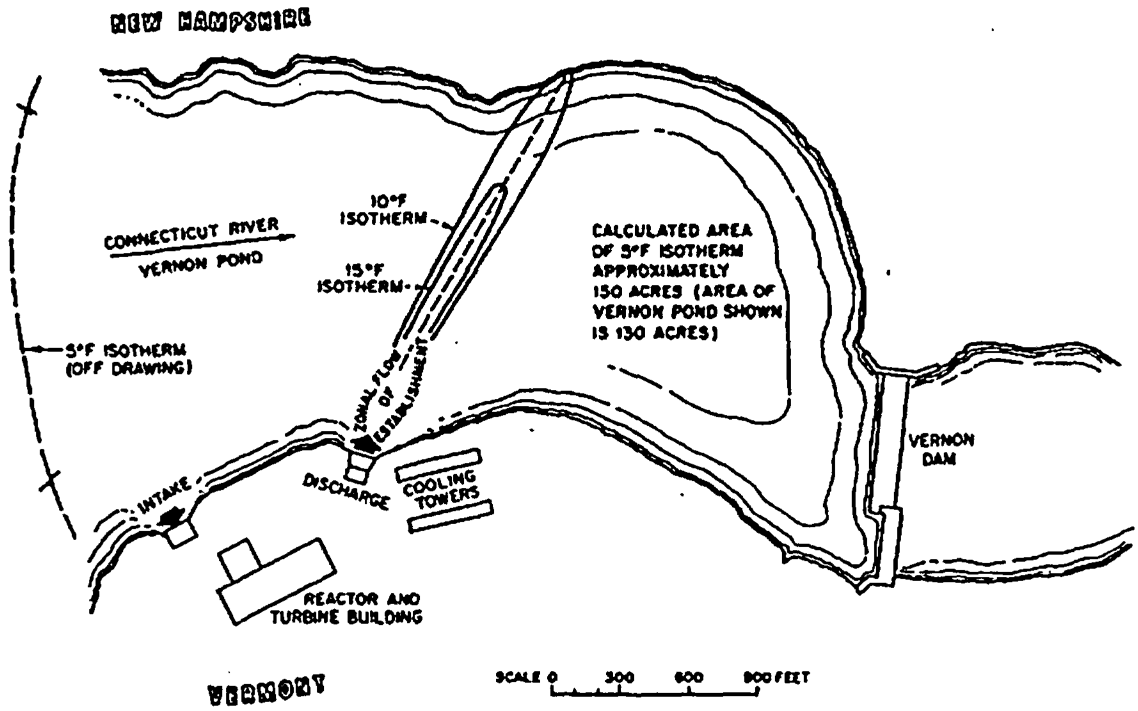

Fig. III-11. Predicted Temperature Increase in the Thermal Plume in Vernon Pond Based on Motz-Benedict Model for River Flow of 1270 cfs. and Discharge Flow of 840 cfs.

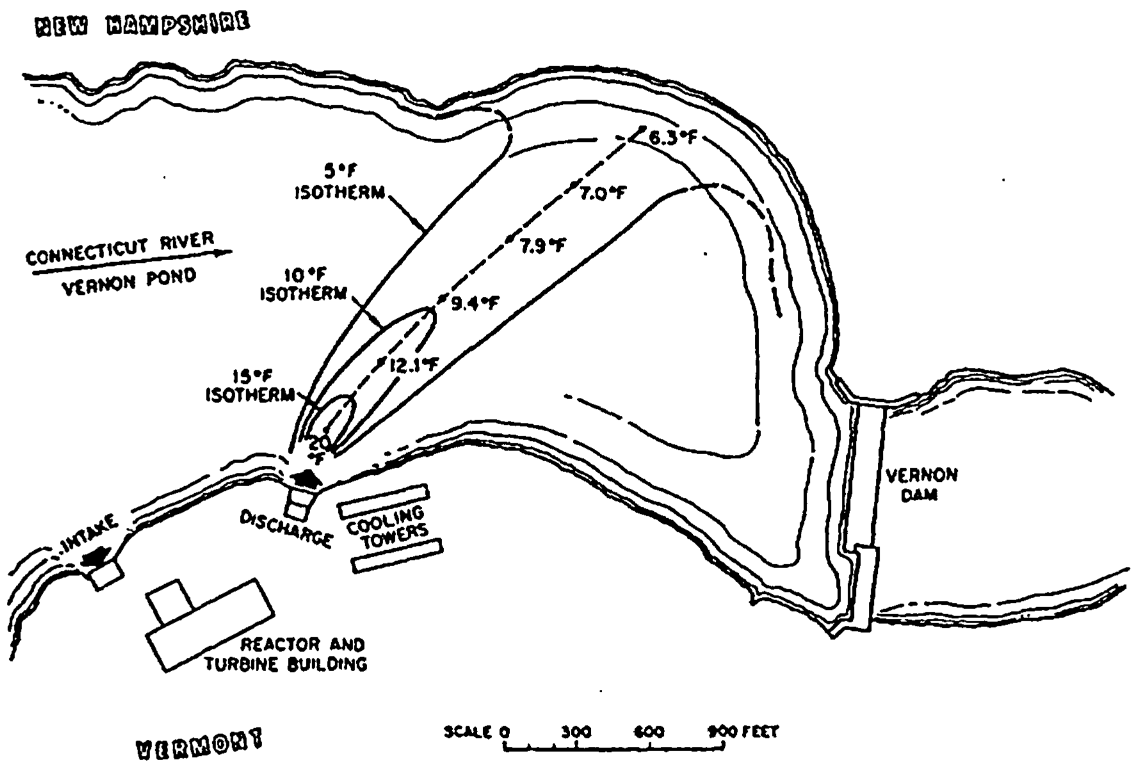

Fig. III-12. Predicted Temperature Increase in the Thermal Plume in Vernon Pond Based on Motz-Benedict Model for River Flow of 4900 cfs. and Discharge Flow of 840 cfs.

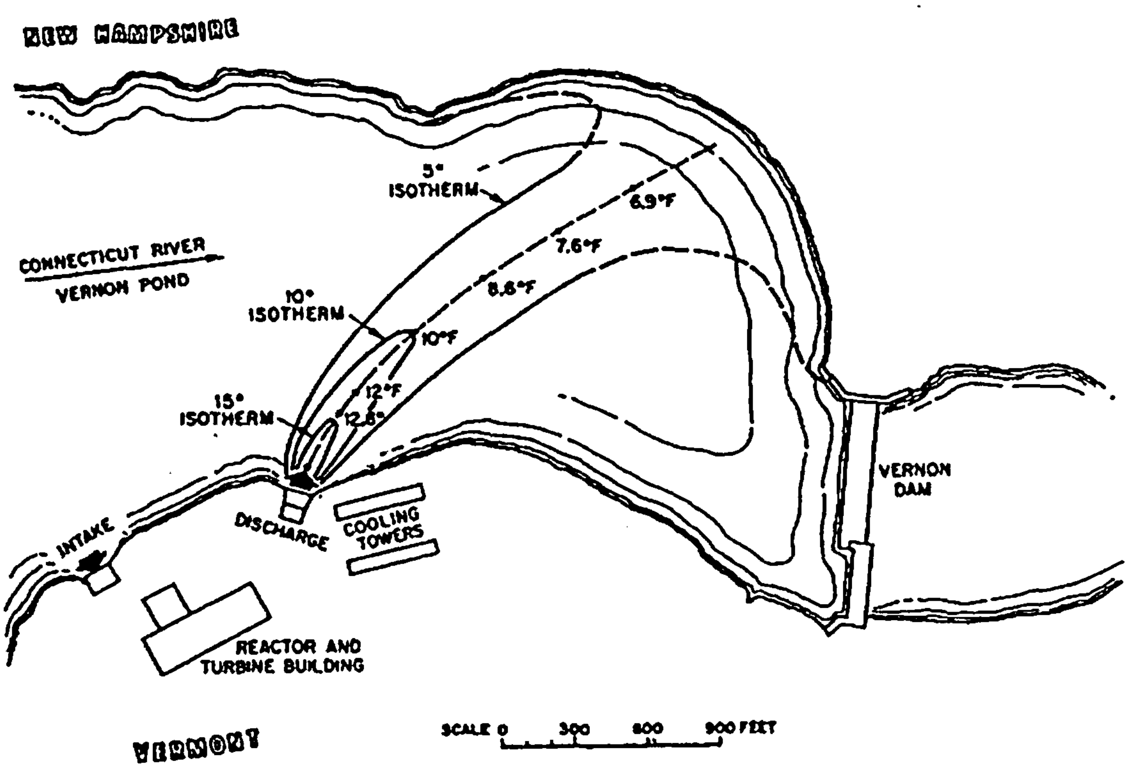

Fig. III-13. Predicted Temperature Increase in the Thermal Plume in Vernon Pond Based on Motz-Benedict Model for River Flow of 10,000 cfs. and Discharge Flow of 840 cfs.

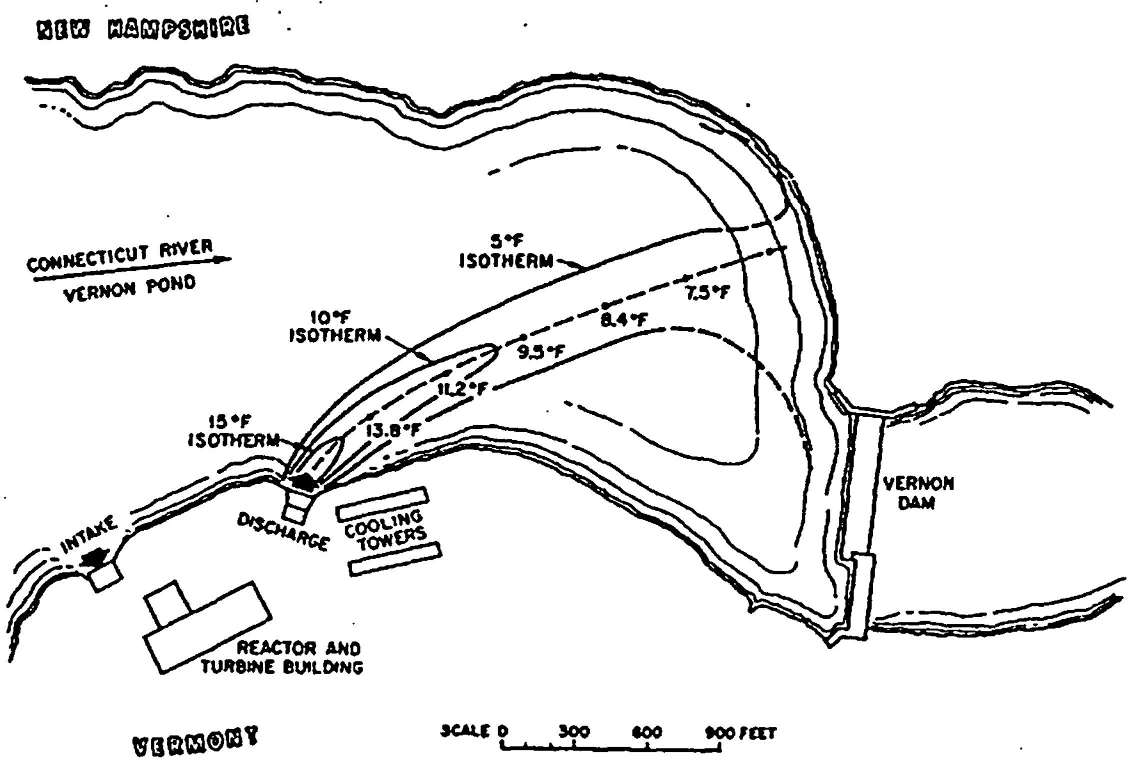

Fig. III-14. Predicted Temperature Increase in the Thermal Plume in Vernon Pond Based on Motz-Benedict Model for River Flow of 15,000 cfs. and Discharge Flow of 840 cfs.

within the Station to minimize the radioactive nuclides that will ultimately be released to the atmosphere and into the Connecticut River at low concentrations under controlled conditions. The radioactivity that may be released during operation of the Station at full power will be in accordance with the Commission's regulations, as set forth in 10 CFR 20 and 10 CFR 50. In addition, modifications will be made to the Station's radwaste system to reduce these levels to the lowest level practicable, and the applicant has stated that he intends to use the present waste treatment system to its full capability.

The waste treatment systems described in the following paragraphs are designed to collect and process the gaseous, liquid and solid waste which might contain radioactive materials.

The waste handling and treatment systems currently installed at the Station are discussed in detail in the Final Safety Analysis Report and in the applicant's Environmental Report, Vermont Yankee Nuclear Power Station, and Supplement to the Environmental Report dated December 21, 1971.

a. Liquid Radioactive Waste

In a boiling water reactor, the circulating primary coolant water receives radioactive isotopes from two sources: (1) fission products escape into this water through defects in the cladding of the fuel rods as the water passes through the reactor core, and (2) corrosion products and erosion products from the reactor coolant circulation system are carried along in this water and made radioactive by neutron (and proton) bombardment in the reactor. To keep the activity level of the reactor primary coolant water low, a fraction of the circulating stream is continually withdrawn, passed through a filter-demineralizer system (the "reactor water cleanup system") to remove suspended and dissolved radioactive (and nonradioactive) materials, and returned to the primary coolant stream. The radioactivities of many of the radionuclides present in the primary coolant were calculated for the condition when equilibrium has been reached between escape of these nuclides from failed fuel elements and their removal by decay, purification of the coolant, and leakage. These activities were calculated with the assumption that 0.25% of the total thermal power is produced in leaking fuel elements and that the reactor water cleanup system had a removal efficiency of 90% for all fission products except molybdenum and yttrium.

Molybdenum and yttrium are not generally removed by demineralizers. However, if no removal is assumed, the calculated activity in the reactor coolant is significantly greater than activity measured in operating boiling water reactors. By ratioing the total activities of the coolants, on the basis of such measurements, the activity level of tellurium is also overpredicted by the calculations. Empirical removal efficiencies were, therefore, used for these isotopes to obtain the primary coolant activities considered in the effluent calculations.

The origins and processing of liquid radioactive wastes in the Vermont Yankee Nuclear Station are shown in Fig. III-15. These wastes will be segregated for treatment into two main streams - the equipment drains stream and the floor drains stream. The equipment drains stream will consist of about 15,000 gpd of "high purity" water which is low in dissolved and suspended solids content. The floor drains stream will consist of about 8,000 gpd of "low purity" effluent which is somewhat lower in radioactivity but higher in dissolved and suspended solids. The processing systems will be operated batchwise with wastes accumulated in tanks and processed as necessary.

The equipment drain stream will be purified by filtration and demineralization, and then returned to the reactor makeup water. The origins of the waste streams entering the system are leakage from the pumps and valves involved in circulating condensate, feedwater, and waste liquids and from the control rod, scram, shutdown, and recirculation systems; drainage and overflows from the above systems; heat exchangers; steam lines; fuel pool system; and reactor water cleanup system.

When enough effluent has collected in the waste collector tank the effluent is passed through a precoat filter and a mixed bed demineralizer. The filter removes sludge and suspended corrosion products. The efficiency of the demineralizer in adsorbing metallic and nonmetallic ions from the solution depends on a number of factors, such as the identity of the ion, the acidity of the solution, and the amount of material already adsorbed in the resin.

After passage through the filter-demineralizer system, the effluent is pumped to the waste sample tanks, where its radioactivity is measured. If the radioactivity level is low enough (e.g., $<3 \times 10^{-3}$ $\mu Ci/cm^3$), the effluent is pumped to the 500,000-gal condensate storage tank to be used as makeup primary coolant water. However, if the activity of the effluent is too high for use as makeup water, the effluent is not sent to the condensate storage tank but is returned to the waste collector tank.

The daily volume of wastes entering these streams (15,000 gal) is made up of 6,000 gal from the drywell equipment drain sump (at the activity of the primary coolant); 2000 gal from the reactor equipment drain sump, 1000 gal from the radioactive building equipment drain sump, 3000 gal from the turbine building drain sump, and 3000 gal of miscellaneous drains (all at an activity of 1% of that of the primary coolant, representing small leakages that are diluted with other process liquids). An overall decontamination factor of about 100 must be realized in the filter-demineralizer to reduce the activity below the required 3×10^{-3} $\mu Ci/cm^3$. The anticipated releases shown in Table III-1 are based on achieving this decontamination factor and on recycling 90% of the influent to the condensate storage tank. Operating experience at other similar reactor stations has shown that this is attainable.

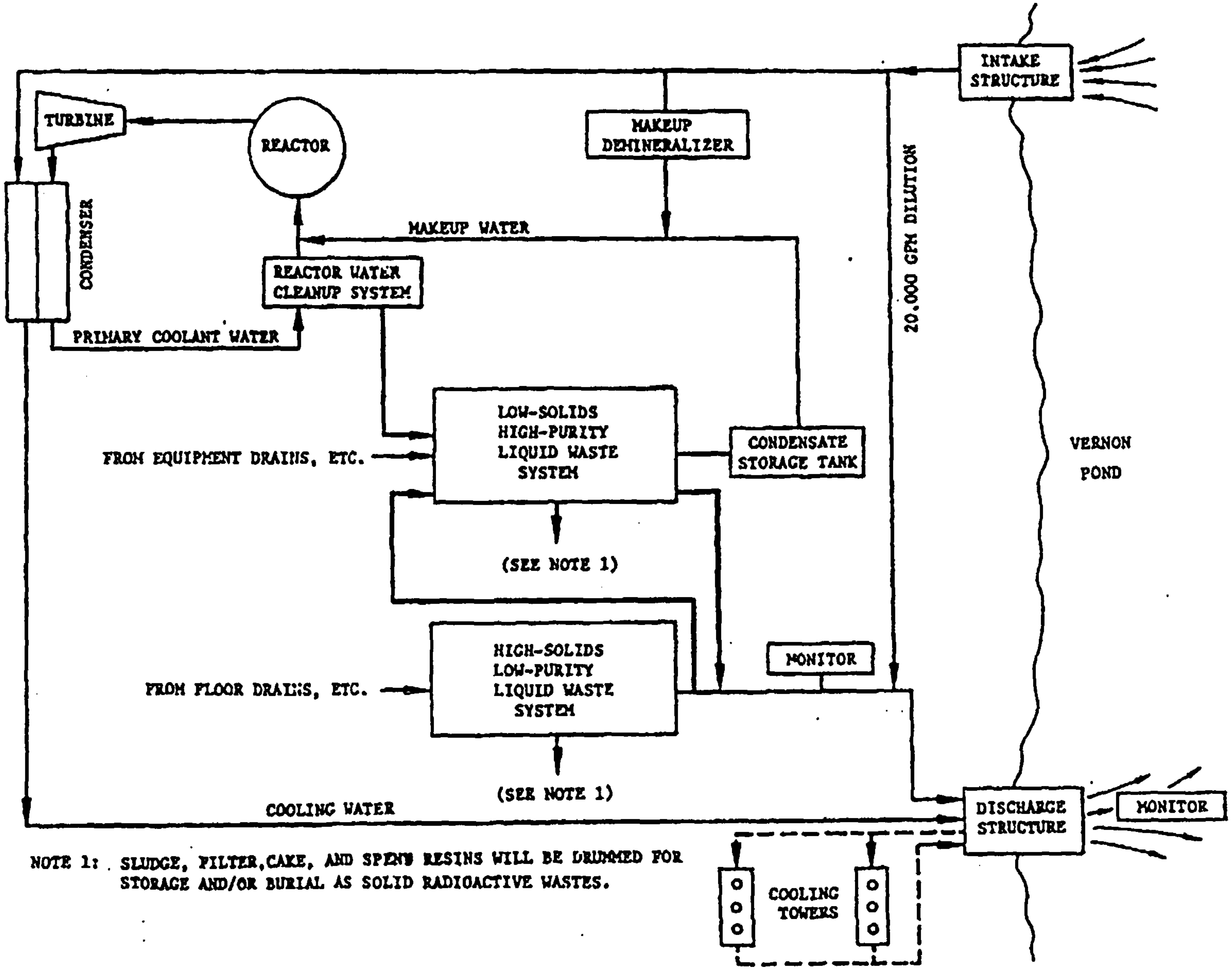

Fig. III-15. Schematic of Vermont Yankee Nuclear Power Station Liquid Radioactive Waste System.

The floor drain system collects liquid wastes from floor drain sumps which are estimated to be 2000 gpd from the reactor building floor drain sump, 1000 gpd from the radioactive waste building floor drain sump, 2000 gpd from the turbine building floor drain sump (all at a radioactivity of 1% of the primary coolant), and 3000 gpd from the drywell floor drain sump (at the activity of the primary coolant). These liquids are processed through a filter to the floor drain sample tank, sampled, and released if the activity is low in comparison to applicable regulations. If the radioactivity content of the sample tank is such that a discharge limit would be approached, the waste can be held in the tank for a period of time to allow radioactivity reduction through decay. If this delayed release is not practical because of the volumes of waste being generated, or because the radionuclides are long lived, then the liquid in the sample tank will be pumped through the equipment drain system filter and demineralizer to the waste sample tank for analysis. This waste may not be of sufficient chemical purity to allow reuse within the reactor system. In this case, the waste sample tank contents would be diluted and discharged. The anticipated releases shown in Table III-1 are based on processing all liquid wastes from the floor drains through the equipment drain system (with a decontamination factor of 100) and releasing them.

Chemical wastes collect in the chemical waste tank. Subsequent treatment is dependent upon the results of analysis to determine chemical purity of the liquid. When this shows that the waste can be chemically neutralized sufficiently to allow treatment as a low purity waste, the contents of the chemical waste tank will be directed, after neutralization, to the floor drain collector tank for treatment as low purity wastes as described above. If the chemical nature or radioactivity content precludes treatment as low purity waste, this liquid may be pumped into drums, mixed with water-adsorbent material to remove free water and handled as a solid waste. Detergent wastes are collected in the decontamination solution tank where they are sampled for radioactivity content. These wastes will then be filtered, diluted, and discharged. Table III-1 includes the calculated releases from these sources.

b. Gaseous Wastes

During power operation of the Station, radioactive materials released to the atmosphere in gaseous effluents include fission product noble gases (krypton and xenon); activated argon and nitrogen; halogens (mostly iodines); tritium contained in water vapor; and particulate material including both fission products and activated corrosion products. Fission products will be released to the coolant and carried to the turbine by the steam if defects occur in the fuel clad or if uranium is present as an impurity in, or on, the clad itself.

Table III-1. Annual release of radioactive material in liquid effluent from Vermont Yankee Nuclear Power Station (100% power)

Nuclide	Ci/year	Nuclide	Ci/year
^{89}Sr	0.45	^{132}I	0.042
^{90}Sr	0.029	^{133}I	0.14
^{91}Sr	0.00044	^{135}I	0.00013
^{90}Y	0.10	^{134}Cs	0.25
^{91m}Y	0.028	^{136}Cs	0.073
^{91}Y	0.22	^{137}Cs	0.19
^{93}Y	0.0044	^{137m}Ba	0.036
^{95}Zr	0.0047	^{140}Ba	0.65
^{97}Zr	0.000079	^{140}La	0.5
^{95}Nb	0.0048	^{141}Ce	0.0050
^{97m}Nb	0.000076	^{143}Ce	0.00055
^{97}Nb	0.0000079	^{144}Ce	0.0032
^{99}Mo	0.095	^{143}Pr	0.0040
^{99m}Tc	0.091	^{144}Pr	0.0032
^{103}Ru	0.0034	^{147}Nd	0.0016
^{106}Ru	0.0011	^{51}Cr	0.040
^{103m}Rh	0.0034	^{54}Mn	0.0035
^{105}Rh	0.00033	^{55}Fe	0.18
^{106}Rh	0.0011	^{59}Fe	0.0066
^{127m}Te	0.00097	^{58}Co	0.42
^{127}Te	0.0010	^{60}Co	0.044
^{129m}Te	0.0091	^{65}Zn	0.000088
^{129}Te	0.0058	^{69m}Zn	0.000021
^{131m}Te	0.0010	^{187}W	0.016
^{131}Te	0.00019	^{24}Na	0.0021
^{132}Te	0.040	^{32}P	0.0015
^{130}I	0.000096	Total	~5
^{131}I	1.2	^{3}H	~20

The major source of gaseous waste activity during normal Station operation will be the off-gas from the steam condenser air ejectors. Other sources include primary containment purge, the gland seal off-gas system and the reactor building, radioactive waste building, and the turbine building exhaust systems. Figure III-16 is a schematic of these systems.

Prior to release, the off-gases from the main condenser air ejectors will be delayed for a minimum of 30 min in a holdup pipe (to allow decay of activity of short-lived radioactive noble gases) and filtered through high efficiency particulate filters and charcoal adsorbers. Release will be through the main station 318-ft-high stack.

The reactor building exhaust system removes air from the reactor building ventilation system and from the drywell and torus purge exhaust system. This air, which normally contains low concentrations of activity, is discharged to the main station stack. The system is so arranged that the exhaust air can be directed to the standby gas treatment system (high efficiency particulate filters and charcoal adsorbers in series) for release through the main station stack if the activity level is high. The primary containment (drywell) is normally a sealed volume. However, during periods of refueling, maintenance, or whenever primary containment access is required, the potential exists for the release of airborne radioactivity to the environment. In such cases, air is removed through the drywell and torus purge system (prefilters and high efficiency particulate filters) and discharged to the reactor building vent stack.

The turbine building exhaust system which is expected to contain low concentrations of activity, primarily from steam system leakage, draws air from the turbine building and is discharged to the atmosphere through the main station stack which is continuously monitored.

The steam/air exhaust from the turbine sealing system passes through a gland seal condenser where the steam is condensed and the non-condensables are exhausted to the gland seal holdup line. The small quantity of radioactive gases released by way of the gland seal off-gas system is delayed for about 2 min to allow decay of the major activation gases (^{16}N and ^{19}O) prior to release through the main station stack. All sources of gaseous wastes are continuously monitored to assure that effluent releases are within applicable standards.

On the basis of operating experience with reactors of similar design, it is expected that the off-gas system described above will keep releases of gaseous radioactive wastes well within the limit specified in 10 CFR 20. In order to reduce these levels to the lowest level practicable during extended power operation, the applicant plans to install additional gaseous holdup equipment. A modification to the present system will provide

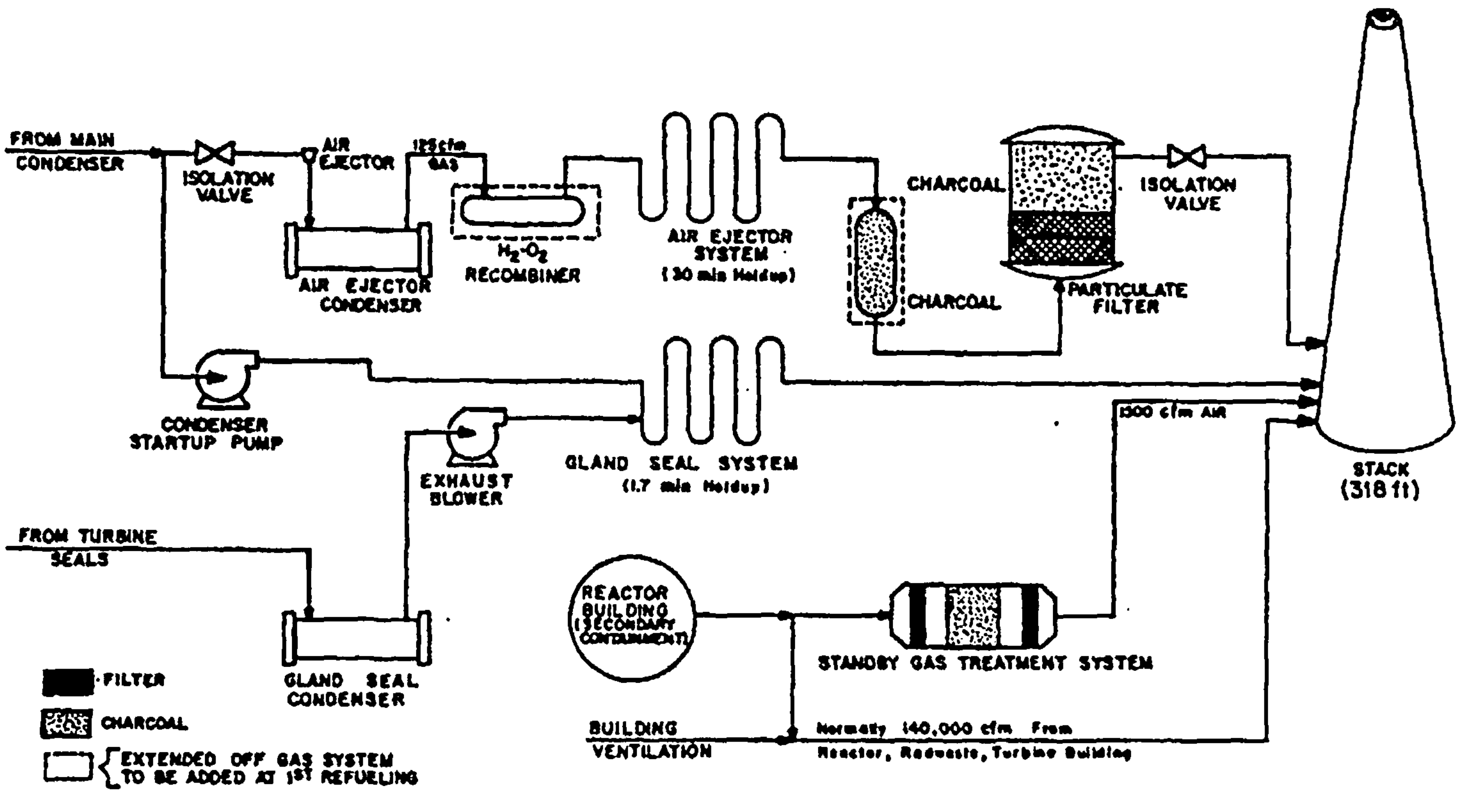

Fig. III-16
Schematic Of Radioactive Gaseous Waste System
Vermont Yankee Nuclear Power Station

recombination of the hydrogen and oxygen formed in the reactor coolant, a condenser to remove much of the water vapor, and a charcoal delay system to provide additional retention time for krypton and xenon and to provide additional adsorption of iodines and particulates. The modified system is expected to be operational by the time of the first refueling. The staff anticipates that the proposed modification will result in a reduction of off-gas activity (curies of noble gases) released by a factor of at least 20 relative to a 30-min holdup system and that ^{131}I from all gaseous sources will be reduced to less than 0.6 Ci/year.

On the basis of experience at other operating plants, gaseous activity releases for Vermont Yankee are estimated at 3,000,000 Ci/year, prior to the installation of the modified treatment system. However, based on commitments made in the Technical Specifications to the operating license, the actual effluents will be administratively controlled to an annual average rate of 22,000 μCi/sec or about 700,000 Ci/yr. The expected distribution is shown in Table III-2.

c. Solid Radwaste

Since both the condensate and reactor water cleanup systems use pre-coat Powdex type ion exchange resins, which are not regenerated, most of the radioactivity from corrosion and fission products is collected and retained on these resins. In addition, activity removed from the high purity wastes by the liquid radwaste system demineralizer is also retained. Therefore, the bulk of the solid radioactivity wastes consists of spent ion exchanger resins. The remaining solid wastes consist of filter sludges, air filters, and miscellaneous paper and rags.

Ion exchange resins are dewatered in phase separators and placed in shielded casks. Dry wastes are compacted in drums. No solid wastes will be stored permanently at the Station. All solid radioactive wastes will be packaged and shipped offsite for disposal at an AEC licensed disposal site in accordance with AEC and Department of Transportation (DOT) regulations.

3. Chemical and Sanitary Wastes

a. Chemical Wastes

There are four operations which affect water quality: (1) cation, anion, and mixed-bed ion-exchanger regeneration, (2) chlorination of the circulating water system, (3) blowdown from the cooling towers, and (4) sewage disposal. Basically, three chemicals will be discharged by Vermont Yankee[8] into Vernon Pond in substantial quantities: residual chlorine, sodium, and sulfate (Sect. V.C.4).

Table III-2. Annual release of radioactive material in gaseous effluents from Vermont Yankee Nuclear Power Station[a]

Nuclide	Ci/year
^{83m}Kr	3,500
^{85m}Kr	39,200
^{85}Kr	100
^{87}Kr	105,000
^{88}Kr	126,000
^{133}Xe	57,400
^{135m}Xe	49,000
^{135}Xe	154,000
^{138}Xe	147,000
Total	~700,000
^{131}I	~1.7

[a]Based on administrative controls in Technical Specifications.

Sulfuric acid and sodium hydroxide are used to regenerate cation and anion exchange resins in both individual and mixed beds. The resultant waste liquid contains sodium sulfate. Sodium hypochlorite will be used to control the growth of algae in the circulating water system. Since this salt is highly alkaline, sulfuric acid will be added to the water to keep it neutral. The quantities of chemicals used and discharged depend on whether the open or closed cycle is used for cooling. Table III-3 gives details.

During the site visit, the applicant advised that no corrosion inhibitors would be added to the cooling water system. In the impact analysis no antifouling agents other than sodium hypochlorite will be assessed (Section V.B.3). However, corrosion inhibitors and antifoulants are discussed in detail in Appendix II-A.

Blowdown water will be released continuously from the plant at a maximum rate of 5000 gpm when the cooling towers are operating in the closed cycle. Under these conditions, solids originally present in the river water will be concentrated by a factor of approximately 2.3 before being discharged in the blowdown water. (Preoperational water quality parameters are listed in Table II-2.) However, the applicant's limits of detection were relatively insensitive and some trace elements (such as mercury and cadmium) were not measured to be far enough below permissible limits in the existing river water to assure that they would remain below these limits after concentration. The applicant has included cadmium and mercury in his operational monitoring program, which will use adequately sensitive instruments and procedures.

About 300 to 700 gpm of cooling water[9] will be discharged to the atmosphere in the form of minute droplets. Although the applicant has estimated a solids deposit from drift of 25 lb/day (4.6 tons/year), the staff feels that a more conservative estimate should be used. Assuming a solids content in the cooling water of 230 ppm (2.3 times the 100-ppm average solids content of river water), a drift loss of 700 gpm, plant operation at 0.8 capacity and cooling tower operation for 9 months of the year, a deposit of slightly more than 200 tons/year would result. In any case, whether the actual deposit is as much as 200 tons/year or as little as 4.6 tons/year, they will be water-soluble and spread over a large area and will be easily removed by rain. However, they may constitute a minor nuisance in the plant area.

b. Sanitary Wastes

The sanitary waste system of the Vermont Yankee Nuclear Power Station was designed to handle the wastes of 120 employees, although only about 70 persons will work at the Station. Water use is expected

Table III-3. Principal Nonradioactive Chemical Components of Effluent Stream

Use	Chemicals added	Discharge schedule: Frequency	Amount (gal)	Rate (gpm)	Maximum concentration[a] (ppm): Na^+	SO_4^{2-}	Cl^-	Free chlorine
Cation and anion bed regeneration	H_2SO_4 NaOH	Twice a week	9,000	50	1900	4100		
Mixed bed regeneration	H_2SO_4 NaOH	Once every 4 to 6 months	9,000	50	1250	2600		
Condenser cooling water chlorination								
Open cycle mode	NaOCl	Twice a day	15,440,000	386,000	4		6	0.1
Closed cycle mode	NaOCl H_2SO_4	Continuous		5000	3	7		

[a]The increase in the concentrations of the discharge stream above ambient river concentration during the period of the discharge.

to average 15 to 35 gpd for each employee; maximum use will therefore be 4200 gpd. A maximum of 20 gal of sludge per employee is expected annually, for a design total of 2400 gal. The detention tank has a volume of 7000 gal, which is more than sufficient to contain the maximum of 4200 gpd plus 2400 gal of sludge.

The sanitary wastes are discharged through a septic tank to a leaching field. No surface discharge or overflow is provided. The leaching field comprises fine alluvial sands deposited by the river. Two separate tests yielded a percolation rate of 1 in. per 5 min. At this percolation rate, a 4200-gpd disposal would require an 1800-ft^2 leaching field. This requirement has been met by installation of 1200 ft of 18-in. trenches that are 300 ft from the turbine building and 250 ft from the river bank at their closest point.

The staff has assessed this system and concluded that it will have no discernible adverse effect on Vernon Pond or the environment of the Vermont Yankee Nuclear Power Station.

4. Other Waste Systems

Floating debris and dead fish will be collected from the trash racks and screens at the intake and buried in a landfill on the plant site.

E. TRANSPORTATION OF NUCLEAR FUEL AND SOLID RADIOACTIVE WASTES

The nuclear fuel for the Vermont Yankee reactor is slightly enriched uranium in the form of sintered uranium oxide pellets encapsulated in zircaloy fuel rods. Each fuel element is made up of 49 fuel rods, is about 14-1/2 ft long, and weighs about 680 lb. In each year of normal operation, about 88 fuel elements will be replaced.

The applicant has indicated that unirradiated fuel for the reactor will be transported by truck from Wilmington, North Carolina, to the plant site, a shipping distance of about 700 miles. The applicant has not stated where the irradiated fuel or solid wastes will be shipped, but he did indicate irradiated fuel will be transported by truck or rail and solid wastes by truck. Distances of 900 miles for shipping the irradiated fuel and of 500 miles for shipping the solid radioactive wastes have been assumed.

1. Unirradiated Fuel

The applicant has indicated that unirradiated (cold) fuel will be shipped in AEC-DOT approved containers which hold two fuel elements per container. About three truckloads of 16 containers each will be required each year.

2. Irradiated Fuel

Fuel elements removed from the reactor will be unchanged in appearance and will contain some of the original ^{235}U (which is recoverable). As a result of the irradiation and fissioning of the uranium, the fuel element will contain large amounts of fission products and some plutonium. As the radioactivity decays, it produces radiation and "decay heat." The amount of radioactivity remaining in the fuel varies according to the length of time after discharge from the reactor. The fuel elements are placed under water in a storage pool for cooling and radioactive decay prior to being loaded into a cask for transport.

Although the specific cask design has not been identified, the applicant states that the irradiated fuel elements will be shipped after a minimum 90-day cooling period in approved casks designed for transport by either truck or rail. The cask will weigh perhaps 30 tons for truck or 100 tons for rail. Transport of the irradiated fuel will require an estimated 15 truckload shipments per year with six fuel elements per cask and one cask per truckload or five rail carload shipments per year with 20 fuel elements per cask and one cask per carload. An equal number of shipments will be required to return the empty casks.

3. Solid Radioactive Wastes

The applicant estimates that the solid radioactive wastes generated by the reactor will amount to from 1500 to 1800 ft^3/year of resins, 65 ft^3 of which may contain up to 15 curies per cubic foot (Ci/ft^3) and the rest, approximately 0.3 Ci/ft^3. In addition, about fifty 55-gal drums of miscellaneous wastes will be generated each year. The resins will be shipped in shielded casks weighing up to 45,000 lb when loaded. The applicant estimates that 8 to 12 truckloads of casks and drums of wastes each year will be shipped for disposal - probably to West Valley, New York - a shipping distance of about 500 miles.

References for Section III

1. State of Vermont Public Service Board No. 3384, Finding and Certificates dated December 31, 1969.

2. State of Vermont Public Service Board No. 3412, Finding and Certificates dated June 12, 1970.

3. U. S. Federal Power Commission, Order Approving the Indenture Between New England Power Company and Vermont Yankee Nuclear Power Corporation, relating to use of lands and reservoir, Project No. 1904, July 31, 1970.

4. Vermont Yankee Nuclear Power Corporation, "Table of Approvals and Permits for Vermont Yankee Nuclear Power Station," Appendix E in Supplement to the Environmental Report (Dec. 21, 1971).

5. Vermont Yankee Nuclear Power Corporation, "Effect of Heated Water Discharge on the Temperature Distribution of the Connecticut River," Appendix B in Supplement to the Environmental Report (Dec. 21, 1971).

6. L. H. Motz and B. A. Benedict, Heated Surface Jet Discharged into a Flowing Ambient Stream, Report No. 4, National Center for Research and Training in the Hydrologic and Hydraulic Aspects of Water Pollution Control, Vanderbilt University, Nashville, Tennessee (August 1970).

7. U. S. Atomic Energy Commission, Division of Radiological and Environmental Protection, Detailed Statement on Environmental Considerations Related to the Proposed Operations of the Oconee Nuclear Station, Units 1, 2, and 3, Docket No. 50-269, -270, and -287 (March 1972).

8. Vermont Yankee Nuclear Power Corporation, "Supplemental Information on Chemical Discharge," Appendix C in Supplement to the Environmental Report (Dec. 21, 1971).

9. Vermont Yankee Nuclear Power Corporation, Environmental Report for Vermont Yankee Nuclear Power Station (Sept. 1, 1970), p. 17.

IV. ENVIRONMENTAL IMPACTS OF SITE PREPARATION AND PLANT CONSTRUCTION

A. SUMMARY OF PLANS AND SCHEDULE

Site preparation and construction, begun in 1967, are essentially complete. Remaining work is primarily landscaping and cleaning up the site. The plant was originally scheduled for operation in the fall of 1971.

B. IMPACT ON LAND, WATER, AND HUMAN RESOURCES

The staff has visited the reactor station to gain familiarity with the site and surrounding area. Although a few private residences are within 1500 ft of the plant, construction noise was not distracting at the site boundary. However, a relocation of wildlife may have resulted from the noise and congestion of construction activities.

The 125-acre site is located on a terrace on the west shore of the Connecticut River. Elevation of the site ranges from 220 to approximately 280 ft above mean sea level, which helped shield the construction activities from the public road on the west boundary where several residences are located. The peak construction period is over, and the landscaping and cleanup should be completed in 1972.

During the construction period, heavily loaded trucks traveled on Governor Hunt Road on the west boundary of the site. The peak traffic periods started at 6:45 AM and at 4:30 PM, each lasting a little more than an hour. At the beginning of construction, concern for the safety of school children attending the local elementary school caused the town of Vernon to build its first sidewalks and a road to the site. The applicant reimbursed the town for the construction.

Mr. Raymond Puffer, Chairman of Selectmen of the town of Vernon, stated in an interview with the Vermont Electric Power Company that the applicant was very cooperative in working out problems with the town of Vernon and that construction of the plant had few adverse effects on the surrounding environment.

Most of the construction workers commuted from distant locations, such as Greenfield, Massachusetts, and Brattleboro, Vermont. At the peak period of construction, approximately 1200 workers were employed. The plant will have a permanent staff of approximately 70 employees. The impact on the local school was estimated as a maximum increase over "normal" of 9 to 12 students, which presented no unusual problems. As a result of the plant a few new homes (6 to 12) have been constructed in the town of Vernon.

Construction of the plant had little impact on the town of Hinsdale, New Hampshire, although it is located directly across the river from the Vermont Yankee Plant. Hinsdale is not readily accessible to the area as the nearest bridge is at Brattleboro. As viewed from the Hinsdale side of the river, the plant is a modern structure. Proper landscaping should help blend the site with the surrounding countryside. The terrace effect and decrease in elevation make the plant appear deceptively small from the public road along the western border.

The more distant towns evidently experienced no concentrated impact from construction workers. Brattleboro, the nearest sizable town, probably had the largest concentration of the 1200 workers. Since Brattleboro has a population of approximately 21,000 and accommodates a transient population of tourist and sports enthusiasts, the city easily absorbed the construction workers. The effect was even more dispersed in more distant towns.

During construction of the plant, excavated material was relocated on the plant site. The shore line of Vernon Pond was extended with fill and "riprap" between the intake and discharge. Other excavated material was relocated to form a level site for the cooling towers. Approximately 60 acres of the site was involved in active construction.

The water level in Vernon Pond is controlled by the Vernon Hydro-electric Station, which is operated as a peaking unit. The daily impounding and releasing of water in Vernon Pond continually flushed the area near the plant; therefore, little silt or debris was noticed on the river during construction.

During construction diesel powered machinery which was employed released some combustion products to the atmosphere creating intermittent and localized air pollution such as any large construction project would cause.

C. CONTROLS OR REDUCE OR LIMIT IMPACT

The location of the site limited the impact of construction to the site itself and to the village of Vernon. The applicant appears to have been successful in minimizing impact upon the town. Only 60 acres of the site will be occupied by plant structures. The remaining area will be cleaned up and will be landscaped with local trees and shrubs to match the surrounding environment.

The historical significance of the Jonathan Hunt House is discussed in Section II.D. The applicant plans to turn this old home over to the Vernon Historians, Inc. (Mrs. Irma Puffer, current Chairman) to serve as a public museum. An addition has been made to the Jonathan Hunt House, which will provide a space for meetings and displays concerning the Vermont Yankee Nuclear Power Station which will provide information on peaceful uses of atomic energy.

V. ENVIRONMENTAL IMPACT OF PLANT OPERATION

A. LAND USE

The plant site is located on a river terrace with a strip of forest interspersed. About 60 acres of the site will be occupied by plant structures. The remaining area will be landscaped with local trees and shrubs to match the surrounding environment.

1. General Effects

During the staff's site visit, little evidence was noted of recreational use of the land around the plant property, and the Recreation Board of the town of Vernon stated that no recreational use was planned for the station property. New England Power Company, one of the parent corporations of the applicant, maintains a small picnic area with tables and toilet facilities on the southern boundary of the plant property. Operation of the plant should not interfere with continued use of this area, although noise from the cooling towers during the summer months may be bothersome. The applicant has announced no plans for recreational facilities in the area. The plant facilities will not be open to the public, but the museum located outside the perimeter fence will be available to the public.

Present water surface activities such as boating and fishing are of relatively low frequency and can continue at present levels. A canoe portage was reported by the applicant to be one of the most frequently used recreational areas near the site. Canoes going down the river must portage around Vernon Dam. The applicant expects that the use of this portage can continue under normal plant operation.

The exclusion area along the New Hampshire side of Vernon Pond is owned by the New England Power Company, and this area will be available to the public except in case of accidents, when the entire exclusion zone would come under the controls specified in state emergency plans. The construction and operation of the Vermont Yankee Station will have little impact on the present recreational use of the land around the site. However, despite findings and assurances that operation of the plant poses no hazard to the health and safety of the public, it can be debated that operation of the plant will create a psychological barrier to some members of the general public in terms of use of Vernon Pond and the land around the site for recreation.

2. Transmission Line Effects

A 51-mile transmission line has been constructed from the Vermont Yankee Station and occupies 12 times more land (1550 acres) than does the plant site. Regardless of the type of power plant, transmission lines are necessary to distribute the electrical power. The land under the power lines, although effectively removed as building sites, can be used for agriculture and wildlife management. Transmission lines reduce the aesthetic value of most environments, especially forest and rural areas. In a "certificate of public good" issued by the State of Vermont Public Service

Board, the Vermont Electrical Power Company, Inc. (VELCO) was required to minimize the visual impact of transmission lines. Special care was taken to assure that critical locations along the route were properly landscaped through various means such as selective clearing, planting, and screening. Underground transmission lines were evaluated, but were dismissed because of excessive costs. Possible inductive interference with railroad signal lines has been reduced by constructing a minimal amount of transmission line next to railroad rights-of-way and by crossing these lines perpendicularly where necessary. Ozone, which is toxic to plants and animals, is known to be produced by transmission lines, but no measurements of ozone production from this source are available.

Two 345-kV transmission lines spanning Vernon Pond detract from the aesthetic appearance of the area; however, on a site visit in September 1971, the staff noted that these lines did not appear obtrusive in the setting. The two transmission lines have effectively eliminated Vernon Pond as a seaplane landing site for which it has been used only about once a year in recent years.

In Vermont and New Hampshire, the general trend has been for agricultural and pasture land to revert to forest. The countryside within 5 miles of the Vermont Yankee Station is between 75 and 80% wooded, and the remainder is agricultural and pasture land, with some small industries and residential property.

3. Cooling Tower Effects

The applicant engaged The Research Corporation of New England (TRC) to predict the effects of the cooling-tower plumes on fogging and icing in the area. Studies were based on the cooling towers operating at full capacity during all seasons. These studies[1] predicted that under some meteorological conditions a layer of stratus clouds would be formed in the Connecticut River Valley which would cause some "fog" when the plume descended to the ground. Fogging is not expected to occur in the vicinity of the towers but in the nearby towns. An additional 22 hr/year of fog all occuring in the fall and winter would be expected in downtown Brattleboro. In the area considered, the greatest amount (129 hr) of additional fog would occur at the Schell Bridge over the Connecticut River in the town of Northfield, Massachusetts.

Results of the cooling tower plume study made by TRC have been evaluated by AEC staff. The study uses the only currently available method for estimating condensation downwind from the towers, and the staff agrees that the estimates are likely to be conservative. For example, the downwind fogging effects of the tower appear to be overestimated. The calculations are based on the Holland plume rise model,[2] which is known to underestimate plume rise. Also, only sensible heat was considered; release of latent heat may increase plume rise. The calculated rise may be low for another reason —

it is based on heat flux from a single cell; Hanna[3] states that rise from a multicell tower is usually greater than the rise calculated for a single cell.

Similarly the applicant has apparently ignored the problem of downwash, i.e., the horizontal propagation of a plume of condensed vapor which may intersect the ground under conditions of relatively high winds. Although there are insufficient data to make an accurate calculation of this factor, gross estimates (based on conditions derived from frequencies of wind speed and direction given in Appendix G of the Final Safety Analysis Report) show that the downwash could conceivably affect State Highway 142 for a period of time not exceeding 15 hr/year if the cooling towers were operated 100% of the time. The drift loss from the cooling towers will be kept to a minimum by drift eliminators, and no icing is expected off plant property.

The mechanical draft cooling towers will use large, high-speed, rotating equipment to drive large quantities of air through the towers for dissipating heat from the condenser cooling water to the atmosphere. In testing the operation of the tower fans, the applicant has measured sound levels of 68 dB(C) or 56 dB(A) in the off-site residential area about 600 ft W of the cooling towers. The predominant noise components with only water running through the towers range from 1000 to 16,000 Hz; with all fans in service, the predominant components range from 31.5 to 500 Hz. Of the three standard sound level weighting scales, the C scale allows a flat response to frequencies between 50 and 500 Hz, with slight rolloff outside these limits. The A scale is considered to give a response generally approximating that of the human ear. The 56 dB(A) measured at the nearest residence is not likely to be more than a minor irritant. With both cooling towers in operation, a maximum sound level of 63 dB(C) was measured near the closest residences in New Hampshire. For purposes of comparison, the Department of Housing and Urban Development has set 45 dB(A) as the external noise standard for new construction.

In assessing the possible harmful effects of noise, we compared 56 db(A) with the occupational standard of 90 dB(A)[4] set by the U.S. Department of Labor pursuant to the Walsh-Healey Public Contracts Act as the maximum permissible occupational noise exposure for an 8-hr day for employees covered by that Act. The residential sound levels measured by the applicant are similar in intensity to automobile traffic noise that would be heard from distances of 50 to 250 ft away from the noise source.[5] These noise levels may possibly be a source of irritation to the populace in the off-site residential areas. However, a recent National Academy of Sciences study indicates that there is no evidence that annoying levels of ambient noise produce any adverse long-term effects on physical health or any increase in diagnosable mental illness.[6] Quantitative assessment of the nuisance effects of the noise levels noted above will be possible only after the plant cooling towers have operated for sustained periods of time.

B. WATER USE

1. Thermal Discharge

The heat-dissipation system of the plant is described in Sect. III.D.1. When the plant is operating in open cycle, 366,000 gpm (815 cfs) of water will pass through the condenser and return to the river about 20°F above the intake temperature. In addition, about 10,000 gpm (22.2 cfs) of plant service water is taken from the river, which is a total of 376,000 gpm (840 cfs) of water being used by the plant. This is more than two-thirds of the minimum flow of 538,000 gpm (1200 cfs) which will be maintained in the river when Vermont Yankee starts operating.

The Vermont Yankee Station has the capability of operating either in open cycle, closed cycle, or helper cycle. In the closed-cycle mode, mechanical cooling towers are used to cool the water. About 5000 gpm will be evaporated during full-power operation on closed cycle, including from 300 to 700 gpm that will be lost to the environment as water droplets. On the helper cycle, water is drawn from the river and pumped to the condenser. Any desired portion (0 to 100%) of the condenser effluents may be circulated through the cooling towers. When the cooling towers are under full-power operation, a continuous discharge of about 5000 gpm will be released to the river at a maximum temperature of 90°F. This is blowdown water to rid the cooling towers of dissolved solids.

Since the average water temperature in Vernon Pond exceeds 66°F during most of June, July, August, and September,[7] the plant is expected to operate on a closed cycle during these months. Thus, 5000 gpm of blowdown water at a maximum temperature of 90°F would be mixed with the minimum required river flow of 538,000 gpm (1200 cfs). This flow of blowdown water is less than 1% of the required minimum river flow as compared with open-cycle operation when about 70% of the minimum river flow will be passed through the condenser.

The river flow will influence greatly the dilution of heated water in Vernon Pond. The average river flow[8] at Vernon from 1944 to 1967 has been 10,000 cfs. However, the monthly flow varies greatly from a high of 32,245 cfs in April to a low of 3,400 cfs in August.[9] Superimposed on the monthly flow rates are the weekly and daily flow rates controlled by the Vernon hydroelectric station. The flow rate has varied from 200 to over 100,000 cfs, but when the plant becomes operational a minimum flow rate of 1200 cfs will be maintained.

The maximum river flow occurs in March, April, and May; if the plant is operating on open cycle during these months, the heated water would be diluted by the greater river flow. A buildup of heated water in Vernon Pond would be anticipated during October, November, and December, when the

plant is operating on open cycle and the river flow is low. At this time, heater water may be taken into the intake structure due to recirculation of heated water in Vernon Pond.

By analyzing preliminary dye studies using unheated water, the applicant has predicted configurations of the thermal plume needed to evaluate the thermal effects of discharged heated effluents in Vernon Pond. These studies are discussed in Sect. III.D.1.b along with the staff's mathematical model prediction studies of the plume shape and size at four different flow rates. The applicant has plans for detailed thermal plume studies in the pond after the plant begins operating; such studies will be necessary for analyzing the thermal and ecological effects of discharged heated effluents. Under some conditions, the warm water discharged could spread through Vernon Pond if the plant is operated on open cycle.

If heated water is released to Vernon Pond during freezing conditions, the surface water will undoubtedly be warmed, and the area around Vernon Dam should be free of ice for most of the year. This will benefit the New England Power Company by reducing the expense of keeping the dam free of ice. Apparently Vernon Pond is not used extensively for winter sports; so there should be no or, at most, a negligible impact on winter recreation in the area.

2. Temperature Monitoring

A comprehensive temperature profile study of Vernon Pond was conducted by Webster-Martin, Inc., as a part of the preoperational aquatic biological study.[7] Temperature measurements were made at quarter points and at various depths along 13 cross sections, beginning approximately 6 miles above the station discharge point and ending at Vernon Dam. In addition, temperature has been and will be measured and recorded continuously at two water quality monitoring stations: one (No. 7) located above any effects of the station cooling water discharge and one (No. 3) located below Vernon Dam (see Fig. II-12).

There is doubt that the continuous temperature recording station below Vernon Dam will give relevant information regarding thermal effects in Vernon Pond. The staff believes that continuous temperature recording stations should be installed in Vernon Pond in accord with the Technical Specifications for operating the plant and that temperature profiles in Vernon Pond should be measured to define the thermal plume after the reactor begins operation. The reason given by the applicant's consultants, Webster-Martin, Inc., for the location of stations 3 and 7 was the difficulty in finding suitable sites. Their contention was that ice conditions and high water make maintenance of permanent stations in the river difficult. The staff believes that permanent stations should be located in Vernon Pond in the vicinity of the plant. Such stations would provide realistic temperature data on Vernon Pond, where the greatest ecological impact is anticipated. Both horizontal and vertical

temperature profiles should be made for each of the reactor cooling and discharge modes, covering the range of river flow rates, and should be correlated with the continuous temperature monitors to provide sufficient data to evaluate the thermal effects of discharged heated effluents in Vernon Pond. This thermal study should be coordinated with a study of the ecological impact on Vernon Pond resulting from plant operation.

For the interim period while these studies are being done, the staff suggests that temperatures in the thermal plume and the location of the interface between bottom water and top water be measured. The use of such data to limit thermal impact on Vernon Pond during this period is discussed in Sects. III.D.1.b and V.C.7.

3. Chemical Discharges

Basically three chemicals will be discharged by the applicant into Vernon Pond in substantial quantities: residual chlorine, sodium, and sulfate. The details of these operations are discussed in Sect. III.D.3.a, and the amounts of chemicals discharged are summarized in Tables III-3 and V-1.

The residual chlorine enters the river at 0.1 ppm in the amount of 25 lb/day during open-cycle cooling. The effects of this discharge will be discussed in Sect. V.C.

Sodium and sulfate ions will be discharged in the regeneration of makeup demineralizers used to process primary coolant makeup water, at rates of 1100 and 90 lb/day, respectively, during open-cycle cooling, and 170 and 360 lb/day, respectively, during closed-cycle cooling. The mixed bed demineralizers are regenerated every 4 to 6 months and will discharge 9000 gallons at each regeneration with sodium and sulfate ion concentrations of 1200 and 2600 mg/liter, respectively. The cation and anion units will be regenerated twice per week and will discharge 9000 gallons per batch to the condenser cooling system with sodium and sulfate concentrations of 1900 and 4100 mg/liter, respectively. Concentrations discharged to Vernon Pond will be 4 and 7 mg/liter, respectively, above existing river concentrations (Table III-3).

Although the amount of dissolved solids released into Vernon Pond appears great, at a minimum river flow of 1200 cfs the water flow will be 3.23 million tons/day and at 100 ppm the normal dissolved solids flow will be about 350,000 lb/day. Therefore, the amount of solids released to the river by the applicant is small compared with the content of the river water. The releases of these salts are not expected to limit the quality or usability of the river water.

Although 275 gal/day of sulfuric acid is added to the circulating water in closed-cycle operation, the pH should remain near neutral. The sulfuric acid is added to neutralize the sodium hypochlorite resulting from cooling-tower treatments. These releases of chemicals should have no adverse effect on the pH of the river water[7] which varies from about 6.3 to 8.0.

Table V-1. Discharge of chemicals to Vernon Pond

	Na^+	Cl^-	SO_4^{2-}	Cl_2
Amount discharged, lb/day				
Open cycle	1100	1640	90	25
Closed cycle	170		360	
Ion concentration, mg/liter				
In ion-exchenger regeneration discharge				
Anion and cation beds[a]	2000		4000	
Mixed beds[b]	1200		2600	
In blowdown discharge[c]	3.4		7.2	<0.1
In Connecticut River, May 1969–May 1970[d]				
Average	4.5	6.7	9.6	
Maximum	7	10	13	
Public water criteria[e]				
Permitted	f	250	250	
Desired	f	<25	<25	
Average of drinking water in 100 large cities[g]				
Median	12	13	26	
Maximum	198	540	572	
Concentration increase in Connecticut River at minimum flow, mg/liter				
Open cycle	0.17	0.26	0.014	0.004
Closed cycle	0.03		0.06	<0.001

[a]Twice each week.
[b]Once every 4 to 6 months.
[c]Continuous during closed-cycle operation.
[d]Ref. 7.
[e]Ref. 10.
[f]No recommendation.
[g]Ref. 11.

The staff asked specific questions about other chemical effluents at the time of their visit to the Vermont Yankee Station, especially those dealing with cooling-tower treatments. The applicant has stated that the discharges listed above were the only ones contemplated. The staff's assessment of the impact is based only on release of chemicals given in Table III-3. In summary, the chemical effluents released by the applicant are expected to have a minimal impact on the Connecticut River.

4. Effects on Drinking Water

Table V-1 gives the amounts of sodium, chloride, and sulfate ions to be discharged to the Connecticut River (i.e., Vernon Pond) during operation of Vermont Yankee. The table also gives the average concentration of these ions measured in the Connecticut River for a typical year,[7] the recommended concentrations for drinking water,[10] and the average concentrations in drinking water of 100 large cities in the United States.[11] An examination of the data shows that the increase of ion concentrations in the Connecticut River is quite small compared to present river concentrations, recommended drinking water concentrations, or actual drinking water concentrations in the United States.

The staff has considered the possible impact of plant operations on drinking water supplies. The proposed Quabbin Reservoir Project will draw water from the Connecticut River for ultimate use as domestic water in Massachusetts (Sect. II.E.2). Calculations of radionuclide concentrations are presented in Section V.D.2. In view of the extreme degree of dilution, one would not expect that detectable levels of chemicals could occur in Quabbin Reservoir from the normal operation of Vermont Yankee.

There are seven municipalities with a total population of 33,944 within a 10-mile radius of the reactor that use groundwater as a source of domestic water supply. Wells and springs within a 1-mile radius of Vermont Yankee are shown in Fig. II-11. The level of the local water table fluctuates and depends upon the amount of precipitation and level changes in the Connecticut River. When Vermont Yankee begins operating, a minimum flow of 1200 cfs will be maintained through Vernon Dam. The Dam has served as a peaking unit in supplying electrical power to the area. When the demand for electrical power is the greatest, the hydroelectric plant operates at full capacity, allowing larger quantities of water to pass through the dam. However, at times of lesser demand for power, usually at night, the water accumulates in Vernon Pond, with as little as 200 cfs passing through the dam. With the activation of Vermont Yankee, a flow of 1200 cfs will be maintained through Vernon Dam by regulating the releases from Bellows Falls Dam upstream. This regulated flow will aid in stabilizing the water table in the low area.

C. BIOLOGICAL IMPACT

1. Terrestrial

The diversion of approximately 60 acres of pasture and agricultural habitat to plant use should have little adverse impact on the local populations of mammals, amphibians, reptiles, and birds (Section II.F). The land used was primarily pasture with a few trees. Most of this area is now lost as habitat to mammals. Possible mammals which could have lost entire home ranges are eastern chipmunks, moles, shrews, cottontail rabbits, woodchucks, mice, and rats. Other mammals which could have included the area as part of their territory are weasels, minks, foxes, muskrats, and striped skunks. Vermont has a large deer herd, but the several residences near the plant site probably had reduced use of the area by deer before the site was established.

Although a small number of mammals, reptiles, and amphibians were undoubtedly affected by construction of the power plant, the local population should suffer little adverse effect. As a general rule, Vermont is reverting to forest from agricultural and dairy land. The size of the area diverted is small compared with the large amount of similar habitat available; consequently the staff concluded that the loss of the site as habitat will have no significant effect on the local terrestrial animals.

More terrestrial habitat will be influenced by transmission lines than by plant structures. In some cases, the land under transmission lines can be managed successfully for wildlife. However, from observation during the visit to the Vermont Yankee Station, the staff concluded that this is not the case in the New England area of Vermont, New Hampshire, and Massachusetts. The transmission lines were very obvious when viewed from an airplane, appearing as brown superhighways bisecting a green forest. Apparently these conditions are the result of clearing the right-of-way or broadcasting of herbicides. Under these circumstances, cover for many animal species is lost. As previously discussed, the Vermont Electric Power Company has been required by the State Public Service Board to provide erosion control and selective cutting procedures in its transmission line maintenance program in order to reduce this environmental impact.

In general, transmission lines cutting through a forest create a different habitat 150 to 250 ft wide and many miles long. Essentially a new plant successional stage is established with an associated animal life. Some species of plants and animals will benefit from these changes while others will be eliminated. If food and cover are provided under power lines, some mobile species benefit from the presence of ecotones (transition zone between diverse communities) between powerline areas and surrounding forest and fields.

With the reversion of habitat from pastures and agricultural land to forest habitat, a shift in the bird populations in Vermont from meadow type to forest type would be expected. The elimination of the construction site for meadow-type birds would continue this population shift. Proper landscaping of the construction area should restore some of the site as good bird habitat. Because of the location of the power plant and its use of river water, the concern for water birds is obvious. Although waterfowl would be anticipated in the area, apparently they are not abundant. Black duck and wood duck are listed in the bird check list as being common to Vermont and would be expected in this area (Sect. II.F.2).

The vascular plant communities associated with the Connecticut River near Vernon, Vermont, are discussed in Sect. II.F.3. Transect studies were made for the applicant on two marshes: one about 0.4 mile upstream from the cooling-water intake and the other about 0.4 mile downstream from the cooling-water discharge. These marshes were studied intensively to serve as indicators of possible changes in water quality. Undoubtedly the marsh downstream will be exposed to effluents from the cooling-water discharge. The extent of the increase in water temperature is unknown and will depend upon the operational mode of the plant and the discharge of water from Vernon Dam. Little adverse effect is anticipated, although the species composition may change. The size of the two marshes restricts their influence on the local environment (Sect. II.F.3).

2. Phytoplankton, Zooplankton, and Benthic Fauna

Phytoplankton and zooplankton will be exposed to thermal shock, pressure changes, and chemical toxicity during entrainment passage through the condenser cooling water. In general, phytoplankton are more tolerant of temperature shock than zooplankton. The sensitivity of both depends upon such factors as the stage of the life cycle during exposure and conditioning periods before entrainment. Undoubtedly, large numbers of phytoplankton and zooplankton will be killed while passing through the condenser of the Vermont Yankee Station, which increases the ambient water temperature 19.7°F. However, the cooling towers will be operating when the phytoplankton and zooplankton populations are at their peaks. Under such conditions, the volume of intake water will be about 3% of the open-cycle intake flow (840 cfs); therefore, a much smaller percentage of organisms will be entrained and killed during closed-cycle operation than during open-cycle operation.

The impact of entrainment depends upon the part of the total volume of the river water diverted through the condenser.[12] In the case of open-cycle operation of the Vermont Yankee Station, approximately two-thirds of the minimum assured river flow of 1200 cfs will pass through the condenser. Under these conditions, a large number of phytoplankton and zooplankton would be affected to the extent discussed below.

Although there is a large amount of literature on temperature and its relation to aquatic fauna, very little is known about the effects of thermal discharges upon algal communities.[13] Each species has an optimum temperature range.[14] Increases in water temperature can shift species composition; for example, Buck[15] noted a phytoplankton and periphyton increase from diatoms to the less desirable blue-green algae in the mixing zone of the Connecticut Yankee Power Plant. Alteration of the seasonal cycle such as lengthening the reproductive season may occur, and algal blooms may extend into fall. In general, until extreme temperatures are reached, increases in temperature enhance total productivity.

If the Vermont Yankee Station were to operate on open cycle during April and May (Sect. V.B), there would be a general increase in the water temperature in Vernon Pond. Phytoplankton populations are usually low during these months;[16] however, the increase in water temperature should bring about an increase in the phytoplankton. Such species as Asterionella formosa and Melosira varians should reach their peak populations earlier in the season than if the increase in water temperature did not occur.

As the temperature of the river water increases during June, the plant will probably have to be operated on closed cycle in order to satisfy State requirements, and the amount of heated water released to Vernon Pond will decrease to about 1% of the minimum flow. As the river water reaches its maximum temperature in July and August, a change in species composition will probably occur in the discharge area. Green algae and diatoms such as Microspora stagnorum, Scenedesmus spp., Fragillaria crotonesis, and Melosira varians will be replaced by filamentous blue-green algae such as Oscillatoria limosa and Oscillatoria agardhii.

In the fall when the temperature of the river decreases, the plant could again be operated on open cycle. Since the phytoplankton population is still dense (about 40,000 organisms per liter), a large number of organisms would be entrained in the condenser cooling water. If stratification and recirculation of the water in Vernon Pond occur (Sect. V.B), the greatest effect on the phytoplankton will be anticipated during October.

In the Green River in Kentucky, biologists found that although zooplankton did not survive passage through the cooling system of the Paradise Power Plant, repopulation occurred a short distance downstream.[17] While thermal shock may kill large numbers of organisms, it does not destroy the carcasses, and these plus the nutrients in discharge water can enrich the water and promote high densities of zooplankton in discharge areas.[12]

The zooplankton population reaches its peak density in June and July (8213 organisms per 10-liter sample).[18] A massing of zooplankton in the vicinity of the power plant is not expected because of the fluctuating river flow. At this time, if the plant is operated on closed cycle, little adverse

effect should be caused by entrainment. The zooplankton population is largely dependent upon the phytoplankton population; therefore, the zooplankton may parallel the phytoplankton and reach its peak population earlier in the season as a result of increased water temperatures in Vernon Pond. The number of zooplankton decreases rapidly at the end of September, and whether or not the reproductive cycle will be extended into the fall by increased water temperatures from open-cycle operation of the plant is unknown. In general, a larger population of zooplankton is expected in Vernon Pond, with some changes in species composition and alteration of the seasonal population peaks.

Benthic organisms may be killed in the summer by heated effluents but the reverse is often the case in the winter. Temperature in excess of 18°F above normal caused an increase in the number of benthic organisms in the discharge area of the Connecticut Yankee Plant.[19] Little change is expected in the temperature of the bottom water in Vernon Pond except in the vicinity of the discharge; therefore, the heated effluents from Vermont Yankee should have little adverse effect on the benthic organisms.

The greatest diversity of benthic organisms was found at three sampling stations below Vernon Dam (Sect. II.F.6). The effluents from the Vermont Yankee Station will have little effect on the fauna at these stations. Warm water from the discharge should be well mixed and should cause little change in temperature there. Impurities released from the plant should be dispersed and add little to the total volume of dissolved solids that now flow down the river.

Several of the benthic species listed have weak-swimming or floating stages of their life cycle. For example, the pupal stage of the life cycle of the Tendipedidae (midges) can be carried by the current and passed through the plant's cooling-water system which would kill a large number by temperature shock, mechanical damage, or chemical toxicity. These organisms do not travel a great distance downstream; therefore, only the organisms developing in the vicinity of the Vermont Yankee Station will be involved in entrainment. Depending upon the dilution of chemical discharges and heated water, a difference in abundance and species composition is likely to occur near the outfall of the water discharge. Typical species that occur in such areas are tubificids (round worms)[20] and pollution-tolerant species of Chironomids (midges).

In general only in the vicinity of the Vermont Yankee Station will the benthic fauna be affected by the effluents from the plant. Entrainment may kill up to 100% of the organisms, but the increased temperature of the water and nutrients should maintain the population. In the vicinity of the outfall, eutrophication probably will occur, with a shift to pollution-tolerant thermophilic species. The extent of this condition will depend upon the degree of dilution of chemical discharges and the change in temperature of the water flow through the dam.

Since the temperature of Vernon Pond will be increased in the vicinity of the Vermont Yankee Station, the phytoplankton, zooplankton, and benthic fauna will be influenced. Many organisms may be killed by entrainment, but the general warming and enrichment of Vernon Pond will probably produce larger populations. Some changes in species composition and alteration of seasonal population peaks are expected, and reproductive cycles of some species may be extended. The greatest effect on the phytoplankton would be expected in the fall when the population density is still high, if the station changes from closed-cycle to open-cycle operation. The staff does not anticipate a serious adverse effect on these populations if the plant is operated in conformity with the temperature limits discussed in Sect. V.C.7. These predictions are made without benefit of field verification of predicted thermal plumes. For this reason, the phytoplankton, zooplankton, and benthic fauna studies will be continued after the plant becomes operational.

3. Anadromous Fisheries Restoration Program

The restoration of the "flounsing Sammon" to the Connecticut River has long been the dream of piscatorial purists and fisheries scientists.[15] Under the provisions of the Anadromous and Great Lakes Fisheries Restoration Act of 1965, a cooperative fishery restoration program was initiated in the Connecticut River Basin.[21] This restoration program includes restoration of the American shad, *Alosa sapidissima*, as well as the Atlantic salmon, *Salmo salar*, to the upper reaches of the Connecticut River. The impact of the Vermont Yankee Station on this program must be considered.

Historically, Atlantic salmon ascended the Connecticut River to West Stewartstown, New Hampshire; however, the magnitude of the original run is unknown. Since the southern limits of the salmon are generally accepted to be just south of the Connecticut River, one would expect that the abundance of this fish would be less than in streams farther to the north. Although the runs may have been small, nevertheless, modern fisheries' techniques may be able to restore the Atlantic salmon to the Connecticut River.

The American shad, which still spawns in the lower reaches of the Connecticut River, originally ascended the river as far upstream as Bellows Falls, approximately 35 miles north of the Massachusetts border. The size of the original American shad run is also unknown.

Navigational dams began appearing more than a century ago on the Connecticut River,[15] and the decline of the Atlantic salmon coincides with the appearance of these dams. The industrial dam in the Chicopee-Holyoke area built in the mid-1800's was responsible for the disappearance of Atlantic salmon and American shad above this point in the river.[18] The

restoration of the anadromous fish to the upper part of the river depends upon providing passageways for the fish around such physical obstacles.

Besides the physical structures on the Connecticut River, the salmon and shad must contend with power-plant mixing zones with temperature rises about 21°F. Merriman[22] lists ten sources of thermal input into the Connecticut River but concludes that thermal effluents from various electrical generating plants along the river from southern Vermont to Haddam Neck, Ct., should not provide barriers either to the emigrant smolt or the returning adult salmon during their run up the river. He reached this conclusion from several studies on the Connecticut River resulting from the building of the Connecticut Yankee Power Plant. However, the sensitivity of advocators of the anadromous fish program to the possibility of another obstacle being added to the gauntlet that must be run by ascending salmon can easily be understood. The fisheries program has already sponsored studies of the resident fish population above Vernon Dam and the release of salmon parr in the Connecticut River[18]; thus the program is more than just conjecture.

A typical temperature distribution (based on Sect. III.D.1.b) in Vernon Pond during the period of an adult salmon run is shown in Fig. V-1.

Providing that a salmon run could be established to Vernon Dam, fish ladders or some means of transporting the fish over the dam will be necessary to continue the run upstream. If a fish ladder is built near Vernon Dam, heated water from Vermont Yankee could flow into the ladder and serve as a thermal obstacle to migrating salmon. Since Vermont Yankee's predicted thermal plume studies only roughly estimate the spread of warm water, post-operational plume studies and temperature recording in Vernon Pond are needed to answer this question. Such studies are expected to provide information to assist in the design and location of the fish ladder to circumvent the problem.

In order to comply with State permit requirements, Vermont Yankee's release of heated water must not interfere with the restoration of anadromous fish to the river. The applicant will have to satisfy the requirements of this program, even though nine other mixing zones with maximum temperature rises from 11 to 24°F[15] must be traversed by the fish or avoided before reaching Vernon Dam.

If salmon were restored above Vernon Dam and smolt started making their run to the sea, the impact of the water intake on this fish population could become more important. The intake has a velocity of 1.0 fps, which should have little adverse effect on the local fish

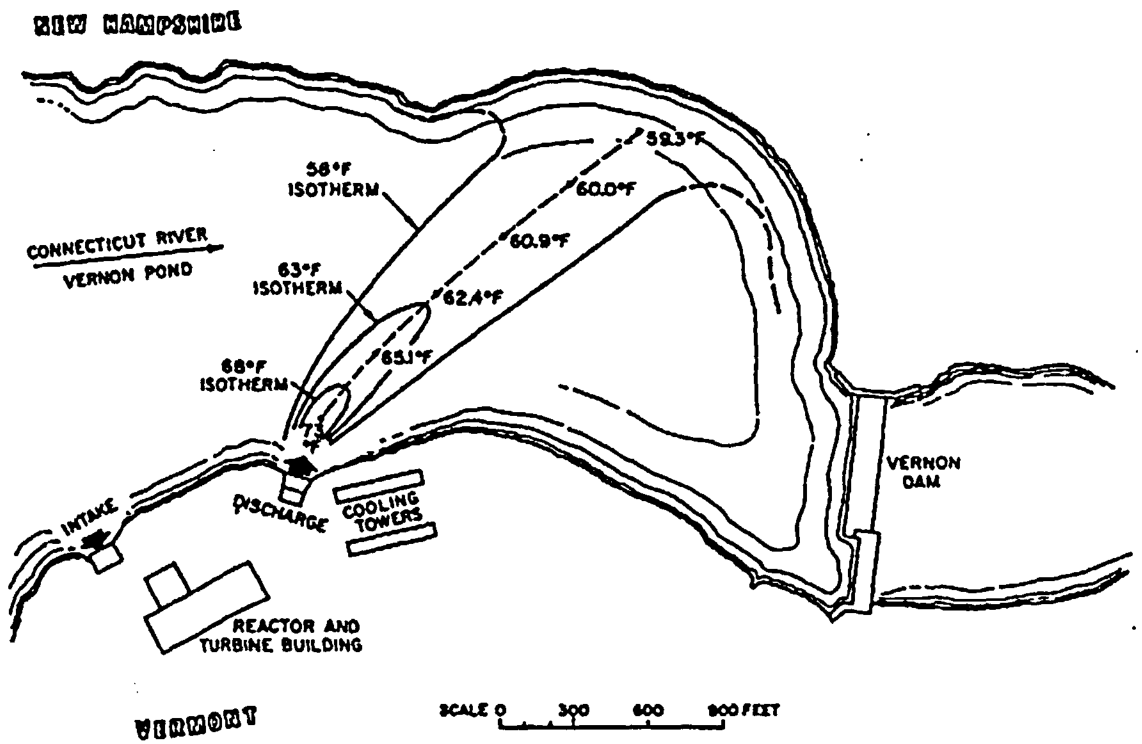

Fig. V-1. Predicted Temperatures in Vernon Pond that Might be Encountered by the Atlantic Salmon Moving Upstream in October (River Flow = 4900 cfs. and Temperature = 53°F).

population, but could present a different problem to sea-bound smolt. Since construction of the fish ladder had not commenced as of April 1972, operational experience with the intake could be obtained before the problem of the returning smolt is faced. Studies on the fish kills by the intake structure and entrainment that may occur could predict whether the structure or plant operations would have to be altered for the anadromous fish program.

According to DeCola,[21] to restore a run of two million shad to the Connecticut River would require passage facilities for 750,000 shad at Vernon. The Department of the Interior's letter of December 28, 1970, to Vermont Yankee questioned whether 1200 cfs would be sufficent stream flow to support the anadromous fish program and suggested a stream flow of 1550 cfs. Vermont Yankee's response was that it had no control over the stream flow, which was controlled by the New England Power Company. In the letter of May 7, 1971, the Department of the Interior accepted the applicant's conclusion but stated that the power plant should remain flexible enough to accommodate any increased flow provided to restore anadromous fish to the river. Obviously after the flow of the Connecticut River required for the anadromous fish program has been established, Vermont Yankee must operate under these conditions. A typical temperature distribution (based on Sect. III.D.1.b) in Vernon Pond during the period of a shad run is shown in Fig. V-2.

In summary, the staff concludes that Vermont Yankee could have two potential deleterious effects on the anadromous fish program. One, heated water could flow into fish ladders and block the progress of ascending fish unless the ladders are properly designed. Two, smolt, migrating to the sea, could be killed in the intake. Post-operational studies by Vermont Yankee can predict the magnitude of these effects, and, if indicated, corrective action could then be taken.

4. Effects on Fish Populations

a. Spawning Habits of Fish in Vernon Pond

The species of fish in Vernon Pond are discussed in Sect. II.F.7. The species listed do not have spawning runs up or down the river, although they may movè into bays or riffles to spawn. Much of the habitat in Vernon Pond near the Vermont Yankee Station does not afford good spawning sites for most of the species. The water level fluctuates daily, the sides of the pond are steep, most of the bottom is too deep for spawning, and the bottom is of silty sand, an unsuitable substrate for many of the species. Of the species listed, *Ictalurus nebulosus*, the brown bullhead, is the most likely to spawn in the area.

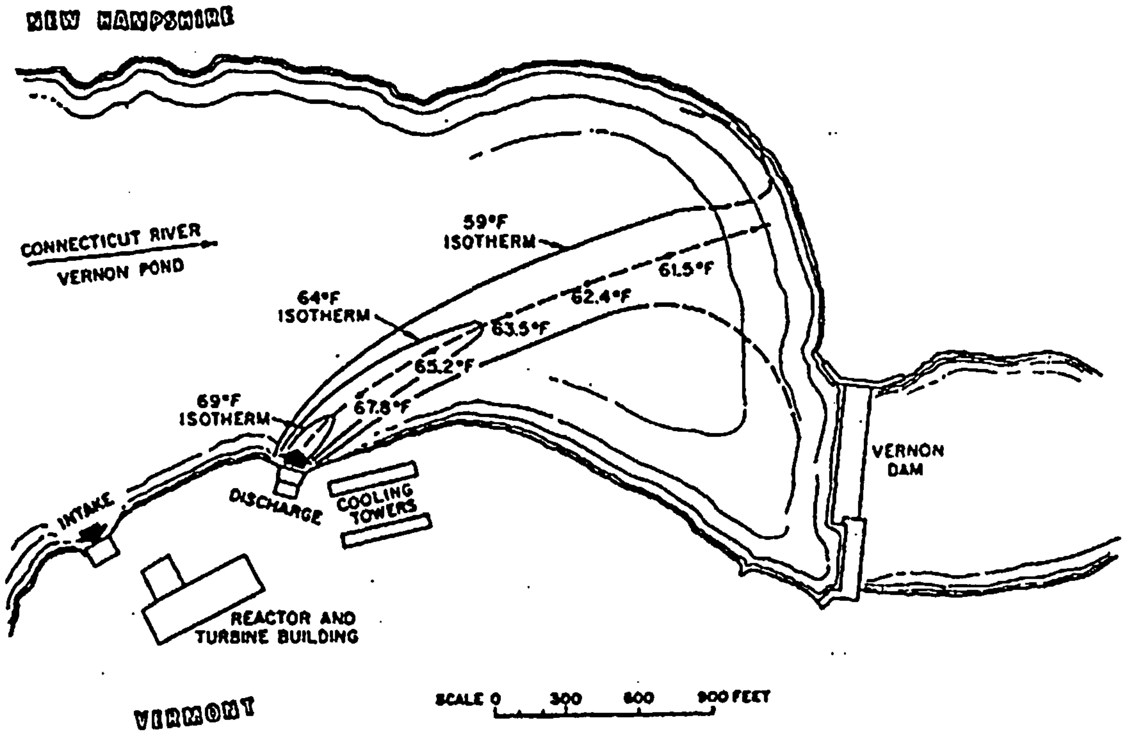

Fig. V-2. Predicted Temperatures in Vernon Pond that Might be Encountered by American Shad Moving Upstream in May (River Flow = 15,000 cfs and Temperature = 54°F).

Carp, Cyprinus carpio, will usually spawn along most shorelines; however, they prefer shallow water with abundant vegetation. Bluegill, Lepomis macrochirus, could spawn in the area, but are more likely to spawn in shallow water. The spawning of fish and the hatching of the eggs are dependent upon the water temperature (Table V-2).[41,42,44-49] Typical temperature distributions across Vernon Pond are shown for two spawning times in Figs. V-3 and V-4. From the above, one would conclude that a minimum amount of spawning occurs in the vicinity of the Vermont Yankee Station. Therefore, there should not be an abundance of embryonic and immature fish in the area susceptible to entrainment in the cooling water.

b. Biological Insults

The plant affects fish by entrainment, by thermal changes, and by chemical impurities.

(1) Entrainment

Experience at another nuclear power plant has demonstrated that a large number of fish can be killed in cooling-water intake structures. The velocity of the water entering the intake structure is one of the critical factors. As the velocity decreased from 1.20 to 0.85 fps, a significant decrease in the number of fish killed has been reported.[23]

The effectiveness of the proposed cooling-water intake structure for Vermont Yankee to eliminate or minimize excessive fish mortalities can only be determined after the plant is placed in operation. The staff has analyzed the plant design which calls for an intake velocity of 1.0 fps through the trash racks and 1.57 fps through the traveling screen behind the trash racks. Experience and new intake designs for other plants have been assessed; the applicant and its consultant have also obtained the guidance and recommendations of the States of Vermont, Massachusetts, and New Hampshire, as well as the Bureau of Sport Fisheries and Wildlife, on the intake structure design.[24] Also, the plant has operated all three circulating water pumps simultaneously for over 200 hours during 1971 without any fish mortalities being observed. While this total pump operating time is short, the apparent lack of any fish entrapment problem is encouraging. However, this aspect of plant operation will require close surveillance since some of the more abundant juvenile fish in Vernon Pond such as Lepomis (sunfish), Perca flavescens (yellow perch), Catostomus commersonii (white sucker), and Micropterus dolomieue (smallmouth bass) will likely be killed. If a significant loss of fish should occur by entrapment or entrainment in the cooling-water system, corrective action will be required.

Table V-2. Spawning conditions required for local fish in Vernon Pond

Species	Usual spawning time	Water temperature required for spawning (°F)	Lethal temperature (°F)
Smallmouth bass	June	62	90.5
Largemouth bass	June	66	90.5
Walleye	Spring	50	84
Yellow perch	Early spring	45–50	91.4
Bluegill	Late spring	67	92.8
Pumpkinseed	Late spring	68	95
Rock bass	Early summer	65 approx	
White perch	Spring	60	
White sucker	Spring	50	82
Carp	Summer	65–68	96

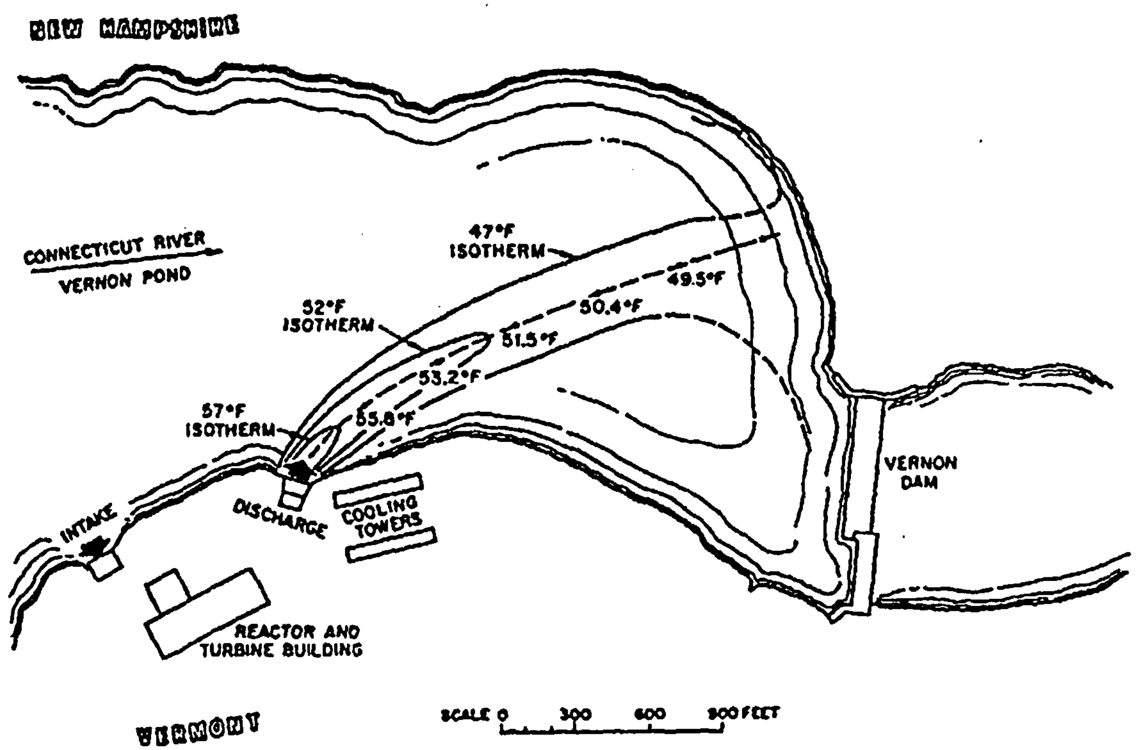

Fig. V-3. Predicted Temperatures in Vernon Pond During Spawning Time (Early Spring) of Yellow Perch, White Sucker, and Walleye (River Flow = 15,000 cfs. and temperature = 42°F).

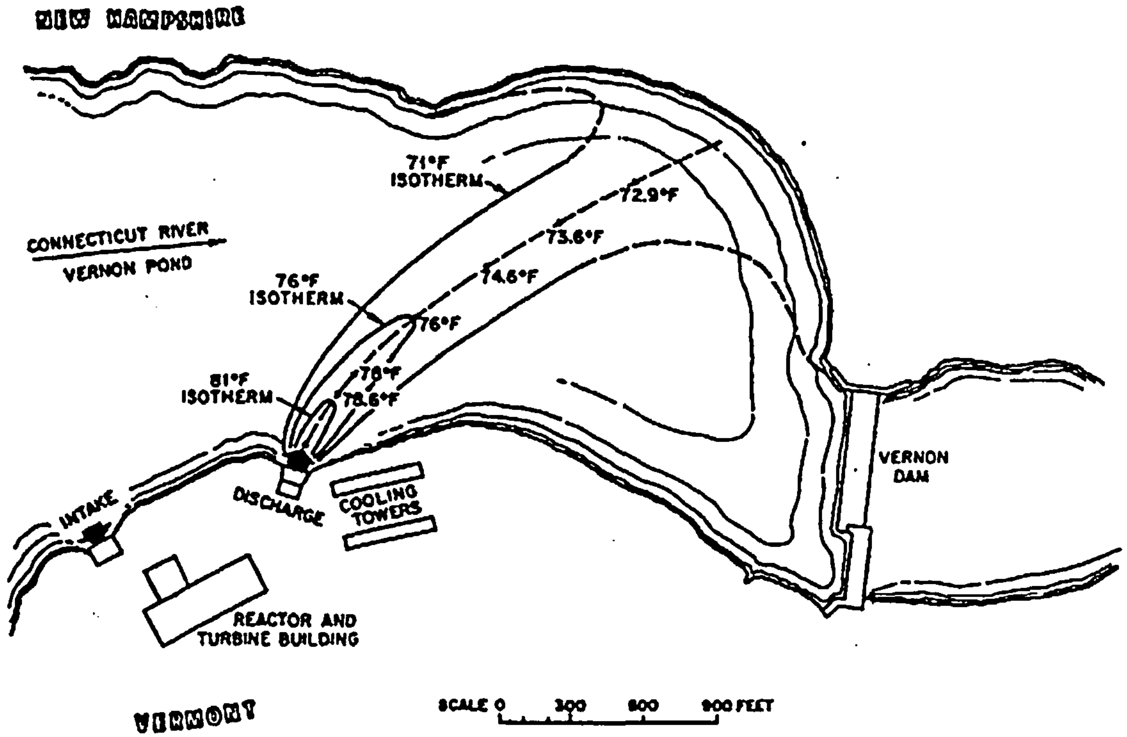

Fig. V-4. Predicted Temperatures in Vernon Pond During Spawning Time (Late Spring) of Smallmouth Bass, Largemouth Bass, Bluegill, Pumpkinseed, Rock Bass, White Perch, and Carp (River Flow = 10,000 cfs. and Temperature = 66°F).

(2) Thermal

Small and immature fish which pass through the condenser of the Vermont Yankee Station will be exposed to a thermal shock of 19.7°F above the temperature of the intake water. Perhaps not all of the fish passing through the condensers of a nuclear power reactor are killed by thermal shock, but sufficient data on most species are not available. High survival rates[25] have been claimed for juvenile chinook salmon and juvenile striped bass actually passing through the condenser of the Contra Costa Steam Plant where the temperature rise was 29°F. At the Connecticut Yankee Power Plant, indications[26] were that larval river herring (Alosa spp.) could pass through the condenser cooling water where the temperature was raised to 93°F. However, as reported later,[27] of nine species of young fish entrained in the condenser cooling-water system of the Connecticut Yankee Plant, none survived passage to the lower end of the plant's discharge canal. Species entrained that are common to Vernon Pond are: white perch, carp, spottail shiner, and American eel. The sudden rise in temperature may not be lethal to the fish; however, the physiological shock may cause them to be more susceptible to predation.[28]

If the Vermont Yankee Station is assumed to operate on open cycle only when the river water is below 66°F, then the organisms passing through the condenser cooling water will be exposed to a maximum temperature of 86°F (30°C). The upper temperature tolerance limits for many of the species found in Vernon Pond are above this temperature — largemouth bass 90.5°F; bluegill 92.8°F; carp 96°F; yellow perch 91.4°F. These tolerance levels tell very little about the thermal effects on fish passing through the condenser cooling system because many other factors are involved. The acclimation temperature, the duration of the temperature shock, the stage of the life cycle, and the temperature of the water to which the fish are returned are important factors to be considered.

When the plant is operating on closed cycle during the summer months, only 10,000 gpm of service water will be taken into the plant, which is less than 2% of the minimum required river flow of 538,000 gpm (1200 cfs). The number of fish killed in the intake structure during closed-cycle operation should be insignificant. On open-cycle operation, about 70% of the minimum river flow will pass through the condenser. In the spring the river flow is much greater than in the fall (Sect. V.B), and a smaller percentage of the total flow will be passing through the condenser. The largest number of fish probably would be killed if the plant is operating on open cycle during the fall and winter months when the river flow is low.[12]

An effect, often overlooked in evaluating thermal effluents, is the creation of a warm pool of water which attracts fish. In general, adult fish will enter heated water up to 90°F, but are driven out when the temperature reaches 95 to 102°F.[12] If there is a considerable difference in the temperatures of the river water and the heated pool — for example, if they are 42 and 68°F (5.5 and 20°C) — a cessation of heated water caused by a shutdown of the power plant can produce mortalities (cold-kill) in fish. Temperatures and the size of the plume across Vernon Pond during February are shown in Fig. V-5.

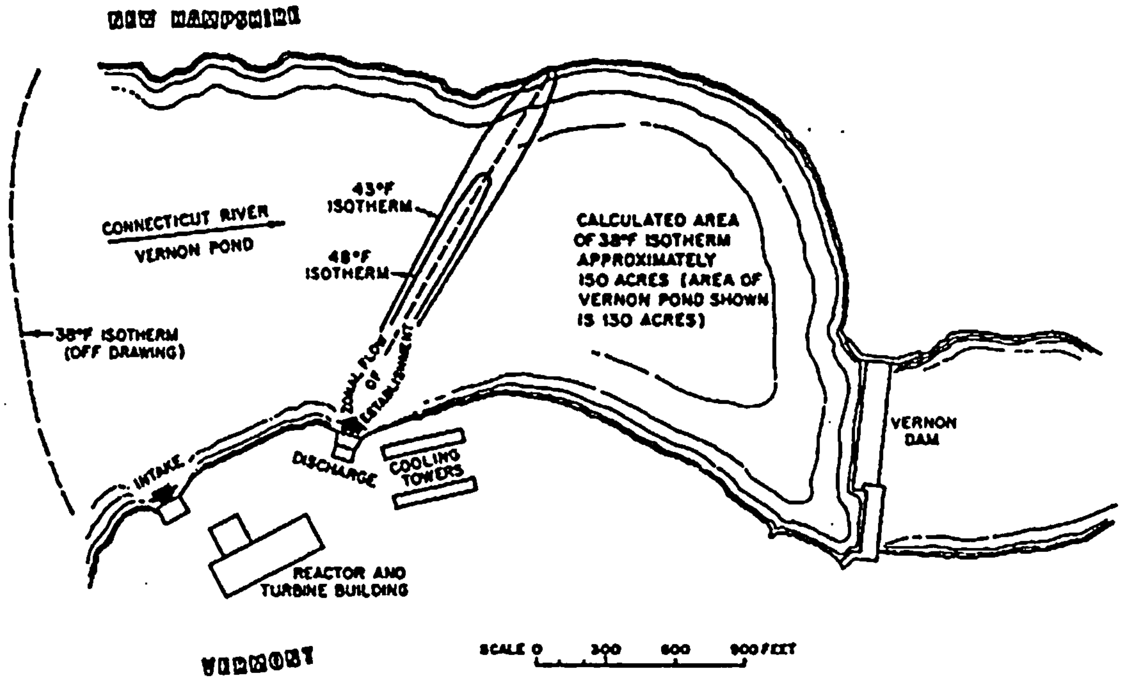

Fig. V-5. Predicted Temperatures in Vernon Pond During February when Cold-Kill Might Occur after Plant Shutdown.

Fish living in heated effluents for any length of time become acclimated to the water temperature. They are subjected to speeded metabolic rates and increased oxygen and food consumption. Such conditions can result in loss of weight. Merriman <u>et al.</u>[29] found that brown bullhead living in the discharge canal of the Connecticut Yankee Plant lost 20% of their weight during the winter. Premature spawning can also occur in discharge canals.[26] Repercussions of premature spawning may result in loss of progeny due to lack of proper food or species change due to overly dominant warm-water fry.[12] The effect of the heated water on Vernon Pond will depend upon the temperature increase in the water and the size of the heated area and will be discussed further in Sect. V.C.7.

Since the solubilities of gases, such as dissolved oxygen, in water vary inversely with temperature, increasing the temperature by 20°F will decrease the dissolved oxygen saturation levels in the cooling water. If oxygen levels were reduced to certain critical levels, the biota in Vernon Pond would be affected.

According to Alabaster and Downing,[30] most unheated water was not saturated, and there was either a slight rise or little change in oxygen concentration in the heated water discharged from condensers. Adams[31] reported similar findings for a power station in California. Measurements at the intake and outfall points showed that dissolved-oxygen concentrations were not decreased by passage through the cooling-water system. Instead, the water merely became supersaturated with oxygen.

The water in Vernon Pond is not saturated with oxygen; at an average temperature of 20°C, the dissolved oxygen[32] was 7.35 mg/liter. According to Parker and Krenkel[33] the solubility of oxygen in water at 20°C (68°F) is 9.2 mg/liter. Thus, increasing the water temperature to approximately 30°C (86°F) should have little effect on the oxygen concentration in the water. However, the water passing over the plant's aeration structures would probably be saturated with oxygen; mixing with Vernon Pond should quickly restore oxygen levels to normal.

Supersaturation of gases in water produces gas-bubble disease in fishes when concentrations exceed 115%. Supersaturation is brought about by increases in temperature and pressure. Neither temperature nor pressure changes in Vermont Yankee are likely to induce supersaturation; therefore, no problem with gas-bubble disease in Vernon Pond is expected.

In water with a high BOD (biochemical oxygen demand), an increase in oxygen demand could exceed the rate of reoxygenation from surface diffusion and photosynthetic production; oxygen levels would decrease below those normally expected. The BOD was relatively small for the water in the Connecticut River. The 5-day BOD at 20°C ranged[32] from 0.70 to 2.95 mg/liter. Although there might be a slight change in dissolved oxygen concentration across the condenser and an increase in BOD near the discharge area, the resulting decrease in dissolved oxygen should have little effect on the biota in Vernon Pond.

(3) Chemical

Fish in the discharge area of the Vermont Yankee Station will be exposed to chemicals in the discharge water. Basically, three chemicals will be discharged into Vernon Pond: residual chlorine, sodium, and sulfate (Sect. III.D). The Vermont Yankee Station will use chlorine to reduce growths of algae and other organisms in the cooling water.

The toxic effects of chlorine and its reaction products with water, ammonia, and nitrogenous material require the most careful consideration of all the chemical effluents. Table V-1 shows that the quantities of sodium, chloride, and sulfate ions discharged into the river will not change the river concentration appreciably. The effects of chlorine are more difficult to assess and its products harder to measure. At pH values of 6 to 8, hypochlorous acid and hypochlorite ions form the principal species in water and are usually called "free" residual chlorine. The Connecticut River near Vernon Pond contains ammonia and nitrogenous material in concentrations that will also form chloramines called "combined" residual chlorine. Although chloramines are generally thought to be less toxic than hypochlorous acid and hypochlorite ions, they are longer lived[34] and thus have a similar toxic effect. The sum of the "free" and "combined" residual chlorines is called "total active" or "total available" residual chlorine. This is the significant quantity to be monitored.[34,35]

The applicant has agreed to analyze for total residual chlorine in the immediate discharge area.

The chemistry of chlorine in natural and waste waters and its analyses are discussed more fully in Appendix V-B.

A comparison of the proposed release of 0.1 mg/liter of residual chlorine for Vermont Yankee with toxicity information in the biological literature is instructive. Merkens[36] studied the toxicity of chlorine and chloramines on fish, separating the effects of free chlorine and each of the chloramines. He found the monochloramines three times less toxic than "free" chlorine; the di- and trichloramines had an effect intermediate between that of monochloramines and that of "free" chlorine. At a pH of 7, with small rainbow trout in 15°C (59°F) flowing water, half the fish were killed in 0.08 mg/liter total residual chlorine in 7 days. Two experiments investigated the dependence of toxicity on total residual chlorine and pH - the least fatal conditions are quoted. Basch[37] reported a 50% kill of rainbow trout at 0.23 mg/liter in 4 days. Coventry <u>et al.</u>[38] reported that trout fry were killed in 2 days at 0.05 mg/liter chloramine. Rainbow trout are probably the most sensitive fish to chlorine residuals. Sprague and Drury[39] showed an avoidance response by this species at 0.001 mg/liter. Arthur and Eaton[40] found a 96-hr survival of half of a population of the invertebrate

Gammarus pseudolimnaeus at a concentration of 0.22 mg/liter; reproduction was reduced where chronic concentrations (15 weeks) were maintained at 0.0034 mg/liter. They also showed that the highest concentration that produced no effect on the life cycle of the fathead minnow was 0.016 mg/liter.

Zillich[35] conducted extensive tests with fathead minnows in dilutions of effluents from two sewage treatment plants having quite different concentrations of metal ions (Cd, Cr, Zn, Cu). He compared the toxic effects of these effluents with the effect of one of the same effluents that had been dechlorinated with thiosulfate treatment. The toxic effects were a function of the total residual chlorine concentrations. The threshold at which the fish showed no symptoms in 4 days was a total residual chlorine concentration of 0.04 mg/liter. In discussing why more fish aren't killed below sewage treatment outfalls, he suggested that since fish can survive several tenths of a milligram per liter for several hours, the fish have time to avoid the toxic concentrations. Thus, the effect of common sewage effluents apparently is to reduce the volume of water available to fish rather than to kill them.

Twelve and one-half pounds of total residual chlorine will be discharged with the open-cycle cooling water at 0.1 mg/liter for 40 min twice daily; the chlorine concentration will be monitored at the discharge exit. At minimum river flow (the worst case), the discharge emerging at 0.1 mg/liter would be diluted 25 times by mixing with subsequent effluent and with river flow; a concentration of 0.004 mg/liter would eventually be reached downstream. The average river flow is eight times greater than the minimum flow; so concentration after average dilution will be even lower than concentration after minimum dilution, which itself is harmless according to the predominance of the evidence.[34-38] Note that the chlorine effluents, unlike thermal effluents, are intermittent, each followed by an 11.3-hr period of chlorine-free condenser discharge.

In closed-cycle operation, nearly all chlorine will be dissipated in the cooling towers. Even if chlorine residues are not eliminated completely in the cooling towers, the blowdown flow is less than 1% of the open-cycle condenser flow. A conservative conclusion is that chlorine residuals will pose even less threat to aquatic life in closed-cycle operation than in open cycle.

The concentrations of sodium and sulfate in the discharge water should not have an adverse effect on aquatic organisms. Nevertheless, fish inhabiting the discharge area could accumulate body burdens of different chemicals. The staff believes that during postoperational biological monitoring of the organisms in the plume area, sensitive chemical analyses of these organisms should be made.

c. Effects on Individual Species

A brief discussion of some of the more important fish species in Vernon Pond follows:

(1) Smallmouth Bass

The smallmouth bass, *Micropterus dolomieui*, was one of the most abundant species found in Vernon Pond. They prefer temperatures of 68 to 70°F but can do quite well in higher temperatures. At an acclimation temperature[41] of 68°F, the upper tolerance limit is 90.5°F and the lower limit is 41.9°F. Smallmouth bass spawn when the water temperature is about 62°F. Nest sites are usually firm bottom with gravel in shallow water (2 to 4 ft). The eggs stick to gravel and other bottom material. The eggs hatch in a few days, and for a short time afterward the fry are guarded by the male bass.

Based on water temperatures, the smallmouth bass in Vernon Pond spawn the first part of June; fish living in heated effluents could spawn 1 month early. If the eggs hatched, the fry would be susceptible to entrainment before the plant would start closed-cycle operation.

Young smallmouth bass will be killed in the intake structure, and some fry may be entrained and killed by temperature shock and chlorine, but the staff does not believe there will be a major impact on the smallmouth bass population in Vernon Pond.

(2) Largemouth Bass

Largemouth bass, *Micropterus salmoides*, were not abundant in Vernon Pond. They are an introduced species which prefer water temperatures[41] of 79 to 81°F. With an acclimation temperature of 68°F, the upper lethal limit is 90.5°F and the lower limit is 41.9°F. Largemouth bass spawn when the water temperature[41] reaches 66°F. In Vernon Pond this temperature would occur about the middle of June, and fish living in heated effluents could spawn a month earlier. Largemouth bass are more tolerant of soft bottom for spawning than smallmouth bass; therefore, more spawning sites for largemouth bass may be available in the vicinity of Vermont Yankee. Because of the small population of largemouth bass, no noticeable adverse effect on the population is anticipated. A general warming of Vernon Pond would probably favor largemouth bass.

(3) Walleye

Walleye, *Stizostedion vitreum*, were not abundant in Vernon Pond. They prefer clear water over gravel, bedrock, and other firm bottoms,[42] which may account for their small population in Vernon Pond.[43] In general, they prefer maximum summer temperatures[42] of 77°F. The upper

temperature limit is 84°F, with an acclimation temperature of 45°F. In the spring when the water temperature reaches about 50°F, the female rolls along the shoreline strewing eggs which are fertilized by the following males.

Some fish in the heated effluents could spawn earlier in the spring, and a few could be killed in the intake structure. A major adverse effect on the walleye population is not expected.

(4) Yellow Perch

The yellow perch, Perca flavescens, was the most abundant sport fish in Vernon Pond. They prefer 63°F water when acclimated at 50°F and have an upper temperature limit[44] of 91.4°F. In the spring when the water temperature reaches 45 to 50°F, yellow perch move into shoal water to spawn. The gelatinous rope of eggs is usually woven around aquatic plant[45,46] There is no parental care of the egg masses, which are often eaten by other animals.

Yellow perch will probably be one of the most numerous fish killed in the intake structure. Since water in the vicinity of the Vermont Yankee Station is not suitable for spawning sites, a large number of egg and immature fish should not be killed by entrainment. Fish inhabiting the thermal plume could spawn about 1 month early. The staff does not anticipate a major adverse effect on the yellow perch population in Vernon Pond.

(5) Bluegill

Bluegill, Lepomis macrochirus, were not abundant in Vernon Pond but were found below Vernon Dam. The largest populations of bluegill are found in warm shallow productive lakes.[47] They prefer water temperatures between 60 and 80°F and have a upper temperature limit of 92.8°F, depending upon the acclimation temperature.[44] Spawning occurs in the spring when the water temperature reaches 67°F. The male prepares a nest to which females are attracted, usually in shallow water on sand and gravel or mud bottoms. The male guards the nest, which contains eggs that are adhesive and cling to the bottom debris. After hatching, the fry are protected by the male for several days.

A few fish may be killed in the intake structure when Vermont Yankee becomes operational. Entrainment of small and immature fish may occur, but no serious adverse effect is anticipated on the bluegill population in Vernon Pond. This species may be benefited by warmer temperatures in the vicinity of the Vermont Yankee Station.

(6) Pumpkinseed

The pumpkinseed, Lepomis gibbosus, were common in Vernon Pond and below Vernon Dam. They prefer moderately warm water but do better than bluegill in colder water. At an acclimation temperature of 86°F, the upper tolerance limit[44] is about 95°F. Spawning occurs in the spring when the water temperature reaches 68°F. Their spawning habits are very similar to bluegill and hybridization often occurs.[48] The operation of the Vermont Yankee Station should not have a major adverse effect on the pumpkinseed population, and they may benefit from the imput of warm water into Vernon Pond.

(7) Rock Bass

The rock bass, Ambloplites rupestris, was abundant in Vernon Pond and below Vernon Dam. Most of the fish collected were small.[43] The rock bass prefers temperatures[44] from 58 to 70°F. It is a prolific and environmentally tolerant species which spawns from early spring to late summer, depending upon the latitude. Spawning is similar to other centrarchids; the male prepares the nest in the shallow water on almost any type of bottom.[45]

No serious adverse effect is expected on the rock bass population in Vernon Pond or below Vernon Dam. Some fish will be killed in the intake structure and by entrainment. Fish in the heated water near the discharge area may spawn prematurely, but like other sunfish the rock bass tends to overpopulate and become stunted under such conditions.

(8) White Perch

The white perch, Morone americanus, was common in Vernon Pond. They are important recreational species in many inland lakes. When the water temperature reaches about 60°F in the spring, they migrate into shoal areas and tributary streams for spawning. The eggs are scattered on the bottom and left unattended to hatch in about three days.[45]

Because of their schooling tendencies, white perch may sometimes be killed in the intake structure of the Vermont Yankee Station. Some small and immature fish may be killed by entrainment, and fish in the discharge area may spawn prematurely. A major adverse effect on this species in Vernon Pond is not expected, unless too many schools are drawn against the intake screens.

(9) White Sucker

The white sucker, Catostomus commersonii, accounted for 13% by weight and 15% by number of all the fish collected in Vernon Pond.[43] They prefer temperatures of about 57°F and, after acclimation at 50°f,

tolerate temperatures[44] up to about 82°F. White suckers are spring spawners and move into shallows around gravelly riffles for spawning. Spawning occurs about the middle of May in Vernon Pond when the water temperature reaches about 50°F. In some lakes and streams, white suckers are considered a nuisance fish because they interfere with the reproduction of other fish.[44]

Some fish may be killed in the intake structure of the Vermont Yankee Station, and premature spawning could occur in the discharge area. An adverse effect is not anticipated on the white sucker population in Vernon Pond.

(10) Carp

Carp, *Cyprinus carpio*, accounted for about 2% of the total number of fish caught in Vernon Pond but for about 53% by weight.[43] An introduced species in Vernon Pond, carp can tolerate high turbidity and temperature and low oxygen concentration. The optimum temperature is 68°F and the upper lethal temperature[44] is 96°F. They spawn at water temperatures between 65 and 68°F. The females move into shallow vegetated areas where they broadcast their eggs. The fertilized eggs, being adhesive, stick to vegetation and are left to develop unguarded. Large carp populations usually degrade the aquatic environment; they commonly roil the water, making it unfavorable for plant growth, fish, and fish food organisms.[49]

The operation of the Vermont Yankee Station should not have an adverse effect on the carp population in Vernon Pond. A slight warming and eutrophication of the water would probably benefit the carp population, but an increase in the carp population would probably be detrimental to some of the other species of fish.

d. Conclusion

The staff concludes that the Vermont Yankee Station will not have a major adverse effect on the fish populations in Vernon Pond if the plant operates on closed cycle in conformity with the temperature limits set in Sect. V.C.7. The fish populations in Vernon Pond are of low density, and the area is not a good spawning ground for most species. Undoubtedly some large fish will be killed by entrainment in the condenser cooling water. Chemicals released by the plant should have little adverse effect on the fish, except for chlorine which at times may cause fish to move from the vicinity of the discharge area or may damage less mobile organisms in a localized area.

5. Biological Monitoring

The applicant has provided preoperational information on water quality

and the aquatic biota. It has indicated that post-operational studies will continue for at least 4 years. The applicant has also provided dye studies of the discharge of unheated condenser water, and the staff has calculated thermal plume isotherms at four river flow rates (Sect. III.D.1.b). These estimates do not represent the field operating conditions closely enough to allow the staff to make predictions of the effects of the heated effluents in the Vernon Pond. The observations of Sect. V.B.2 cannot be over-emphasized. Operational profiles of the thermal plume in three dimensions will be made for each of the reactor cooling and discharge modes. These studies will be conducted to determine thermal plume configuration and extent for various river flows and correlated with the continuous temperature monitors to provide sufficient data to evaluate the thermal impact on Vernon Pond.

Studies of the phytoplankton, periphyton, and zooplankton will be continued on a seasonal basis in the vicinity of the plant and at the two permanent sampling stations. Preoperational and operational studies on species diversity and population numbers will be compared. Emphasis will be placed on ascertaining the chemical and radionuclide concentrations in different organisms.

Collection of benthic fauna in Vernon Pond and below Vernon Dam will continue. Species which are known to concentrate chemicals will be analyzed for chemical and radionuclide concentration, and bottom sediments will also be analyzed for the accumulation of radionuclides. Aquatic vascular plants below the discharge area will be investigated for change in species composition due to thermal effluents, and radionuclide concentrations in the different species will be determined.

Fish collections will be continued in Vernon Pond, especially in the intake and discharge areas. These fish will be examined to determine species, condition, and size, along with sensitive analyses of chemical and radionuclide concentrations. The intake screens will be checked at frequent intervals, and records will be kept of dead fish and other organisms, along with other pertinent information. Seasonal collections of organisms from the cooling water system will be made at a point after transit through the condenser, and the number and kind of dead organisms recorded. Simultaneous collections of organisms at the intake will be made so that entrainment mortalities can be estimated.

Full details of the biological monitoring program, such as frequency, location, and method of sampling, will be provided in the Technical Specifications.

6. Radiological Effects

Organisms living in the discharge water of the Vermont Yankee Station will be exposed to radiation from the radionuclides released in the discharge water from which they will receive an immersion (external) dose. In addition, they will receive an internal dose from radionuclides ingested in their food or directly absorbed from the water.

Assessment of the possible effects of radiation on these organisms requires that the total accumulated dose be calculated. The dose was calculated with the assumption that the concentration of radionuclides in water remained constant. The water concentrations used for calculating the dose are at the highest values for either summer or winter releases. The radionuclide concentrations used for calculating the dose (listed in Table V-3, column 2) were derived by assuming that the predicted yearly releases in Table III-1 were continuous during the entire year and were diluted by 20,000 gpm, when the cooling towers are operated 30% of the year and by 386,000 gpm during once-through cooling the rest of the year (a dilution with 19 times as much water).

The immersion dose was computed with the EXREM computer code[50,51] assuming the organism remained continuously submerged. The total immersion dose to an organism was less than 1 mrad/year.

The internal dose to the organism was much more significant than the external dose because of the high bioaccumulation factors (defined as the ratio of radionuclide concentration in the organism to that in water, usually in μCi/mg:μCi/cc) listed in Table V-4, columns 2 through 5. Each species usually has a different accumulation factor, which can be influenced by environmental factors; therefore, the highest accumulation factors found in the literature[52-54] for each grou in Table V-4 were selected. Not all animals in each group would have such a high accumulation factor, and this leads to an overestimation of the dose. Also as previously stated, the highest concentration for either winter or summer releases of radionuclides was used in the calculations, and this also leads to an overestimation of the dose.

Table V-3. Radiation dose to biota by water immersion

RADIO-NUCLIDES	CONCENTRATION (μCi/ml)	BETA + GAMMA DOSE (MILLIRADS/YEAR)	GAMMA DOSE (MILLIRADS/YEAR)
SR-89	7.9E-10	4.1E-03	0.0E+00
SR-90	5.3E-11	5.4E-04	0.0E+00
SR-91	8.0E-13	2.7E-05	1.7E-05
Y-90	1.8E-10	1.6E-03	0.0E+00
Y-91	5.1E-10	2.8E-03	3.4E-05
Y-93	7.9E-12	8.6E-05	1.5E-05
ZR-97	1.5E-12	5.6E-05	3.8E-05
NB-95	8.7E-12	1.3E-04	1.2E-04
MO-99	1.7E-10	1.5E-03	8.7E-04
RU-103	6.2E-12	6.3E-05	5.8E-05
RU-106	2.0E-12	3.7E-05	1.0E-05
RH-105	5.9E-13	1.4E-06	3.5E-05
TE-127M	1.7E-12	6.7E-06	3.0E-06
TE-127	1.8E-12	4.1E-06	1.3E-07
TE-129M	1.0E-11	6.6E-05	3.6E-05
TE-131M	3.4E-13	1.7E-05	1.5E-05
TE-132	7.2E-11	3.7E-03	3.3E-03
I-130	1.7E-13	7.9E-06	6.7E-06
I-131	2.2E-09	2.0E-02	1.6E-02
I-133	2.5E-10	4.0E-03	2.8E-03
I-135	2.3E-13	1.4E-05	1.4E-05
CS-134	4.5E-10	1.4E-02	1.3E-02
CS-136	1.3E-10	5.9E-03	5.4E-03
CS-137	3.4E-10	4.5E-03	3.9E-03
BA-140	1.2E-09	6.7E-02	5.8E-02
LA-140	8.7E-10	4.3E-02	3.9E-02
CE-141	8.7E-12	2.6E-05	1.3E-05
CE-143	1.0E-13	1.9E-06	1.2E-06
CE-144	5.8E-12	7.4E-05	5.7E-06
PR-143	7.2E-12	2.3E-05	0.0E+00
ND-147	2.9E-12	1.8E-05	9.7E-06
CR-51	7.2E-11	4.1E-05	4.1E-05
MN-54	5.9E-12	9.3E-05	9.3E-05
FE-55	3.3E-10	6.0E-05	6.0E-05
FE-59	1.2E-11	2.8E-04	2.6E-04
CO-58	8.0E-10	1.5E-02	1.5E-02
CO-60	8.0E-11	3.8E-03	3.7E-03
ZN-65	1.6E-13	1.6E-06	1.6E-06
ZN-69M	3.8E-14	5.9E-07	2.9E-07
W-187	2.9E-11	3.8E-04	2.9E-04
NA-24	3.8E-12	2.9E-04	2.9E-04
P-32	2.7E-12	1.8E-05	0.0E+00
TOT DOSE		1.9E-01	1.6E-01

Table V-4. Bioaccumulation factor for various organisms

RADIONUCLIDE	BIOACCUMULATION FACTOR			
	AQUATIC PLANTS	INVERTEBRATES	FISH	MUSKRATS
SR-89	3.00E+03	4.00E+03	1.50E+02	6.52E+03
SR-90	3.00E+03	4.00E+03	1.50E+02	7.39E+05
SR-91	3.00E+03	4.00E+03	1.50E+02	5.18E+01
Y-90	1.00E+04	1.00E+03	1.00E+02	3.86E-01
Y-91	1.00E+04	1.00E+03	1.00E+02	8.35E+00
Y-93	1.00E+04	1.00E+03	1.00E+02	6.19E-02
ZR-97	1.50E+03	1.50E+02	1.00E+01	1.50E-02
NB-95	1.00E+03	1.00E+02	1.00E+01	3.35E+00
MO-99	1.00E+02	1.00E+02	1.00E+02	2.07E+01
RU-103	2.00E+03	2.00E+03	1.00E+02	5.36E+01
RU-106	2.00E+03	2.00E+03	1.00E+02	6.22E+01
RH-105	2.00E+03	2.00E+03	1.00E+02	1.15E+01
TE-127M	1.00E+02	2.50E+01	4.00E+02	6.62E+00
TE-127	1.00E+02	2.50E+01	4.00E+02	1.12E-01
TE-129M	1.00E+02	2.50E+01	4.00E+02	3.60E+01
TE-131M	1.00E+02	2.50E+01	4.00E+02	4.14E+00
TE-132	1.00E+02	2.50E+01	4.00E+02	9.36E+00
I-130	2.00E+02	1.00E+03	5.00E+01	1.44E+01
I-131	2.00E+02	1.00E+03	5.00E+01	2.19E+02
I-133	2.00E+02	1.00E+03	5.00E+01	2.51E+01
I-135	2.00E+02	1.00E+03	5.00E+01	8.06E+00
CS-134	2.50E+04	1.10E+04	1.00E+03	2.34E+05
CS-136	2.50E+04	1.10E+04	1.00E+03	3.96E+04
CS-137	2.50E+04	1.10E+04	1.00E+03	2.52E+05
BA-140	5.00E+02	2.00E+02	1.00E+01	3.85E+01
LA-140	1.00E+04	1.00E+03	1.00E+02	2.42E-01
CE-141	1.00E+04	1.00E+03	1.00E+02	4.32E+00
CE-143	1.00E+04	1.00E+03	1.00E+02	1.92E-01
CE-144	1.00E+04	1.00E+03	1.00E+02	2.75E+01
PR-143	1.00E+04	1.00E+03	1.00E+02	1.94E+00
ND-147	1.00E+04	1.00E+03	1.00E+02	1.60E+00
CR-51	1.00E+02	5.00E+01	2.00E+02	1.92E+00
MN-54	3.50E+04	1.40E+05	2.50E+01	2.82E+03
FE-55	5.00E+03	3.20E+03	3.00E+02	3.33E+04
FE-59	5.00E+03	3.20E+03	3.00E+02	3.07E+03
CO-58	2.50E+03	1.50E+03	5.00E+02	9.07E+02
CO-60	2.50E+03	1.50E+03	5.00E+02	1.03E+03
ZN-65	4.00E+03	4.00E+04	1.00E+03	1.12E+03
ZN-69M	4.00E+03	4.00E+04	1.00E+03	3.34E+01
W-187	3.00E+01	3.00E+01	2.00E+00	2.16E-01
NA-24	1.60E+02	2.70E+01	3.20E+01	1.38E+01
P-32	1.00E+05	1.00E+05	1.00E+05	1.36E+05

The internal dose to an organism living in the discharge water of the Vermont Yankee Station was calculated from the following equation:

$$D_i = 1.87 \times 10^7 \, W_i C_i E_i ,$$

where

D_i = dose rate due to i^{th} radionuclide (mrads/year),

1.87×10^7 = a constant to convert μCi/g of organism to mrads/year,

W_i = the amount of radionuclide in water (μCi/ml),

C_i = bioaccumulation factor, and

E_i = the effective absorbed energy (MeV).

The maximum effective absorbed energies (E_i) in man were used in these calculations.[55] Therefore, for small one-cell organisms, the internal dose will tend to be an overestimate, since some of the energy will not be absorbed but dissipated from the organisms. The total doses for the different groups are given in Table V-5, columns 3 through 6.

A total dose was calculated also for a terrestrial animal or bird near the Vermont Yankee Station. There are many potential pathways of radiation exposure to terrestrial organisms; the one selected would most likely lead to the highest dose. The animal selected would be a duck or a muskrat which consumes only aquatic vegetation growing in the water near the point in discharge of the radionuclides. Since the aquatic vegetation concentrates radionuclides from the water by factors ranging from about 10^2 to 10^4 relative to the water, the internal dose to the selected animal should be much greater than for animals having other food-chain pathways.

The internal dose for an animal consuming aquatic vegetation was calculated from the following equation:

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

where

D_i = dose rate due to i^{th} radionuclide (mrads/year),

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

X_i^{eq} = body burden of the i^{th} radionuclide (μCi) at equilibrium in the animal consuming 100 g of aquatic vegetation per day,

Table V-5. Internal radiation dose to biota

RADIO-NUCLIDE	CONCENTRATION (μCi/ml)	INTERNAL DOSE (MILLIRADS/YEAR)			
		AQUATIC PLANTS	INVERTE-BRATES	FISH	MUSKRATS
SR-89	7.9E-10	2.4E+01	3.3E+01	1.2E+00	5.3E+01
SR-90	5.3E-11	3.3E+00	4.3E+00	1.6E-01	8.0E+02
SR-91	8.0E-13	9.4E-02	1.3E-01	4.7E-03	1.2E-03
Y-90	1.8E-10	3.0E+01	3.0E+00	3.0E-01	1.2E-03
Y-91	5.1E-10	5.6E+01	5.6E+00	5.6E-01	4.7E-02
Y-93	7.9E-12	2.5E+00	2.5E-01	2.5E-02	1.4E-05
ZR-97	1.5E-12	8.5E-02	8.5E-03	5.7E-04	6.5E-07
NB-95	8.7E-12	8.3E-02	8.3E-03	8.3E-04	1.4E-04
MO-99	1.7E-10	1.8E-01	1.8E-01	1.8E-01	3.2E-02
RU-103	6.2E-12	1.0E-01	1.0E-01	5.1E-03	1.7E-03
RU-106	2.0E-12	1.0E-01	1.0E-01	5.1E-03	3.2E-03
RH-105	5.9E-13	4.0E-03	4.0E-03	2.0E-04	2.3E-05
TE-127M	1.7E-12	1.0E-03	2.6E-04	4.2E-03	6.9E-05
TE-127	1.8E-12	8.1E-04	2.0E-04	3.2E-03	9.1E-07
TE-129M	1.0E-11	2.1E-02	5.2E-03	8.3E-02	5.6E-03
TE-131M	3.4E-13	1.0E-03	2.5E-04	4.1E-03	2.6E-05
TE-132	7.2E-11	2.6E-01	6.4E-02	1.0E+00	1.4E-02
I-130	1.7E-13	8.5E-04	4.2E-03	2.1E-04	2.8E-05
I-131	2.2E-09	3.6E+00	1.8E+01	8.9E-01	2.7E+00
I-133	2.5E-10	7.9E-01	4.0E+00	2.0E-01	7.6E-02
I-135	2.3E-13	1.1E-03	5.6E-03	2.8E-04	2.7E-05
CS-134	4.5E-10	2.3E+02	1.0E+02	9.2E+00	1.1E+03
CS-136	1.3E-10	4.0E+01	1.7E+01	1.6E+00	3.4E+01
CS-137	3.4E-10	9.4E+01	4.1E+01	3.8E+00	6.6E+02
BA-140	1.2E-09	2.5E+01	1.0E+01	5.0E-01	1.2E+00
LA-140	8.7E-10	3.1E+02	3.1E+01	3.1E+00	4.3E-03
CE-141	8.7E-12	3.4E-01	3.4E-02	3.4E-03	1.3E-04
CE-143	1.0E-13	1.8E-02	1.8E-03	1.8E-04	3.1E-07
CE-144	5.8E-12	1.4E+00	1.4E-01	1.4E-02	3.9E-03
PR-143	7.2E-12	4.3E-01	4.3E-02	4.3E-03	8.4E-05
ND-147	2.9E-12	2.2E-01	2.2E-02	2.2E-03	2.8E-05
CR-51	7.2E-11	3.4E-03	1.7E-03	6.8E-03	3.6E-05
MN-54	5.9E-12	2.0E+00	7.9E+00	1.4E-03	7.2E-02
FE-55	3.3E-10	2.0E-01	1.3E-01	1.2E-02	1.3E+00
FE-59	1.2E-11	8.8E-01	5.6E-01	5.3E-02	2.8E-01
CO-58	8.0E-10	2.3E+01	1.4E+01	4.5E+00	3.9E+00
CO-60	8.0E-11	5.6E+00	3.3E+00	1.1E+00	1.1E+00
ZN-65	1.6E-13	3.8E-03	3.8E-02	9.5E-04	5.0E-04
ZN-69M	3.8E-14	1.8E-03	1.8E-02	4.5E-04	1.2E-05
W-187	2.9E-11	1.1E-02	1.1E-02	7.4E-04	5.2E-05
NA-24	3.8E-12	3.0E-02	5.1E-03	6.1E-03	1.5E-03
P-32	2.7E-12	3.5E+00	3.5E+00	3.5E+00	4.7E+00
TOT DOSE		8.6E+02	3.0E+02	3.2E+01	2.7E+03

E_i = the effective absorbed energy (MeV) of the i^{th} radionuclide for a 10-cm-diam cylindrical-shaped animal, and

m = mass of the animal (1000 g).

The following expression was used to calculate the body burden, X_i^{eq} (μCi), of the i^{th} radionuclide at equilibrium:

$$X_i^{eq} = 1.4\ T_i W_i C_i g F_i ,$$

where

T_i = effective half time in days of the i^{th} radionuclide in the animal,

W_i = concentration (μCi/ml) of the i^{th} radionuclide in water (Table V-3),

C_i = bioaccumulation factor for aquatic vegetation,

g = mass in grams consumed per day (100 g/day), and

F_i = fraction of ingested quantity of radionuclide initially assimilated in the tissue.

The dose rate to the animal consuming only aquatic vegetation growing near the point of discharge of radionuclides was 2.7 rads/year (Table V-5).

A voluminous amount of literature relates to radiation effects on organisms. Most of the literature deals with acute, relatively high-level external exposure to laboratory animals. Very few studies have been conducted on the effects of chronic low-level radiation on natural populations of aquatic organisms. The most recent and pertinent studies have been reviewed by Auerbach et al.[56] and Templeton, Nakatani, and Held.[57] In general, results of the studies in these two reviews support the prediction that radiation effects would not be detected at the dose rates calculated for the aquatic organisms.

The literature on the effects of chronic low-level radiation on terrestrial animals is also meager.[58] French[59] found a suggested shortening of the life span in the pocket mouse induced by 0.9 rad/day of chronic gamma radiation. There is no information available to indicate that a detectable radiation effect would be found at a dose rate of 2.7 rads/year for terrestrial animals. This dose rate was calculated by assuming a hypothetical situation where an animal consumed only aquatic vegetation growing in the discharge area of the Vermont Yankee Station. This exercise conservatively demonstrates the maximum possible dose that an animal could receive under circumstances that are very improbable.

An increased mutation rate in these organisms cannot be dismissed completely. At 0.009 rad/min (12.9 rads/day), Russell[60] found a mutation rate in mice of 5.6×10^{-8} mutation/locus.rad. Purdom[61] concluded that the spermatozoa of fish (Lebistes reticulatus) are less sensitive than the spermatozoa of the mouse to the mutagenic effects of ionizing radiation. Newcome and McGregor[62] predicted that an acute dose of 26 rads would be required for sperm and eggs of rainbow trout to double the rate of malformations observed in controls. These doses are much greater than the chronic doses calculated for the organisms in the effluents of the Vermont Yankee Station. As is well known, an irradiation dose delivered within a short time (acute exposure) will have a much greater effect (assuming a dose high enough to produce a discernible effect) than the same dose delivered over a longer period of time (chronic exposure). Therefore, an increased mutation rate above the spontaneous mutation rate would be extremely difficult to determine in natural populations at doses of 2.7 rads/year in mammals and 0.32 rad/year in fish.

In summary, the staff concluded that no detectable adverse effect will be produced on the aquatic biota or terrestrial animals as a result of radionuclides released in the discharge water of the Vermont Yankee Station at the levels given in Sect. III.D.2.

7. Criteria for Limiting Environmental Impact of Thermal Discharges

So that the environmental impact of thermal discharges upon Vernon Pond will not be excessive, definite limits must be set upon the amount of the pond to be subjected to thermal impact and upon the allowable temperature increase.

Monitoring of water temperature in Vernon Pond (Sect. V.B.2) has been suggested because measurements of the water temperature at station 3 below Vernon Dam are not expected to give a realistic indication of the water conditions above the dam. During operation of the Vermont Yankee Station, constant recordings of water temperature should be made in the vicinity of the plant: in the discharge area and near the intake structure. Temperatures should be recorded at different depths and at a sufficient number of points to determine how far the heated water extends into Vernon Pond and whether the heated water is recirculated through the condenser cooling water system.

When the water temperature falls below 55°F, compliance with Vermont's Final Order of Permit, as amended, will allow an increase of 5°F as measured downstream of the mixing zone, a point which is now below the base of Vernon Dam. Therefore, all of the water in Vernon Pond in the vicinity of the Vermont Yankee Station could be increased 5°F or greater. The effect of a 5°F increase of all of the water in the vicinity of the power plant on the aquatic biota should be explored. The temperature of the water in the discharge area will be higher than the temperature in the rest of the pond. The effects of the heated water on the aquatic biota in the discharge area have been discussed in Sect. V.C.5.

In the months of December, January, February, and March, an increase of 5°F should have very little detrimental effect on the aquatic biota. During these months, the water temperature is near 33°F, and even a 10°F increase should produce very little impact on the biota. Some species sensitive to low temperature could probably overwinter more easily at these temperatures. The primary effect probably would be the extension of the season for species that benefit from warmer water temperatures. In the spring, reproduction of the different organisms would begin earlier and extend later in the fall.

If the 5°F increase continued through the summer months and water temperatures reached 80°F and above in July, August, and September, a shift in species composition probably would occur. Fish species such as bluegill, largemouth bass, pumpkinseed, bullhead, and carp would become more abundant; smallmouth bass, rock bass, yellow perch, and white suckers probably would decrease in number because of the increased temperature or increased competition from other species. Denser populations of phytoplankton and zooplankton would be expected during the summer months with a shift from diatoms and green algae to filamentous blue-green algae. Such undesirable conditions probably could be tolerated without a major adverse effect on the aquatic biota.

If the water temperature in Vernon Pond were increased 10°F, the most serious effect on the aquatic biota would occur in the summer months. The water temperatures would exceed 85°F during July, August, and September. These temperatures are near the lethal limit for some cold-water species and considerably above their preferred temperatures. Species diversity would decrease, and less desirable species would dominate the pond. The phytoplankton population probably would be dominated by blue-green algae and the fish population by carp. Cold-water fish species would be eliminated, and very few desirable ones would be found in the pond. The parts of Vernon Pond not under the influence of the heated water could be adversely affected, and anadromous fish such as salmon might find it difficult to pass through this part of the pond during most of the year. Essentially, an increase of 10°F in the water temperature in warm weather in Vernon Pond would change the existing aquatic biota. However, a 10°F increase in pond temperature during the winter months could be tolerated.

Thus, if temperature increase in the main part of Vernon Pond is limited to 5°F above ambient temperature, the effects on aquatic biota would not be excessive; however, if the water temperature is allowed to increase by 10°F year round, appreciable effects would occur. The plan for regulating thermal discharges by monitoring temperatures below the dam does not provide assurance that water temperatures in the pond will be limited to a 5°F temperature rise. In order to limit the ecological impact of thermal discharge to acceptable levels on the basis of predicted plume dispersion

information, temperature monitoring within the pond will be necessary as discussed in Sect. III.D.1.b. When the temperature of unheated river water is less than 40°F, the pond temperature should not be allowed to exceed 45°F; when the temperature of unheated river water is more than 40°F, the pond temperature must not be more than 5°F higher.

About 150 acres of Vernon Pond in the vicinity of the station could possibly be subjected to direct thermal discharges from the station. If this entire area were subject to the above temperature limitations, the ecological impact on Vernon Pond caused by thermal discharges would be minimal. However, in order to permit the Vermont Yankee Station to operate, the Staff believes that a small area of the pond could be permitted to exceed these temperature limits without significant adverse effect. For adequate protection of the pond, the exempt area should be only a small fraction of the pond area. Ecological considerations fail to provide sufficient information to specify precisely this small exempt area. The staff has established 10 acres as the extent of this exempt area; i.e., at the edge of the 10-acre area, the temperature cannot exceed 45°F when the unheated river water is less than 40°F or increase more than 5°F when the unheated river water is above 40°F. Such an area is less than 10% of the area of Vernon Pond below the station. Because the location of the thermal plume from the plant's discharge is dependent on fluctuating river flows, no location for this exempt area has been specified, rather the location of this area will be allowed to fluctuate and occupy any 10 acre area in Vernon Pond at any given instant.

Because the location and size of the thermal plume are dependent on fluctuating river flows and because the ecological basis for setting a 10 acre exempt area is admittedly uncertain, the staff believes that a larger area could be made available for testing purposes during the first year of station operation. Fifty acres is considered the maximum area that could be temporarily made available for such purposes. This area would be used, in accordance with the comprehensive monitoring program detailed in the plants Technical Specifications, to obtain needed information on the configuration of the thermal plume and on thermal and ecological effects. If the results from the 1-year testing program, as proposed by the applicant, indicate that an area larger than 10 acres could be permanently established without a significant or irreversible effect on Vernon Pond, an appropriate permanent enlargement of the 10-acre limit would be considered.

If the staff's proposed limits on allowable temperature increases and on the maximum area which may be subjected to thermal impact are observed, the staff believes that ecological impact of thermal discharges on Vernon Pond will be minimal.

D. RADIOLOGICAL IMPACT ON MAN

An independent calculation has been made by the staff to assess the dose increments received through various exposure modes and pathways. These dose

increments are examined, with reference to the limits set forth in 10 CFR Part 20[63] and proposed Appendix I to 10 CFR Part 50.[64]

1. Radioactive Effluents and Exposure Modes

The potential radiological impact from the operation of the Vermont Yankee Station will arise from radioactive materials released as liquids or gases. The amounts and isotopic composition of these mixtures of fission products and activation products are discussed in Sect. III, as are the control measures, available or planned, by which such releases may be limited.

First, the potential modes and pathways of external and internal radiation exposure of individuals are considered. Potential external exposures, which deliver an increment of dose during their persistence, may result from (a) immersion in the gaseous effluent from the stack as diluted and transported by the wind, (b) swimming in the waters of Vernon Pond or other parts of the Connecticut River into which liquid radioactive waste effluents are diluted and dispersed, or (c) ground contamination by deposition of iodine, radioparticulates, and daughter products of noble gases.

Potential internal exposures may result from radionuclide intake through (a) drinking water from the Connecticut River containing released radioactive effluents, (b) eating fish which have spent sufficient time in areas of the river containing radioactive effluents to acquire radionuclides in their flesh, (c) inhalation intake of iodine, radioparticulates, and daughter products of noble gases, or (d) drinking milk from cows pastured within the wind transport range of iodine isotopes released in gaseous effluents. Other potential internal exposure pathways are examined and discussed in Appendix V-A and are found to be insignificant.

The total dose estimated to result from internal exposures from the time of radionuclide intake until terminated by processes of metabolism and radioactive decay is the calculated dose commitment. Throughout these discussions the use of the term "dose" should be understood to include "dose commitment" whenever internal exposure modes are involved. The interval over which the dose commitment is received will vary with different isotopes and for different organs of the body. The doses from separate radionuclide components which may apply to different body organs in the case of potential exposure to a mixture of radionuclides have been calculated. To be conservative, in the sense of maximizing the dose estimate, the potential dose commitments were calculated for the body organ receiving the most

significant dose for each of the radionuclides. In many cases, one isotope will be by far the major dose contributor and — since different organ doses are not additive — will dominate the internal-dose evaluation.

Finally, the potential contribution by the power plant to exposures of local subpopulations and also its contribution to the total population exposure in "man-rem" is examined for those living within differing radial distances from the reactor site, up to 50 miles. The man-rem dose is a summation of the estimated dose increments of potential external and internal exposures of each group of the individuals according to location, totaling those within the specified radial distance. An unusual situation led to the estimation of the exposures of a population group much further away which might be exposed via the drinking water pathway. The population man-rem dose for a 50-mile radius is of interest for comparison with background doses and for comparison of various power reactor sites as regards their radiological impact.

2. Liquid Effluents

In Sect. III.D.2.a, the staff point out that, in handling radioactive liquid effluents, the applicant has both the flexibility of batch processing and the option of limited holdup (for decay) by use of tank storage or of disposal in drums as solid wastes. In the calculations, potential intakes for the purpose of estimating associated increments of dose commitment were postulated. These intakes are based on the isotopic composition provided in Sect. III.D.2. Various uncertainties, such as the effect of thermal flow patterns on dilutions in Vernon Pond, prompt the choice of pessimistic assumptions. These are given and discussed in Appendix V-A. The extent to which they lead to overestimates of exposure may eventually be determined from environmental monitoring after the plant is operating.

a. Eating Fish

Fish that may be exposed to radioactive effluents discharged into Vernon Pond are presently restricted to the river between Vernon Dam and Bellows Falls Dam, next upstream. However, this area of the river is not at present heavily populated with edible fish. A reasonable estimate of an average radionuclide concentration for Vernon Pond, characteristic of the fish habitat, cannot be made due to the current lack of diffusion and dispersion data and the potential effects of thermal stratification. In lieu of this, the amount of activity in fish is assumed to be the amount that they would accumulate by living and feeding in water of the same radiochemical composition as the undiluted water discharged from the plant (8.9×10^{-9} µCi/ml). Calculations, as detailed in Appendix V-A, yield an estimated dose commitment from eating these fish of 1.8 mrem to the adult thyroid per year of reactor operation. This is more than twice as large as the next dose component, 0.83 mrem/year to the bone.

Edible fish downstream from Vernon Dam may incorporate, from the water and from organisms on which they feed, significantly lesser amounts of radioisotopes released by the applicant than such fish near the plant above the dam. This is due not only to the diminishing concentrations resulting from tributary dilution and from adsorption onto sediments but also to the wider range of habitat over which downstream fish may rove.

Over the year as a whole, the river flow at Vernon Dam averages 10,166 cfs (20 years of data) or 9.1×10^{15} ml/year. Hence the average concentration below the dam will be less than 5.4×10^{-10} µCi/ml. If an "average" individual supplies his normal total intake[65] of fish 20 g/day = 16 lb/year) by eating fish postulated as having lived in water with the above potential activity level, his yearly increment of dose commitment from this pathway would be 0.11 mrem/year of release for the stipulated waste composition. This again is the component of dose received by the thyroid. The results are given in Table V-6. The size of the subpopulation which eats a significant amount of fish from these reachs of the Connecticut River is not available but, at most, might possibly number a few hundred.

b. Swimming

Swimming in Vernon Pond or other contaminated parts of the Connecticut River may occur principally during the warm weather. The radiation exposure was estimated on the basis of immersion for 1% of a year (87 hours), such as about an hour a day during out-of-school vacation. The maximum concentration available is in Vernon Pond at the discharge from the plant, as discussed in Appendix V-A. To swim there would give a potential exposure increment of approximately 1.1×10^{-3} mrem/year. A reasonable assumption is that the number of such regular river swimmers would not exceed half the total population within 5 miles of the plant.

c. Drinking Water

Drinking the untreated, silt-laden water from Vernon Pond or the Connecticut River below Vernon Dam is an improbable exposure pathway. As discussed in some detail in Appendix V-A, the dose an individual would receive if he were to use the river as his sole source of drinking water has been estimated, based on a standard daily intake[66] of 1200 ml/day. The result, 1.7 mrem to the thyroid per year of plant operation, is given with other values in Table V-6. Such an individual drinking below Vernon Dam could receive an estimated 0.11 mrem to the thyroid per year of plant operation, with the corresponding calculated concentration averaging 5.4×10^{-10} µCi/ml. For perspective, note that this average concentration in the Connecticut River is the additional radioactivity postulated to result from the maximum annual release of 4.9 Ci/year. The average gross beta background activity in the Connecticut River before plant operation, as measured in water samples[67] taken over a 2-year period (July 1, 1969, through June 30, 1971) for all stations was 3 pCi/liter or 30×10^{-10} µCi/ml, i.e., about six times as much.

Table V-6. Estimated doses to individuals per year from liquid effluent[a]

Exposure pathways	Dose estimates (millirem/year)[b]
Eating fish caught	
In Vernon Pond	1.8 (thyroid)
Below Vernon Dam	0.11 (thyroid)
Swimming 1% of the year	
In Vernon Pond	1.1×10^{-3} (total body)
Drinking water from	
Plant discharge outfall	1.7 (thyroid)
Below Vernon Dam	0.11 (thyroid)
Quabbin Reservoir	0.007 (thyroid)

[a]Based on total release of ~5 Ci/year with dilutions as discussed in the text and Appendix V-A.

[b]Most significant organ given for reference. Organs with lesser dose covered in Appendix V-A.

At present, no municipal water systems take water from the Connecticut River below Vernon Dam. In view of a proposal to divert water from the Connecticut River via Northfield Upper Reservoir to recharge Quabbin Reservoir (Sect. II.E.2), the potential exposure such usage may represent should be estimated.

If the plan of diverting the Connecticut River to recharge Quabbin is adopted, such diversion will occur only when the Connecticut River flow rate is 17,000 cfs or greater.[68] An average flow rate during the period of spring freshet flows, when water may be transferred, may be assumed as 20,000 cfs (9×10^6 gpm, 4.89×10^{13} ml/day) for the purpose of estimating potential concentrations. During this period, a continued random release of liquid radioactive effluents has been assumed, at their postulated average radionuclide concentrations corresponding to the full open-cycle flow of 386,000 gpm (860 cfs, 2.1×10^{12} ml/day). The resultant concentration values in 3.84×10^{-10} mCi/ml for the source mixture considered.

A maximum of 2.6×10^{10} gal/year of Connecticut River water would be diverted to Quabbin Reservoir, whose volume[68] is 4.15×10^{11} gal. Hence, there should be a further dilution of at least a factor of 15 to 2.5×10^{-11} µCi/ml. Use of this water at this concentration as a supply for drinking would represent a thyroid dose commitment of .007 mrem/year from the isotopic mixture involved. Since the Quabbin Reservoir could ultimately supply drinking water for up to 2 million people, this would represent a potential population dose of 14 man-rem/year if no allowance is made for radioactive decay during the average holdup line of two years in the reservoir. There is a limitation to the effective dose reduction by decay since the bone dose (principally from strontium isotopes) is 20% of the amount of the thyroid dose cited.

These increments of exposure are summarized in Table V-6.

3. Gaseous Effluents

The radioactive materials released to the atmosphere are principally the fission-product noble gases krypton and xenon. The resulting potential exposures depend on the composition of the mixture of isotopes and their concentrations. In turn, the airborne concentrations and locations in the environment as a function of time depend on meteorological conditions. The three principal exposure modes to consider are immersion, inhalation, and the radiation from surface deposition. The potential annual doses have been calculated, using annual averages for meteorological conditions and assuming the constant release rate given in Section III.D.2. The exposure condition considered is the initial period of proposed operation (for the first fuel cycle).

The potential consequences of the release of the radioiodine component of the gaseous effluent have been examined. The estimated dose which could be received by the thyroid of a child via the grass-cow-milk-infant exposure pathway, assuming an intake of 1 liter of milk per day produced by a cow grazing for 5 months/year, was calculated to be 1.3 mrem/year of effluent release (based

on milk pooling, see Appendix V-A). This does not appear to represent an important radiological impact in comparison with other doses examined. The peak air concentration noted in Table A-7 of Appendix V-A is about five times the weighted average value. Hence, the milk from the corresponding group of cows, if not combined with other milk, could provide a respectively greater dose to an infant using it regularly (about 6.5 mrem/year). When the extended holdup charcoal system is used, a further reduction in radioiodine release will result.

Estimated annual potential exposures from gaseous effluents for several groups in the population, both local and remote, have been calculated. In addition, the annual dose at the Vernon Elementary School that could result from gamma-ray shine of ^{16}N in the turbine is estimated by the staff to be 20 mrem assuming an occupancy factor of 0.2 The applicant has been informed of this estimate and a radiation dosimeter has been placed at the school which will be evaluated during operation of the plant. Details relevant to the remote groups are given in the discussion in Appendix V-A. Table V-7 presents the different modes of exposure and their total estimated dose. The peaking of the annual dose for an individual occurs away from the reactor because of the distance and direction that gaseous effluents are carried by prevailing winds before diffusion to ground level.

The potential external exposures from radioactive gases were evaluated by comparison with the background exposure. Two years of preoperational environmental monitoring[67] show an average of 14 stations of 156 mrem/year external gamma background radiation.

The potential exposures for the approximately 1-1/2-year period of proposed operation before installation of the extended off-gas holdup system are a small fraction of the present applicable limits set forth in 10 CFR Part 20. The applicant will be required to comply with the design objectives of Appendix I to 10 CFR Part 50, as finally formulated.

4. Dose Evaluation

In the preceding sections the various potential exposure pathways have been examined and the exposures to individuals within specific groups or at particular locations calculated on the basis of available data and conservative (i.e., upper limit) assumptions. The collective effects of the more significant exposures to the population living in the vicinity of the reactor are considered. Tables V-6 and V-7 show that the potential exposures from gaseous effluents are more important than those from liquid effluents. The estimated exposures from liquid effluents are either very small or, if received, involve groups of people who are few in number. Population distribution data are available, by distance and direction, which can be combined with the corresponding estimates of exposure increments from the gaseous effluents. The results are given in Table V-8 for the present population sizes. The peak average annual

Table V-7. Estimated potential doses to individual members of explicit groups per year of gaseous effluent discharge

Group and location	Number of individuals	Dose (millirems) per year of discharge			
		Air immersion	Air inhalation	Surface contamination	Total
Vernon Green Nursing Home 1.1 Mi SSE	54[a]	18.9	0.064	1.01	20.0
Vernon Elementary School[b] 0.36 Mi SW	163	0.059	0.00007	0.001	0.060
Hinsdale School 0.7 Mi ENE	900	2.23	0.005	0.08	2.31
Brattleboro Hospital 5.2 Mi NNW	372[c]	3.29	0.023	0.31	3.62
Trailer park[d] 3.0 Mi NNW	240[e]	5.43	0.034	0.49	5.96
Northfield and Mt. Hermon Schools 6.0 Mi SSE	1,130	5.28	0.037	0.49	5.80
Picnic area 1.8 Mi W	100	1.93	0.013	0.18	2.13
Yankee Atomic, Rowe, Mass. 20 Mi WSW	2,400	0.037	0.0002	0.002	0.040
Springfield, Mass. 46 Mi S	459,000[f]	0.028	0.00003	0.001	0.029

[a] With new addition.
[b] Similar values apply to the nearest houses west of the site. Does not include 20 mrems of gamma shine from ^{16}N.
[c] 103 beds; the rest are staff.
[d] Hinsdale Race Track is occupied approximately 1% of year. Doses compare with Brattleboro Hospital and with trailer park if full year.
[e] Approximately 100 of 115 units with 2.4 average occupants.
[f] Metropolitan area population, 1970.

dose for cumulative population occurs at 4 miles and is a consequence of the population distribution in the high wind frequency direction.

As part of the assessment of the total radiological impact of the Vermont Yankee station, a comparison should be made between the annual average radiation dose from the reactor and the annual average dose from natural background. The total doses are 147 man-rem (0.13 mrem/person) from Vermont Yankee and 179,000 man-rem (about 156 mrem/person) from background sources. Thus, operation of the Station will contribute only an extremely small increment to the radiation dose that area residents receive from natural background. Since fluctuations of the background dose may be expected to exceed the increment contributed by the plant, the dose will be immeasurable in itself and will constitute no meaningful risk to be balanced against the benefits of the plant.

5. Environmental Radiation Monitoring

The applicant has developed a two-phase environmental radiation monitoring program to determine the magnitude and nature of the radioactivity in the air, water, silt, vegetation, and aquatic biota near the Vermont Yankee Power Station.[69] The first phase, a preoperational survey, was initiated in July 1969 to provide two years of baseline data for evaluating changes in radioactivity levels resulting from operation of the station. Radiation monitoring stations were located so that data could be obtained concurrently from two regions about the station site. Data collected in Zone I, an area within a 5-mile radius of the site that is considered to be under the influence of the station, include: (1) integrated gamma doses at six locations about the station boundary and (2) radionuclide concentrations in air, integrated gamma doses, and radioactivity concentration in vegetation at five locations ranging from 0.9 to 2.5 miles from the station. Data collected in Zone II, an area outside the 5-mile radius that is not considered to be significantly under the influence of the station, include radionuclide concentrations in air, integrated gamma doses, and radionuclide concentrations in vegetation at three locations ranging from 7 to 15 miles from the station. Station locations in the two-zone network were chosen on the basis of stack effluent diffusion calculations for maximum ground-level concentrations under average meteorological conditions (Zone I), population distribution, annual wind rose directional data, coordination with state radiological monitoring programs, availability of sites for long-term study, and accessibility of sites for year-round servicing and maintenance.

The Vermont Yankee environmental monitoring program includes a flexible network for collecting river and ground water to identify and determine the magnitude of any radionuclide reconcentrations. Sampling stations for wells and springs are located on site, in Vernon, and in Brattleboro. Collections from the wells and springs are made quarterly and analyzed for gross beta and gamma activities.

The river is monitored by measuring the radioactivity in grab samples of water, stream sediments, benthos organisms, and fish collected at two locations

Table V-8. Cumulative populations, cumulative man-rems, and average annual doses within selected circular areas

Year 1970

Radius (miles)	Cumulative population	Cumulative man-rems	Average annual dose (millirems) for cumulative population
1	455	1.23	2.71
2	2,060	7.26	3.56
3	2,840	10.6	3.73
4	3,580	13.7	3.82
5	6,590	25.1	3.81
10	23,030	56.4	2.45
20	87,830	87.4	1.00
30	211,600	103.4	0.49
40	477,400	121.1	0.25
50	1,149,000	146.6	0.13

(3.2 miles and 7.7 miles) upstream from the station, at the station discharge structure, and at three locations (1.5 miles, 5.6 miles, and 7.3 miles) downstream from the station. In addition, aquatic plants are sampled and analyzed from the swamp areas about 0.3 mile upstream and downstream from the station (Fig. II-2). The sampling is performed under contract by Webster-Martin, Inc., who is conducting the aquatic biological studies on the river above and below the station.

The second phase of the monitoring program, the continuing operational survey after the station begins operations, will be the same as the preoperational survey except that sampling of air and milk[70] for the analysis of radioiodine will be added, and the river will be sampled at the station discharge point by a continuous sampler. The sample collection and analysis frequency for the various environmental media range from weekly for air samples to quarterly for biological media (both food chain and indicator) and river sediments. The radiometric analysis of samples is performed under contract by Eberline Instrument Corporation, Department of Nuclear Sciences, and is limited primarily to gross activity and gamma spectral measurements. The sensitivities of the analytical methods used by the contractor are given in Table V-9.

The objectives of the continuing survey are:

a. To assure that radiation levels and concentrations of radionuclides in the environment, resulting from station operation, stay within AEC regulations.

b. To make possible the prompt recognition of any increase in environmental levels of radioactivity related to station operation; and

c. To differentiate station-released radioactivity from other abnormal trends in environmental radioactivity due to natural or manmade sources.

The applicant plans to augment the operational radiation monitoring program if plant effluent measurements or radionuclide concentrations in the environment indicate projected population doses in excess of 3% of those that would result from exposure to 10 CFR 20 concentrations. The steps to be taken to augment the program include: (1) an appropriate increase in sampling frequency and number of sampling stations throughout the network for the environmental media involved and (2) a correlation study to compare the environmental levels in the media in question with plant release records and other media sampled.

The radiation monitoring program at Vermont Yankee is well designed, with regard to sampling locations and environmental media sampled, for the measurement of radioactive concentrations in the important exposure pathways. Further specific details on the environmental radiation monitoring program are provided in the Technical Specifications for the station.

Table V-9. Analytical Capabilities

Sample media	Type of analysis	Minimum aliquot size[a]	Sensitivity
Air particulate	Alpha and beta	100 m^3	0.01 pCi/m^3
Water	Alpha	150 ml	3 pCi/liter
Water	Beta	150 ml	2 pCi/liter
Water	Tritium	10 ml	2 pCi/ml
Vegetation	Alpha	25 g (dry wt)	0.03 pCi/g
Vegetation	Beta	25 g (dry wt)	0.02 pCi/g
Bottom sediments	Alpha	25 g (dry wt)	0.03 pCi/g
Bottom sediments	Beta	25 g (dry wt)	0.03 pCi/g
Fish	Beta	250 g (wet wt)	0.01 pCi/g
All media	Gamma	See below	See below

Sensitivities (pCi/sample) for key gamma emitters with 4-in.-diam by 4-in.-thick NaI(Tl) detector.

Gamma emitter	Small sample next to crystal	Large sample[b] in Marinelli beaker
^{137}Cs	11	30
^{100}Ru	90	270
^{144}Ce	70	210
^{131}I	9	30
^{60}Co	14	40
^{58}Co	31	90
^{54}Mn	9	30
^{51}Cr	80	240
^{65}Zn	23	70
^{40}K	140	420

[a]Aliquot taken from a larger sample after it has been blended to provide a representative aliquot.
[b]Up to 3.5 liters distributed equally on top and sides of the 4-in. by 4-in. crystal.

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VI. ENVIRONMENTAL IMPACT OF POSTULATED ACCIDENTS

A. PLANT ACCIDENTS

Protection against the occurrence of postulated accidents in the Vermont Yankee Nuclear Power Station is provided through the defense in depth concept of design, manufacture, operation and testing, and a continued quality assurance program is used to establish the necessary high degree of assurance for the integrity of the reactor system. Postulated accidents were considered in the Commission's Safety Evaluation for the Vermont Yankee facility, dated June 1, 1971 and in the Supplements to the Safety Evaluation. Off-design conditions that may occur are limited by protective systems which place and hold the power plant in a safe condition. Notwithstanding this, the conservative postulate is made that serious accident might occur, even though unlikely, and engineered safety features are installed to mitigate the consequences of these postulated events.

The probability of occurrence of accidents and the spectrum of their consequences to be considered from an environmental effects standpoint have been analyzed using estimates of probabilities and realistic fission product release and transport assumptions. For site evaluation in the staff's safety review, extremely conservative assumptions were used for the purpose of evaluating the adequacy of engineered safety features and for comparing calculated doses resulting from a hypothetical release of fission products from the fuel against the 10 CFR 100 siting guidelines. The computed doses that would be received by the population and environment from actual accidents would be significantly less than those presented in the staff's Safety Evaluation.

The Commission issued guidance to applicants on September 1, 1971,[1] requiring the consideration of a spectrum of accidents with assumptions as realistic as the state of knowledge permits. The applicant's response was contained in the applicant's Supplement to the Environmental Report, Volume I, dated December 21, 1971.

The effect of accidents has been evaluated, using the standard accident assumptions and guidance issued by the Commission as a proposed amendment to Appendix D of 10 CFR 50.[2] Nine classes of postulated accidents and occurrences ranging in severity from trivial to very serious have been identified by the Commission. In general, accidents in the high potential consequence end of the spectrum have a very low occurrence rate, and those on the low potential consequence end are characterized by a higher occurrence rate. The examples selected by the applicant for these classes of accidents are shown in Table VI-1. The examples selected are reasonably homogeneous in terms of probability within each class with the exception of the failure of the off-gas holdup system which the staff considers as more appropriately in Class 3.

TABLE VI-1. CLASSIFICATION OF POSTULATED ACCIDENTS AND OCCURRENCES

Class	AEC Description	Applicant's Example
1	Trivial incidents	Not considered
2	Miscellaneous small releases outside containment	Turbine building effluents from leaks or breaks within technical specification limits
3	Failures of radioactive waste system	Single functional system or equipment failures or single operator error
4	Events that release radioactivity into the primary system	No events identified
5.	Events that release radioactivity into the primary and secondary systems	No events identified
6.	Refueling accidents inside containment	Dropped fuel assembly onto reactor core, spent fuel racks into fuel pool, or against fuel pool, shipping cask drop
7.	Accidents to spent fuel outside containment	Transportation incident
8.	Accident initiation events considered in design-basis evaluation in the Safety Analysis Report	Loss of coolant accident inside and outside primary containment; control rod drop accident; off-gas holdup system failure
9.	Hypothetical consequences of failures more severe than Class 8	None

Certain assumptions made by the applicant, such as the assumption of an iodine partition factor in the suppression pool during a loss-of-coolant accident, in our view, are optimistic; but the use of alternative assumptions does not significantly affect the overall environmental risk.

Commission estimates of the dose which might be received by an assumed individual standing at the worst location off-site, using the assumptions in the proposed Annex to Appendix D, are presented in Table VI-2. Estimates of the integrated exposure in man-rem that might be delivered to the population within 50 miles of the site are also presented in Table VI-2. These man-rem estimates were based on the projected population around the site for the year 2010.

To rigorously establish a realistic annual risk, the calculated doses in Table VI-2 would have to be multiplied by estimated probabilities. The events in Classes 1 and 2 represent occurrences which are anticipated during plant operation and their consequences, which are very small, are considered within the framework of routine effluents from the plant. Except for a limited amount of fuel failures, the events in Classes 3 through 5 are not anticipated during plant operation but events of this type could occur sometime during the 40 year plant lifetime. Accidents in Classes 6 and 7 and small accidents in Class 8 are of similar or lower probability than accidents in Classes 3 through 5 but are still possible. The probability of occurrence of large Class 8 accidents is very small. Therefore, when the consequences indicated in Table VI-2 are weighted by probabilities, the environmental risk is very low. The postulated occurrences in Class 9 involve sequences of successive failures more severe than those required to be considered for the design basis of protection systems and engineered safety features. Their consequences could be severe. However, the probability of their occurrence is so small that their environmental risk is extremely low. Defense in depth (multiple physical barriers), quality assurance for design, manufacture, and operation, continued surveillance and testing, and conservative design are all applied to provide and maintain the required high degree of assurance that potential accidents in this class are, and will remain, sufficiently small in probability that the environmental risk is extremely low.

Table VI-2 indicates that the estimated radiological consequences of the postulated accidents would result in exposures of an assumed individual at the worst location off-site to concentrations of radioactive materials which are within the Maximum Permissible Concentrations (MPC) listed in Appendix B, Table II of 10 CFR 20. The table also shows that the estimated integrated exposure of the population within 50 miles of the plant from each postulated accident would be orders of magnitude smaller than from naturally occurring radioactivity which corresponds to approximately 280,000 man-rem/year based on a natural background level of 0.156 rem/year. When considered with the probability of occurrence, the annual potential radiation exposure of the population from all the postulated accidents is an even smaller fraction of

TABLE VI-2. SUMMARY OF RADIOLOGICAL CONSEQUENCES OF POSTULATED ACCIDENTS

Class	Event	Estimated dose at worst location offsite (fraction of 10 CFR Part 20 limit)[a]	Estimated dose to population within 50-mile radius (man-rems)
1.0	Trivial incidents	b	b
2.0	Small releases outside containment	b	b
3.0	Failures of radioactive waste system		
3.1	Equipment leakage or malfunction	0.52	6.8
3.2	Release of waste gas storage tank contents	2.1	27
3.3	Release of liquid waste storage tank contents	0.002	<0.1
4.0	Fission products to primary system (BWR)		
4.1	Fuel cladding defects	b	b
4.2	Off-design transients that induce fuel failures above those expected	0.022	0.7
5.0	Fission products to primary and secondary systems (PWR)	Not applicable	Not applicable
6.0	Refueling accidents		
6.1	Fuel assembly drop into core	<0.001	0.12
6.2	Heavy object drop onto fuel in core	0.003	1.0

[a]Represents the calculated whole-body dose as a fraction of 500 millirems (or the equivalent dose to an organ).

[b]These releases will be comparable with the design objectives indicated in the proposed Appendix I to 10 CFR 50 for routine effluents (i.e., 5 millirems/year to an individual from either gaseous or liquid effluents).

Table VI-2 - cont'd

Class	Event	Estimated dose at worst location offsite (fraction of 10 CFR Part 20 limit)[a]	Estimated dose to population within 50-mile radius (man-rems)
7.0	Spent fuel handling accident		
7.1	Fuel assembly drop in fuel storage pool	<0.001	0.22
7.2	Heavy object drop onto fuel rack	0.001	0.42
7.3	Fuel cask drop	0.78	10
8.0	Accident initiation events considered in design basis evaluation in the Safety Analysis Report		
8.1.	Loss-of-coolant accidents inside containment		
	Small break	<0.001	<0.1
	Large break	0.004	9.3
8.1(a)	Break in instrument line inside reactor building	<0.001	<0.1
8.2(a)	Rod ejection accident (PWR)	Not applicable	Not applicable
8.2(b)	Rod drop accident (BWR)	0.024	0.83
8.3(a)	Steamline breaks outside containment (PWR)	Not applicable	Not applicable
8.3(b)	Steamline breaks outside containment (BWR)		
	Small break	0.018	0.24
	Large break	0.093	1.2

the exposure from natural background radiation and, in fact, is well within naturally occurring variations in the natural background. It is concluded from the results of the realistic analysis that the environmental risks due to postulated radiological accidents at the Vermont Yankee Nuclear Power Station are exceedingly small.

B. TRANSPORTATION ACCIDENTS

1. Principles of Safety in Transport

Protection of the public and transport workers from radiation during the shipment of nuclear fuel and waste, described in Sect. III.3, is achieved by a combination of limitation on the contents (according to the quantities and types of radioactivity), the package design, and the external radiation levels. Shipments move in routine commerce and on conventional transportation equipment. Shipments are therefore subject to normal accident environments, just like other nonradioactive cargo. The shipper has essentially no control over the likelihood of an accident involving his shipment. Safety in transportation does not depend on special routing.

Packaging and transport of radioactive materials are regulated at the Federal level by both the Atomic Energy Commission (AEC) and the Department of Transportation (DOT). In addition, certain aspects, such as limitations on gross weight of trucks, are regulated by the States.

The probability of accidental releases of low-level contaminated material is sufficiently small that, considering the form of the waste, the likelihood of significant exposure is extremely small. Packaging for these materials is designed to remain leakproof under normal transport conditions of temperature, pressure, vibration, rough handling, exposure to rain, etc. The packaging may release part or all of its contents in an accident.

For larger quantities of radioactive materials, the packaging design (Type B packaging) must be capable of withstanding, without loss of contents or shielding, the damage which might result from a severe accident. Test conditions for packaging are specified in the regulations and include tests for high-speed impact, puncture, fire, and immersion in water.[3]

In addition, the packaging must provide adequate radiation shielding to limit the exposure of transport workers and the general public. For irradiated fuel, the package must have heat-dissipation characteristics to protect against overheating from radioactive decay heat. For fresh and irradiated fuel, the design must also provide nuclear criticality safety under both normal and accident damage conditions.

Each package in transport is identified with a distinctive radiation label on two sides, and by warning signs on the transport vehicle.

Based on the truck accident statistics for 1969,[4] a shipment of fuel or waste from a reactor may be expected to be involved in an accident about once every six years. In case of an accident, procedures which carriers are required[5] to follow will reduce the consequences of an accident in many cases. The procedures include segregation of damaged and leaking packages from people, and notification of the shipper and the Department of Transportation. Radiological assistance teams are available through an inter-Governmental program to provide equipped and trained personnel. These teams, dispatched in response to calls for emergency assistance, can mitigate the consequences of an accident.

2. Exposures During Normal (No Accident) Conditions

a. Cold Fuel

The transport of cold fuel has been described in Sect. III.E.1. Since the nuclear radiations and heat emitted by cold fuel are small, there will be essentially no effect on the environment during transport under normal conditions. Exposure of individual transport workers is estimated to be less than 1 millirem (mrem) per shipment. For the three shipments, with two drivers for each vehicle, the total dose would be about 0.01 man-rem* per year. The radiation level associated with each truckload of cold fuel will be less than 0.1 mrem/hr at 6 ft from the truck. A member of the general public who spends 3 min at an average distance of 3 ft from the truck might receive a dose of about 0.005 mrem/shipment. The dose to other persons along the shipping route would be extremely small.

b. Irradiated Fuel

Irradiated fuel will be transported either by truck or by rail. Based on actual radiation levels associated with shipments of irradiated fuel elements, we estimate the radiation level at 3 ft from the truck or rail car will be about 25 mrem/hr. The individual truck driver would be unlikely to receive more than about 30 mrem in the 900-mile shipment. For the 15 shipments by truck during the year with 2 drivers on each vehicle, the total dose would be about 1 man-rem/year.

Train brakemen might spend a few minutes in the vicinity of the car at an average distance of 3 ft, for an average exposure of about 0.5

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*Man-rem is an expression for the summation of whole body doses to individuals in a group. In some cases, the dose may be fairly uniform and received by only a few persons (e.g., drivers and brakemen) or, in other cases, the dose may vary and be received by a large number of people (e.g., 10^5 persons along the shipping route).

mrem per shipment. With 10 different brakemen involved along the route, the total dose for five shipments during the year is estimated to be about 0.03 man-rem.

A member of the general public who spends 3 min at an average distance of 3 ft from the truck or rail car might receive a dose of as much as 1.3 mrem. If 10 persons were so exposed per shipment, the total annual dose for the 15 shipments by truck would be about 0.2 man-rem and for the five shipments by rail, about 0.1 man-rem. Approximately 270,000 persons who reside along the 900-mile route over which the irradiated fuel is transported might receive an annual dose of about 0.1 man-rem if transported by truck, and 0.04 man-rem if transported by rail. The regulatory radiation level limit of 10 mrem/hr at a distance of 6 ft from the vehicle was used to calculate the integrated dose to persons in an area between 100 ft and 1/2 mile on both sides of the shipping route. It was assumed that the shipment would travel 200 miles/day and the population density would average 330 persons per square mile along the route.

The amount of heat released to the air from each cask will vary from about 30,000 Btu/hr for truck casks to about 250,000 Btu/hr for rail casks. For comparison, 35,000 Btu/hr is about equal to the heat released from an air conditioner in an average size home. No appreciable thermal effects on the enviornment will result because the amount of heat is small and is being released over the entire transportation route.

c. Solid Radioactive Wastes

As noted in Sect. III-E.3, about 12 truckloads of solid radioactive wastes will be shipped to a disposal site. Under normal conditions, the individual truck driver might receive as much as 15 mrem/shipment. If the same driver were to drive the 12 truckloads in a year, he could receive an estimated dose of about 180 mrem during the year. A total dose to all drivers for the year, assuming 2 drivers per vehicle, might be about 0.4 man-rem.

A member of the general public who spends 3 min at an average distance of 3 ft from the truck might receive a dose of as much as 1.3 mrem. If 10 persons were so exposed per shipment, the total annual dose for the 12 shipments by truck would be about 0.2 man-rem. Approximately 150,000 persons who reside along the 500-mile route over which the solid radioactive waste is transported might receive an annual dose of about 0.2 man-rem. These doses were calculated for persons in an area between 100 ft and 1/2 mile on either side of the shipping route, assuming 330 persons per square mile, 10 mrem/hr at 6 ft from the vehicle, and the shipment traveling 200 miles/day.

3. Exposures Resulting from Postulated Accidents

a. Cold Fuel

The cold fuel to be transported to Vermont Yankee has been described in Sect. III.E.1. Under accident conditions other than accidental criticality, the pelletized form of the nuclear fuel, its encapsulation, and the low specific activity of the fuel limit the radiological impact on the environment to negligible levels.

The packaging is designed to prevent criticality under normal and severe accident conditions. To release a number of fuel assemblies under conditions that could lead to accidental criticality would require severe damage or destruction of more than one package, which is unlikely to happen in other than an extremely severe accident.

The probability that an accident could occur under conditions that could result in accidental criticality is extremely remote. In the highly unlikely event that criticality were to occur in transport, persons within a radius of about 100 ft from the accident might receive a serious exposure but, beyond that distance, no detectable radiation effects would be likely. Although there would be no nuclear explosion, heat generated in the reaction would probably separate the fuel elements so that the reaction would stop. The reaction would not be expected to continue for more than a few seconds and normally would not recur. Residual radiation levels due to induced radioactivity in the fuel elements might reach a few roentgens per hour at 3 ft. There would be very little dispersion of radioactive material.

b. Irradiated Fuel

Effects on the environment from accidental releases of radioactive materials during shipment of irradiated fuel were estimated for the situation where contaminated coolant is released and the situation where gases and coolant are released.

(1) Leakage of Contaminated Coolant

Leakage of contaminated coolant resulting from improper closure of the cask is possible as a result of human error, even though the shipper is required to follow specific procedures which include tests and examination of the closed container prior to each shipment. Such an accident is highly unlikely during the 40-year-life of the plant.

Leakage of liquid at a rate of 0.001 cm^3/sec or about 80 drops/hr is about the smallest amount of leakage that can be detected by visual observation of a large container. If undetected leakage of contaminated

liquid coolant were to occur, the amount would be so small that the individual exposure would not exceed a few millirems and only a very few people would receive such exposures.

(2) Release of Gases and Coolant

Release of gases and coolant is an extremely remote possibility. In the improbable event that a cask is involved in an extremely severe accident such that the cask containment is breached and the cladding of the fuel assemblies penetrated, some of the coolant and some of the noble gases might be released from the cask.

If such an accident were to occur, the amount of radioactive material released would be limited to the available fraction of the noble gases in the void spaces in the fuel pins and some fraction of the low-level contamination in the coolant. Persons would not be expected to remain near the accident due to the severe conditions which would be involved, including a major fire. If releases occurred, they would be expected to take place in a short period of time. Only a limited area would be affected. Persons in the downwind region and within 100 ft or so of the accident might receive doses as high as a few hundred millirems. Under average weather conditions, a few hundred square feet might be contaminated to the extent that it would require decontamination (that is, Range I contamination levels) according to the standards[6] of the Environmental Protection Agency.

c. Solid Radioactive Wastes

It is highly unlikely that a shipment of solid radioactive waste will be involved in a severe accident during the 40-year life of the plant. If it does happen that a shipment of low-level waste (in drums) becomes involved in a severe accident, some release of waste might occur but the specific activity of the waste will be so low that the exposure of personnel would not be expected to be significant.

Other solid radioactive wastes will be shipped in Type B packages. Considering the probability of release from a Type B package, and in view of the solid form of the waste and the remote probability that a shipment of such waste would be involved in a severe accident, the likelihood of significant exposure would be extremely small.

In either event, spread of the contamination beyond the immediate area is unlikely and, although local clean-up might be required, no significant exposure to the general public would be expected to result.

4. Severity of Postulated Transportation Accidents

The events postulated in this analysis are unlikely but possible. More severe accidents than those analyzed can be postulated and their

consequences could be severe. Quality assurance for design, manufacture, and use of the packages, continued surveillance and testing of packages and transport conditions, and conservative design of packages ensure that the probability of accidents of this latter potential is sufficiently small that the environmental risk is extremely low. For these reasons, more severe accidents have not been included in the analysis.

References for Section VI

1. U. S. Atomic Energy Commission, Scope of Applicant's Environmental Reports with Respect to Transportation, Transmission Lines and Accidents, dated September 1, 1971.

2. Proposed Rule Making, Licensing of Production and Utilization Facilities: Consideration of Accidents in Implementation of the National Environmental Policy Act of 1969, proposed Annex to Appendix D of 10 CFR Part 50 (36 Fed. Reg. 22852, December 1, 1971).

3. Department of Transportation Regulations, 40 CFR §173.398; Atomic Energy Commission Regulations, 10 CFR §71.36.

4. Federal Highway Administration, 1969 Accidents of Large Motor Carriers of Property (December 1970).

5. Department of Transportation Regulations, 49 CFR §171.15, §174.566, and §177.861.

6. Federal Radiation Council Report No. 7 (May 1965).

VII. UNAVOIDABLE ADVERSE EFFECTS

The construction and operation of a large facility such as the Vermont Yankee Nuclear Power Station will produce some unavoidable adverse effects. The estimated life of a nuclear power plant is 30 years; thus, the land for the structure is committed for long-term use. The part of the site not used for construction, the restricted zone, and the exclusion zone are effectively removed as home and building sites.

The plant is not an imposing structure on the landscape because of the terrace effect provided by the difference in elevation. However, it is a modern structure thrust into rural surroundings, which detracts from the continuity of the environment. For some people, the presence of the plant would decrease the aesthetic value of the area.

Transmission lines do reduce the aesthetic value of most environments, especially forest and rural areas. The combined area of the right-of-way for the power lines is several times that of the plant itself.

The operation of Vermont Yankee would not greatly increase the level of nonradioactive air pollution in the area. Only minor amounts of combustion products will be released from the plant during operation of diesel-powered engines for internal plant heating and process requirements and also for emergency use.

Operation of the cooling towers will produce some adverse effects. The mechanical draft cooling towers are noisy (88 decibels near the air inlet) and can be heard beyond the site boundary. Use of the cooling towers in the fall and winter months might cause additional fogging in the nearby towns (Sect. V.A). Icing would be produced from drift loss in the vicinity of the cooling towers, but the condition should be limited to the plant property. The staff does not consider the loss of water by evaporation from the cooling towers a serious adverse effect. The maximum loss is 5000 gpm (11 cfs) — 1% of the instantaneous minimum flow of 538,000 gpm (1200 cfs).

Regardless of whether the plant operates with or without cooling towers, some heated water will be released to Vernon Pond. The discharge of heated water in the winter will reduce icing conditions in the plant vicinity and possibly, attract fish and fish food organisms to this section of the river. Potential problems of "cold shock" can be created if the plant is then required to be shutdown. Also, there probably will be some changes in the aquatic biota in the vicinity of the discharge because of increased temperature and nutrients in the water. These changes are expected to be limited to the vicinity of the discharge and not affect the total biota of Vernon Pond.

Some loss of fish and aquatic life will result as organisms are drawn into the cooling water intake. Entrainment in the condenser system will kill some small and immature fish along with other aquatic biota, by thermal shock, chemical toxicity, or mechanical damage. Since aquatic organisms will be affected only in the vicinity of the plant, these adverse effects should not

seriously alter the populations in Vernon Pond. The Vermont Yankee Station has the capability of operating with or without cooling towers; the operational mode of the plant can be managed so as to minimize adverse effects on aquatic biota.

Continued environmental studies to monitor the operation of the Vermont Yankee Station are essential to obtain the temperature and biological data needed to develop and establish a successful Anadromous Fisheries Restoration Program in this section of the Connecticut River. Warm water released to Vernon Pond might flow over conventionally designed fish ladders and prevent fish from entering the ladder. Sea-bound smolt of the Atlantic Salmon and eggs and larvae of the American Shad could be killed by entrainment in the condenser cooling system. Since Atlantic Salmon and American Shad have not been restored to the Connecticut River below Vernon Pond and the plant has the capability of operating on either open or closed cycle, these adverse effects can be prevented or limited.

The discharge of chemicals by Vermont Yankee into Vernon Pond should produce few adverse effects on the aquatic biota. Chlorine will be released at a maximum concentration of 0.1 ppm. Although some adverse effects might occur in the immediate vicinity of the discharge, the residual chlorine is further diluted in Vernon Pond and no significant impact on the aquatic biota in the pond is expected, especially since the releases will be limited and intermittent. The other chemicals which will be released in substantial quantities are sodium chloride and sodium sulfate. These chemicals will not be released at levels that will produce adverse effects on the aquatic biota.

The release of radioactive material from the plant will add to the background radiation of the area. Since the Vermont Yankee Station was designed, a proposal has been made that the conservative Federal guideline for the release of radioactive material be made more restrictive. While the potential exposures are not in excess of the present applicable limits as set forth in the Code of Federal Regulations, Title 10, Part 20 (10 CFR 20), the applicant will have to meet the limits as finally established in the amendments to Appendix I of 10 CFR 50. The applicant has submitted plans for an augmented off-gas removal system which will result in potential exposures consistent with the objectives adopted in Appendix I to 10 CFR 50. Despite findings and assurances that operation of the plant poses no hazard to the health and safety of the public, it is likely that operation of the plant will create a psychological barrier to some members of the general public in terms of use of Vernon Pond and the land around the site for recreation.

Transportation to and from the Plant of non-irradiated and irradiated fuel and solid radioactive wastes which are packaged and shipped in Federally-approved containers and shielded casks will be subject to both the Commission's regulations in 10 CFR 70 and 71 and the Department of Transportation's (DOT) regulations in 49 CFR 170-179. The probability of accidental release of any radioactivity during transport is sufficiently small, considering the form of the transported material and its packaging, that the likelihood of significant radiation exposure is remote. With use of proper packages and containers, continued surveillance and testing of packages, and conservative design of packages, the environmental risk is small.

The potential exposures to the population from postulated accidents during operation of the Plant will depend on the type and magnitude of the accident that may result. In Chapter VI, different types of accidents and the probabilities of occurrence indicate that when multiplied by the probability of occurrence, the potential annual radiation exposure of the population from all the postulated accidents is an even smaller fraction of exposure than that from natural background radiation and is, in fact, well within naturally occurring variations in the natural background. It is concluded from the results of the "realistic" analysis that the environmental risks due to postulated accidents involving abnormal release of radioactivity during operation of Vermont Yankee Nuclear Power Station are exceedingly small.

VIII. SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

The region in the vicinity of the plant site is peripheral to a major American megalopolis. It has been the home of much industry and also has been part of the agricultural base for the industrialization of the Northeast. In recent decades industrialization has generally declined. Although there are several towns in the area which are economically independent of industries, many area towns would probably welcome more industry. The farming in Vermont is largely dairying, but this activity has also declined over recent decades; many old farms have reverted to woodland. About a quarter of the land area in Vermont is in the Green Mountain National Forest. Tourism is a very important industry in Vermont and could reasonably be predicted to become more important as the affluence and population in the nearby urban area increases. Tourism continues throughout the year in Vermont, centering around the many lakes and mountains.

The region in close proximity to the plant includes the town of Brattleboro, which is significantly dependent on tourism. In Vernon, Vermont, the land is used largely for agriculture and for residences. The reactor site has been owned by the utility for several years and has been used for agriculture; the land that would be employed for power transmission was also largely devoted to agriculture.

The plant should reduce power costs in this area, which would tend to encourage industry to return. In general, the plant would likely cause an increased population density and increased per capita income. The balance between population density and standard of living is properly a subject of public debate and political decision and is thus beyond the scope of this report.

The town of Vernon will be affected by the presence of the plant itself and by the significant tax revenue from the plant. The noise and drift from the cooling towers, at least during part of the year, will make the immediately adjacent land less desirable for residential use. Agricultural use of this land would not suffer (except for possible effects of increased periods of fog). The plant might (along with the Hunt House) attract some tourists. The increased tax revenue might attract residents to Vernon. The effects of the plant operation on the river may tend to compensate each other; the fluctuation in the water level will be less than previously, but additional impurities and heat will be released into the river. The effects of these changes on the life in the river or on life, which might later become possible if the river is generally cleaned up and the anadromous fish program succeeds, cannot be completely predicted. However, the plant can operate in different modes, which

provides flexibility for adjusting the plant operation to assure ecological protection of Vernon Pond and the Connecticut River. A monitoring program designed to provide a basis for determination of an optimum operational mode will be implemented.

After the period of the useful life of the reactor, the site and the transmission avenues possibly would continue to be used for power generation and transmission. However, if these operations have to be terminated, the plant could then be decommissioned.

Decommission of the plant would be implemented by removing and reclaiming fuel, decontaminating or otherwise "fixing" in place radioactive material, removing salvageable equipment, and final sealing of reactor components. If required, the entire plant area could be restored to its original condition, even to the extent of removing the reactor hardware and razing the buildings. Hydrological condition at the site are an important factor in determining the degree of removing underground structures and plant component systems from the site. Analysis of the dismantling costs for smaller reactors has determined that approximately 10 to 15% of the original construction costs would be required to decommission the facility and restore the site to its original productivity.

However, the degree of dismantlement, as with most abandoned industrial plants, would be determined by the intended new use of the site and a balance of safety considerations, salvage values, and environmental impact.

On a scale of time reaching into the future through several generations, the life span of the Station would be considered a short term use of the natural resources of land and water. The resource which will have been dedicated exclusively to the production of electrical power during the 30 years anticipated life span of the Station will be the land itself. No significant commitment of water for consumptive use will have been made, since on an average Connecticut River flow basis, less than 1% of the flow will be lost through evaporation from the cooling towers. No deterioration of water quality is anticipated to occur due to the station effluents.

In conclusion, the benefits derived from the plant in serving both the economic and electrical needs of the state and New England region as a whole outweigh the short-term uses of the environment in the vicinity of the plant.

IX. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The construction and future operation of the Vermont Yankee Nuclear Power Station will use a certain amount of air, water, and land. The plant site and the nature and use of Vernon Pond will be affected. It is likely that the plant site will be used for power production for a long period. The staff believes that industry and population will increase in the region, which will lead to increased commitments of resources and perhaps irreversible changes in natural areas around Vernon.

Long-lived radioactive materials will be produced by fission of nuclear fuel in the core of the reactor and neutron activation of reactor parts near the core. The eventual disposal and storage of radioactive materials will require a certain amount of space, probably in an area remote from this plant, for a very long period of time, and could for all practical purposes be considered as an irreversible commitment of resources.

Other possible irreversible changes include the long-range effects on fish population, discussed in Sect. V.C.4, and transmission line requirements, in Sect. III.B.

Some of the ^{235}U, ^{238}U, and ^{239}Pu in the core of the reactor will be consumed and must be considered an irretrievable use of resources. Additional chemicals and fuels will be consumed for operation of associated plant equipment, such as emergency diesel generators and cooling towers. These commitments are small compared with the need for production of essential electrical energy for this area.

Of the ~ 60 acres of land used for plant buildings, it would appear that only a small portion of this land (less than 5 acres) beneath the reactor, control room, radwaste and the turbine-generator buildings and the cooling tower structures, would be irreversibly committed. Also, some components of the facility such as large underground concrete foundations and certain equipment are, in essence, irretrievable due to practical aspects of reclamation and/or radioactive decontamination. The degree of dismantlement of the plant, as previously noted, will be determined by the intended future use of the site, which will involve a balance of health and safety considerations, salvage values, and environmental effects.

X. NEED FOR POWER

A. GROWTH OF POWER DEMAND IN NEW ENGLAND

The Vermont Yankee Nuclear Power Station will serve the New England area. In power system planning, the Federal Power Commission has designated the power supply areas (PSA's) in New England as PSA-1 (Maine) and PSA-2 (Vermont, New Hampshire, Massachusetts, Connecticut and Rhode Island). The combined PSA-1 and PSA-2 is known as the Coordinated Study Area A (CSA-A). In CSA-A the utilities coordinate planning and operations under the New England Power (NEPOOL) Agreement.[1] At the end of 1970, NEPOOL had a total capacity, including purchases and sales, of 13,627 MWe, a peak load (Dec. 22, 1970) of 11,656 MWe, and a total annual energy requirement of 62,005 MW-hr.[2]

The 1970 National Power Survey[1] shows that the peak demand for electrical energy from the New England Power Pool increased 6.9% per year during the period 1965-70 and is expected to increase at a rate of 6.7% per year during the decade 1970-80.* Since the 1970 National Power Survey's analysis of the New England area was based on information developed prior to December 1968, the forecasts were reviewed in 1971 by the Technology Advisory Committee on Load Forecasting Methodology for the National Power Survey.[3] The Committee concluded that "on balance, there will be an increase in electric energy loads over the original 1970 National Power Survey forecasts."

The schedule for addition of generating facilities in the New England area has been summarized recently by the Northeast Power Coordinating Council.[2] The Council's schedules for increased load and capacity in New England are based on summer peak loads, projected and actual, that increase during the period 1970 to 1980 at an average rate of 8.0% per year and winter peak loads that increase at an average rate of 7.6% per year during the same period. The fact that these rates are somewhat higher than those of the 1970 National Power Survey is consistent with the Advisory Committee's conclusion.[3] (In this connection, individual projected values of peak demand seldom exactly equal actual experience primarily because of the weather dependence of the peak demand. As a consequence, planning has to be based on the extrapolation of average growth over a number of years with the extrapolation being continually revised as experience accumulates.)

To meet these projected annual growth rates, the utilities in New England are building new fossil-fueled and nuclear-fueled power plants for base-load capability and hydroelectric, pumped-storage, diesel, fossil-fueled, and gas-turbine power plants for peaking or long-hour emergency service. The Vermont

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* These rates are to be compared with 7.7%, the average annual growth of electric energy demand in the contiguous United States during 1965-70, and 7.4%, the projected growth rate in 1965-70. (See Chapter 3 of Part I of the National Power Survey.)

Yankee Nuclear Power Station is one of the larger base-load plants in the planned growth of the New England Power Pool.

B. VERMONT YANKEE CONTRIBUTION TO NEPOOL

The applicant is a corporation formed by ten New England investor-owned utilities* who have contracted to pay the costs and purchase the power generated by the Vermont Yankee Nuclear Power Station. Three utilities (Central Vermont Public Service Corporation, Green Mountain Power Corporation, New England Power Company) have about 70% of the ownership; the remaining seven utilities (Connecticut Light and Power Company, Central Maine Power Company, Public Service Company of New Hampshire, Hartford Electric Light Company, Cambridge Electric Light Company, Montaup Electric Company, and Western Massachusetts Electric Company) each own from 6% to 2.5% of the Corporation stock.

The power supply situation in the area to be served by the Station is summarized in Table X-1. The data have been obtained from several sources.[5,6,7] Without the Vermont Yankee Station, the reserve margin during this summer will be 15.4%. This is less than the margin that is considered necessary to provide reliable power during scheduled and/or unscheduled outages and maintenance.

The flooding accident (April 22, 1972) at the Northfield Mountain Pumped Storage Station has resulted in a delay of the availability of its four 250-MW reversible units (1000 MWe total). Two of these units were scheduled to be in service in May and June. It appears unlikely that more than one of these units will be in service by the end of 1972. This accident, plus the fact that Vermont Yankee may not be available during the summer peak, does not create a critical situation, but, as noted by the FPC,[6] "does not allow leeway for extensive maintenance programs." Moreover, "the ability of the New England Power Pool to assist the summer-peaking New York Pool will be quite limited," as noted in an FPC Bureau of Power report (Attachment 3, Appendix A of Reference 7).

The situation in winter 1972-73 will be about the same as during the summer of 1972, unless at least one of the Northfield Mountain units is in service by the end of 1972. It should be noted (Table X-1) that to achieve the expected 15.4% reserve margin during this summer, the New England Pool has made firm commitments to purchase 471 MWe (60% of this from the New Brunswick Electric Power Commission). If Vermont Yankee were in full operation, the amount of purchased capability could be reduced and some reduction in power costs might be realized.

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* The applicant notes, in Section 7.1 of Reference 4, that 5.8% of the corporation common stock has been purchased from Central Vermont Public Service Corp. and Green Mountain Power Corp. by four municipal and cooperative utilities in the State of Vermont.

TABLE X-1

RESERVE MARGINS IN THE NEW ENGLAND POWER POOL

	Feb. 29, 1972	Summer 1972	Winter 1972-73
Planned capability (including new stations and net of transactions), MWe	13,407[a]	13,845[b]	15,429[d,e]
Peak load, MWe	—	11,994[a]	13,477[c]
Necessary 20% reserve, MWe	—	2,399	2,695
Reserve (MWe and % peak load)	—		
Without Vermont Yankee	—	1,851 (15.4%)	1,952[e] (14.5%)
With Vermont Yankee	—	2,364 (19.7%)	2,465[e] (18.3%)

a. Data from FPC "Summer Load-Power Supply Situation" (April 21, 1972).

b. Data from FPC April 21, 1972 report (op. cit.). Summer ratings. Assumes: (1) Northfield Mountain pumped storage units not available, (2) 98 MWe retirements and rating changes, (3) 471 MWe from purchases, (4) 65 MWe planned additions available, (5) Vermont Yankee (513 MWe) and Pilgrim (657 MWe) plants not operating.

c. Letter T. A. Phillips, Chief, Bureau of Power, Federal Power Commission, to Lester Rogers, Director, Division of Radiological and Environmental Protection, U.S. Atomic Energy Commission, dated May 10, 1972.

d. Appendix to Statement by J. N. Nassikas, Chairman, Federal Power Commission, before the Subcommittee on Fisheries and Wildlife Conservation, Committee on Merchant Marine and Fisheries, House of Representatives, March 27, 1972. Capability given here includes Pilgrim but not Vermont Yankee or Maine Yankee. Assumes no Northfield pumped storage units available.

e. Salem Harbor No. 4 (465 MWe), a fossil-fueled plant, is scheduled to become operational by October 1972. If its schedule slips, the capability will be reduced by 465 MWe and the reserve margin by 3.5%.

As noted earlier, the Vermont Yankee Nuclear Power Station will provide power for its owner-operators. Since the Vermont utilities hold about 55% of the applicant's stock,[4] it is apparent that they anticipate requiring up to 55% of the Station's capability or 282 MWe. The energy use in Vermont during 1971 was 3,200 million kilowatt-hours with a winter peak demand of about 700 MWe. The applicant has indicated[4] that the generating capability in the State of Vermont at the end of 1971 was less than this, that is, there was a negative reserve margin at that time. This required outside purchases of capacity. When the Vermont Yankee Station is in full operation, the availability of the power from its operation will bring the reserve margin in the State of Vermont up to a reasonable value during winter 1972-73. If Vermont Yankee is not operating by next winter, the utilities in the State will have to continue importing sizable blocks of power. This will result in increased cost to the customers in the area. It will also mean that the utilities of Vermont will be unable to carry their share of the New England Power Pool load.

From the foregoing, it is concluded that (1) the State of Vermont now needs the output of Vermont Yankee to meet the growing demand for electrical power within the State, and (2) the New England Power Pool needs Vermont Yankee in order not only to assure that the State of Vermont has a reliable power supply but also to strengthen the regional stability of the electrical service provided by NEPOOL to all its members.

References for Section X

1. Federal Power Commission, "The National Power Survey," in four parts, U. S. Government Printing Office. Part II includes the Northeast Regional Advisory Committee's "A Report to Federal Power Commission - Electric Power in the Northeast, 1970-1980-1990" dated Dec. 2, 1968. Part I (published in December 1971) includes Chapter 3, "The Projected Growth in the Use of Electric Power" and Chapter 17, "Coordination for Reliability and Economy."

2. Northeast Power Coordinating Council, "Data on Coordinated Regional Bulk Power Supply Programs," Appendix A, April 1, 1972.

3. The Technical Advisory Committee on Load Forecasting Methodology for the National Power Survey, "Changed Underlying Factors Influencing Electric Load Growth," A Report to the Federal Power Commission, 1971.

4. Vermont Yankee Nuclear Power Corporation, Supplement to the Environmental Report (Dec. 21, 1971).

5. FPC News Release 18,209 "1972 Summer Load-Power Supply Situation," April 21, 1972.

6. Letter from T. A. Phillips, Chief, Bureau of Power, Federal Power Commission to Lester Rogers, Director of Division of Radiological and Environmental Protection, U. S. Atomic Energy Commission, dated May 10, 1972.

References for Section X (Continued)

7. Statement of John N. Nassikas, Chairman, Federal Power Commission, before the subcommittee on Fisheries and Wildlife Conservation of the Committee on Merchant Marine and Fisheries, House of Representatives, March 27, 1972.

XI. ALTERNATIVES TO THE PROPOSED ACTION AND COST-BENEFIT ANALYSIS OF THEIR ENVIRONMENTAL EFFECTS

A. Alternatives

1. Alternative Sources of Power

The need for power is discussed in Sect. X of this report. Short-term alternatives to the operation of the Vermont Yankee Nuclear Power Station are load reduction under abnormal conditions, further purchases of power from other utilities, delay in scheduled retirements of old units, and installation of gas turbines.

Load reduction under abnormal conditions, resulting from unusually high system load or unusually high unscheduled outage, could mean dropping contractually interruptible loads, instituting voltage reductions, requesting load curtailment by large industrial and commercial customers, and appealing to the general public for load curtailment. This course of action should be avoided, if possible, and certainly should not be used repeatedly. The New England planning criterion for system reliability is that this should not occur more often than once in ten years.

The possibility of purchases of power needs to be examined in the context of the power supply situation in the New England Power Pool. In the winter of 1971-72, a deficiency in capacity to meet the December peak in Vermont was overcome by securing 95 MW of capacity from another member of the New England Power Pool (Northeast Utilities). As noted in Section X, for the winter of 1972-73 the reserve margin for the Pool would be only 14.5% without Vermont Yankee. This assumes that the Pilgrim nuclear plant and the Salem Harbor No. 4 fossil-fueled plant will become fully operational by that time. When allowance is made for scheduled maintenance and for the average value of unscheduled outages based on operating experience in the winters of 1970-71 and 1971-72, it appears that the power generated within the Pool would not provide sufficient reliability without the operation of Vermont Yankee.

Power can be transferred from other areas to New England. The maximum transfer on existing transmission lines from New York is between 1100 and 1200 MW and from New Brunswick, Canada, is 500 MW. There are firm contracts for 150 MW from New York and 260 MW from New Brunswick. Any additional large blocks of power are not expected to be available on a firm basis because of delays in operation of new plants in New York and because of the relatively small capability of the New Brunswick system.

Even if power were available, a utility suffers an economic penalty by purchasing it, paying a price that includes amortization of another utility's plant, instead of operating an existing plant of its own, especially a nuclear plant with its relatively low operating costs. Such increased costs would ultimately have to be passed on to customers of the utility.

With regard to the alternative of delaying retirement of old generating units, only 195 MW is scheduled for retirement in New England in 1972 and just 1 MW (from miscellaneous hydroelectric units) is in Vermont. Most of these units will have to be retired on schedule because of worn-out equipment and environmental requirements. In any case, these old units do not represent a dependable source of power.

The alternative of installing gas turbines could be accomplished in a few years at low capital cost, but the costs of fuel and of operation and maintenance would be high. These units are intended for peaking and are not feasible for meeting intermediate or base loads. In New England, extensive use of pumped storage for peaking is planned and should provide a more economical approach than gas turbines.

A long-term alternative is the installation of a generating plant of the capacity of the Vermont Yankee Nuclear Power Station but using a nonnuclear source of energy. A hydroelectric source is not a possibility because all available streams in Vermont are already being used to their flow limits. Natural gas is in stringent supply and is not available for use in an electric generating plant. Low-sulfur coal is not available in New England, and many existing coal-fired units are being converted to burning oil in order to satisfy air quality regulations. Equipment to remove sulfur dioxide from stack gases is being tried by several utilities in the United States, but its technical and economic feasibility has not yet been demonstrated.

The remaining alternative is the construction of an oil-fired unit, which would require about 5 years. Supplies of low-sulfur oil are limited, and it is difficult to arrange for long-term contracts. Prices under short-term arrangements have risen substantially. A cost-benefit analysis of this alternative is included in Sect. XI.B.

2. Alternative Sites

The applicant sponsored an investigation of 23 sites for a nuclear plant in the state of Vermont, six on the Connecticut River and 17 on Lake Champlain. After a preliminary appraisal of the topography, cooling water, transportation, and AEC site requirements, six of these sites were subjected to further investigation. One river site at Vernon and two lake sites at Five Mile Point and the Way Property were then selected for study of costs of site preparation, cooling facilities, equipment delivery and access, and energy transport. The lake sites, which otherwise would have been economically favorable, would have required extensive construction in the lake for cooling facilities. The Vernon site was nearer the transmission grid and therefore required shorter transmission lines, with consequent lesser impact on the environment.

3. Alternative Cooling Systems

One alternative to the mechanical-draft cooling towers of the Vermont Yankee Nuclear Power Station is a natural-draft cooling tower, and this is included in the cost-benefit analysis of Sect. XI.B. The natural-draft cooling tower would not use mechanical fans and would therefore not affect noise levels at the site. It would be a massive structure, 300 ft in diameter and 400 ft high, compared with the two mechanical-draft cooling towers, each of which is 460 ft long by 60 ft wide by 50 ft high.

Another alternative is to rely entirely on once-through cooling, which could be accomplished by drawing 840 cubic feet of water per second from the Connecticut River through a canal, passing it through the condensers where its temperature would be raised by about 20°F, and discharging it to Vernon Pond. This is also included in the cost-benefit analysis in Sect. XI.B.

Other alternatives are a spray pond requiring at least 17 acres and a cooling pond requiring considerably more acreage. The staff has concluded that the environmental impact of a cooling pond would be greater than that of the present system, since a pond with an area greater than 1,000 acres would have to be constructed. Comparison of the estimated impact of a spray pond with a power spray module with the impact of the existing mechanical draft cooling towers shows no appreciable difference between the two as regards the impact on Vernon Pond, potential fogging, and concentration of dissolved solids. The cooling tower requires less land but the spray module would cause less noise, use less power, and might cause less aesthetic impact. In balance, the preferred alternative is to use the existing mechanical draft towers.

4. Alternative Modes of Operation of Cooling System

The adopted cooling system contains pumps, gates, and valves that permit flexibility in the mode of operation. It can be operated on a total open-cycle or once-through basis, with all of the cooling water from the condensers by-passing the cooling towers and flowing directly to the discharge structure in Vernon Pond. Or it can be operated on a helper-cycle basis, with an adjustable portion of the cooling water from the condensers diverted to the cooling towers and subsequently mixed with the remainder of the water before discharge to Vernon Pond. Or it can be operated on a closed-cycle basis, with all of the water from the condensers diverted to the cooling towers and subsequently returned to the intake structure for recirculation to the condensers. The choice among operating modes will vary with the season of the year, the cooling towers being used as necessary to assure that the biological impact of the water discharged to Vernon Pond is minimized.

5. Alternatives to Use of Chlorine in Cooling System

The applicant has selected chlorine (sodium hypochlorite) for biocide control and sulfuric acid for pH control in his cooling water system. The use of chlorine for this purpose requires careful plant control in order to assure

that residual chlorine as discharged will not be toxic to aquatic life. Heat exchanger design and cooling tower construction materials usually determine the potential corrosion and thus the choice of chemicals to be added to the recirculating water. Many corrosion inhibitors are used (chromate, zinc, and phosphate compounds). Similarly, biocides, other than chlorine or hypochlorite, include various nonoxidizing organic chemicals such as chlorophenols, amines, and numerous organometallic compounds, the use of which may be restricted because of potential stream pollution. (See Appendix XI-A for detailed discussion of the effectiveness and environmental limitations of these chemicals). Recent stream pollution abatement laws and water quality standards are placing increasing restrictions on the use of chromate, zinc, and many organic chemicals. On balance, when one considers both condenser heat transfer and cooling tower requirements, the use of hypochlorite and sulfuric acid appears reasonable. If adverse biological effects are observed in Vernon Pond, with the residual chlorine operating limit of 0.1 mg/l, mechanical cleaning systems could be backfitted to the steam condensers.

6. Alternative Radwaste Systems

A modification to the gaseous radwaste system is planned to be ready for operation upon completion of the first scheduled shutdown of the reactor for refueling. The purpose is to reduce the off-site dose due to release of radioactive krypton and xenon to less than 1% of the limit established by the AEC in 10 CFR 20. This will be done by installing a number of tanks filled with charcoal, which will increase the holdup time for radioactive gases and permit further radioactive decay before release. This system will also remove any radioactive iodine from the off-gas stream. During the same modification, equipment will be added to recombine hydrogen and oxygen in the off-gas system to reduce the volume of gaseous effluents and to improve the holdup efficiency.

The applicant is evaluating a modification of the liquid radwaste system to provide additional filtration and demineralization of low-purity wastes and is considering whether further segregation and treatment would purify these wastes sufficiently to permit recycle to the reactor system. This would reduce the total volume of liquids discharged from the Vermont Yankee Nuclear Power Station.

7. Alternative Transmission Lines

Transmission lines from the Vermont Yankee Nuclear Power Station cross the Connecticut River into New Hampshire by means of towers on each shore and on an island in the river. One alternative considered was to eliminate the tower on the island and make the towers on the shore substantially higher; this would have made the towers on the shore visible at a much greater distance and would have increased the cost of the crossing by about 30%. Another alternative considered was to use underground cables; this would have required termination towers, pothead cable-termination facilities, and a cleared right-of-way on both banks of the river and would have increased the cost of the crossing by a factor of about five. A third alternative considered was to use an existing

right-of-way crossing the river south of the Vermont Yankee site; this would have required clearing trees from a stretch of land extending into the river and possibly constructing towers in the river and would have routed the lines through a more developed area south of Hinsdale, New Hampshire.

8. Alternatives to Normal Transportation Procedures

Alternatives, such as special routing of shipments, providing escorts in separate vehicles, adding shielding to the containers, and constructing a fuel recovery and fabrication plant on the site rather than shipping fuel to and from the station, have been examined by the regulatory staff for the general case. The impact on the environment of transportation under normal or postulated accident conditions is not considered to be sufficient to justify the additional effort required to implement any of the alternatives.

B. Cost-Benefit Analysis

1. Use of Natural Resources

Land. The site of the Vermont Yankee Station consists of about 125 acres of lowlands and of terraces rising to about 80 ft above the Connecticut River. The adjacent land area is used for dairy feed products and pasture or for residences or is undeveloped. There are only 85 people per square mile within a 5-mile radius of the plant. Approximately 85% of the land within a 25-mile radius is undeveloped. The construction of the Vermont Yankee Plant has not replaced residential or commercial property. An oil-fired plant would require about 250 acres, including an area for oil storage facilities. Land amounting to 1550 acres is used as a right-of-way for a transmission line running northward from the site for 51 miles to a substation near Ludlow, Vermont, and can be made available for agriculture and wildlife management, but not for building sites.

Water. The consumptive use of water at the site amounts to 5,000 gallons per minute during the closed-cycle mode of operation. This represents evaporative and windage losses from the cooling tower. It is less than 1% of the required minimum river flow of 538,000 gallons per minute (1,200 cubic feet per second) and less than 0.15% of the average flow. Comparatively, during the open-cycle mode of operation, about one half of the quantity of water that would be lost through cooling tower evaporation would be normally lost through surface evaporation of the receiving water course.

Fuel. The Vermont Yankee Plant will be fueled with uranium enriched in the isotope U-235 in gaseous diffusion plants owned by the AEC. For this purpose, natural uranium will be mined and converted to U_3O_8 (yellowcake). The amount of U_3O_8 required is 420 short tons for the initial loading of the reactor and about 100 tons per year for makeup. The AEC Report to Congress for 1971 gives on page 136 a preliminary figure of 246,000 tons as of the end of 1971 for U.S. reserves of U_3O_8 recoverable at costs of $8 per pound, representing a 10 year forward supply. Potential U_3O_8 resources at costs of $10

per pound or less were estimated at 650,000 tons, but this additional supply will require a major exploration effort to discover, develop, and bring into production. The alternative of an oil-burning unit would require 5,500,000 barrels of fuel oil per year, with a sulfur content of less than 1%. Such oil is presently in short supply and high in cost. Also, substantial construction of oil storage facilities would be required.

2. Impact on Air and Land

Construction. Construction of the Vermont Yankee Station was accomplished with little adverse effect on the terrestrial environment. Some impacts of construction were noise heard at several residences near the plant, heavy truck traffic on local roads that caused concern among parents whose children encountered this traffic on their way to school, a small (9 to 12) increase in the school population, a few new houses (6 to 12) for workers, the visual impact of construction, grading, and the moderately tall structures on the rural scene. The disruptions in living conditions were felt primarily by the community of Vernon, although slight visual impact may have been felt on the opposite side of the Vernon Pond by some residents of Hinsdale, New Hampshire.

Starting during early construction, Vernon received taxes from the applicant's property that enabled the town to make capital improvements to the town property, namely, to build a new town office building and library and at the same time to reduce the tax rate. One specific adverse impact was corrected when the applicant reimbursed the town of Vernon for the money spent on construction of a new roadway and sidewalk along Governor Hunt Road to eliminate danger to school children from periodic heavy traffic along that road.

Some 1200 workers were used during the peak of construction, but they were so dispersed among the nearby towns that no particular impact on any one town seems to have been felt. Very few of the 1200 lived in Vernon. The few families who established homes in Vernon and the few additional children in the Vernon Elementary School did not noticeably affect the community. Income to construction families must have caused a slight increase in the total money spent in Vernon.

Fogging. Operation of the cooling towers of the Vermont Yankee Plant will produce a visible plume that ordinarily will form a layer of stratus clouds in the Connecticut River Valley but occasionally will descend to the ground some distance downwind or be intercepted by the side of a hill and cause fogging. The increase in potential fogging if the cooling towers were operated continuously has been provided by the applicant on the basis of assumptions that probably overestimate the effects. The results are shown in the following table in hours per year.

Location	Spring	Summer	Fall	Winter
Vermont Yankee Switchyard	1	0	0	0
Gov. Hunt Road	0	0	0	0
Vernon Elementary School	0	0	0	0
Vermont State Highway 142	2	0	0	0
Hinsdale, New Hampshire	0	0	0	0
Brattleboro, Vermont (downtown)	0	0	8	14
Schell Highway Bridge (Mass.)	0	0	0	129
Northfield, Mass. (town center)	0	0	0	73

The main effects would be in the winter, but the cooling towers are expected to operate only 25% of the time during that season. Applying this percentage to the figures given above for the winter would reduce the potential fogging problem to 11.5 hours per year for Brattleboro, 32 for Schell Highway Bridge, and 18 for Northfield. A comparison can be made with the estimated natural occurrence of fogging, which is 48 hours per year in the winter or 140 hours per year for all seasons, as exemplified by data taken in 1967-68 at the Vermont Yankee site.

The staff has evaluated the results of the applicant's cooling tower plume study in Sect. V and concluded that the estimates of potential fogging effects of the towers appear conservatively high. The analysis given above is for the mechanical-draft cooling towers already installed; a natural-draft cooling tower with its greater height would probably cause less fogging.

Icing. The same study mentioned in the previous paragraph indicated that the plume from the cooling towers would not create icing problems because the condensed droplets would be so small (less than 100 microns in diameter) that they would not fall to the surface. Drift losses from the towers would consist of droplets assumed to be of the order of 500 microns in diameter, at the borderline between a drizzle and a rain, and any precipitation would occur on site within a few hundred feet of the towers. Drift eliminators will be used to reduce drift losses to approximately 700 gallons per minute. As a result, any on-site icing due to operation of the cooling towers will be less likely than the natural occurrence of freezing rain and subsequent ice formation on station facilities. Compared with the mechanical-draft towers installed, a natural-draft tower would have a lesser tendency to produce any icing. The open-cycle or once-through mode of operation would not cause icing.

Chemicals in Drift Water. Sodium hypochlorite will be added to the cooling system to control biological fouling. During closed cycle operation, free chlorine is expected to be removed within the cooling towers, but minimal quantities of chloramines will be released with the blowdown and will be contained in the drift water. Closed cycle operation will also require the addition of sulfuric acid to prevent the deposit of calcium scale on the condenser tubes and the deterioration of any wood in the cooling tower structures.

In addition, there will be concentration by evaporation, so that the total dissolved solids will be increased from an average 100 mg/l in normal river water to about 230 mg/l. The rate of discharge of solids dissolved in the drift water will be about 80 pounds per hour during closed cycle operation. Most of these solids will be deposited on site, and there should be no appreciable effects elsewhere.

Noise. The two Vermont Yankee cooling towers each contain 11 fans and are designed so that the total sound level of the installation does not exceed 88 decibels above ASA Standard Reference Level at the midpoint of the tower, 50 feet from the air inlet, and 5 feet above grade. The sound level measured in the residential area about 600 feet west of the cooling tower is approximately 70 decibels (C scale). The sound level measured near the closest residences on the New Hampshire side of the river is a maximum of 63 decibels (C scale). These noise levels may possibly be a source of irritation, but there is no evidence that these annoying levels cause any long or short-term health effects. A natural-draft cooling tower would not contain fans and would not generate such noise.

Gaseous Radwaste. The gaseous effluents from the Vermont Yankee Plant in normal operation will contain some radioactive noble gases, primarily krypton. With the off-gas system as it presently exists, the total man-rems per year within a radius of 50 miles would be about 147, compared with 179,000 from natural sources and 171,000 from medical sources. The modified system to be installed will reduce the radioactivity of the gaseous effluents by a factor of about 20.

Emissions from Alternative Oil-Burning Plant. If fuel oil containing 1% sulfur were available in sufficient quantities for operation of the alternative plant, about 18,000 tons of sulfur dioxide would be emitted annually. In addition, about 900 tons of particulates and 8,300 tons of nitrogen oxides would be emitted per year. During the five-year period required for construction of an oil-burning plant, replacement power (if available) would probably come from more intensive use of older fossil units in New England and would increase the emissions of sulfur dioxide by about 100,000 tons, particulates by about 5,000 tons, and nitrogen oxides by about 50,000 tons during that period.

3. Impact on Water

Intake from River. Water from the river contains various species of plankton, the numbers being much greater in the summer and fall than during the rest of the year. During these seasons, the Vermont Yankee Plant is expected to operate on closed cycle with the intake of water amounting to less than 1% of the required minimum river flow. Therefore, only a small proportion of the total number of plankton in Vernon Pond will then pass through the condenser and be killed. During the colder months, a greater proportion of the small number of plankton then present will be killed during open-cycle operation, but this may be balanced by an enhancement of growth in the river resulting from the increase in temperature of the discharge water. Spawning grounds

for the principal fish found in Vernon Pond are at a considerable distance upstream, and it is not expected that fish eggs or larvae will be present in the intake water. Some small fish may be entrained in the cooling system and killed. Larger fish may be drawn through the trash racks of the intake structure and caught on the traveling screen, although this is believed to be minimized by the presently designed system. These effects will be greatly reduced in the closed-cycle mode of operation.

Thermal Discharge to River. For open-cycle operation, the temperature of the discharge water will be about 20°F higher than the temperature of the intake water. For closed cycle operation, the discharge water consists only of blowdown and its temperature will depend on the wet-bulb temperature of the air but will rarely exceed 90°F. (It may reach 93°F for exceptionally high wet-bulb temperatures recorded for a few days in July and August.) A thermal impact on Vernon Pond will exist. However, it will not be excessive if the applicant controls the heated water discharge so as to limit the area of the thermal plume to 10 acres and its maximum temperature difference from pond temperature to 5°F (summer) and 10°F (winter). To establish whether less restrictive limits are acceptable, the applicant must provide additional information on the extent of the thermal plume and its effects on aquatic biota.

Chemical Discharge to River. Maximum concentrations in the discharge water are to be 0.1 part per million (ppm) for residual chlorine (only for open-cycle operation), 28 ppm for sodium, and 30 ppm for sulfates. There conceivably could be some adverse effects on aquatic life in the immediate neighborhood of the discharge structure before much dilution has occurred. However, after mixing with the river water, the concentrations in Vernon Pond relative to ambient conditions will at most be increased from 4.5 to 4.7 ppm for sodium, from 10.0 to 10.4 ppm for sulfates, and from 100 to 101 ppm for total dissolved solids. These values are well below established water quality standards and criteria for drinking water and other important water uses such as irrigation, stock and wildlife watering, fish and other aquatic life.

Radiological Discharge to River. Radioactive materials in the discharge water might be absorbed by fish and might result in an annual radiation dose of a maximum of 1.8 mrem to the thyroid of a person who ate 20 grams of the flesh of such fish daily. This level of exposure if received, is about 1.2% of that due to natural background. Connecticut River water is not currently being used for municipal drinking-water supplies downstream of the Vermont Yankee Plant, but there is a proposal to divert river water at Northfield to the Quabbin Reservoir, which provides a significant portion of the drinking water for metropolitan Boston. Without allowing for radioactive decay during the average holdup time of two years in the reservoir, the yearly population dose has been computed as 14 man-rems, compared with about 300,000 man-rems for the normal background dose (based on an estimated population of 2 million people).

4. Radiological Impact of Transportation and Postulated Plant Accidents

The radioactive materials to be transported in and out of the plant will be shipped in specially designed containers, which will be hauled by common carrier under rigorous shipping controls of the Department of Transportation. These heavy shipments must conform to the loading limits of the various highway authorities responsible for public thoroughfares. The shipments will be so infrequent that the resulting wear and tear on public roads will not have a significant effect on their maintenance or useful life. By comparison, if fossil-fuel power installations had been located in this area, the shipments of coal or oil would likely have required a combination of rail and truck transport that would have amounted to a major fraction of the total current transportation activities in this region.

From an analysis of the environmental risks due to postulated radiological accidents at the plant and in the transport of nuclear fuel and radioactive wastes, it is concluded that these risks are small.

5. Aesthetic and Cultural Effects

The composition of the landscape is noticeably changed by the power plant structures, although the impact of this change is somewhat softened by the architectural treatment and the low profile the structures present. This low-profile effect is the result of the plant elevation being lower than that of the nearby residences. The net result is an appearance alteration that blends the industrial installation with the New England farm community with less contrast than might be expected. In comparison with the approaches taken in adding new industrial plants in many other rural areas throughout the United States, a commonly accepted action to enhance the economic well-being of a community, the addition in this case is extremely well executed.

When the cooling towers are operated, the plume will be visible from Vernon, Vermont, and occasionally from Hinsdale, New Hampshire. The alternative of a natural-draft cooling tower would require a massive structure 300 feet in diameter by 400 feet high, which would be aesthetically unpleasing in comparison with the existing cooling towers having a height of 50 feet.

The most important alteration to the landscape results from the transmission line rights-of-way which, by their nature, form contrasting strips of habitat through much of the landscape through which they pass. The transmission line routing and maintenance practices have been established to break up the effect as seen from various points along the ground. Consequently, if the established programs are faithfully followed, the impact will continue to be mild, and, from most vantage points, the lines will not dominate the surrounding scene.

For the alternative of an oil-burning plant, additional detrimental aesthetic aspects would be the visible effects of air pollution and facilities for transport and storage of large quantities of fuel oil.

The restoration of the historic Governor Hunt House reclaims a cultural asset for the region, and this historic building and the modern power plant structures may draw tourist interest to the area. Since the winter sports activities at nearby Brattleboro already have attracted some tourist interest in the region, this additional influence is not a totally new impact.

6. Generating Costs

A comparison of generating costs of the Vermont Yankee Nuclear Power Station and its alternatives is presented in Table XI-1, together with environmental costs. The capital cost of the Station is about $158,000,000 ($307 per net kilowatt), including $6,400,000 for the mechanical-draft cooling tower. Operating costs in mills per kilowatt hour are taken as 1.73 for the nuclear fuel cycle, 0.50 for operation and maintenance, and 0.17 for nuclear insurance. Annual operating costs are then $8,600,000 including about $1,000,000 for operation of the mechanical-draft cooling tower. This is based on a capacity factor of 80%, which is equivalent to 7,000 hours of full-power operation per year. At a discount rate of 8.75% per annum, the present worth of these annual costs for thirty years of operation is $90,000,000.

As discussed in Section VIII, if plant operations are terminated after a certain operating period, it is estimated that up to approximately 15% of the original construction costs would be required to decommission the facility. At a discount rate of 8.75% per year, the present worth of these costs after thirty years of operation is approximately $2,000,000.

The alternative mode of operation on a once-through or open-cycle basis, bypassing the cooling tower, would reduce annual operating costs by about $1,000,000 and would reduce the present worth for thirty years of operation by about $10,500,000.

The alternative of installing a natural-draft cooling tower for operation in place of the existing mechanical-draft cooling tower would mean an incremental capital cost of about $8,900,000, but the annual operating costs would be decreased by about $70,000, primarily because of savings from not having to operate fans to create a forced draft. At a discount rate of 8.75% per annum, the present worth of the decreased annual operating costs for thirty years of operation would be $740,000.

The alternative of installing an oil-burning unit for operation in place of the existing nuclear unit would require about five years of construction time. This leaves 25 years for operation of the oil-burning unit within the total calendar period of 30 years considered for operation of the nuclear unit. During the period of construction of the oil-burning unit, replacement power would have to be purchased and, if available, would cost $150,000,000, according to the applicant. On the assumption that this cost is spread equally over each of the five years, the present worth at a discount rate of 8.75% per annum would be $117,000,000.

Table XI-1. Cost analysis for Vermont Yankee Nuclear Power Station and alternatives

	Vermont Yankee Nuclear Power Station			Alternative oil-burning plant (incremental cost)
		Closed-cycle operation		
	Open-cycle operation	Existing mechanical-draft cooling tower	Alternative natural-draft cooling tower (incremental cost)	
Generating costs (millions of dollars)				
Capital	158	158	8.9	101
Operating[a]	~~90~~ 70	90	-0.7	75-121[b]
Plant dismantling[a]	2	2		
Replacement power				117
Total	~~250~~ 240	250	8.2	293-339
Use of natural resources				
Land, acres	125	125	Same	250
Water, gpm consumed	2500	5,000	5,000	3500
Fuel	U_3O_8: 420 tons + 120 tons/year	U_3O_8: 420 tons + 120 tons/year	Same	5,500,000 bbl/year
Impact on air and land				
Fogging	Negligible	Possible increases of 11.5 hr/year at Brattleboro, 32 at Schell Bridge, and 18 at Northfield	Less than for mech. draft cooling tower	Similar to nuclear
Icing	Negligible	Increase on site	Negligible	Similar to nuclear
Chemicals in drift	None	80 lb/hr	80 lb/hr	Similar to nuclear
Noise	Negligible	70 decibels at nearest houses	Negligible	Similar to nuclear
Gaseous radioactive waste[c]	147 man-rem/year	147 man-rem/year	Same	None
Combustion products, tons/year	None	None	None	18,000 for SO_2 8,300 for NO_x 900 for particulates
Impact on water				
Intake from river	Death of fraction of plankton and fish in Vernon Pond in water	Negligible	Negligible	Similar to nuclear
Discharge to river				
Thermal	Possible adverse effects on aquatic life in mixing zone	Negligible	Negligible	Similar to nuclear
Chemical	Possible adverse effects on aquatic life near the discharge point			Similar to nuclear
Radioactive waste	Dose of 1.8 millirem/year to person eating 20 g of river fish daily Population dose of 14 man-rem/year from drinking water if part of river should be diverted to Quabbin Reservoir in the future			None
Transportation of fuel and waste				
	Dose of about 2 man-rem annually to personnel involved			
Accidents				
	Very low probability of release of radioactive materials			Possibility of release of oil
Aesthetics				
	Unobtrusive appearance of existing plant Obtrusive appearance of transmission lines		Conspicuous tower Same	Similar to nuclear, except for visible effects of air pollution and oil transport and storage facilities

[a] Present worth for 30 years of operation at discount rate of 8.75%/year.
[b] On an incremental basis, the $90 million for operating cost of the nuclear plant has been deducted. The first figure is without escalation of oil prices, and the second figure is with an escalation of 2%/year.
[c] After a planned modification, emission will be reduced by a factor of 20.

The capital cost of the oil burning unit would be about $129,000,000 ($250 per net kilowatt), and the present worth of the capital expenditures taken at a uniform rate over the construction period would be about $101,000,000. For fuel oil at a current delivered cost of 70 cents per million Btu and a heat rate of 9,200 Btu per kilowatt hour, fuel costs would be 6.44 mills per kilowatt hour or $23,200,000 per year at a capacity factor of 80%. Present worth of the cost of fuel oil for 25 years of operation, starting 5 years from now, would be $153,000,000. The cost of operation and maintenance at 0.5 mills per kilowatt hour would be $1,800,000 per year, and the present worth for 25 years of operation, starting 5 years from now, would be $12,000,000.

The cost of fuel oil given in the preceding paragraph makes no allowance for escalation of oil prices with time. If it is assumed that oil prices increase 2% per year, starting 1 year from now, the present worth of the cost of fuel oil for 25 years would be $199,000,000. This assumption is used to give a range of operating costs in Table XI-1 in order to show the effect of continuing increases in oil prices, which have been rising rapidly in recent years. Such a trend has not been experienced to date with respect to costs of the nuclear fuel cycle.

The present worth of the incremental cost of the alternative of installing and operating an oil-burning unit in place of the existing nuclear unit, including capital cost, operating cost, and cost of replacement power, is given in Table XI-1 as $293,000,000 with no escalation of oil prices or $339,000,000 with escalation.

7. Benefits

The principal benefit of the Vermont Yankee Plant will be the generation of about 3.6 billion kilowatt hours of electricity per year. Another important benefit is that the Vermont Yankee Plant will increase the reserve capacity and, consequently, the reliability of the power supply for the State of Vermont and the New England region as a whole. The reserve situation may be especially critical in the winter of 1972-73 if there are delays in starting operation of the Vermont Yankee, Pilgrim, and Maine Yankee plants. Such operation may well be needed to prevent power curtailments at that time. Of longer-range significance is the role that an economical and dependable supply of electric power from the Vermont Yankee Plant will play in permitting further residential, commercial, and industrial development of the State of Vermont.

There are a number of benefits that contribute to the local and state economy. The construction of the Vermont Yankee Plant provided a peak employment of almost 1,000 persons and a peak payroll of $1,650,000 per month. More than 10,000 local purchase orders have been issued for various types of materials and services, including minor construction contracts. Through the end of 1971, Vermont Yankee paid the Town of Vernon $1,650,000 in property taxes. Future property taxes will be levied at an annual rate of 1.9% of the appraised value of the plant, which is presently about $160,000,000; this will amount to

about $3,000,000 per year and will be shared by the State of Vermont and the Town of Vernon. Other continuing benefits to the local economy will result from the operating payroll of approximately $500,000 per year.

The guarantee of a flow of 1,200 cubic feet per second through Vernon Dam is a definite benefit to the environment associated with the operation of the Vermont Yankee Plant. This will result in an increase in ground water supply and an improvement in food sources for waterfowl at locations downstream.

Vermont Yankee has purchased the Governor Hunt House, which was built in the 1780's and is located near the site. (See Seection II.) The outside of the main building is to be restored to near its original condition during 1972. This structure is of historical significance, and the hope is that Vernon Historians, Inc., will utilize the house as a public museum and will furnish part of it in a style of the period when it was built. Attached to the back of the building, in a consistent architectural design, is the Public Information Center of Vermont Yankee.

8. <u>Balancing of Costs and Benefits</u>

The environmental costs of the Vermont Yankee Plant are the use of 125 acres of grazing land in a region where there is much undeveloped land; the consumption of water amounting to less than 1% of the required minimum river flow; a possibility of an increase by as much as ~~32~~ 212 hours per year in the occurrence of winter fogging at a few locations where people live or travel; a possibility of an increase in the occurrence of on-site icing; gaseous and liquid effluents containing small amounts of radioactive materials that will be negligible in their effects on human beings; an extremely low probability of any accidents releasing radioactivity either on site or during transportation; discharges of heat, chemicals and radioactive materials to the river water with no appreciable effects on aquatic life except possibly in the immediate neighborhood of the discharge structure; death of plankton and small fish entrained in the cooling system and of larger fish caught on the intake screen, the numbers varying with the mode of operation and the season of the year but not expected to affect significantly the fishing potential of the Connecticut River; increased noise levels in off-site residential areas during operation of the cooling towers; the use of land for transmission lines and the aesthetic effect of those lines.

These adverse effects must be compared with the benefits of supplying needed electricity and improving the reliability of such supply, thereby permitting economic growth in the locality, the state, and the region. The alternative of abandoning the Vermont Yankee Plant and constructing an oil-burning plant would involve incremental costs on a present-worth basis of about $290,000,000 or $340,000,000 (depending on escalation of oil prices) and would make large contributions to pollution of the air with sulfur dioxide, nitrogen oxides, and particulates. The alternative cooling system of

a natural-draft cooling tower, installed for operation in place of the existing mechanical-draft towers to reduce off-site noise and fogging, would mean incremental costs on a present-worth basis of about $8,000,000 and would adversely affect the appearance of the station.

The conclusion is that the benefits of the Vermont Yankee Plant outweigh the environmental costs associated with it and that the alternatives considered are not economically or environmentally justified.

XII. DISCUSSION OF COMMENTS RECEIVED ON THE DRAFT DETAILED STATEMENT ON ENVIRONMENTAL CONSIDERATIONS

Pursuant to paragraphs A.6 and D.1 of Appendix D to 10 CFR Part 50, the Draft Detailed Statement was transmitted with a request for comment to: Department of Agriculture; Department of Army (Corps of Engineers); Department of Commerce; Environmental Protection Agency; Federal Power Commission; Department of Health, Education and Welfare; Department of Housing and Urban Development; Department of the Interior; Department of Transportation; Advisory Council on Historic Preservation; Massachusetts Department of Public Health; Massachusetts Department of Natural Resources; Massachusetts Department of Public Utilities; Massachusetts Water Resources Commission; New Hampshire State Department of Health and Welfare; New Hampshire Department of Labor; New Hampshire Public Utilities Commission; New Hampshire Fish and Game Department; New Hampshire Water Supply and Pollution Control Commission; Vermont Agency of Environmental Conservation; Vermont Department of Industrial Relations; and Vermont Office of the Attorney General. In addition, the AEC requested comments on the Draft Detailed Statement from interested persons by a notice published in the Federal Register on April 14, 1972 (37 FR 7423).

Comments in response to the requests referred to in the preceding paragraph were received from the Department of Agriculture; Department of the Army (Corps of Engineers); Department of Commerce; Environmental Protection Agency; Federal Power Commission; Department of Interior; Department of Transportation; the Advisory Council on Historic Preservation; the State of Vermont Agency of Environmental Conservation; the State of New Hampshire Fish and Game Department; the State of New Hampshire Water Supply and Pollution Control Commission; the Commonwealth of Massachusetts, Department of the Attorney General; Vermont Yankee Nuclear Power Corporation; and New England Coalition on Nuclear Pollution.

Our consideration of comments received is reflected in part by revised text in other sections of this statement and in part by the following discussion.

A. CHEMICAL DISCHARGES

Vermont Yankee Nuclear Power Corporation is establishing a post operational ecological program which includes a water-quality monitoring program upstream and downstream of the station. The monitoring program will provide the information necessary to evaluate chemical discharges and their effects. Several agencies expressed concern over the concentrations of cadmium and mercury in the blowdown water from the cooling towers, which will not be known until the station becomes operational. The applicant now proposes to monitor cooling tower blowdown for metals whose discharge concentrations may exceed the maximum values present in the Connecticut River. Analytical methods used

for analyses in the earlier surveys were less sensitive than those presently available, as noted by the staff in the Draft Environmental Statement. If cadmium and mercury were in the river water at concentrations slightly below the old sensitivity levels, a toxic effect could be produced on aquatic biota after concentration in the blowdown water. This is highly unlikely, since the concentrations of cadmium and mercury in waters of rivers in the U. S. are extremely low. Mercury and cadmium in very low concentrations in water can produce toxic effects on aquatic organisms. The concentration factors for cadmium and mercury in fish are relatively high and toxic effects could be produced in some fish. Blowdown water is released in the summer months when the river water temperatures are the highest. Therefore, fish should not be attracted to the thermal plume as they are during the winter months. In addition, the size of the plume created by the blowdown water and dilution by the minimum required stream flow, produces conditions that make it highly unlikely that a sufficient number of fish would reach concentrations of mercury or cadmium in their tissues that would produce a toxic effect if eaten by man.

Newer instrumentation and procedures will permit a lower limit of detection for metals (such as cadmium and mercury) and chemicals in the water-quality control program to be conducted by the applicant. If treatment to reduce concentrations becomes necessary, the applicant will install facilities as needed.

Several agencies commented on the analysis of total residual chlorine that the applicant will release into Vernon Pond. The applicant has instrumentation to measure free chlorine at the effluent exit; however, the applicant has agreed to measure total residual chlorine in the immediate vicinity of the outfall.

B. TEMPERATURE STANDARDS

The State of Vermont has, in effect, approved a mixing zone reaching to about 0.5 mile below Vernon Dam. Temperatures of river water below this point cannot exceed the ambient river temperature measured near Brattleboro by more than 5°F (when the ambient temperature is 55°F or below). If these standards are met, no thermal effect could ever be evident as far down the river as 30 miles, where the Mt. Holyoke unit will be located.

Some agencies questioned whether discharge temperatures of 20°F above the ambient river temperature should be permitted even under limited conditions and critized the concept of an exempt area where temperatures would be allowed to be 5°F above ambient in summer and 10°F above in winter. State of Vermont would permit even higher temperatures over areas larger than the exempt area, as long as the

temperature, as monitored below the dam, is sufficiently low. The use of an exempt area is more restrictive on allowable effluent temperatures than the restriction imposed by State of Vermont standards.

C. THERMAL MONITORING

Comments were received from several agencies concerning expansion of the thermal and biological monitoring program, the basis for exempting a 10-acre area from temperature limits, and the difficulty of measuring the 10-acre area itself. As indicated in Sect. V.C.7, the staff feels that exempting 10 acres will assure that no significant ecological damage to Vernon Pond will occur. Because thermal and ecological effects on the pond need to be examined and because the ecological basis for choice of exempt area is admittedly uncertain, a mobile 50 acre area could be made available for study during the first year of station operation. This area would be used in accordance with the applicant's monitoring program to obtain needed information on the configuration of the thermal plume and on thermal and ecological effects. The staff feels that 50 acres is the maximum area that could be temporarily made available for monitoring study without significant irreversible adverse impact on the environment.

If, after the first year of station operation, the results from the applicant's one year study program indicate that an area larger than 10 acres could be permanently exempted from the temperature limits without a significant or irreversible effect on Vernon Pond, an appropriate permanent enlargement of the 10 acres limit will be considered. If ecological damage does occur in the first year of operation of the station because of the 50 acres testing limit, such damage is not likely to have a long-lasting effect on the pond.

1. Thermal Plume Studies

The dye studies furnished by the applicant provided useful information on plume dispersal but did not take into account the buoyancy of the heated discharge. Mixing of unheated water, as used in the dye studies, would occur at all levels, while heated effluent would tend to rise to the surface before dispersing. This limitation caused the staff to seek some type of mathematical model analysis to verify the dye study results or to provide additional information on the thermal plume. The staff realizes that a three-dimensional model is superior to a two-dimensional model, as used by the staff; however, a sufficiently sophisticated three-dimensional model is not available at the present time. In this case, the Motz-Benedict model was chosen by the staff since it was reasonably reliable for surface discharges.

Additional modeling, using more sophisticated mathematics, would give more exact results. Physical modeling is also limited in its application. Vernon Pond itself is the least distorted physical model available. At this time, actual field testing under operational parameters (with proper temperature limits) can show exactly what types of the thermal plumes will be obtained. A temperature-monitoring system in Vernon Pond will allow operation under closely observed conditions that show the types and extent of thermal plumes generated during plant operation. As temperature limits are reached in the pond, operating modes of the plant can be adjusted as required.

2. Temperature Measurements

Close observation of temperatures in Vernon Pond using a system of monitoring stations will allow operation to begin on an experimental basis. The results of dye and mathematical model studies should be used to establish the preliminary locations of monitors. As tests progress, especially under varying river conditions, a pattern is expected to emerge that will indicate the optimum locations of monitors.

These temperature monitors will provide warning of the spread of water with temperatures exceeding the 5°F limit for summer or the 10°F limit for winter. Such warning will allow station operators to vary the mode of plant operation to prevent further spreading. These methods preclude recirculation of heated effluents exceeding 5°F (or 10°F) above river ambient temperature.

The preliminary locations, the numbers and types of monitors, and the test procedures will be stated in the Technical Specifications.

3. Attraction of Fish to Intake Structure During Winter

Concern was expressed that heated water used for de-icing the intake structure might attract fish into the intake stream. The heated water would be taken in immediately with the intake water. The area of heated water created in Vernon Pond by such an operation should be relatively small in comparison with the discharge plume. It is very unlikely that such a small heated area would attract large numbers of fish.

D. SKIMMER WALL

Several agencies commented on the suggestion in the Draft Environmental Statement of constructing a skimmer wall (submerged baffle) at Vernon Dam that would enable the dam to use heated water off the top of the pond for turbine operation. This device was mentioned as a possible method to alleviate potential heated water conditions in Vernon Pond if complete mixing of the Vermont Yankee Station condenser cooling water and the pond does not occur. A concensus of agency comments indicates

a concern that such a device might adversely affect operation of fish passage facilities below the dam and may also, by transfer of warm water through the dam, be damaging to aquatic organisms downstream. The comprehensive thermal and biological monitoring program as previously described will determine the extent of the thermal plume and its mixing characteristics in Vernon Pond. If evaluation of the results of the monitoring program reveals unacceptable ecological damage in the pond, the applicant will be required to take corrective action.

E. ANADROMOUS FISH RESTORATION PROGRAM

Several agencies commented on the impact that the operation of the Vermont Yankee Station would have on the restoration of anadromous fish to the Connecticut River. The major comments concerned blockage of fish ladders with heated water, operation of plant during critical migration periods, and entrainment of immature and small fish migrating to the ocean. These comments are addressed in Sect. V.C.3.

F. USE OF HERBICIDES UNDER TRANSMISSION LINES

Some agencies commented on the use of herbicides by VELCO to control vegetation under transmission lines. VELCO's program consisted of applying a ground or basal spray of Amchem Weedone to stumps shortly after the right-of-way was cleared. This treatment was to control rapid growth of vegetation with strong root systems which can send up large sprouts within one year. This reduces the number of applications of herbicides required. After the basal spraying which was completed in the fall of 1971, the right-of-ways will not need to be treated for another six years. In accord with this schedule the right-of-ways will not be treated again until 1976-77. At that time, they would be treated every 2-3 years with Amchem 171DP. Only areas containing brush are sprayed and no defoliant spraying takes place when the vegetation is below 4 feet. Defoliant is not applied within 100 feet of streams to protect aquatic biota. Similarly, it is not applied within 100 feet of roadways or areas which have been selectively cut to reduce visual impact.

Amchem Weedone contains 2-4-5T as the active ingredient and is applied at a concentration of 4 pounds in 30 gallons of water. Amchem 171 DP contains 2-4-D and 2-4-DP as the active ingredient and is applied from a helicopter at a concentration of 6 pounds of active ingredient in 12 gallons of water to a brush acre. These chemicals are applied at a rate recommended for brush control in accordance with suggested precautions and labeled registration with the EPA and the U.S.D.A., as regulated by the Pesticide Advisory Council in the Vermont Department of Agriculture.

G. CLEARING OF FOREST AREAS IN PLANT & TRANSMISSION LINE CONSTRUCTION

A question was raised by one commenter concerning the amount of forest land cleared during plant and transmission line construction. The applicant has reported that no forest land was cleared in the construction of the Vermont Yankee Station. The procedures used in minimizing environmental impact of transmission line construction has been presented in public hearings before the Vermont Public Service Board and certificates of public good were issued in 1969, 1970 and 1971 (see Appendix I-A). Further details on transmission line location, alternatives considered, and methods of rights-of-way clearing which were used are provided in Section 5.5 of Volume I, Supplement to the Applicants' Environmental Report.

H. COOLING TOWER OPERATION

1. Extended Operation of the Cooling Towers

Comments were received that the cooling towers should be operated 8-9 months of the year and also that they should be operated until results of the biological monitoring program are known. The applicant is proposing to operate the towers in accord with State of Vermont and New Hampshire temperature standards. It is clear that the towers will be needed and will be operated during the summer to protect Vernon Pond when the ambient river temperatures are high. Similarly, once-through cooling will be used during the winter months (January-March), when river temperatures and biological productivity are low. During the spring and fall months, there will be times when the towers should be operated (low stream flows, high river temperatures, or both); likewise, there will be times during this period that once-through cooling could be used with minimal thermal effects in Vernon Pond. It is the staff's opinion that operation of the cooling towers should be based on an evaluation of the overall environmental effects (blowdown, drift, fogging, noise, aquatic) and economic costs to determine the optimum operating schedule. It is also believed that the flexible modes of cooling system operation available to the applicant and if the plant is operated in accord with the temperature limits and comprehensive thermal monitoring program outlined in this statement and detailed in the Technical Specifications, adequate ecological protection of Vernon Pond and the Connecticut River will be provided.

2. Atmospheric Effects of Cooling Towers

The estimated amount of fogging caused by cooling tower operation and possible remedies for this condition caused several comments. The staff feels that the small probability of excessive fogging and the lack of any basis for predicting the time of occurrence of such fogging preclude the establishment of operating controls at this time. The environmental effects

of cooling tower operation are clearly less than the effects of abruptly shutting down the station or of allowing full or partial operation of the station with the proposed temperature limits in abeyance.

I. RADIOACTIVE WASTE SYSTEMS

1. Iodine Adsorbers in the Station Ventilation System

A comment was received inquiring as to the benefits and costs of providing iodine adsorbers in the station ventilation systems. The Staff has not made a feasibility study of adding iodine adsorbers to the station ventilation systems. However, from analysis performed on other stations, it appears that the principal potential source of airborne radioiodine in ventilation systems is from steam leakage in the turbine building. If this source were treated, we would project total annual airborne I^{131} releases of less than 0.2 Ci/yr (with the augmented offgas system) rather than our present estimate of 0.6 Ci/yr. As indicated in Table III-2, the total I^{131} prior to installation of the augmented offgas system is 1.7 Ci/yr. Neither the applicant nor the AEC has performed cost estimates for this treatment system. The augmented offgas system, when installed, will reduce iodine releases to below the proposed Appendix I, 10 CFR Part 50, as finally adopted.

2. Use of an Evaporator for Chemical & Floor Drain Wastes

A comment was received requesting that the feasibility and need of adding an evaporator to treat the chemical and floor drain liquid waste be evaluated. The Staff has not studied the feasibility of adding an evaporator to the existing liquid radwaste treatment system. The need to add an evaporator to the system has been considered on the basis of operating experience at the Monticello Nuclear Generation Plant, a comparably sized BWR. At this plant, which uses a nonregenerative Powdex resin in the full flow condensate demineralizers and has no evaporator in the liquid waste system, nearly all the liquid influent to the radwaste system is returned for reuse within the plant. Based on this experience, the addition of an evaporator would not substantially reduce the radioactivity released in liquid effluents.

3. Doses From Secondary Gaseous Sources

One comment indicated that doses from secondary gaseous sources should be provided. The gaseous source term as presented in Table III-2 and the resulting doses, include containment venting, gland seal condenser venting, and radwaste and turbine ventilation. Turbine shine dose is discussed in Section XII.J.1.

J. RADIOLOGICAL IMPACT

1. Turbine Shine Radiation Dose

Several agencies inquired as to the reasons for differences in radiation dose estimates made by the AEC and the applicant for gamma shine (decay of ^{16}N in the station turbine) to students at the Vernon Elementary School. These differences result from different interpretation of the radiation measurements made at the Oyster Creek BWR. Interpretations can differ significantly due to assumptions regarding the effective source distribution within the reactor complex. It should be noted that at the low levels being considered and with the approximations necessary to make these estimates, the difference between 2 and 20 mrem/year (a factor of 10) is within the accuracy of the estimate.

It is also noted that recent radiation measurements have been made of the natural background in the Vernon schoolyard and in the school building which indicated radiation levels of 80 mrem/year and 105 mrem/year, respectively. In any case, the Vernon Elementary School will be monitored routinely by use of a pressurized ion chamber and thermoluminescent dosimeters as part of the environmental monitoring program.

2. Radioiodine Dose from Milk

A comment was received covering the overall grass-cow-milk food chain as a critical radiation pathway to man. In this regard it should be noted that Table A-7 indicates the locations of dairies by sector and the number of cows at these locations. Combining the milk from these dairies tends to reduce the effect of the iodine impact on any significant portion of the population. The calculated dose to the thyroid of a child based on combining or pooling milk is 1.3 mrem/year. There may be isolated instances where dairies do not pool their milk, and the dose to an individual could be higher. The highest calculated dose on a non-pooling basis would be about five times the average (approximately 6.5 mrem/year). These doses do not represent a significant radiological impact and are lower than any increment that can be reliably measured due to background fluctuations. When the extended hold-up charcoal system is used, the doses will be further reduced.

3. Radiological Effect of Gaseous Effluents

Meteorological assumptions used in computing radiological effects of gaseous effluents have not been provided in the environmental statement. This information is normally discussed in detail in the applicant's safety analysis report and is not duplicated in the environmental statement. Diffusion and other meteorological data for the Vermont Yankee Nuclear Power Station are provided in Appendices E and G of the applicant's Final Safety Analysis Report.

4. Strontium Bioaccumulation Factor (BAC)

The calculation of doses to fish properly include the contribution from ^{90}Sr accumulated in a fish's bones. However, since people eating fish do not normally consume the fish bones, this ^{90}Sr intake is avoided; hence a lower BAC is used to reflect this effect.

5. Estimated Doses to Individuals from Liquid Effluents

A comment was received that Table V-6 should contain whole body dose estimates for eating fish and drinking water as well as thyroid doses. Whole body doses are not cited because they are much less than thyroid doses. To cite whole body doses would be misleading since the controlling thyroid dose is more important.

K. PLANT ACCIDENT ANALYSIS

1. Assumed Release Rates for Failed Fuel and Radwaste Systems

A comment was made that the value for failed fuel used in the analysis of plant accidents and the value used for analysis of the radioactive waste treatment system should be the same although the difference in the level of risk associated with the present numbers is small. Consideration will be given to lowering the value presently specified for analysis of plant accidents in the proposed Annex to Appendix D of 10 CFR Part 50 to a level consistent with that used in the analysis of the radioactive waste treatment system. This would result in lower dose consequences for plant accidents than those indicated in Sect. VI.

2. Environmental Impact of Postulated Accidents

A comment was made that the environmental effects of releases to water are lacking. In this regard, the doses calculated as consequences of the postulated accidents are based on airborne transport of radioactive materials resulting in both a direct and an inhalation dose. Our evaluation of the accident doses assumes that the applicant's environmental monitoring program and appropriate additional monitoring (which could be initiated subsequent to an incident detected by in-plant monitoring) would detect the presence of radioactivity in the environment in a timely manner so that remedial action could be taken if necessary to limit exposure from other potential pathways to man. The small quantities of dispersed radioactive material which might enter the food chain would not be significant in terms of endangering aquatic life.

3. Radiation Doses From Certain Accident Classes

A comment was made that the doses from accident classes 1, 2 and 4.1 should be presented in the statement. These releases are included in the

estimates of routine release quantities and doses in Sections III and VI of this statement. Specific accident mechanisms have not been postulated for Classes 1.0 or 2.0 but operating experience has indicated that occassional minor releases, which are well within the routine effluent design objectives, can occur. It is anticipated that these events would result in doses less than one one-thousandth of the 10 CFR Part 20 limit.

L. RADIATION EXPOSURE DURING NORMAL TRANSPORT OF RADIOACTIVE MATERIALS

A comment was expressed that the exposures to truck drivers hauling irradiated fuel and solid wastes seem excessively high when compared to the 5 rem/yr radiation limit in plants and the 5 mrem/yr at the site boundary in proposed Appendix I to 10 CFR 50. It was also stated that a substantial effort should be devoted to reduction of truck drivers' exposure. In this regard, it is noted that the number of truck drivers who might receive the kinds of exposure referred to when transporting radioactive materials to and from Vermont Yankee is estimated to be about 4 during the year. These truck drivers will be subjected to the exposure as part of their employment as radiation workers. Furthermore, they may choose whether they want to drive a truck hauling radioactive material. Their employers are required by DOT regulations to give the drivers instructions necessary for handling the material safely.

The limits on radiation levels from shipment of radioactive materials used for estimating the exposures are imposed by the Department of Transportation regulations. Measures used for reducing the exposures include (1) reducing the quantity of radioactive material in each package; (2) increasing the amount of shielding in the package; and (3) adding shielding between the driver and the package.

M. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Comments were received regarding the ultimate use of the land directly beneath the reactor buildings. Leakage of radioactive materials beyond and below the reactor buildings is not expected. If required, the applicant could restore the entire plant area to its original condition, even to the extent of removing the reactor hardware and razing the buildings. If the plant were decommissioned, fuel and long-lived radioactive materials could be removed from the site; there would be no effect on local ground water or on the Connecticut River.

N. NEED FOR POWER

Two responders commented that the information from which the staff prepared their analysis of the need for power was either inadequate or out of date. The applicant pointed out that flooding of the Northfield Pumped Storage facility

has removed a generating source from availability; they will report the latest information on overall load demands and generation capability as soon as it is available. Section X has been revised to reflect information and data on energy needs and peak demands in the New England area which have become available to the staff.

O. COST-BENEFIT ANALYSIS

A request was received for an explanation of the basis for using a discount rate of 8.75% per year. The discount rate may be figured from the return on new investments in electric utilities. About 65% of such investments consists of bonds and preferred stock with a rate of return taken as 7% per year. The other 35% of the investments consists of common equity (common stock and retained earnings) with a rate of return taken as 12% per year. The weighted average is then (0.65 x 7%) + (0.35 x 12%) = 8.75% per year. These figures vary from time to time and from utility to utility but are believed to provide a reasonable basis for calculations of present worth in AEC environmental statements.

Present worth calculations have been modified and are in general agreement with the suggestions made in comments on the draft statement. Corrections consist primarily of present worthing the fuel and operating costs so as to take into account the five years between the present (1972) and the start of operation for an oil-fired plant. The $129,000,000 capital cost of the oil-fired plant has been divided into five equal yearly installments and its present worth, $101,000,000, is shown in Table XI-1.

One agency comment stated that the benefits of the plant primarily accrue to a larger segment of society than do the environmental costs. The region surrounding the small community of Vernon will feel the benefits of increased tax revenue and at least part of the salaries paid for plant operation as well as the benefits of power availability. Thus local environmental costs are at least partially balanced by local benefits.

It was also suggested that Table XI-1 should be expanded to include benefits from plant operation and impacts from the transmission lines. Table XI-1 is a comparison of economic and environmental costs of four alternatives. Benefits are primarily the result of power generation and therefore are essentially independent of the particular alternative considered. Considerations of benefits are incorporated in the text of the statement.

Since the alternatives chosen for tabular comparison do not include either a different site or the purchase of power, the impact of transmission lines would be the same for each of the alternatives tabulated.

P. EFFLUENTS FROM AUXILIARY POWER SOURCES

The Vermont Yankee Station has two diesel-powered generators as emergency sources of on-site power. These units are normally on standby; however, they are tested monthly as part of the maintenance program for emergency equipment. Each diesel generator is rated at 3000 kW and consumes 220 lb/hr of No. 2 fuel oil when in operation. The station also has two 400-bhp fire-tube auxiliary boilers to provide steam for space heating and process requirements. Each boiler uses about 120 lb/hr of No. 2 fuel oil when operated at full capacity.

Although none of these units is large enough to be considered a point source of air pollution, the applicant should use low-sulfur oil to reduce the possibility of noxious emissions. Combustion of 100,000 gallons of No. 2 fuel oil, with a density of 0.83 g/cc and 0.2% sulfur, would result in emission of more than 1 ton of SO_2 and almost 2 tons of NO_x each year.

Q. LOCATIONS OF PRINCIPAL CHANGES IN THIS STATEMENT IN RESPONSE TO COMMENTS

TOPICS COMMENTED UPON	SECTION WHERE TOPICS ARE ADDRESSED
Population Density	I.A
Contacted State Historical Officials	II.D
Weather Records	II.E.1
Summary of Water Quality Data	Table II-2
Sampling of Benthic Fauna	II.F.6
Comparison of Fish Captured	Table II-8
Transmission Lines	III.B, V.A.2
Herbicides Use	III.B
Cooling Tower Noise	III.D.1
Temperature Predictions	III.D.1
Mathematical Models and Dye Studies	III.D.1
Cadmium and Mercury Monitoring	III.D.3
Cooling Tower Drift	III.D.3
Exclusion Zone	V.A.1
Psychological Barrier Against Nuclear Power	V.A.1
Cooling Tower Noise	V.A.3
Entrainment of Biota	V.C.2
Anadromous Fish Restoration Program	V.C.3

Potential Fish Kills at Intake Structure	V.C.4
Effects of Thermal Release on Dissolved Oxygen	V.C.4
Total Residual Chlorine Analyzer	V.C.4
Biological Monitoring Program	V.C.5
Thermal Monitoring	V.C.7
Radiation Dose from Milk	V.D.3
Dose Evaluation from Gaseous Effluents	Table V-7 & V-8
Environmental Radiation Monitoring	V.D.5
Need for Power	X
Cost-Benefit Analysis	XI.A.1, 3 & 8; XI.B.6, 7 & 8; Table XI-1
Estimation of Potential Dose Increments from Gaseous Effluents	App. V-A.C

Where comments raised questions which are adequately answered by material carried over in the same form that it appeared in the draft statement, no attempt is made to address such comments in this section of the final statement.

APPENDIX I-A

Listing of Government Agency Applications, Permits, and Actions Involving the Vermont Yankee Nuclear Power Station

Government Agency or Organization	Dates of Action	Subject or Agreement
	Federal	
Atomic Energy Commission	11-30-66	Applicant's application to AEC for construction permit
	8-1-67 8-2-67 9-6-67 9-7-67	Public hearing (Brattleboro, Vermont) on provisional construction permit
	12-11-67	Provisional construction permit issued by AEC
	1-28-69 2-18-69	Public hearings (Washington, D.C.) on financial qualification of applicant
	6-19-70	AEC request to applicant for environmental data
	8-12-70	Construction Permit CPPR-36 issued by AEC
	9-4-70	Construction Permit supplemented
	8-26-70	Applicant submits Environmental Report to AEC
	9-23-70	(1) Applicant's Environmental Report made available to public and sent to Federal Register for filing and publication (published 9-26-70; 35 F.R. 15026) (2) Copy of notice sent to applicant (3) Copies of report sent to Council on Environmental Quality, appropriate Federal Agencies, and State of Vermont Agency on Environmental Conservation
	11-13-70	Applicant submits Water Quality Certification
	11-19-70	AEC letter to applicant transmitting comments from HUD, DOD, N.H. Fish and Game Department, and N.H. Water Supply and Pollution Control Commission
	12-7-70	AEC letter to applicant transmitting HEW and USDA comments
	12-11-70	Applicant's Water Quality Certification sent to Environmental Protection Agency (EPA)
	12-24-70	Copy of applicants Environmental Report sent to Chairman, Vernon, Vermont, Board of Selectmen
	1-7-71	AEC letters to State of New Hampshire Fish and Game Department and Water Supply and Pollution Control Commission
	1-14-71	AEC letter to applicant transmitting FPC, DOI, and State of Vermont comments, and AEC responses to N. H. Fish and Game Department, and Water Supply and Pollution Control Commission
	2-18-71	AEC request to applicant for additional information

Government Agency or Organization	Dates of Action	Subject or Agreement
	2-24-71	(1) Notice of availability of AEC Draft Detailed Environmental Statement (DDES) sent to Federal Register for filing and publication (2) Copy of AEC-DDES sent to applicant (3) Copies of AEC-DDES sent to Council on Environmental Quality, appropriate Federal and State Agencies (VT., N.H., and Mass.)
	3-30-71	Applicant's letters to AEC requesting additional information
	4-1-71	Applicant's letter to AEC in response to AEC's letter of 2-18-71
	6-1-71	Detailed Environmental Statement (DES) on Vermont Yankee Station issued by AEC
	6-7-71	Copies of AEC-DES sent to Council on Environmental Quality and appropriate Federal, State, and Local Agencies (Vt., N.H., and Mass.)
	6-14-71	Safety evaluation of the Vermont Yankee station issued by AEC and supplemented on 6-19-71
	9-3-71	AEC letter to applicant requesting compliance with "Calvert Cliffs" decision, and revision to Appendix D, 10CFR50, regarding scope of applicants Environmental Report with respect to Transportation, Transmission Lines, and Accidents
	12-21-71	Applicant submits "Supplement to the Environmental Report," updating previous versions
	12-27-71	Copies of Applicant's Supplemental Report (Vol. 1 and 2) sent to appropriate Federal Agencies
AEC Public Hearings	8-1-67 8-2-67 9-6-67 9-7-67	In Brattleboro, Vermont, on provisional construction permit (AEC)
	1-28-69 2-18-69	In Washington, D.C., on financial qualification of applicant (AEC)
	8-10-71 11-29-71 12-2-71 1-31-72 3-13-72	In Brattleboro, Vermont, on issuance of an operating license (AEC)
Department of Housing and Urban Development (HUD)	9-23-70	Applicant's Environmental Report sent to HUD
	10-12-70	Comments to AEC from HUD on Report
	11-19-70	HUD comments sent to applicant

Government Agency or Organization	Dates of Action	Subject or Agreement
Department of Defense (DOD)	9-23-70	Applicant's Environmental Report sent to DOD
	10-28-70	Comments to AEC from DOD on Report
	11-19-70	DOD comments sent to applicant
	12-28-70 1-28-71	Applicant's responses to DOD
U.S. Department of Agriculture (USDA)	9-23-70	Applicant's Environmental Report sent to USDA
	11-17-70	Comments to AEC from USDA on Report
	12-7-70	USDA comments sent to applicant
U.S. Department of Health, Education, and Welfare (HEW)	9-23-70	Applicant's Environmental Report sent to HEW
	12-1-70	Comments to AEC from USDA on Report
	12-7-70	HEW comments sent to applicant
	1-28-71	Applicant's response to HEW
Federal Power Commission (FPC)	7-31-70	Order from FPC approving use of project lands and reservoir
	9-23-70	Applicant's Environmental Report sent to FPC
	12-8-70	Comments to AEC from FPC on Report
	1-14-71	FPC comments sent to applicant
Department of Transportation (DOT)	2-24-71	AEC Draft Detailed Environmental Statement sent to DOT
	3-26-71	Comments to AEC from DOT
U.S. Department of the Interior (DOI)	9-23-70	Applicant's Environmental Report sent to DOI
	12-30-70	Comments to AEC from DOI on Report
	1-14-71	DOI comments sent to applicant
	2-2-71	Applicant's response to DOI
	5-7-71	Comments to AEC from DOI
Council on Environmental Quality (CEQ)	9-23-70	Applicant's Environmental Report sent to CEQ
	2-24-71	AEC Draft Detailed Statement sent to CEQ
Environmental Protection Agency (EPA)	2-18-71	EPA (Boston Regional Office) letter to Massachusetts and New Hampshire advising of Water Quality Certification issued by Vermont
Federal Aviation Administration (FAA)	4-4-69	Letter from FAA to applicant approving construction of Vermont Yankee Station plant stack
	5-16-69	Letter from FAA to applicant approving construction of meteorological tower
	State	
State of Vermont	9-23-70	Applicant's Environmental Report sent to State of Vermont Agency on Environmental Conservation
	11-23-70	Telegram from Vermont Attorney General and Vermont State Board of Health requesting extension of time to file letter and AEC letter, dated 12-1-70, granting request

Government Agency or Organization	Dates of Action	Subject or Agreement
	12-10-70	Letter from Attorney General of Vermont requesting extension of time for comments and AEC letter, dated 1-27-71, granting request
	12-18-70	Comments from State of Vermont
	12-18-70	Letter from State of Vermont transmitting comments of Dr. Irving Lyon
	1-14-71	AEC letter to applicant transmitting comments from State of Vermont
	2-10-71	Applicant's response to State of Vermont's comments
	2-24-71	AEC Draft Detailed Statement sent to State of Vermont
Vermont Water Resources Board (VWRB)	6-10-68	Petition of Vermont Yankee Nuclear Power Corporation presented to VWRB for Discharge of Cooling Water and Radioactive Substances to the Connecticut River, Vernon, Vermont
	8-24-70	Application to VWRB for certification that discharges into Connecticut River will not violate applicable water quality standards
	10-29-70	Approval of VWRB that discharges into Connecticut River will not violate applicable water quality standards
	11-26-71	Amendment to VWRB approval of 10-29-70, adding certain restrictions
	11-29-71	Letter from VWRB (M. L. Johnson) to Vermont Yankee Nuclear Power Corporation stating restriction on discharges to Connecticut River of liquid radwaste
Vermont Water Resources Board Public Hearings	8-21-67 9-5-67 11-30-67 7-9-71	Public hearings in Brattleboro, Vermont before the Vermont Water Resources Board, on water quality of discharges of Vermont Yankee Station into Connecticut River
Vermont Department of Water Resources (VDWR)	9-9-68	Vermont Yankee proposal for water quality and biological studies found to be satisfactory by VDWR (letter)
	2-3-69	Approval from VDWR of Environmental Radiation Surveillance Program of Vermont Yankee Nuclear Power Corporation (Dated 1-8-69 and submitted to VDWR on 1-21-69) (letter)
	4-23-69	Approval from VDWR of application from Vermont Yankee for permission to alter or divert a natural stream on the Connecticut River at Vernon, Vermont (letter)
	9-5-69	Approval by VDWR of concept of proposed ecological studies by Vermont Yankee (letter)
	9-18-69	Preliminary outline of radiation emergency plan for Vermont Yankee Station approved as adequate for developing detailed plan
	10-1-69	Approval by VDWR of concept and location of Water Quality monitor station No. 7 for Vermont Yankee Station

Government Agency or Organization	Dates of Action	Subject or Agreement
	10-2-69	Approval by VDWR of designs for intake and discharge structures, with certain restrictions
	11-30-71	Discharge permit from VDWR for Vermont Yankee Station
Vermont Department of Health (VDH)	2-5-70	Approval by VDH of sewage disposal system for Vermont Yankee Nuclear Power Station
	8-5-70	Approval by VDH of plans for plumbing and drainage system for Vermont Yankee Station
Vermont Public Service Board	12-31-69	Certificate of Public Good, No. 3384, issued
	6-12-70	Certificate of Public Good, No. 3412, issued; supplemental findings (1-15-71); second supplemental findings (6-8-71)
State of New Hampshire	2-24-71	AEC Draft Detailed Environmental Statement sent to state of N.H.
	4-21-71	Request to AEC from State of N.H. for hearing on Water Quality Certification
New Hampshire Fish and Game Department	9-23-70	Applicant's Environmental Report sent to N.H. Fish and Game Department
	10-23-70	Comments from N.H. Fish and Game Department
	11-19-70	AEC letter to applicant transmitting comments from N.H. Fish and Game Department
	1-7-71	AEC letter to N.H. Fish and Game Department
	1-14-71	AEC letter to applicant transmitting AEC response to N.H. Fish and Game Department
New Hampshire Water Supply and Pollution Control Commission	9-23-70	Applicant's Environmental Report sent to N.H. Water Supply and Pollution Control Commission
	11-2-70	Comments from N.H. Water Supply and Pollution Control Commission
	11-19-70	AEC letter to applicant transmitting comments from N.H. Water Supply and Pollution Control Commission
	1-7-71	AEC letter to N.H. Water Supply and Pollution Control Commission
	1-14-71	AEC letter to applicant transmitting AEC response to N.H. Water Supply and Pollution Control Commission
	3-2-72	Issued water quality permit to Vermont Yankee Nuclear Power Corporation
Public Utilities Commission of New Hampshire	6-16-69	License for two-span crossing, Order No. 9728, issued
State of Massachusetts	2-24-71	AEC Draft Detailed Environmental Statement sent to State of Massachusetts
	4-23-71	Comments to AEC from State of Massachusetts
	Local	
Board of Selectmen, Vernon, Vermont	12-24-70	Copy of applicant's Environmental Report sent to Chairman, Board of Selectmen, Vernon, Vermont
	2-24-71	Copy of AEC Draft Detailed Statement sent to Chairman, Board of Selectmen, Vernon, Vermont

APPENDIX V-A

ESTIMATION OF POTENTIAL DOSES AND DOSE COMMITMENTS

A. GENERAL

The consequences of each type of effluent has been examined in turn. The various components of external and internal dose which are significant are then summed and evaluated.

B. ESTIMATES OF DOSE INCREMENTS FROM LIQUID EFFLUENTS

The sources and processing of radioactive wastes are discussed in Sect. III.D.2.a, in which is presented the composition of the mixture of effluent radionuclides. This mixture has been used as the source term in calculations of dose estimates for ingesting fish, swimming in the river, and drinking river water. The various isotopes of the mixture are presented in Table A-1 together with the percentages of their presence as weighting factors. Given herein, also, are values of dose per unit intake for individual component isotopes and the food chain concentration factors used, as well as submersion exposure rates per unit concentration. This permits consideration of the relative importance of constituent discharged radionuclides. As an upper bound for the dose estimates, it is assumed as a starting point that exposures involve the water discharged as effluent from the site. The discharge flow under open-cycle operation is 386,000 gpm (860 cfs, 210.4×10^{10} ml/day). However, subject to compliance with limitations on the thermal rise of the receiving waters (according to river temperature values shown in Fig. II-10), the cooling towers will have to be used at least 30% of the year. When the cooling towers are used on closed cycle, the discharge flow is reduced to 20,000 gpm (44.6 cfs, 10.9×10^{10} ml/day). The expected maximum volume of water discharged is thus 14.5×10^{10} gal/year (55×10^{13} ml/year). The predicted annual quantity of radioactivity in the liquid waste effluents, exclusive of tritium, is given in the source term as 4.9 Ci, compared with the suggested guidance value of 5.0 Ci/year in 10 CFR 50, proposed Appendix I. The resultant average annual concentration of the effluent water is 8.9×10^{-9} µCi/ml, a factor of approximately 2.2 below the suggested guidance value of 2×10^{-8} µCi/ml, in proposed Appendix I to 10 CFR 50. Average exposure concentrations should be less than this locally, or anywhere in the river above Vernon Dam, regardless of what diffusion and dispersion patterns result from the thermal content of the discharged waters. Neither will there be a significant influence on this postulated maximum from the effects of potential thermal stratification or the intermittent drawdown of Vernon Pond by peak load requirements for operation of the hydroelectric plant.

Table A-1. Detail for estimates of radiation dose to individuals from liquid effluents

Isotope	Reference organ[a]	Percent composition	Drinking water: Unit dose[b] (millirems/μCi)	Drinking water: Weighted dose[c] (millirems/μCi)	Eating fish: Bioaccumulation factor $\left(\frac{\mu Ci/g}{\mu Ci/ml}\right)$	Eating fish: Weighted bioaccumulation factor (μCi/g at 1 μCi/ml)	Eating fish: Weighted dose[d] (millirems/g at 1 μCi/ml)	Submersion[e]: Unit dose (millirems/year at 1 μCi/ml)	Submersion[e]: Weighted dose (millirems/year)
^{24}Na	GI	0.0428	9.7	0.0042	32	0.0137	0.133	7.70×10^5	0.33×10^3
^{32}P	BN	0.0306	193.8	0.0593	100,000	30.6	5,930.28	0.0	0.0
^{51}Cr	GI	0.8151	0.97	0.0079	200	1.630	1.581	5.66×10^3	0.05×10^3
^{54}Mn	GI	0.0713	19.4	0.0138	25	0.0178	0.345	1.57×10^5	0.11×10^3
^{55}Fe	SPN	3.6679	2.46	0.0902	300	11.004	27.070	1.87×10^3	0.07×10^3
^{59}Fe	GI	0.1345	32.3	0.0434	300	0.4035	13.033	2.25×10^5	0.30×10^3
^{58}Co	GI	8.5584	19.4	1.6603	500	42.792	830.165	1.83×10^5	15.66×10^3
^{60}Co	GI	0.8966	38.8	0.3479	500	4.483	173.940	4.68×10^5	4.20×10^3
^{65}Zn	TB	0.0018	6.5	0.0001	1,000	0.018	0.117	1.02×10^5	0.0
^{69m}Zn	GI	0.0004	32.3	0.0001	1,000	0.004	0.129	7.80×10^4	0.0
^{89}Sr	BN	9.1697	310.3	28.4536	15	1.375	426.663	0.0	0.0
^{90}Sr	BN	0.5909	8312.0	49.1156	15	0.0886	736.443	0.0	0.0
^{91}Sr	GI	0.0090	38.81	0.0035	15	0.0014	0.054	1.58×10^5	0.01×10^3
^{90}Y	GI	2.0377	97.02	1.9770	100	2.0377	197.698	0.0	0.0
^{91m}Y	GI	0.5706	0.65	0.0037	100	0.5706	0.371	9.86×10^4	0.56×10^3
^{91}Y	GI	4.4830	64.68	2.8996	100	4.483	289.960	6.77×10^2	0.03×10^3
^{93}Y	GI	0.0897	64.68	0.0580	100	0.0897	5.802	1.89×10^4	0.02×10^3
^{95}Zr	GI	0.0958	32.34	0.0310	10	0.0096	0.310	1.37×10^5	0.13×10^3
^{97}Zr	GI	0.0016	97.0	0.0016	10	0.0002	0.019	9.46×10^3	0.0
^{95}Nb	GI	0.0978	19.40	1.8973	10	0.0098	0.190	1.42×10^5	0.14×10^3
^{97m}Nb	*f*	0.0015	*f*		10	0.0002		1.38×10^5	0.0
^{97}Nb	GI	0.0002	2.16	0.0004	10	0.0	0.0	1.25×10^5	0.0
^{99}Mo	KID	1.9358	10.1	0.1955	100	1.9358	19.552	2.34×10^4	0.45×10^3
^{99m}Tc	GI	1.8543	0.65	0.0121	1	0.0185	0.012	2.43×10^4	0.45×10^3
^{103}Ru	GI	0.0693	24.3	0.0168	100	0.0693	1.684	9.02×10^4	0.06×10^3
^{106}Ru	GI	0.0224	194.0	0.0435	100	0.0224	4.346	0.0	0.0
^{103m}Rh	GI	0.0693	0.19	0.0001	100	0.0693	0.013	4.01×10^3	0.0
^{105}Rh	GI	0.0067	19.4	0.0013	100	0.0067	0.130	5.85×10^3	0.0
^{106}Rh	*f*	0.0224	*f*		100	0.0224		5.23×10^4	0.01×10^3
^{127m}Te	KID.	0.0198	36.0	0.0071	400	0.0792	2.851	1.66×10^4	0.0
^{127}Te	GI	0.0204	6.47	0.0013	400	0.0816	0.528	7.14×10^2	0.0
^{129m}Te	GI	0.1854	97.02	0.1799	400	0.7416	71.950	5.96×10^3	0.01×10^3

Table A-1. (Continued)

Isotope	Reference organ[a]	Percent composition	Drinking water: Unit dose[b] (millirems/μCi)	Drinking water: Weighted dose[c] (millirems/μCi)	Eating fish: Bioaccumulation factor $\left(\frac{\mu Ci/g}{\mu Ci/ml}\right)$	Eating fish: Weighted bioaccumulation factor (μCi/g at 1 μCi/ml)	Eating fish: Weighted dose[d] (millirems/g at 1 μCi/ml)	Submersion[e]: Unit dose (millirems/year at 1 μCi/ml)	Submersion[e]: Weighted dose (millirems/year)
^{129}Te	GI	0.1182	2.43	0.0029	400	0.4728	1.149	4.53×10^4	0.05×10^3
^{131m}Te	GI	0.0204	48.51	0.0099	400	0.0816	3.958	3.50×10^5	0.07×10^3
^{131}Te	f	0.0039	f		400	0.0156		7.39×10^4	0.0
^{132}Te	GI	0.8151	97.02	0.7908	400	3.260	316.285	4.56×10^4	0.37×10^3
^{130}I	THY	0.0020	279.0	0.0056	50	0.0010	0.279		
^{131}I	THY	24.4525	1922.0	469.977	50	12.2263	23,498.95	7.52×10^4	18.39×10^3
^{132}I	THY	0.8558	69.31	0.5932	50	0.4279	29.658	4.10×10^5	3.51×10^3
^{133}I	THY	2.8528	516.5	14.7347	50	1.4264	736.736	1.10×10^5	3.14×10^3
^{135}I	THY	0.0026	160.1	0.0042	50	0.0013	0.208	6.11×10^5	0.02×10^3
^{134}Cs	LVR	5.0943	139.3	7.0964	1,000	50.943	7,096.36	2.95×10^5	15.03×10^3
^{136}Cs	TB	1.4875	32.34	0.4811	1,000	14.875	481.058	4.34×10^5	6.46×10^3
^{137}Cs	LVR	3.8716	110.1	4.2626	1,000	38.716	4,262.63	0.0	0.0
^{137m}Ba	f	0.7336	f		10	0.0734		1.13×10^5	0.83×10^3
^{140}Ba	GI	13.2451	97.02	12.8504	10	1.3245	128.503	3.87×10^4	5.13×10^3
^{140}La	GI	10.1885	97.02	9.8849	100	10.189	988.537	4.57×10^5	46.56×10^3
^{141}Ce	GI	0.1019	21.56		100	0.1019	2.197	1.52×10^4	0.02×10^3
^{143}Ce	GI	0.0102	48.51		100	0.0102	0.495	1.17×10^5	0.01×10^3
^{144}Ce	GI	0.0652	194.0	0.1265	100	0.0652	12.649	3.97×10^3	0.0
^{143}Pr	GI	0.0815	38.8	0.0316	100	0.0815	3.162	0.0	0.0
^{144}Pr	f	0.0652	f		100	0.0652		5.75×10^3	0.0
^{147}Nd	GI	0.0326	32.3	0.0105	100	0.0326	1.053	3.26×10^4	0.01×10^3
^{187}W	GI	0.3260	32.34	0.1054	15	0.0489	1.581	1.08×10^5	0.35×10^3
Total									122.54×10^3[g]

[a]This is the organ receiving the largest dose commitment. GI, gastrointestinal tract; BN, bone; SPN, spleen; TB, total body; KID, kidney; THY, thyroid; LVR, liver.

[b]Normally based on soluble isotope; for GI, the larger dose (soluble or insoluble) is used.

[c]To estimate total dose per year of effluent discharge, multiply by concentration of this mixture of radionuclides in water (μCi/ml) and by the annual intake (1200 ml/day × 365 days/year). The component doses are summed for like organs to get the differing organ doses.

[d]To estimate total dose per year of effluent discharge, multiply by concentration of this mixture of radionuclides in water (μCi/ml) and by the assumed annual intake (approx 6350g). The component doses are summed for like organs to get the differing organ doses.

[e]Assumes submersion only 1% of year.

[f]Assumes internal dose contribution of this daughter isotope is considered in connection with the parent.

[g]To estimate total dose per year of effluent discharge, multiply by concentration of this mixture of radionuclides in water (μCi/ml).

Below the dam the average concentration is found by dividing the annual release of activity (4.9 Ci/year) by the total average annual flow (10,166 cfs = 9.1×10^{15} ml/year) as noted in the text portion of the report. Actual average concentrations will be less than this because of successive dilutions by tributaries, adsorption losses, etc.

1. Eating Fish

The uptakes of different isotopes by fish from the water in which they live and by lower elements of the food chain on which fish prey are different. This results from the specific behavior of different chemical elements in the metabolic processes encountered in the food chain. Based on the best available realistic values for uptake, considered as "bioaccumulation factors," the resulting activity per gram of fish flesh for each constituent isotope may be calculated from its concentration in the water of the fish's habitat. To these values "dose factors" are applied that are the dose commitment components resulting from unit intakes of the corresponding isotope. With a postulated average dietary intake from sport fish, in this case approximately 20 g/day, the potential dose commitment can be calculated. This is done for exposure components to the whole body, bone, thyroid, liver, kidneys, and gastrointestinal tract. These respective components from the constituent isotopes as reconcentrated are summed and the maximum reported.

2. Swimming

The exposure rate per unit concentration of each isotope of the source is applied to the respective concentrations of the mixture under the postulated dilution conditions. The sum of these component exposures is considered to apply for the time interval postulated.

Closed-cycle operation of the cooling towers, with only 20,000 gpm (44.6 cfs, 10.9×10^{10} ml/day) released from the plant will coincide with much of the warm weather favored for swimming. Thus for swimming in Vernon Pond, even if the river flow were only the guaranteed minimum of 1200 cfs, the released liquid effluent would be diluted greatly. The extent of this probable dilution indicates the factor by which the dose may have been overestimated.

3. Drinking Water

The case of drinking untreated water from the Connecticut River has been examined as a potential exposure pathway. The dose commitment per unit ingestion intake of each respective component isotope of the mixture

released is applied to the corresponding concentration of that isotope. These dose commitments from each isotope to the different body organs are calculated on the basis of a standard drinking water consumption per year and summed, with the maximum reported. The maximum concentrations available are found only at the discharge outfall from the plant. That an individual would use this as his sole annual source of drinking water is not credible. This, however, is an upper limit estimate which amounts to a dose commitment of 1.7 mrem/year to the thyroid.

A more realistic estimate of the conceivable, although unlikely, dose increment from year-round consumption of untreated river water should use the yearly average river flow rate (based on 20 years) of 10,166 cfs (4.56×10^6 gpm, 2.49×10^{13} ml/day). This amounts to a total annual flow volume of 9.1×10^{15} ml. The maximum total annual amount of radioactivity in the released liquid waste effluents was calculated, above, to be 4.9 Ci for the postulated composition. This gives an annual average concentration in the river of 5.4×10^{-10} μCi/ml. Drinking river water at this concentration throughout the year would result in a dose increment of 0.11 mrem/year.

The estimate of dose in the paragraph above would apply only below Vernon Dam, as the lack of data on diffusion, dispersion, thermal stratification, and drawdown effects does not permit realistic estimates of concentrations in various parts of Vernon Pond. An estimate is feasible of average exposures resulting from drinking water below the dam for only a part of the year, with suitable adjustment for the fraction of the year applicable.

Occasional use of the Connecticut River as a source of drinking water by swimmers, fishermen, or even summer houseboat residents does not represent a regular, continuing, or significant intake. There are no data available to estimate the numbers of such users or the extent of their consumption of untreated river water.

The increments of exposure possibly sustained by those receiving their drinking water from Quabbin Reservoir have been estimated and discussed in Sect. V.D.2.

4. Exposure Pathways of Minor Importance

Calculations were not made of the potential exposure from use of Connecticut River water for irrigation, as no instances of this usage are known. Nor was consideration given to the ingestion of ^{131}I by cows which might drink water from the Connecticut River. If there are any such dairy cattle, their numbers are not considered to be significant.

The Connecticut River below Vernon Dam already receives liquid radioactive waste contributions from two existing nuclear power plants. Yankee-Rowe, on the Deerfield River which drains into the Connecticut River at Greenfield, Massachusetts, released 0.034 Ci in 1970.[2] This had no radiological health significance with respect to public water supply, because the Connecticut River below this confluence is not used for this purpose. Connecticut Yankee at Haddam was reported to have released 3.9 Ci in 1968.[3] The same conclusion of lack of significance applies to the approximately 18 miles of Connecticut River between Connecticut Yankee and Long Island Sound. It, therefore, follows that the radioactive liquid wastes discharged from existing nuclear power plants impose no restraint on the operations of Vermont Yankee.

In view of the applicant's capability to control the timing and the amounts of liquid radioactive wastes he will discharge, and the low exposure potential of the conservative estimates made in Sect. V.D.2, the radiological impact of these wastes appears acceptable.

C. POTENTIAL DOSE INCREMENTS FROM GASEOUS EFFLUENTS

The off-gas system and gas-borne radioisotopes released via the stack are discussed in Sect. III.D.2.b and listed in Table III-2. Exposure concentrations were calculated using a meteorological dispersion computer code;[4] the results were converted to appropriate estimates of dose increments from immersion, inhalation, and deposition using another computer code.[5] The values of dose increments for the postulated off-gas release condition of operation (and source term) are tabulated for a number of distances and directions in Tables A-2 through A-4. From these doses, values can be selected that are applicable to individual members of particular local subpopulation groups in which there may be an interest. These values of dose are cited in Sect. V.D.3, Table V-7. These dose estimates are considered to be upper limit values because: (1) the source terms are based on maximum leakage at the end of the fuel cycle, hence average values should be significantly less, and (2) environmental decay by weathering and leaching of daughters of noble gases that are deposited on the surface of the soil has been ignored.

The only nuclear production or utilization facility within the 50-mile radius of Vermont Yankee is the Yankee Nuclear Power Station at Rowe, Massachusetts. This facility has been the subject of surveillance studies[2] which indicated maximum exposure rates, corrected for background, at its northeast perimeter of 3 μr/hr dropping to 0.3 ± 0.3 μr/hr within a kilometer. (These measurements are essentially at the threshold of sensitivity of the instruments used.) The maximum exposure rate would correspond to 26 mrems/year at the perimeter, while a calculation in the report on these surveillance studies showed that the 17.2 Ci/year (beta-gamma) of effluent gaseous releases

Table A-2. Estimated Immersion Doses to Individuals from Gaseous Effluents (mrem per year of Discharge) by Distance (meters) and Direction

VERMONT YANKEE

TOTAL DOSE

DISTANCE	E	ENE	NE	NNE	N	NNW	NW	WNW
805.	0.2886E 01	0.1267E 01	0.6808E 00	0.1185E 01	0.2558E 01	0.1902E 01	0.1817E 01	0.2391E 01
1609.	0.5172E 01	0.2483E 01	0.1894E 01	0.2479E 01	0.5660E 01	0.6000E 01	0.6284E 01	0.7593E 01
3218.	0.4131E 01	0.1768E 01	0.1499E 01	0.1982E 01	0.5017E 01	0.6433E 01	0.5911E 01	0.6070E 01
4827.	0.3247E 01	0.1295E 01	0.1073E 01	0.1555E 01	0.4000E 01	0.5430E 01	0.4744E 01	0.4332E 01
6436.	0.2538E 01	0.9744E 00	0.7918E 00	0.1208E 01	0.3114E 01	0.4299E 01	0.3715E 01	0.3168E 01
8045.	0.2023E 01	0.7562E 00	0.6066E 00	0.9550E 00	0.2465E 01	0.3419E 01	0.2952E 01	0.2406E 01
16090.	0.7778E 00	0.2689E 00	0.2053E 00	0.3437E 00	0.9226E 00	0.1226E 01	0.1049E 01	0.7808E 00
32187.	0.2286E 00	0.7281E-01	0.5115E-01	0.8903E-01	0.2637E 00	0.3135E 00	0.2569E 00	0.1778E 00
48280.	0.1035E 00	0.3129E-01	0.2086E-01	0.3726E-01	0.1184E 00	0.1294E 00	0.1034E 00	0.6840E-01
64374.	0.5664E-01	0.1641E-01	0.1050E-01	0.1926E-01	0.6486E-01	0.6608E-01	0.5197E-01	0.3333E-01
-80467.	0.3461E-01	0.9665E-02	0.5971E-02	0.1126E-01	0.3991E-01	0.3826E-01	0.2969E-01	0.1864E-01

DISTANCE	W	WSW	SW	SSW	S	SSE	SE	ESE
805.	0.4580E C0	0.2977E 00	0.3315E 00	0.1022E 01	0.2970E 01	0.9186E 01	0.5235E 01	0.4413E 01
1609.	0.2110E 01	0.1847E 01	0.1732E 01	0.2600E 01	0.6295E 01	0.1905E 02	0.1135E 02	0.7934E 01
3218.	0.1795E 01	0.1637E 01	0.1489E 01	0.1910E 01	0.4835E 01	0.1474E 02	0.8780E 01	0.6001E 01
4827.	0.1248E 01	0.1102E 01	0.1006E 01	0.1335E 01	0.3640E 01	0.1113E 02	0.6646E 01	0.4454E 01
6436.	0.9000E 00	0.7766E 00	0.7023E 00	0.9650E 00	0.2755E 01	0.3449E 01	0.5066E 01	0.3367E 01
8045.	0.6813E 00	0.5782E 00	0.5144E 00	0.7251E 00	0.2138E 01	0.6579E 01	0.3963E 01	0.2628E 01
16090.	0.2157E 00	0.1771E 00	0.1504E 00	0.2275E 00	0.7387E 00	0.2347E 01	0.1436E 01	0.9795E 00
32187.	0.4342E-01	0.3536E-01	0.2878E-01	0.4920E-01	0.1845E 00	0.5363E 00	0.3975E 00	0.2883E 00
48280.	0.1520E-01	0.1232E-01	0.9698E-02	0.1832E-01	0.7557E-01	0.2747E 00	0.1747E 00	0.1312E 00
64374.	0.6982E-02	0.5599E-02	0.4343E-02	0.8846E-02	0.3863E-01	0.1452E 00	0.9389E-01	0.7228E-01
80467.	0.3771E-02	0.2978E-02	0.2304E-02	0.4963E-02	0.2243E-01	0.3649E-01	0.5678E-01	0.4448E-01

21,600 μCi/sec (6.81 × 10^5 Ci/year).

Table A-3. Estimated Inhalation Doses to Individuals from Gaseous Effluents (mrem per year of Discharge) by Distance (meters) and Direction

VERMONT YANKEE

TOTAL DOSE

DISTANCE	E	ENE	NE	NNE	N	NNW	NW	WNW
805.	0.3225E-02	0.1764E-02	0.1126E-02	0.1668E-02	0.3379E-02	0.3397E-02	0.3447E-02	0.4500E-02
1609.	0.1310E-01	0.7346E-02	0.7531E-02	0.7785E-02	0.1808E-01	0.2319E-01	0.2736E-01	0.3286E-01
3218.	0.1711E-01	0.8281E-02	0.8573E-02	0.9911E-02	0.2420E-01	0.3531E-01	0.3553E-01	0.3739E-01
4827.	0.1668E-01	0.7357E-02	0.6886E-02	0.9338E-02	0.2253E-01	0.3438E-01	0.3168E-01	0.2956E-01
6436.	0.1481E-01	0.6161E-02	0.5420E-02	0.7983E-02	0.1917E-01	0.2929E-01	0.2616E-01	0.2261E-01
8045.	0.1281E-01	0.5101E-02	0.4319E-02	0.6600E-02	0.1606E-01	0.2423E-01	0.2137E-01	0.1753E-01
16090.	0.5679E-02	0.1990E-02	0.1517E-02	0.2511E-02	0.6650E-02	0.8994E-02	0.7660E-02	0.5652E-02
32187.	0.1663E-02	0.5184E-03	0.3504E-03	0.6162E-03	0.1887E-02	0.2147E-02	0.1713E-02	0.1163E-02
48280.	0.7177E-03	0.2108E-03	0.1332E-03	0.2421E-03	0.8100E-03	0.8298E-03	0.6362E-03	0.4083E-03
64374.	0.3763E-03	0.1051E-03	0.6288E-04	0.1184E-03	0.4258E-03	0.3997E-03	0.2981E-03	0.1837E-03
80467.	0.2212E-03	0.5882E-04	0.3335E-04	0.6562E-04	0.2527E-03	0.2187E-03	0.1589E-03	0.9500E-04

DISTANCE	W	WSW	SW	SSW	S	SSE	SE	ESE
805.	0.9925E-03	0.6622E-03	0.6825E-03	0.1463E-02	0.4010E-02	0.1251E-01	0.7517E-02	0.4707E-02
1609.	0.1056E-01	0.1010E-01	0.9119E-02	0.1052E-01	0.2075E-01	0.5902E-01	0.3698E-01	0.2111E-01
3218.	0.1200E-01	0.1146E-01	0.1030E-01	0.1168E-01	0.2514E-01	0.7141E-01	0.4368E-01	0.2562E-01
4827.	0.8938E-02	0.8080E-02	0.7334E-02	0.9092E-02	0.2229E-01	0.6429E-01	0.3872E-01	0.2285E-01
6436.	0.6586E-02	0.5752E-02	0.5162E-02	0.6825E-02	0.1825E-01	0.5362E-01	0.3218E-01	0.1935E-01
8045.	0.5003E-02	0.4279E-02	0.3765E-02	0.5201E-02	0.1479E-01	0.4415E-01	0.2652E-01	0.1630E-01
16090.	0.1522E-02	0.1251E-02	0.1051E-02	0.1611E-02	0.5369E-02	0.1706E-01	0.1040E-01	0.7053E-02
32187.	0.2639E-03	0.2137E-03	0.1710E-03	0.3128E-03	0.1263E-02	0.4502E-02	0.2818E-02	0.2105E-02
48280.	0.7869E-04	0.6347E-04	0.4800E-04	0.1046E-03	0.4831E-03	0.1850E-02	0.1181E-02	0.9194E-03
64374.	0.3165E-04	0.2489E-04	0.1848E-04	0.4636E-04	0.2336E-03	0.9319E-03	0.6065E-03	0.4861E-03
80467.	0.1533E-04	0.1147E-04	0.8700E-05	0.2421E-04	0.1289E-03	0.5298E-03	0.3513E-03	0.2886E-03

21,600 μCi/sec (6.81 × 10^5 Ci/year)

Table A-4. Estimated External Exposure Doses to Individuals (mrem/year) from Ground Deposition by Distance (meters) and Direction

VERMONT YANKEE

TOTAL DOSE

DISTANCE	E	ENE	NE	NNE	N	NNW	NW	WNW
805.	0.5330E-01	0.2905E-01	0.1848E-01	0.2745E-01	0.5565E-01	0.5568E-01	0.5639E-01	0.7366E-01
1609.	0.2103E 00	0.1177E 00	0.1183E 00	0.1242E 00	0.2868E 00	0.3662E 00	0.4282E 00	0.5148E 00
3218.	0.2648E 00	0.1272E 00	0.1264E 00	0.1505E 00	0.3656E 00	0.5306E 00	0.5217E 00	0.5461E 00
4827.	0.2514E 00	0.1091E 00	0.9704E-01	0.1354E 00	0.3282E 00	0.4938E 00	0.4411E 00	0.4059E 00
6436.	0.2178E 00	0.8850E-01	0.7353E-01	0.1103E 00	0.2704E 00	0.4026E 00	0.3469E 00	0.2937E 00
8045.	0.1839E 00	0.7113E-01	0.5660E-01	0.8816E-01	0.2203E 00	0.3197E 00	0.2710E 00	0.2168E 00
16090.	0.7337E-01	0.2435E-01	0.1715E-01	0.2910E-01	0.8277E-01	0.1019E 00	0.8276E-01	0.5908E-01
32187.	0.1789E-01	0.5183E-02	0.3214E-02	0.6010E-02	0.2034E-01	0.2034E-01	0.1546E-01	0.1032E-01
48280.	0.6702E-02	0.1859E-02	0.1102E-02	0.2128E-02	0.7731E-02	0.7147E-02	0.5263E-02	0.3379E-02
64374.	0.3212E-02	0.8658E-03	0.4990E-03	0.9807E-03	0.3721E-02	0.3272E-02	0.2375E-02	0.1473E-02
80467.	0.1796E-02	0.4684E-03	0.2607E-03	0.5265E-03	0.2088E-02	0.1744E-02	0.1248E-02	0.7519E-03

DISTANCE	W	WSW	SW	SSW	S	SSE	SE	ESE
805.	0.1619E-01	0.1076E-01	0.1112E-01	0.2401E-01	0.6601E-01	0.2060E 00	0.1236E 00	0.7779E-01
1609.	0.1636E 00	0.1552E 00	0.1404E 00	0.1643E 00	0.3290E 00	0.3412E 00	0.5886E 00	0.3366E 00
3218.	0.1710E 00	0.1609E 00	0.1445E 00	0.1682E 00	0.3762E 00	0.1086E 01	0.6617E 00	0.3909E 00
4827.	0.1175E 00	0.1043E 00	0.9395E-01	0.1213E 00	0.3166E 00	0.9402E 00	0.5638E 00	0.3395E 00
6436.	0.8032E-01	0.6888E-01	0.6084E-01	0.8502E-01	0.2476E 00	0.7569E 00	0.4524E 00	0.2812E 00
8045.	0.5708E-01	0.4807E-01	0.4138E-01	0.6118E-01	0.1927E 00	0.6035E 00	0.3612E 00	0.2321E 00
16090.	0.1452E-01	0.1171E-01	0.9776E-02	0.1627E-01	0.6132E-01	0.2060E 00	0.1260E 00	0.9191E-01
32187.	0.2255E-02	0.1759E-02	0.1453E-02	0.2845E-02	0.1227E-01	0.3617E-01	0.2931E-01	0.2334E-01
48280.	0.6418E-03	0.5046E-03	0.3918E-03	0.9017E-03	0.4227E-02	0.1703E-01	0.1103E-01	0.8887E-02
64374.	0.2537E-03	0.1974E-03	0.1486E-03	0.3854E-03	0.1925E-02	0.7982E-02	0.5246E-02	0.4267E-02
80467.	0.1226E-03	0.9171E-04	0.6988E-04	0.1965E-03	0.1030E-02	0.4339E-02	0.2894E-02	0.2387E-02

21,600 μCi/sec (6.81 X 10^5 Ci/year).

would produce a dose of 0.4 mrem/year at the perimeter. The report attributes the measured exposure rates to radioactive wastes (stored aboveground) which would be shielded by the terrain to yield a zero dose rate within and beyond 2 kilometers. Seventy-five percent of the area within 50 miles of Vermont Yankee is within 50 miles of Yankee-Rowe. From the information cited above, the staff concludes that the radiological impact resulting from the gaseous effluents released by Yankee-Rowe will not impose any restraint on the operation of Vermont Yankee.

Conversely, Tables A-2 through A-4 have been examined for the dose increments calculated to result at Yankee-Rowe from the projected operation of Vermont Yankee. Yankee-Rowe is 20 miles WSW and will receive a dose increment totaling 0.040 mrem/year of release for the off-gas holdup conditions considered. (Winds have an average annual frequency in that direction of less than 2% of the time.) This projected dose is less than one-tenth of a percent of present background values and a factor of ten below that of the maximum exposure from Yankee-Rowe's own off-gas. The staff does not regard the resultant dose at Yankee-Rowe as a significant impact or such as to impose any constraint on the operation of Vermont Yankee.

The city of Springfield, Massachusetts (metropolitan area population 459,000, per 1970 census) is within the 50-mile radius of Vermont Yankee, centered 46 miles due south. The residents may receive estimated dose increments, calculated as mentioned in earlier paragraphs, which total 0.029 mrem/year of discharge from released effluents. However, this community has been given additional consideration since it is potentially affected also by releases from three other nuclear power reactors - (Connecticut Yankee, Millstone Point, and Yankee-Rowe) at distances varying from 43 to 57 miles. At these distances, there is greater uncertainty as to the precision obtained with the meteorological dispersion formulas normally employed. Therefore, a secondary (conservative) evaluation was undertaken by an independent professional meteorological staff.[6] Table A-5 presents their calculated dilution factors (χ/Q) for unit emissions together with either the emission rates (Q^*) authorized by Technical Specifications or reported actual annual emissions. The product π may be considered as an applicable index of exposure rate. The comparison is of particular interest for Millstone Point since it is also a boiling water reactor, currently with 30-min holdup of off-gas.

Table A-5 shows that only Millstone Point has the same order of radiological impact as Vermont Yankee. The dose contributions due to off-gases from Connecticut Yankee and Yankee-Rowe, two pressurized-water reactors, are much less. The combined radiological impact is not considered significant, in conformity with the spirit of the guidance provided by proposed Appendix I to 10 CFR 50.[7] In this instance, the aggregate effect of the multiple impact of the several power reactors cited will not impose any restraint on the operation of Vermont Yankee.

Table A-5. Calculation of Exposure at Springfield, Massachusetts, from Four Nuclear Power Reactors

Reactor	Distance (miles)	x/Q (sec/m³)[a]	Q* (Ci/year)[b]	(Basis)	π (relative merit)[c]
Vermont Yankee	46	2.8×10^{-9}[d]	6.81×10^{5}	(Sect. III-D.2)	1.91×10^{-3}
Connecticut Yankee	43	1.9×10^{-9}	3.8	(1968, ref. 3)	7.2×10^{-9}
Millstone Point	57	7.8×10^{-10}	2.52×10^{7}	(T.S. 0.8 Ci/sec)	19.7×10^{-3}
Yankee-Rowe	44	4.9×10^{-9}	17.2	(1970, ref. 2)	84.3×10^{-9}

[a]For a unit release of 1 Ci/sec, these are numerically equal to χ(Ci/m³).
[b]Because of differences in isotopic composition of releases from different reactors, comparisons of effects are not necessarily proportional.
[c]This product is an approximate index of relative merit. If divided by 3.154×10^{7} (sec/year), the resulting estimate of concentration χ(Ci/m³) will reflect exposure rate within variations of composition.
[d]Compares with 2.4×10^{-9} Ci/m³ for 1 Ci/sec unit emission rate as calculated by computer code[4]. In Table V-7, for the release rate and composition postulated, the associated exposure is 0.029 mrem/year.

The amounts of airborne radioparticulates and radioiodine potentially released will vary over the life of the fuel during its cycle, according to the integrity of the cladding, the reactor design, the off-gas treatment, etc. (see Sect. III.D.2). Because of the differing characteristics of newer stations, care must be exercised in estimates extrapolated from measurements of earlier reactors. If, when the reactor is operated, the surveillance monitors indicate release of a measurable quantity of ^{131}I, a degree of effect can be predicted in the proportion of the observed value to the release rate assumed in Sect. III and used in these calculations. Again, an independent estimate has been made using a meteorological dispersion code[4] to calculate ground-level air concentrations as a function of distance and direction. The results are given in Table A-6 (values of ^{131}I expected to be released when the system is installed after the first fuel cycle will be further reduced). Application of suitable factors will relate ground-level air concentrations to deposition, and deposition areal density to resultant concentration in milk.[8] The local farmers, in most cases, in effect, combine (or pool) their milk by sending it to the central processing facility. This results in an averaged concentration to the extent that such milk pooling is operative. The distribution of dairy cows by distance and direction is given in Table A-7, together with the appropriate ^{131}I average air concentrations computed from values in Table A-6. A weighted average (for the number of cows involved) is computed, which was 8.9×10^{-15} μCi/cm^3 . The concentration of ^{131}I in milk from cows grazing with an air concentration of 1 μCi/cm^3 would be approximately 5.6×10^8 μCi/liter. Application of this conversion factor to the weighted average shows that if all the milk from these cattle were pooled, the average ^{131}I concentration would be 0.5 pCi/liter. Milk not pooled would have ^{131}I concentrations in proportion to the air concentration values.

Regular milk consumed by an infant, up to the age of 1 year, is assumed to be 1 liter (approximately a quart) of milk per day. If this milk has an average concentration of 1 pCi/liter, the estimated dose to the thyroid of the infant would be 6.25 mrems/year. Hence, the dose increment which may be expected from the average milk concentration of 0.5 pCi/liter is 1.3 mrems/year (based on cow grazing 5 months/yr.).

Any other pathways from gaseous effluents do not seem credible or realistic. Tritium in gaseous effluents is much below the levels at which it could be significant, according to other studies.[2,3]

D. DOSE EVALUATION

Population distributions by distance and direction in the vicinity of Vermont Yankee for the year 1970 are presented in Table A-8. These

Table A-6. ^{131}I Ground-Level Air Concentrations (μCi/cm^3) by Distance (meters) and Direction

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RELEASE RATE 0.53900D-07

GROUND LEVEL AIR CONCENTRATION(CURIES/M**3)

DISTANCE METERS	NUCLIDE	E	ENE	NE	NNE	N	NNW	NW	WNW
805.	1	1.050E-15	4.602E-16	2.471E-16	4.315E-16	9.300E-16	6.897E-16	5.587E-16	8.666E-16
1609.	1	1.874E-15	8.980E-16	6.923E-16	8.984E-16	2.059E-15	2.186E-15	2.304E-15	2.780E-15
3218.	1	1.519E-15	6.528E-16	5.787E-16	7.414E-16	1.886E-15	2.441E-15	2.303E-15	2.377E-15
4827.	1	1.226E-15	4.980E-16	4.407E-16	6.176E-16	1.575E-15	2.190E-15	1 395E-15	1.850E-15
6436.	1	9.915E-16	3.927E-16	3.466E-16	5.139E-16	1.290E-15	1.858E-15	1.696E-15	1.481E-15
8045.	1	8.214E-16	3.199E-16	2.830E-16	4.358E-16	1.075E-15	1.586E-15	1.461E-15	1.229E-15
16090.	1	3.759E-16	1.401E-16	1.251E-16	2.065E-16	4.947E-16	7.537E-16	7.122E-16	5.608E-16
32187.	1	1.396E-16	4.966E-17	4.318E-17	7.253E-17	1.784E-16	2.628E-16	2.475E-16	1.876E-16
48280.	1	7.410E-17	2.545E-17	2.162E-17	3.649E-17	9.253E-17	1.312E-16	1.228E-16	9.102E-17
64374.	1	4.551E-17	1.521E-17	1.265E-17	2.142E-17	5.598E-17	7.649E-17	7.104E-17	5.197E-17
80467.	1	3.040E-17	9.941E-18	8.099E-18	1.377E-17	3.706E-17	4.889E-17	4.498E-17	3.266E-17

DISTANCE METERS	NUCLIDE	W	WSW	SW	SSW	S	SSE	SE	ESE
805.	1	1.659E-16	1.079E-16	1.202E-16	3.715E-16	1.080E-15	3.339E-15	1.902E-15	1.607E-15
1609.	1	7.809E-16	6.899E-16	6.452E-16	9.544E-16	2.289E-15	6.905E-15	3.118E-15	2.883E-15
3218.	1	7.272E-16	6.778E-16	6.159E-16	7.595E-16	1.836E-15	5.497E-15	3.288E-15	2.231E-15
4827.	1	5.655E-16	5.112E-16	4.713E-16	5.921E-16	1.484E-15	4.356E-15	2.614E-15	1.705E-15
6436.	1	4.588E-16	4.031E-16	3.719E-16	4.775E-16	1.214E-15	3.490E-15	2.104E-15	1.332E-15
8045.	1	3.893E-16	3.344E-16	3.049E-16	3.968E-16	1.015E-15	2.871E-15	1.739E-15	1.077E-15
16090.	1	1.886E-16	1.550E-16	1.346E-16	1.789E-16	4.653E-16	1.279E-15	7.863E-16	4.736E-16
32187.	1	6.257E-17	5.100E-17	4.228E-17	5.768E-17	1.585E-16	4.506E-16	2.804E-16	1.723E-16
48280.	1	2.998E-17	2.442E-17	1.941E-17	2.699E-17	7.797E-17	2.294E-16	1.442E-16	9.119E-17
64374.	1	1.691E-17	1.378E-17	1.061E-17	1.500E-17	4.509E-17	1.365E-16	8.653E-17	5.614E-17
80467.	1	1.050E-17	8.344E-18	6.451E-18	9.245E-18	2.870E-17	8.907E-17	5.681E-17	3.767E-17

Emission rate of 53.9×10^{-3} μCi/sec will be reduced by a large factor with extended holdup.
The concentration above then will be reduced correspondingly.

Table A-7. Distribution of milk cows around Vermont Yankee (1970, estimated) with associated average airborne ^{131}I concentrations

Sector	1 mile			5 miles			10 miles			15 miles			Overall total
	χ ^{131}I ($\mu Ci/cm^3$) $\times 10^{-16}$	No.[a]	Π[b] $\times 10^{-16}$	χ ^{131}I[c] ($\mu Ci/cm^3$) $\times 10^{-16}$	No.	Π $\times 10^{-16}$	χ ^{131}I ($\mu Ci/cm^3$) $\times 10^{-16}$	No.	Π $\times 10^{-16}$	χ ^{131}I ($\mu Ci/cm^3$) $\times 10^{-16}$	No.	Π $\times 10^{-16}$	
N–NNE		0		6.17	60	371	3.20	31	99	1.74	305	530	
NNE–NE		0		4.40	64	281	2.04	30	60	1.05	131	138	
NE–ENE		0		4.97	65	323		0		1.17	75	87	
ENE–E		0		12.25	81	991	5.99	95	569	3.17	217	689	
E–ESE		0		17.04	76	1,294	7.73	85	656	3.95	30	120	
ESE–SE		0		26.14	156	4,078	12.64	90	1,138		0		
SE–SSE		0		43.57	383	16,688	20.75	760	15,772	10.72	38	407	
SSE–S		0		14.85	250	3,713	7.40	579	4,282	3.89	111	431	
S–SSW		0		5.93	172	1,021	2.87	303	871	1.50	73	111	
SSW–SW		0		4.70	148	695	2.19	491	1,072	1.11	286	317	
SW–WSW		0		5.12	76	389	2.46	241	593	1.29	619	797	
WSW–W		0		5.66	10	57	2.87	296	850	1.56	177	275	
W–WNW	8.65	110	952	18.51	22	407	8.95	284	2,542	4.67	177	826	
WNW–NW		0		19.94	76	1,515	10.87	225	2,446	5.96	45	269	
NW–NNW		0			0		11.71	225	2,635	6.32	212	1339	
NNW–N		0		15.75	21	329	7.85	29	228	4.16	306	1273	
Total product			952			32,152			33,813			7609	74,526
Total cows		110			1660			3764			2802		8336

Cow-weighted average air concentration 8.94 × 10^{-16} $\mu Ci/cm^3$

[a]Number of cows, information sources: University of Vermont Extension Service – Mr. Fred Webster (Burlington); New Hampshire Department of Agriculture – Mr. Vincent Peterson (Concord); Franklin (Mass.) County Agent – Mr. Hill (Greenfield).

[b]Product of number of cows and concentration of ^{131}I.

[c]Based on 1.7 Ci/year ^{131}I as gaseous effluent, interpolated from meterological code, ref. 4.

Table A-8. 1970 Population Distribution in the Vicinity of Vermont Yankee

Section	Distance (miles)[a]									
	1	2	3	4	5	10	20	30	40	50
N	10		100	150	50	520	1,900	5,900	11,100	5,800
NNE			50	60		1,190	1,700	54,000	4,100	22,100
NE	15	50	120			915	2,100	1,200	3,600	4,600
ENE	100	1,000	100	20			5,400	2,200	6,200	4,300
E	60	150	50	100	250	590	1,800	5,700	8,100	24,900
ESE				20	20	1,160	3,700	16,300	49,900	59,200
SE		50	50	50	60	590	10,200	6,900	6,800	60,600
SSE		50	30	30		1,290	1,900	1,300	14,600	26,500
S	40	60	50			950	9,900	20,200	72,400	331,200
SSW	60	50				890	16,600	2,900	20,800	32,700
SW	20	45				335	3,000	2,300	4,700	39,700
WSW	40			40	40	280	1,100	1,700	38,400	35,500
W	60	20	60		120	240	900	1,100	17,700	13,000
WNW	50	50	50	70	120	2,260	1,100	700	2,300	4,600
NW				100	350	4,730	2,200	900	2,100	3,500
NNW	—	80	120	100	2,000	500	1,300	500	3,000	3,600
Total	455	1,605	780	740	3,010	16,440	64,800	123,800	265,800	671,800

[a]Population is from preceding to stated distance.

may be combined, as a product, with the increments of estimated dose by distance and direction given in Tables A-2 through A-4 and the products summed to give the population doses in man-rems presented earlier in Table V-8.

The exposure rates growing out of operation of the plant appear to be very small compared with natural exposure rates.

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APPENDIX V-B

CHEMISTRY OF CHLORINE IN FRESHWATER

A summary of the chemistry of chlorine in freshwater is presented because the possible impacts of chlorine are not well established. To appreciate the potential impacts, one must become reasonably familiar with a concise terminology and some applied chemistry.

Much progress was made in the 1940's in the use of chlorine for the sterilization of water supplies. Griffin[1] gave an annotated guide to over a hundred papers published between 1939-1952. Fair[2] gave a lucid exposition of the behavior of chlorine as it was then understood. The subject has been summarized recently by Lewis.[3]

Certain terms have come into use to describe chlorine in water. They are often used carelessly in industrial practice. The distinctions given are those of Lewis.[3]

a. Free Chlorine (Short for Free Available Chlorine)

That part of the chlorine injected into the water that remains as molecular chlorine, hypochlorous acid, and hypochlorite ion.

b. Combined Chlorine (Short for Combined Available Chlorine)

That part of the chlorine injected into the water that remains combined with ammonia or other nitrogenous compounds.

c. Active Chlorine (Alternative for Total Available Chlorine or Chlorine Residual).

The total free and/or combined chlorine that remains. The terms "active" and "available" refer by implication to activity and availability for sterilization. The amount of "active chlorine" present is recognized as being equivalent to the amount of iodine that will be released from potassium iodide at acid pH.

d. Chlorine Demand

By implication, the exact amount of chlorine required to oxidize completely all compounds that reduce free chlorine in the water. In practice, the term is used when referring to the difference between the dose and the active chlorine left (chlorine residual) after a particular period of contact, for one particular dose rate.

Reactions During Chlorination

When chlorine or sodium hypochlorite dissolves in water the equilibrium between hypochlorous acid and hypochlorite ion is quickly established.

$$Cl_2 + H_2O = HClO + H^+ + Cl^-$$

and

$$Na^+ + ClO^- + H_2O = HClO + OH^- + Na^+.$$

Only when the pH is below 3.0, or if the chlorine concentration is of the order of 1,000 mg/liter, is there any measurable quantity of chlorine. The full oxidizing capacity of the chlorine is retained in the hydrolysis products, HClO and ClO^-. The hypochlorous acid ionizes:

$$HClO = H^+ + ClO^-.$$

At pH 7.0 the equilibrium is approximately 75% HClO and 25% ClO^-, and at pH 8.0 this is reversed to approximately 25% HClO and 75% ClO^- (at a water temperature of 20°C).

When ammonia or organic amines are present in the water they react with hypochlorous acid to give chloramines that are also toxic to aquatic life.

$$NH_3 + HClO = NH_2Cl + H_2O.$$

Similarly $NHCl_2$ and NCl_3 are formed with increasing HClO concentration. The rate of reaction between ammonia and hypochlorous acid is dependent on pH and is maximum at pH 8.3. Fair et al.[2] found that for a mixture of 0.8 ppm chlorine and 0.32 mg/liter ammonia-nitrogen, at 25°C, 99% of the chlorine reacted in 1 min at pH 8.3, in 210 min at pH 5.0, and in 50 min at pH 11.0. The rate of reaction varied with temperature (Q_{10} values ranging from 2.0 to 2.5 according to pH).

Although the most stable products of hypochlorous acid and ammonia are N_2, Cl^-, and H^+, intermediate products can and do persist. Pullham[4] found chloramines continue to exist in the presence of excess chlorine.

Ingols et al.[5] studies reactions between chlorine and amino acids at concentrations of 10^{-4} <u>M</u> amino acid. HClO would oxidize sulfhydryl groups to sulfonic groups and then deaminate the amino acid through the formation of chloramines. With slightly more monochloramine an organic chloramine formed that was stable for some hours. With monochloramine the sulfhydryl groups were oxidized to give disulfide linkages.

Analyzing for Chlorine Residuals

Several evaluations have been made of the numerous analytical methods used for determining residual chlorine in water. Nicolson,[6] who evaluated nine colorimetric and three titrimetric methods, found that the barbituric acid method was the best laboratory colorimetric procedure if combined chlorine residual was absent. In the presence of combined chlorine, the N-diethyl-p-penylenediamine (DPD) method was more satisfactory. Lishka et al.,[7] who analyzed the results from 72 participating laboratories using several different analytical methods, reported that the ferrous-DPD method had the best accuracy and precision, followed closely by the methyl orange, SNORT (Stabilized Neutral Orthotolidine), and amperometric methods. None of the methods has outstanding reliability even when care is taken (see Table B-1). Reliability is undoubtedly even less in routine analyses.

The Standard Methods for the Examination of Water and Wastewater[8]

The ferrous-DPD, the orthotolidine-arsenite, the leuco crystal violet, the methyl orange, and the SNORT methods all determine both free and combined chlorine residuals. However, the determination of combined chlorine residual is dependent upon monochloramine and dichloramine, and the extent of their influence depends upon the types of organic compounds present.

References for Appendix V-B

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7. R. J. Lishka, E. F. McFarren, and J. H. Parker, Water Chlorine (Residual) No. 1 Study Number 35, U.S. Department of Health, Education and Welfare, Public Health Service (1969).
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Table B-1. Precision and accuracy data for residual chlorine methods based upon determination by several laboratories

Method	Residual chlorine concentration (μg/liter) Free	Total	Number of laboratories	Relative standard deviation (%)	Relative error (%)
Iodometric		840	32	27.0	23.6
		640	30	32.4	18.5
		1830	32	23.6	16.7
Amperometric	800		23	42.3	25.0
		640	24	24.8	8.5
		1830	24	12.5	8.8
Ortho-tolidine	800		15	64.6	42.5
		640	17	37.3	20.2
		1830	18	31.9	41.4
Ortho-tolidine–arsenite	800		20	52.4	42.3
		640	21	28.0	14.2
		1830	23	35.0	49.6
Stabilized neutral ortho-tolidine	800		15	34.7	12.8
		640	16	8.0	2.0
		1830	17	26.1	12.4
Ferrous DPD	800		19	39.8	19.8
		640	19	19.2	8.1
		1830	19	9.4	4.3
Leuco crystal violet	800		17	32.7	7.1
		640	17	34.4	0.9
		1830	18	32.4	18.6
Methyl orange	800		26	43.0	22.0
		640	26	30.1	14.2
		1830	26	19.9	7.2

Source: ref. 8.

APPENDIX XI-A

COOLING TOWER CHEMICALS--POTENTIAL ENVIRONMENTAL DEGRADATION*

Introduction

Cooling towers dissipate heat directly into the atmosphere without first utilizing a reservoir or heat sink as in once-through cooling. The main justification for the towers, as at Vermont Yankee, has been concerned for the environmental effects of once-through cooling on aquatic life. However, cooling towers, too, have the potential for environmental damage that should be carefully studied prior to their widespread installation and use. The principal impact to be studied is long-range meteorological changes caused by large amounts of heat and water vapor added to the atmosphere from the towers. Other environmental impacts, most notably dispersion of the chemical discharges of the blowdown and drift from cooling towers, have been little studied.

Wet cooling towers require large amounts of chemicals in the recirculating water to prevent corrosion and to inhibit biological attack. Because large amounts of water evaporate, salt concentrations build up in the remaining tower water, and some of this--the blowdown--must be bled off and discharged. In addition to losses from blowdown and evaporation, there is a drift (droplets of water that escape from the tower stacks along with the vapor plume) that contains chemicals in the same concentration as in the recirculating water and blowdown. Thus, chemicals added to tower water can find their way directly into surrounding aquatic or terrestrial ecosystems through blowdown and drift.

Although untreated blowdown is undoubtedly the major source of environmental problems connected with cooling towers (its quantity and content of chemicals are easily determined), drift is too often considered negligible. Depending upon tower design and drift eliminators, calculated drifts vary from 0.01% to 0.3% of the recirculating water rate, the losses usually being higher for small towers. Drift from large natural draft cooling tower serving a 2,500 megawatt power plant has been calculated to be 4 tons of solids per day, assuming makeup water with 200 ppm of total dissolved solids (TDS) and drift of 0.2% of the recirculation rate.[1] Most of the solids would be calcium and magnesium salts occurring naturally in the makeup water, and the rest would be chemicals added to the tower water.

Relative volumes of blowdown to the aquatic environment and drift to the terrestrial environments have been calculated for smaller towers. Drift is 30% to 45% of the water loss, so that treatment of the blowdown alone removes only 55% to 70% of the chemical pollution. In order to further reduce the chemical effluents from cooling towers, drift eliminators must be used.

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* Summarized from draft manuscript, S. H. Hale, R. S. Carlsmith, and C. C. Coutant, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

COMPOSITIONS AND CONCENTRATIONS OF COOLING TOWER CHEMICALS

Corrosion and Scale Inhibitors

Commonly used corrosion inhibitors for open recirculating systems include various mixtures of zinc, chromate, phosphate (organic or inorganic), sodium silicate, nitrate, borate, and organic inhibitors. To prevent scale deposition and to provide effects, organic phosphate compounds such as aminimethylenephosphate are used in concentrations up to 3 ppm. Mr. R. J. Cunningham, Calgon Corporation, listed the following corrosion and scale-inhibiting chemicals (with their concentrations) in an open letter to Mr. Frank Rainwater of the Environmental Protection Agency:(3)

1. Chromate plus zinc	5 to 30 mg/liter* CrO_4 1 to 15 mg/l Zn
2. Chromate plus zinc plus phosphate	5 to 30 mg/l CrO_4 1 to 15 mg/l Zn 1 to 5 mg/l PO_4 (inorganic) 1 to 5 mg/l PO_4 (organic)
3. Zinc plus inorganic phosphate	10 to 30 mg/l PO_4 2 to 10 mg/l Zn
4. Zinc plus organic phosphate	1 to 10 mg/l Zn 3 to 15 mg/l PO_4 (organic)
5. Organic phosphate scale inhibitor	1 to 18 mg/l PO_4 (organic)
6. Specific copper corrosion inhibitors	1 to 5 mg/l sodium mercaptobenzothiazle or benzotriazole

* 1 mg/liter = 1 ppm

As seen in numbers 1 and 2 above, chromate, zinc, and phosphate are often used together because of the synergistic anticorrosive effects produced when they are combined.

Biocides

Of the commonly used biocides, chlorine or hypochlorite (as planned at Vermont Yankee) or nonoxidizing organic compounds such as chlorophenols, quaternary amines, and organo-metallics such as organotin compounds, organosulfur, and organothiocyanate (Table 1) are most frequently employed. They are all used to prevent deterioration of tower wood, loss of heat transfer

efficiency, general fouling or plugging arising from active microbial growths, and corrosion that results from microbial attack.[2] Organotin must be formulated with quaternary ammonium and other complex amines to produce a synergistic effect and to be dispersible. Chlorophenols, as soluble potassium and sodium salts, are more persistent than free chlorine and remain in systems longer. Common chlorophenols include: 2,4,5-trichlorophenate; 2,4,6-T; 2,3,4,6-T; tetrachlorophenol; and pentachlorophenol. Organosulfurs are noted for low toxicity to animals, but are effective against bacteria, fungi, and especially sulfate-reducing bacteria. Quarternary and complex amines are effective wetting agents and destroy microbial agents by surface-active properties; these are the least toxic of all antimicrobial compounds to animals, although they may cause aesthetic problems. The organothiocynates, the most modern of the nonoxidizing biocides, are used whenever problems are rather severe and where the use of free chlorine is not acceptable. Typical concentrations for continuous use are 1 to 25 ppm; for periodic treatment typical concentrations are $\sim$200 ppm. Elemental chlorine is an oxidizing agent and can cause rapid deterioation of wood. The use of free chlorine as a biocide is usually restricted to 1.0 ppm as free residual chlorine for a maximum of 1 to 2 hours per day.[3]

The use of extremely toxic biocides such as those containing mercury, arsenic, lead, or boron is limited by stringent regulations that prohibit release to the environment. These biocides are rarely if ever used now; however, a review of label names in Table 1 reveals that the potentially toxic materials, copper and thiocyanate ions, are present in some commercial compounds. Tin is also questionable as far as toxicity is concerned. All chemical labels reviewed noted that precautions should be used in handling of the product, and two indicate that the product may be harmful or fatal if absorbed through the skin. Only two, however, cautioned against release into lakes, streams, or ponds. Some of the products containing 2,4,5-T listed no such precautions; yet release of this compound to waterways is now expressly banned.

pH Adjustors and Silt Control (Antifoulant) polymers

Scale and corrosion inhibitors and biocides require the addition of acid or alkali to makeup water to keep the pH at an optimum level, usually a range from 5.5 to 7.5. Silt control polymers may be used if the makeup is raw water from a nearby lake or river. Lignin-tannin dispersives such as 1 to 50 ppm sodium lignosulfonate may also be employed. Antifoulants such as 0.1 to 5 ppm of acrylamids, polyacrylate, polyacrylate, polyethyleneimine, or other high molecular weight synthetic organic polyelectrolytes may also be used.[3]

Table 1. CHEMICAL COMPOSITION OF TRADE NAME MICROORGANISM CONTROL CHEMICALS

(From company sources and Environmental Protection Agency)

	COMPOSITION (%)	USAGE
NALCO 21-S		
Sodium pentachlorophenate	21.3	periodically,
Sodium 2,4,5-trichlorophenate	11.9	as needed
Sodium salts of other Chlorophenols	3.0	25-400 ppm
Inert ingredients	63.8	or continuously
NALCO 25-L or NALCO 425-L		
1-Alkyl (C_6 to C_{18})-amino-3-aminopropane propionate-copper	15.0	weekly
Isopropanol	30.0	20-300 ppm
Copper sulfate expressed as metallic copper	0.55	
Inert ingredients	55.0	
NALCO-201		
Potassium pentachlorophenate	15.7	periodically,
Potassium 2,4,5-trichlorophenate	9.0	as needed
Potassium salts of other chlorophenals	1.8	300-400 ppm
Inert ingredients	70.3	or
		12-60 ppm
		continuously
NALCO-202		
Methyl-1, 2-dibromopropionate	29.7	5-200 ppm
Inert ingredients	70.3	periodically
		or
		continuously
NALCO-207		
Methylene bisthiocyanate	10.0	weekly
Inert ingredients	90.0	25-50 ppm
NALCO-209		
1.3-Dichloro-5, 5 dimethyl hydantoin	25.0	as needed
Inert ingredients	75.5	50-100 ppm

	COMPOSITION (%)	USAGE
NALCO-321		
1-Alkyl (C_6 to C_{18})* amino-3aminopropan monoacetate	20.0	weekly
Isopropanol	30.0	5-200 ppm
Inert ingredients	50.0	

* As in fatty acids of coconut oil

	COMPOSITION (%)	USAGE
NALCO-322		
1-Alkyl (C_6 to C_{18})* amino-3-aminopropane monoacetate	19.8	as needed
2,4,5-Trichlorophenol	9.5	10-200 ppm
Isopropanol	27.0	
Inert ingredients	43.7	

* As in fatty acids of coconut oil

	COMPOSITION (%)	USAGE
NALCO-405		
2, 4-Dinitrochlorobenzene	22.2	as needed
2, 6-Dinitrochlorobenzene	2.8	100-200 ppm
Inert ingredients	75.0	
Betz A-9		
Sodium pentachlorophenate	24.7	
Sodium 2, 4, 5-Trichlorophenate	9.1	
Sodium salts of other chlorophenates	2.9	
Sodium dimethyl dithiocarbamate	4.0	
N-Alkyl (C_{12}-4%, C_{14}-50%, C_{16}-10% dimethyl benzyl ammonium chloride	5.0	
Inert ingredients (including solubilizing and dispersing agents	54.3	
Betz C-5		
1, 3, Dichloro-5, 5-Dimethylhydantoin	50	
Inert ingredients (including solubilizing and dispersing agents)	50	
Betz C-30		
Bis (trichloromethyl sulfone	20.0	
Methylene disthiocyanate	5.0	
Inert ingredients (including solubilizing and dispersing agents)	75.0	

	COMPOSITION (%)
Betz C-34	
Sodium dimethyl dithiocarbamate	15.0
Nabam (disodium ethylene bisdithiocarbamate)	15.3
Inert ingredients (including solubilizing and dispersing agents)	60.7
Betz J-12	
N-Alkyl (C_{12}-5%, C_{14}-60%, C_{16}-30%, C_{18}-5%) dimethyl benzyl ammonium chloride	24.0
Bis (tributyltin) oxide	5.0
Inert ingredients (including solubilizing and dispersing agents)	71.0
Betz F-14	
Sodium pentachlorophenate	20.0
2,4,5, T or Sodium 2,4,5 trichlorophenate	7.5
Sodium salts of chlorophenate	2.5
Dehydrobutyl ammonium phenoxide	2.0
Inert ingredients, including dispersants	68.0

Chemical Action

Corrosion Inhibition

The chromate ion is one of the most effective corrosion inhibitors. It is effective where it can react with iron-containing alloys to form alpha ferric oxide and chromic oxide film on the iron surface. Usually this treatment is most effective when a high concentration of chromate is circulated throughout the system until the film forms; then maintenance of a low concentration of chromate is sufficient to maintain the protective film.

Phosphate acts both as a corrosion and a scale inhibitor and may be found as sodium tripolyphosphate, sodium hexametaphosphate, as several types of "glassy" phosphates of high molecular weight. These compounds also form a protective film on metal, mostly on cathodic areas. However, at high temperatures, low pH, or high calcium concentrations, the polyphosphates revert to orthophosphates, of low molecular weight or react with iron or water hardness salts to form an insoluble sludge.

The zinc ion alone is a relatively weak corrosion inhibitor but has strong synergistic qualities. It is a cathodic inhibitor that forms a deposit of zinc hydroxide on cathodic areas, thereby diminishing cell potential.

Sodium silicate forms a thin protective gelatinous film over the first layer of corrosion product on the metal surface. High concentrations of chloride or sulfate ions may distrub the protective layer.

Organic inhibitors aid in developing protective metal oxide films by forming a protective layer of insoluble material or by creating a surface-active barrier.

Nitrite is a passivator for steel that makes the steel effectively a more noble metal. A similar passivation is provided by tin alloys; copper is a bit weaker. High concentrations of chlorides reduce the effectiveness of nitrites; for example, about 4,000 ppm of NO_2 is required in a 3% NaCl solution, as compared with only 50 ppm in distilled water to achieve the same effect.

Borax is often included in nitrite-based inhibitors to maintain a pH of 8 to 10 in the water. It has not been demonstrated to be effective as an inhibitor.

Antifoulant Polymers[2]

Flocculants agglomerate individual particles so that they remain suspended and are easily bled off. Dispersants interfere with the agglomeration of colloidal particles that are attracted to metal surfaces, often modify their crystallization, and allow them to slough off. Chelating agents react with certain metal ions to form stable, soluble complexes; calcium, magnesium, iron, aluminum, and manganese ions may be chelated to prevent their precipitation but the reaction is stoichiometric and chelation of water hardness ions is generally uneconomical.

Toxicity

General

Table 2 lists some elements (present in different valent states in chemical compounds) which, historically have been used in cooling towers, together with their respective concentration factors by plankton and blown algae.[5] These concentration factors may signify increased toxic effects of various elements through a food chain, and suggest that even low concentrations of some contaminants in water may be harmful by the third or fourth trophic levels. Some high concentration factors, such as those exhibited by Foraminifora and Porifora for silicon, are normal. Some elements, not toxic to aquatic life, may unbalance the ecosystem by overstimulating the growth of certain plants or animals. It is well established that nitrogen and phosphorus, particularly in combination, cause massive algal blooms under conditions where these elements were previously limiting factors. While the accumulating poisons, mercury

Table 2. TOXICITY AND CONCENTRATION FACTORS OF ELEMENTS ONCE – OR PRESENTLY USED IN COOLING TOWERS

ELEMENT SYMBOL[a]	CONCENTRATION FACTOR***		FUNCTIONS	ENVIRONMENTAL TOXICITY (not injected)
	Plankton	Brown algae		
*As		2,500		carcinogenic; moderately toxic to plants, highly to mammals—especially as AsH_3;
B		6.6	essential for green algae, angiosperms	moderately toxic to plants, slightly to mammals
*Br		2.8	essential for marine organisms; amino acids	Br_2 is very toxic; Br- is relatively harmless to organisms
*Cl	1	.062	essential for mammals and angiosperms	Cl- is relatively harmless; Cl_2, ClO ClO_3 are highly toxic
*Cr	17,000	6,500	may serve some physiological function	Cr(III) is moderately toxic; Cr(VI) is highly toxic to organisms and is probably carcinogenic (by inhalation)
*Cu	17,000	920	essential to all organisms	very toxic to algae, fungi, and seed plants; highly so to invertebrates; moderately so to mammals
*Hg	-	250	--	a cumulative poison in mammals very toxic to fungi and green plants; highly to mammals in some forms
N	19,000	7,500	essential as structural atom	relatively harmless; concentrations higher in plankton and fish
*P	15,000	10,000	vital in many ways	
*Pb	41,000	70,000	none	very toxic to most plants, moderately so to mammals; cumulative poison

Table 2. (cont'd)

*S	1.7	3.4	--	S^{2-} high to bacteria and fungi; relatively harmless to green algae, seed plants and mammals; H_2S is highly toxic to mammals; SO_3^{2-} moderately to highly; SO_4^{2-} is relatively harmless
*Si	-	-	essential to some plants	scarcely toxic, but large amounts in mammalian lung harmful (used by Foraminifera and Porifera, etc.)
*Sn	2,900	92	none	very toxic to plants and green algae
*Zn	-	-	essential to all organisms	moderately toxic to plants, slightly toxic to mammals; uptake by plant roots not linked to metabolic process

(a) The elements listed above exist in the form of different chemical compounds with the element in different valent forms to which biota are toxic but concentrations are expressed in terms of ppm of the element not the actual compound.

* accumulator species or genera known

** ppm in fresh organism/ppm in sea water
Toxicity terms; very, 1-10 ppm, highly, 10-100 ppm; moderately, 100-1,000 ppm; slightly, over 1,000 ppm

(as 24 hr TL_m in moderate sized organisms--i.e., fish)

and lead, are no longer marketed for use in cooling towers, any of the heavy metals (e.g., chromium, zinc, or tin) may cause environmental problems if they remain in sediments or are concentrated in some forms of aquatic life. Establishment of the potential threat to the environment becomes extremely difficult because the different forms and valence states of elements may vary greatly in toxicity--as with sulfur, chlorine, and mercury. Factors contributing to the change from one state to another and synergistic toxic effects must be known before cooling tower chemicals can be ranked in order of potential environmental threat.

Chromium*

Because of its widespread use and high toxicity, chromium present in different valent states in compounds merits careful attention in its relation to aquatic life. It is not currently being considered for use at the Vermont Yankee Station, but it is an alternative, if the effects of residual chlorine prove harmful to aquatic life in Vernon Pond. Some sources say that the trivalent form shows none of the toxicity of the hexavalent form (as in the chromate ion) and is not of concern in drinking water supplies.[6] However, according to a report of the Federal Water Pollution Control Administration (FWPCA,)[7] (now part of the Environmental Protection Agency), "Most evidence points to the fact that under long-term exposure the hexavalent form is no more toxic toward fish than the trivalent form."* Thus total chromium in a water supply may be much more indicative of a possible environmental problem than hexavalent chromium alone. In environments containing chromium, fish have shown that the toxicity of chromium varies with the species of fish, pH of the water, valence state of the element, and hardness of the water--the last a synergistic or antagonistic effect. Although the FWPCA recommends 0.05 ppm as the drinking water standard, it states that data are too incomplete to warrant more than caution in the discharge of chromium.

Concentrations of 0.01 and 0.02 ppm chromium in soft water have been found safe for salmonid fish, but Daphnia and Microregma show threshold effects at Cr^{6+} concentrations of 0.016 to 0.7 ppm, and 0.032-0.32 ppm inhibits growth of diatoms.[7] Oyster mortality studies at long-term (2 years) concentrations of 0.01 and 0.012 ppm showed a definite increase with an increase in temperature, so that synergistic effects may intensify the damages resulting from exposure to chromium in low concentrations.[7] Thus, even these low levels (less than drinking water standards) were found to be toxic to certain forms of plant and animal life. As concentrations of chromium increase, the ingestion-elimination balance changes and accumulation takes place. Some fish accumulate chromium when it is in concentrations as low as 1 microgram per liter or 1 part per billion.[8]

In 1958 Fromm and Schiffman published a study of the toxic action of Cr^{6+} on largemouth bass in which they determined the 48-hour median tolerance limit, TL_m, to be 195 ppm.[9] However, the focus of the study was on the physiological effects of less than acutely lethal dosages. At 94 ppm of Cr^{6+} no changes were observed in the respiratory epithelium of the fish, but a slight decrease in general metabolism did occur along with widespread destruction of the intestinal epithelium. these effects differ markedly from those caused by zinc, copper, and lead, where mucus is caused to be secreted by the gills and damage to gill tissue causes eventual death.

---

* Chromium can exist as Cr^{3+} (trivalent) or CrO_4^{2-} (hexavalent - Cr^{6+} but concentrations are based on the weight of Cr.

In 1959 the same authors reported a 24-hour median tolerance limit for rainbow trout to be 100 ppm of chromium.[10] A concentration of 20 ppm of Cr^{6+} was chosen for the study of chronic physiological changes. Red blood cell concentration (hematocrit) in the circulating blood of the trout significantly increased as a result of the exposure, most probably because of an unmeasurable decrease in plasma volume. Perhaps more importantly, the hematocrit is affected at 2 to 4 ppm of chromium, a concentration much lower than the median tolerance limit and one which could easily be found in a stream receiving blowdown.

Not all fish are as tolerant of Cr^{6+} as are trout, bass, and bluegill.[11] The median tolerance limit for 24-hour exposure to potassium dichromate in soft water was 4.10 ppm (as CrO_4^{2-} for guppies, 39.6 ppm for fathead minnows, and up to 284 ppm for bluegills. In these tests, there were insignificant differences for 24, 48-, and 96-hour exposures. Trivalent chromium was found to be a toxicant; mortality rates, however, did not always increase with increasing concentration. At acutely toxic levels for fish (in the range of the medium tolerance limit), the hexavalent chromium was more toxic, but no comparisons were made of the two valence states at very low concentrations.

Water Quality Standards

Table 3 lists FWPCA recommendations for drinking water standards with respect to chemicals used in cooling towers.[7] As yet, not all of the elements have been assigned limits; some limits were set lower because of aesthetic considerations rather than because of health considerations; for example, the low concentration limit for phenol was probably set in light of the threshold for phenol taste in water.

Severity of the Environmental Problem from Blowdown

The magnitude of the environmental chemical dispersion problem, if any, connected with blowdown from a specific cooling tower depends upon: (1) the rate of blowdown, which is usually directly related to the size of the system and the number of cycles of concentration allowed by the quality of input water; (2) the choice of chemicals—a choice often dictated by the system's potential for corrosion or microbial attack, which in turn is often directly dependent on tower design and construction materials; and (3) the effectiveness of treatment of blowdown water before discharge to the environment. Drift has received less study, and the factors controlling its quantity and content are less well-known.

Environmental problems associated with blowdown can be substantial, although immediate impact on aquatic environments may depend more upon the ratio of the stream flow rate to blowdown rate (the dilution factor) than on absolute amounts. Less immediate problems, such as the dispersion of heavy metals to the entire ecosystem, would revolve more around absolute amounts.

Reducing Impact

1. Cycles of Concentration

Pretreatment techniques can increase cycling of water in cooling towers and thus decrease system discharge. They include: (1) clarification and chemical softening of makeup water, (2) partial zeolite softening or demineralization of makeup water and (3) bypass or side-stream filtration.[5] By removing from the makeup many of the original dissolved solids which could concentrate to unacceptable levels very quickly, many more cycles of concentration—more recirculation with less blowdown may be allowed before concentrations become too high.

2. Choice of Chemicals

Heat exchanger design and tower construction materials usually determine the potential corrosion and thus determine the choice of chemicals to be added to the recirculating water. Some towers, notably natural draft towers, use no corrosion inhibitors (except acid as a pH control), while others require high concentrations of chromium, zinc and PO_4^{3-} as inhibitors. Similarly, some towers can use chlorine as a biocide, while others use a nonoxidizing biocide. TVA's cooling tower at its Paradise Steam Plant uses only acid and chlorine in the cooling water. Because corrosion resistant construction materials, principally concrete, was used and due to a low heat flux at the exchanger, heavy metals and phosphate are not needed in that tower for corrosion control.

3. Construction of Towers

Certain design characteristics can be adopted to avoid galvanic corrosion and reduce the need for chemical treatment.[12, 13] Operational factors influencing the corrosion rate (and thus choice of inhibitor chemicals) include mineral content of the system water (which also may dictate how many times it may be recirculated), dissolved gases, electrical conductivity, suspended matter (turbidity) in the water, slime and microbial activity. More important are the design factors such as the use of corrosion resistant metals and the use of dissimilar metals of which one is expendable, a common practice throughout the industry. If the metals differ significantly in electrochemical potential, one may serve as the cathode of an electrochemical corrosion cell, and the expendable metal acts as an anode and corrodes rapidly at a rate determined to some extent by the difference between the electrode potentials of the metals. If the water has good electrical conductivity, the metals need not be coupled or adjacent to corrode. The choice of metals and proper construction of the heat exchanger are extremely important, as a mistake might necessitate heavy chemical applications for the life of the tower. The primary concern is not with rapid destruction or perforation of the tube sheet, since design specifications normally call for adequate thickness, but is with the buildup of corrosion products that effectively block tubes or restrict water flow. Under certain conditions, metals that are

Table 3. RECOMMENDED UPPER LIMITS TO THE IONIC CONCENTRATIONS IN DRINKING WATER (Ref. 7)

Element or Compound	Upper Limit (ppm)
As	0.05
B	1.00
Br	*
Cl	250
Cr	0.05
CN	0.01
Cu	1.0
Hg	*
K	*
N (total)	10.0
NO_3	45.0
P	*
Pb	0.05
S	250
Sn	*
Zn	5.0
Phenols	0.001

* No criterion has been established.

normally cathodic can corrode, particularly where deposits form on the metal surface to set up locally different corrosion cells. Metals to be concerned with most are those that are electropositive with respect to steel, since steel adjacent to copper or copper alloys can corrode rapidly. Other unsuitable metallic pairs are copper-aluminum or steel-aluminum. However, some alloys such as admirality brass and stainless steel are extremely corrosion-resistant metals if they are protected from galvanic activity.

4. Cooling Temperatures

Temperature of the heat exchanger has a major role in determining corrosion potential. Control of scale and corrosion in the heat exchanger is more difficult at high temperature.

5. Blowdown Treatment

Effective blowdown treatment systems have been developed for removal of chromium. Basically two methods are recognized, reduction-precipitation that discards the chromium and ion exchange that provides for chromate recovery.[14] The best known process, reduction-precipitation, is commonly used in the chrome-plating industry. When property employed, it removes virtually all traces of chromium from the waste stream, leaving a chromium-containing sludge for disposal. This method also is effective in removing zinc and other heavy metals, phosphate, insoluble chromic hydroxide, and all dirt and suspended solids. Some biocides may also be reduced in concentration (by a factor of 1/2 or more).[15] Ion exchange on the other hand, while effective for removing chromate for reuse (which must be in the dichromate form), is ineffective for zinc salts or phosphate even when these are used in combination with chromates. Accessory treatment must therefore be employed for these ions. Sodium hydroxide and sodium chloride are used to regenerate the ion exchange resin, and these may be detrimental if released to natural environments.

Conclusions

All factors--environmental, economic, engineering design, and construction--should be weighed before a tower is constructed in order that adequate environmental protection can be built in. There is very little information concerning biocides, their fate after discharge, and methods to render them harmless. Evidence indicates that most biocides will not remain unchanged for long periods of time. However, since their toxicity is the very reason for the use of biocides in the towers danger to aquatic ecosystems receiving blowdown remains a matter of concern. Breakdown and dilution of biocides should be monitored after release. It is recommended that tests to ascertain necessary levels of usage in each tower be performed since possible overuse in current practice is indicated by the broad ranges of concentrations suggested on product labels. Corrosion tests are perhaps more common and relatively easy to do, the results indicating the concentrations of chromium that are sufficient and whether nonchromate inhibitors such as

phosphate could be substituted. However, substitution of phosphate would involve a trade-off among alternative environmental damages, since phosphate encourages the growth of noxious plants. If blowdown treatment is not employed, resort to biocides less toxic to animal life (such as the organo-sulfurs or quaternary and complex amines) or those that volatilize quickly and are not released in the blowdown would reduce environmental impact. Redesigning of common industrial heat exchangers may result in use of little or no corrosion inhibitors, but some biocide will still be required.

Blowdown treatment seems to be the final determinant over what chemicals will be discharged to the environment. Increased use of chemical additives for recirculating cooling water should include consideration of blowdown treatment.

REFERENCES FOR APPENDIX XI-A

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10. Schiffman, R. H., and Fromm, P. O., "Chromium-induced Changes in the Blood of Rainbow Trout, Salmo gairdneri," Sewage and Ind. Wastes, 206, February, 1959.

11. Pickering, Q. H., and Henderson, C., "The Acute Toxicity of Some Heavy Metals to Different Species of Warm Water Fishes," Air Water Pollution International Journal, 10, 453-463 (1966).

12. Hurst, E. H., "Factors Other Than Mineral Content Which Influences the Corrosiveness of Cooling Water," NALCO Chemical Co., Chicago, Illinois, (undated).

13. Hurst, E. H., "Water Treatment for Poly-Metallic Cooling Systems," NALCO Chemical Co., Chicago, Illinois, (undated).

14. Kelley, B. J., "Removing Chromates," Ind. Water Engineering, 1, September, 1968.

15. Fiber Industries, Inc., "Reuse of Chemical Fiber Plant Waste Water and Cooling Tower Blowdown," Environmental Protection Agency Contract No. WPRO-100-01-68, (1970).

APPENDIX XII-A

COMMENTS ON DRAFT DETAILED STATEMENT ON THE ENVIRONMENTAL CONSIDERATIONS OF THE VERMONT YANKEE NUCLEAR POWER STATION

ROLAND A. LOVELESS
SECRETARY

STATE OF VERMONT
AGENCY OF DEVELOPMENT AND COMMUNITY AFFAIRS
MONTPELIER, VERMONT 05602
(802) 223-2311, EXT. 481

June 9, 1972

Daniel R. Muller
Assistant Director for Environmental Projects
Directorate of Licensing
U.S. Atomic Energy Commission
Washington, D.C. 20545

Subject: Docket No. 50-271

Dear Mr. Muller:

In reply to your letter regarding environmental effect of the Vermont Yankee Nuclear Power Station, there are no nationally registered historic sites in the vicinity of the Vernon plant. It is, therefore, our understanding that effect on historic places is not a consideration in determining its environmental impact.

Sincerely yours,

William B. Pinney
Director
Historic Sites Division

WBP:md

cc: L. G. Farrar
Oak Ridge National Lab.
P.O. Box P
Oak Ridge, Tenn. 37830

DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20250

May 3, 1972

50 - 271

RECEIVED
MAY 8 1972
U.S. ATOMIC ENERGY COMMISSION
Regulatory
Mail Section

Mr. Lester Rogers
Director Division of Radiological and
Environmental Protection
U. S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Rogers:

We have had the draft environmental statement for the Vermont Yankee Nuclear Power Corporation, AEC Docket No. 50-271, reviewed in the relevant agencies of the Department of Agriculture, and comments from the Forest Service and the Soil Conservation, both agencies of the Department, are attached.

Sincerely,

T. C. BYERLY
Coordinator, Environmental
Quality Activities

Attachments

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

We have reviewed the draft detailed statement relating to the proposed issuance of an operating license to the Vermont Yankee Power Corporation for the operation of the subject Station.

The Station is located on the west shore of the Connecticut River, in the town of Vernon, Vermont approximately four miles north of the Massachusetts state line. The statement indicates that 125 acres of land has been modified during plant construction, and that required transmission lines will extend over 50 miles of countryside. In each instance the statement should indicate the acreage of forest land that was cleared. Loss of forest land is related only to a reduction in aesthetic values in the statement. Other adverse impacts of forest clearing, which should be added include the displacement of wildlife, the loss of timber inventory base and its annual growth and an increase in soil movement and sediment production.

The statement would be improved if it would discuss criteria that was used in locating transmission lines to assure adequate consideration of environmental values. If possible, costs that are associated with environmental protection in line location, construction and maintenance should be made known. Also the statement might report the company's policy in respect to utilization of non-air polluting practices in disposal of waste vegetation and methods of controlling vegetative growth in right-of-way lands.

On page 123, reference is made to a two-phase environmental radiation monitoring program. We are in agreement with the emphasis placed on radiation monitoring; however, the statement is not clear as to whether chemical, thermal and physical impacts are being monitored. The environmental monitoring program should provide a basis for the detection of all significant impacts, and should be explained in detail.

In regard to gaseous radioactive wastes which would be held for decay before discharged through a 318-ft. stack, the statement might give consideration to the amount and contents of the discharged gases at the stack and discuss any effects they would have on the environment.

Soil Conservation Service, U.S.D.A., Comments on Draft Environmental Statement Prepared by the Atomic Energy Commission for Operation of the Vermont Yankee Nuclear Power Station at Vernon, Vermont

We have no specific comments regarding the impact of plant operation. The statement does document the fact that a great deal of careful study has been given to all environmental aspects.

Whether the plant is permitted to operate or not, it would appear that the site is committed to its present use for some time to come. The statement recognizes the need for protecting this land against erosion, and for enhancing aesthetic values. We do note that surficial geology and soils are not discussed in as much detail as some other physical features of the site, and would point out that information on this resource, available locally through the Soil Conservation Service, could be useful in planning for optimum use of the site, its surrounding area, and transmission corridors.

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION. CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

50-271

IN REPLY REFER TO:
NEDED-R

22 May 1972

RECEIVED MAY 24 1972

Mr. Lester Rogers
Director, Division of Radiological
and Environmental Protection
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Rogers:

Your letter of 7 April 1972 to the North Atlantic Division of the Corps of Engineers requesting comments on the following document has been referred to this Division for appropriate reply:

> Draft Detailed Statement on the Environmental Considerations Related to the Proposed Issuance of an Operating License to the Vermont Yankee Nuclear Power Station, Docket No. 50-271, By the U.S. Atomic Energy Commission, Division of Radiological and Environmental Protection. Issued April 7, 1972.

Our comments on the draft Environmental Impact Statement are inclosed.

Sincerely yours,

JOHN WM. LESLIE
Chief, Engineering Division

Incl(dupe)
as stated

2813

COMMENTS RELATED TO THE

DRAFT DETAILED STATEMENT BY THE DIVISION OF RADIOLOGICAL AND ENVIRONMENTAL PROTECTION U. S. ATOMIC ENERGY COMMISSION ON THE ENVIRONMENTAL CONSIDERATIONS RELATED TO THE PROPOSED ISSUANCE OF AN OPERATING LICENSE TO THE VERMONT YANKEE NUCLEAR POWER STATION

DOCKET NO. 50-271

Prepared by

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND, WALTHAM, MASSACHUSETTS

MAY 1972

COMMENTS

General. It is suggested that a new paragraph be added to Section V, Environmental Impact of Plant Operation, in order to bring together descriptions of the methods and techniques to be used in performing continuing studies, tests and analyses related to environmental impacts.

The following comments are made by the Environmental Resources Section, Planning Branch:

PAGE	COMMENT
vi, Sect. III. D. 1.	Omitted "b," Dispersion of Heat, after "a."
7 to 13	In Sect. IIc, under"... Land Use," you mentioned aquatic recreation (sport fishing and boating) but what about land recreational use; such as, sport hunting in the general area. Is there seasonal hunting for deer, pheasant, squirrels, ducks, etc. in the area?
19, 3rd Par.	In last sentence of this paragraph, mentioned "river is not considered seriously polluted." What water quality criteria standard has State of Vermont designated for this section of the river?
21	Table II-2. Recommend that the table include a range of values (minimum & maximum) plus mean in order to get a better idea of water quality of area.
24, 3rd Par.	In last sentence, mentioned applicant plans for post-operational ecological studies. How long will studies continue?
29, Sect. II-F-3	2nd Par. Recommend that during discussion of marsh, reference should be made back to Figure II-2 for location of marsh areas.
32, Sect. II-F-6	1st Par. Why was benthos surveyed only during summer months? Should have extended sampling throughout the year, barring ice conditions.
34	Table II-7. Genus for white perch is now Morone instead of Roccus. Also, there is a subspecies for Walleye and therefore should be: Stizostedion vitteum (for reference, see American Fisheries Society, 1970. A list of Common and Scientific Names of Fishes, Spec. Publ. No. 6). In addition, recommend put asterisk (*) i

Page	COMMENT
34 (cont'd)	front of those species more commonly abundant in Vernon Pond (e.g. Rock bass, yellow perch, etc.)
39, Sec. IIIA	1st Par. Should expand on details of planned landscaping or given reference to Section where it is explained.
45, 2nd Par.	What type of herbicides, in what concentration, and how often used should be included.
46, D. 2nd Par.	Should give definition of service water system.
51, D 1b	Under Dispersion or Heat, information should be given on a 3-dimensional heat plume instead of just 2-dimensional. How deep will thermal plume extend?
61, Sec. III-D-2-a	"...a fraction of circulatory stream is continually withdrawn..." What fraction (vol. per 1 unit time) is this
64, 2b.	Under Gaseous Wastes, recommend give limit of gaseous radioactive waste as specified in 10CFR20, rather than just referring to that reference; for example, might include it in Table III-2, p. 69.
75, Sect. IVB	Should either include impact of excavation, clearing, construction and destruction of terrestrial flora and fauna at the 125 acre site, or make reference to p. 85 and p. 159.
79, Sec. V-A-3	No mention or discussion is made of the possibility of air contamination by fog formed from condensed water vapor from cooling towers, as suggested on p. ii.
88, 1st Par.	Disagree as to little adverse effect on aquatic life during closed cycle operation. True that only 2% of minimum flow will be taken in during closed cycle, but the fact that plankton is not uniformly distributed across Vernon Pond but tend to congregate in masses can cause severe consequences to these weak swimmers if sucked in by the intake. Since they will be experiencing 90°F temperatures, toxic chemicals and physical agitatio mortality might be expected to be high.
94, 9th-10th line	What about embryonic and immature fish drifting down into Vernon Pond from upstream.

Page	COMMENT
108, 5th Par.	Should define "bioaccumulation factor."
108, Sec. V-C-6	Discussion in "Radiological Effects," is excellent.
119	Table V-6, is a good idea. Recommend that a 3rd column be added to include maximum critical values (mrem/yr) for man, as a reference. This would be of interest to the layman reading the impact statement.
144, Sec. VII	3rd Par. "proper design and location of lines can minimize some visual impacts..." Will this be done? If so, how?
144	No discussion is presented here on unavoidable adverse effects on aquatic life during plant shutdown (reverse thermal shock) for refueling which will take place about once per year - If discussion will not be included here, at lease make reference to it on p. 98.
169+	The included appendices are a good idea.

Mention should be made of the fact that the mortality to organisms within the cooling tower water will be 100 per cent. Any organism within the cooling water will probably not be able to survive the continual cooling, reheating, as well as mechanical injury and chlorination procedures associated with the recirculation of cooling tower water.

This will include mortality to those organisms within the initial 376,000 gallons as well as the 10,000 gpm which will be used as makeup water. The 10,000 gpm of makeup water will be pumped to the cooling towers during the months of June, July, August and September, the months in which planktonic organisms are in the greatest abundance. How this relates to the planktonic population in general as well as to the impact it will have upon Vernon Pond should also be mentioned.

The last three sentences at the bottom of page 53 state "the computer output indicates that about 150 acres-or a part of Vernon Pond up past the intake structure--would be covered by water at 5°F or more above ambient river temperature." Studies should be performed to determine if recirculation will occur between the discharge and intake waters.

The following comment is made by the Hydrologic Engineering Branch:

On Page 17, par. 2, surface Water Hydrology, 3d Par, 4th line. Change the sentence beginning "The Corps of Engineers---" to read: The Corps of Engineers Standard Project Flood would have a flow, with its present 16 flood control dams in place, of 230,000 cfs and a stage of 235.1 msl.

A-53

THE ASSISTANT SECRETARY OF COMMERCE
Washington, D.C. 20230

50-271

RECEIVED MAY 8 1972

May 5, 1972

Mr. Lester Rogers, Director
Division of Radiological and
Environmental Protection
U.S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

The draft detailed statement on the environmental considerations by the U.S. Atomic Energy Commission related to the proposed issuance of an operating license for the Vermont Yankee Nuclear Power Station, Docket Number 50-271, which accompanied your letter of April 7, 1972, has been received by the Department of Commerce for review and comment.

In order to give you the benefit of the Department's analysis, the following comments are offered for your consideration.

The statement candidly discusses various environmental effects that are expected to result from construction and operation of the facility. Consideration of the following points may, however, be of value in strengthening the statement.

The fourth paragraph on page 33 (7. Fish) contains an error in that smallmouth bass are listed as the fourth most abundant fish species taken by Countryman (1971). Table II-8 indicates that rock bass is the fourth most abundant species (if the sunfish-bluegill category is ignored).

There is apparently a discrepancy in the figures given in Table II-8 and on page 105 for the white sucker. It is stated that this species made up 11 percent by number of the fish taken in Vernon Pond (Countryman, 1971). Assuming that Table II-8 remains the reference point for this study, the catch amounts more nearly to 24 percent of the total number taken. This apparent contradiction likely results from the fact that Table II-8 does not include <u>all</u> of the fish taken. If so, the

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true situation could be displayed by simply adding a "miscellaneous" or "other species" category to Table II-8. The same type of discrepancy pertains to carp, wherein the text refers to 2 percent of the catch by number and the table indicates about 4 percent.

The meaning or intent of the last sentence of the second paragraph of page 52 is not clear.

The last sentence on page 86 states that ". . . it is planned to operate the cooling towers when these populations are at their peak. The inference here is that operation of the cooling towers will lessen the mortality of plankters passing through the condenser. However, the statement might also be interpreted as indicating that the mortality is less significant because populations are at their peak, and that the degree of significance is a matter of relativity. In either case, the first assumption appears erroneous, and the second at least illogical. Deletion or clarification of the sentence would seem warranted.

The several attempts to explore the probable effects of heated discharges on plankters, benthic organisms, and fishes is exceptionally complete and noteworthy. Moreover, we think it is commendable that candid recognition is given (page 92) to the possible adverse influences that the plant may conceivably have on the attempt being made to restore anadromous fish runs to the Connecticut River, and that suggestions are made concerning conducting operational studies that will deal with problems that may arise and the remedial actions that may be required to ensure the success of the restoration program.

The conclusion that a major adverse effect on the fish population will not result from the operation of the reactor is not clearly established. Although the effect of thermal variations is discussed in detail for a variety of fish, the possibility of severe damage to small and immature fish has not been demonstrated to be small. These fish can be killed by being drawn against the intake screens or through the cooling system. Although some may survive in going through the system this

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should not be assumed (it is not clear in the report whether a 100% loss is assumed or not). Clearly the fraction of small and immature fish killed in this way is important. The report states that under some operating conditions as much as 70% of the minimum river flow goes through the cooling system. This would seem to present a serious problem. The assumption in the report seems to be that the fraction when averaged over actual river flow and weighted by the time of year when small and immature fish are most prevalent (presumably spring) is much smaller than the maximum value of 70%. Although this may be true, the report does not attempt to give this any quantitative support.

The last sentence of the first paragraph on page 94 draws the conclusion that young fish should not be abundant in the area susceptible to entrainment in the cooling water. This conclusion is unsubstantiated in that no information is provided concerning the distribution of fish eggs, larvae, or juveniles in Vernon Pond.

In the discussions of temperature-related influence on individual species of fish (pages 103-106), several subjective conclusions are presented. The validity, for example, of assuming that largemouth bass will benefit from warming of Vernon Pond, while at the same time conjecturing that there will be no major influence on the smallmouth bass population seems debatable and subject to various interpretations.

The report states that the noise level in some residential off-site areas may be as high as 70dB. This is below 90dB (A) permissible occupational noise level for an 8-hour day. It does say that these levels may be a source of irritation. A more detailed analysis of the degree of irritation for a 24-hour day might be desirable before plant operation commences.

In the discussion of the liquid waste treatment the report appears to base its conclusions on two assumptions. One is that much of the untreated liquid waste is only 1% as radioactive as the primary and the other is that the equipment drain system has a decontamination factor of 100. Although both

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assumptions appear reasonable, the bases do not appear to be given for either. Such important assumptions should be thoroughly substantiated.

On page 68 the report states that after modification of the present off-gas system the iodine-131 will be reduced to 0.6 Ci/yr from all sources. Since Table III-1 shows 1.2 Ci/yr as being emitted in liquid effluent which should not be changed by modifications to the off-gas system, we don't see how the statement on page 68 can be consistent with Table III-1. Furthermore, Tables III-1 and III-2 indicate a total iodine-131 release of 2.9 Ci/yr. The reduction to 0.6 Ci/yr for the modified system as stated on page 68 would give about a reduction of a factor of five. On page 121, however, the report states that a factor of 100 or more is expected when the extended holdup charcoal system is used. If this is different from the modified system referred to on page 68 shouldn't it be discussed there? If it is the same system, why is credit taken for a factor of 100 on page 121 when only a factor of 5 appears to result from the earlier discussions on page 68. If there is a rational explanation, it should be clearly stated. The whole iodine-131 picture appears to be presented in pieces which makes it appear inconsistent from one part of the report to another.

The annual dose to school children near the plant boundary of 20 mrem is high compared to the new AEC guidelines of no more than 5 mrem/yr at the site boundary. Although this may be a very conservative calculation, it appears to be dismissed too lightly. Although these levels are to be checked after plant operation starts, we believe the conclusions of the report that the adverse effects of the plant are acceptable are considerably weakened by their 20 mrem estimate of the dose to occupants of the elementary school. Perhaps a more realistic calculation could be made or steps taken to minimize the nitrogen-16 sky shine itself.

The subsection on Radiological Effects (pages 108-114) properly evaluates radiation exposure of aquatic organisms, but the subsection on Radiation Monitoring (pages 123-126) would benefit from the addition of certain specific information.

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The locations of sampling stations are simply said to be "upstream and downstream from the station." These locations should be described and delineated more accurately and shown on a map of the area. In the postoperational program, water will be sampled near the effluent discharge. Sediments and biota should also be sampled at this location so that any radioactive accumulation will be detected quickly. The frequency of biota sampling is given only as "periodic." We recommend that time intervals between sampling periods should not exceed 6 months. Furthermore, the types of benthic organisms and fishes selected for sampling should be specified, and the species should be representative of different feeding habits. If possible, organisms should be selected that are known to accumulate certain radionuclides.

The AEC submitted a copy of a suggested insert to the Draft Third Edition and we note this insert appears as the last paragraph on page 78 and the first paragraph on page 79 of the current (4/7/72) draft statement.

The AEC staff's insert to the report covers most of the deficiencies of the consultant's plume rise model. However, without specific information on how the staff computed downwash effects on State Highway 142 for a period of time not exceeding 15 hours per year, we cannot substantiate the results.

Again, in general, we believe the consultant's estimate of fogging at the ground is conservative except for the remaining question of downwash.

We are unable to usefully comment on the radiological effect of gaseous effluents since the computed doses as they appear in Table A-2, A-3 and A-4 do not specify the meteorological assumptions. The applicant is equally noncommittal about these assumptions saying only on page 5.3-14 of Volume I, Supplement to the Environmental Report dated 12/21/71 that they were based on "Meteorology Data Collected at the Site from August 1967 to July 1968." In order to assess the radiological effect of routine and inadvertent releases to the

atmosphere we would need a listing of the meteorological assumptions and the resulting relative atmospheric diffusion rates in units of sec m^{-3}.

We hope these comments will be of assistance to you in the preparation of the final statement.

Sincerely,

Sidney R. Galler
Deputy Assistant Secretary
for Environmental Affairs

ENVIRONMENTAL PROTECTION AGENCY 50-271
WASHINGTON, D.C. 20460

MAY 1 2 1972

OFFICE OF THE ADMINISTRATOR

Mr. L. Manning Muntzing
Director of Regulation
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Muntzing:

The Environmental Protection Agency has reviewed the draft environmental statement for the Vermont Yankee Nuclear Power Station and we are pleased to provide our comments to you.

The major environmental impact of operating the Vermont Yankee Nuclear Power Station involves the potential impact on aquatic biota due to the direct discharge of condenser cooling water to Vernon Pond. Since several modes of operating are possible with regard to discharging heated condenser cooling water, we believe that the station should be operated on the basis of data from an adequate biological and thermal monitoring program. This program should be developed as soon as possible; in the interim we recommend that the station should be operated using closed cycle cooling.

With respect to radiological aspects of the facility, an evaluation should be made of the feasibility and need for the addition of an evaporator in the liquid radioactive waste treatment system to treat chemical and floor drain wastes. Additional attention should also be given to the impact of direct radiation doses at Vernon Elementary School from turbine shine.

We will be pleased to discuss our comments with you or members of your staff.

Sincerely,

Sheldon Meyers
Director, Office of Federal Activities

Enclosure

ENVIRONMENTAL PROTECTION AGENCY

Washington, D.C. 20460

MAY 1972

EPA#D-AEC-00046-03

ENVIRONMENTAL IMPACT STATEMENT COMMENTS

Vermont Yankee Nuclear Power Station

TABLE OF CONTENTS

INTRODUCTION AND CONCLUSIONS

The Environmental Protection Agency has reviewed the draft environmental impact statement for Vermont Yankee Nuclear Power Station prepared by the U.S. Atomic Energy Commission and issued on April 7, 1972. Following are our major conclusions:

1. In order to insure compliance with Federally approved state standards and to adequately protect the aquatic biota of Vernon Pond, the Vermont Yankee Nuclear Power Station should be operated in accordance with biological and thermal data generated from an adequate monitoring program. The development of this monitoring program, in conjunction with expanded biological studies, should be initiated as soon as possible. In the interim, the plant should be operated using closed cycle cooling.

2. In order to achieve lowest practicable radwaste discharge levels until treatment system modifications become operational, the present waste treatment system should be utilized to its full capability.

3. In considering modifications to the liquid radioactive waste treatment system, the applicant should also evaluate the feasibility and need for evaporator capability to treat chemical and floor drain wastes.

4. Actual population doses should be estimated for plant operation with the modified gaseous treatment system and the dose estimates should include contributions from all secondary sources. Special emphasis should be given to the turbine shine dose at the Vernon

Elementary School and the applicant should indicate the levels of turbine shine doses that will require corrective action. The corrective actions that will be taken if needed should also be presented.

5. Additional information is needed to evaluate the impact of cooling tower and turbine generator noise. An octave band analysis should be done giving special attention to possible speech interference levels at the Vernon Elementary School.

RADIOLOGICAL ASPECTS

Radioactive Waste Management

The present waste treatment systems are not capable of limiting the Vermont Yankee Station radioactive discharges to levels which can be considered "as low as practicable." The draft statement indicates that the Vermont Yankee Station will operate with the originally designed gaseous radwaste system until the first scheduled shutdown of the reactor for refueling at which time the modification to the gaseous radwaste system will be ready for operation. An installation schedule for operation of the modifications to the liquid treatment system was not presented. Until the system modifications are operational, the minimization of radioactive effluent discharges will primarily depend on administrative controls.

In order to minimize radioactive effluent discharges, the existing waste management equipment should be utilized to its design capabilities. This position is consistent with 10 CFR Part 50.36a. Examples of procedures which would restrict discharges to "lowest practicable levels" include : operation of the liquid waste system with emphasis on the solidification of wastes to minimize discharges of liquid radwaste to Vernon Pond ; and utilization of the standby gas treatment system to treat the reactor building exhaust. Providing iodine absorbers for the building ventilation system would also minimize discharges.

The draft statement indicates that in the event of high activity levels, the standby gas treatment system can provide for charcoal adsorption and particulate filtration of the reactor building exhaust

system which removes air from the reactor building ventilation system and from the drywell and torus purge exhaust system. The levels of radioactivity which determine when this system will be utilized were not specified. The standby gas treatment system is designed as an engineering safeguard; therefore, it may not be desirable to use the system during routine operations because of reliability considerations. The statement should discuss the feasibility of using the system during routine operations and the measures that will be taken to insure the availability and reliability of the system as an engineering safeguard. If the standby gas treatment system is not to be utilized to treat routine releases from the reactor building and containment purging, the feasibility of alternative methods of treatment should be discussed.

Radioiodine in the main condenser off-gas line will be treated by the charcoal beds in the modified system. Radioiodine in the building ventilation system which includes the turbine and radwaste building exhaust and radioiodine in the gland seal exhaust will be discharged untreated. The statement should discuss the feasibility and expected benefits of providing iodine adsorbers in the station ventilation system and the additional costs involved.

The draft statement indicates that the charcoal system modification to the gaseous radwaste system will result in a reduction factor for off-gas activity of at least 20 relative to that using a 30 minute delay system; whereas, the applicant's environmental report indicates that the modification will result in an activity reduction factor of

40. The amount of xenon and krypton holdup provided by the charcoal system modification and the overall dose reduction benefit gained from the use of the system should be specified.

Additional information on aging characteristics and degradation of the charcoal beds should be provided and plans for periodic testing of the retention characteristics of the filters should be stated. Estimates of the buildup of radionuclides on the charcoal beds, particularly the particulates formed as a result of noble gas decay, should be provided. The ultimate disposal of the charcoal containing residual quantities of radioactive material should be discussed.

The draft statement and the applicant's environmental report indicate that the applicant is evaluating a modification of the liquid radwaste system to provide additional filtration and demineralization of low-purity wastes in a manner that would permit a degree of recycle to the reactor system. A summary of the modification to be made to the liquid system and any implementation schedule should be included in the final statement. In the environmental report, the applicant also indicated that other alternate treatment methods such as increasing the holdup capacity for the low-purity radwaste system have been examined. In considering modifications to the liquid waste treatment system, the applicant should also evaluate the feasibility and need of adding an evaporator to treat the chemical and floor drain waste. Nearly all other BWR nuclear power plants currently under design or construction have an evaporator in the chemical waste treatment system. The

applicant has provided for solidification of waste within the chemical liquid treatment system rather than using an evaporator. The statement should address the adequacy of the solidification system to routinely treat chemical waste as compared with evaporation to maintain discharges at the lowest level practicable.

Population Dose Assessment

Dose estimates from gaseous effluents were presented in the draft statement for the first fuel cycle; however, doses were not presented for plant operation after the extended holdup charcoal system becomes operational. The estimated doses with the extended holdup charcoal system in operation should also be presented so that an assessment can be made of the effectiveness of the gaseous system modification.

Because of the addition of extended gaseous holdup and proposed additional treatment for liquid radwaste, usually minor sources of radiation effluents may become of primary importance in determining the ability of this facility to meet the proposed Appendix I criteria of the Atomic Energy Commission. These secondary sources will constitute a much greater portion of the total station radwaste discharge. Doses from the following sources of exposure should be presented:

a. direct radiation exposure from the liquid radwaste tanks and turbine shine

b. drywell and torus purge exhaust (containment venting)

c. gland-seal leakage

d. radwaste and turbine building gaseous exhaust

In addition to the maximum off-site individual dose, doses (including secondary contributors) should also be calculated at the Visitor Center and Vernon Elementary School.

Both the applicant and the AEC have estimated the turbine shine dose at the school; however, the estimates differ greatly. The applicant calculated a turbine shine dose of 8 mr/yr for 100 percent occupancy and no shielding to the nearest neighbor (dose would be slightly less at the school); whereas the AEC calculated a dose of 100 mr/yr for 100 percent occupancy and 20 mr/yr for 20 percent occupancy. Details regarding both calculations should be given so that the differences in the calculated doses can be resolved. From a site visit to the station, it was determined that the applicant's calculations are based on actual turbine shine measurements made at an operating BWR power station with credit for the eighteen inches of concrete shielding between the high pressure turbine and the school.

In addition to the resolution of dose discrepancies between the applicant and the AEC, a determination should be made as to what levels of turbine shine doses will require corrective action and what corrective action will be taken if needed. Interpretation by the AEC on allowable turbine shine doses would be helpful since the proposed Appendix I does not address direct radiation doses.

The draft statement indicates that a radiation dosimeter will be placed at the school; however, the type of dosimeter was not specified. The type of dosimeter that will be employed should be specified with emphasis on the dosimeter's ability to discriminate the ^{16}N radiation

dose from other gamma dose components and for its efficiency in the assessment of dose to school children. The experience gained from actual field measurements from operating BWR's should be utilized in choosing the dosimeter to monitor the turbine shine.

Transportation and Reactor Accidents

In its review of nuclear power plants, EPA has identified a need for additional information on two types of accidents which could result in radiation exposure to the public; (1) those involving transportation of spent fuel and radioactive wastes and (2) in-plant accidents involving reactor systems. Since many of the factors in accident analysis apply to all nuclear power plants, the environmental risk for each type of accident is amenable to a general analysis. Although the AEC has done considerable work for a number of years on the safety aspects of such accidents, we believe that a thorough analysis of the probabilities of occurrence and the expected consequences of such accidents is necessary. A general study would result in a better understanding of the environmental risks than would a less-detailed examination of the questions on a case-by-case basis. An understanding has been reached with the AEC that they will conduct such analyses, with EPA participation, concurrent with reviews of impact statements for individual facilities and will make the results public in the near future. We believe that any changes in equipment or operating procedures for individual plants, required as a result of these analyses, could be included without appreciably changing the overall plant design. If major redesign of the plants to include engineering changes were expected, or if an immediate public or environmental

risk were being taken while these two issues were being resolved, we will, of course, make our concerns known, and an updated impact statement may be necessary.

The statement concludes "...that the environmental risks due to postulated radiological accidents at the Vermont Yankee Nuclear Power Station are exceedingly small and constitute a negligible hazard when compared to the benefits gained from the plant operation." This conclusion is based on the standard accident assumptions and guidance issued by the AEC for light-water-cooled reactors as a proposed amendment to Appendix D of 10 CFR Part 50 on December 1, 1971. EPA commented on this proposed amendment in a letter to the Commission on January 13, 1972, indicating the necessity for a detailed discussion of the technical bases of the assumptions involved in determining the various classes of accidents and expected consequences. We believe that the general analysis of accidents mentioned above will be adequate to resolve these points and that the AEC will apply the results to all licensed facilities.

NON-RADIOLOGICAL ASPECTS

Thermal and Biological Effects

Condenser cooling can be accomplished at the Vermont Yankee Nuclear Power Station by employing the once-through cooling system, the cooling towers, or a combination of both of these systems (helper mode). Because of this flexibility, the plant can be operated in compliance with Federally approved state standards for thermal discharges and in a manner that will provide adequate protection for aquatic biota. This can be accomplished, however, only if the decision to employ a particular cooling mode is based on information gained from an expanded thermal and biological monitoring program. We commend the AEC for supporting such a program and suggest that it be developed as soon as practicable. The final environmental statement should describe the proposed monitoring program in detail, indicate its state of development, and provide interim operational plans for meeting standards and protecting aquatic life.

If it is not possible to institute this program prior to operation of the Vermont Yankee plant, it is recommended that cooling towers be employed during the interim period. In our opinion, the environmental effects of these towers are less severe than suggested in the draft statement and, until the operation of the once-through and helper modes are proven to be environmentally acceptable, cooling towers are preferred. For example, the draft statement indicates that high drift rates will occur resulting in fogging, icing, and transport of chemicals dissolved in the cooling water to the environment. We believe however, that the drift rate will be closer to 20 gpm rather than the 300 to 700

gpm cited in the statement. In addition to developing an expanded monitoring program, it is recommended that, prior to plant operation, further thermal studies and modeling be done. In our opinion, neither the mathematical model of Motz and Benedict nor the use of field dye dispersion data for temperature prediction, constitute reliable predictive techniques for the Vernon Pond.

The mathematical model of Motz and Benedict is applicable to a situation that is steady state (i.e., time independent), non-recirculating and two-dimensional. The conditions in Vernon Pond, however, are not steady state and, as a result, the plume temperature distributions change with continued discharge of heated water even though the environment and river flow do not change appreciably. This is particularly true during low flows, when conditions for heat accumulation are most favorable. In addition to these fundamental difficulties, the model requires the use of an entrainment coefficient of 0.1. It is not known whether this value is appropriate for Vernon pond.

The applicability of dye dispersion data to temperature prediction is questionable. A heated plume has buoyancy that cannot be simulated with dye alone. Knowledge of the buoyancy characteristics of the thermal plume is essential for proper modeling. The dye might have identified some of the problems related to the buildup of heat in the Vernon Pond; however, no dye dispersion history is reported; nor will the three-day dispersion test be adequate for predictions over an extended period.

In our opinion, techniques such as the use of undistorted physical models are more appropriate for the Vernon Pond system and would, in all probability, provide more accurate predictions than the mathematical

model and field studies employed by the applicant. Reliable modeling and preoperational thermal studies will supply not only needed basic information to operate the plant during the interim period, but may well prove beneficial to the development of the monitoring program.

As indicated in the draft statement, the aquatic biology of Vernon Pond and the Connecticut River is not well understood. It is appropriate, therefore, that the biological studies being done on this system be expanded to determine more fully the types, numbers, distribution, and life patterns of those principal species present. Such baseline information, in conjunction with the biological monitoring program, would contribute to development of operational plans for the Vermont Yankee plant that will adequately protect the biota in Vernon Pond and in waters below the dam site.

In our opinion, the operation of the Vermont Yankee plant, unless conducted in accordance with an adequate monitoring program, may have adverse effects on aquatic biota. The most critical of these involves the effect on present and future fisheries. In particular, the Atlantic Salmon and American Shad, should they be reintroduced to the river, may experience adverse effects from the heated discharge. Both shad and salmon develop sexual maturation and migration problems at temperatures above normal ambient conditions. Since these biological activities occur during the spring and fall of the year when the plant may be employing once through cooling, the heated discharge could interfere with the general health and distribution of the species. In particular, this would be most likely to occur if the thermal plume from the Vermont Yankee plant blocked or occupied a major part of the Vernon Pond.

In addition to possible future effects on the shad and salmon, nonmigratory fish species such as the yellow perch, white perch, smallmouth bass, and white sucker may also react adversely to the elevated water temperatures in Vernon Pond and below the dam site. For example, the heated discharge could, during periods when the receiving waters contain gases at near-saturation levels, induce supersaturation conditions. This may lead to significant fish kills from gas bubble disease. Also, increased water temperature in Vernon Pond and below the dam site during the spring and fall, may favor the more thermally resistant fish species. This could lead to increased numbers of suckers and bass and reduce or displace salmon and other species. In addition, during the winter, fish will tend to congregate in the warmer water of the discharge plume. Should the plant shut down for any reason a temperature shock effect may occur, leading to a fish kill.

In order to avoid or mitigate the effects of the heated discharge, it is recommended that, during periods of critical ambient water temperature or low flow, the plant be operated so as to minimize the size of the thermal plume. Also, as indicated previously, should the Atlantic Salmon and American Shad be reintroduced, it is important that the plume, regardless of the total area it occupies, not block or occupy a major part of Vernon Pond.

To aid in lowering the thermal discharge to Vernon Pond the draft statement recommended the construction of a skimmer wall or submerged baffle. This will allow warm water, that extends down to Vernon Dam, to pass over the dam while permitting retention of the cool deep water

in the pond. Although this approach will enhance the ability of Vernon Pond to accept larger amounts of heat, the warm water discharged through the dam would be damaging to aquatic organisms downstream. In our opinion, the decision to construct such devices should await the results of new thermal models and expanded biological studies. This is necessary in order to accurately predict the effects on the water temperature in Vernon Pond and below the dam site. The final statement should discuss in detail the plans to regulate the size and effects of the thermal discharge on Vernon Pond and on the water below the dam.

The cooling system for the Vermont Yankee plant may entrain significant numbers of various fish species. Entrainment problems are particularly critical during the Atlantic salmon smolt migration in the spring and during the low water periods of the fall months. The final statement should discuss this problem and indicate the desirability of installing intake structure protective devices or adopting other measures to prevent entrainment.

In addition to fish, other aquatic biota will be drawn into the cooling water intake. The final statement should include a more detailed analysis of this problem and indicate the principal species affected, numbers entrained, the duration of exposure to elevated temperatures in the cooling system, and probable mortality rates. Studies performed at the Connecticut Yankee Power Station indicate that mortality rates up to 100% were experienced for fish eggs and larvae of those fish species found at the Vermont Yankee site.

The problem of entrainment could be intensified by the intentional recirculation of treated water to clear the intake of ice during the winter. This practice could, by raising the water temperature at the discharge point, attract fish and fish food organisms directly into the intake and thus increase entrainment rates.

In addition, the applicant should further consider the development of a system that would recover living organisms from the moving intake screens. The present design does not provide for sluicing the entrapped organisms back into the river. Instead, they are periodically washed into a catch basket and dumped into a solid waste disposal site. The importance of returning living organisms to the water, however, will increase in the future as programs to restore the Connecticut River to its natural state progress.

The draft statement indicates that chlorine will be used as a biocide for condenser cleaning. The rate of chlorine addition, however, may on occasion lead to residual levels in the discharge that pose a hazard to aquatic biota. In the past, EPA has recommended that the level of residual chlorine should not exceed 0.1 mg/liter for 30 minutes/day or 0.5 mg/liter for 2 hours/day. The final statement should indicate the plans for chlorine addition and describe the probable adverse effects on the aquatic biota.

Presently there exist unusually high levels of cadmium and mercury in the Connecticut River. During periods when it is necessary to employ cooling towers, the concentration of these metals will increase. This occurs because the blowdown water from the cooling towers contains

higher concentrations of dissolved substances as a result of evaporative losses. Thus, fish and other aquatic biota that are attracted to the heated blowdown discharge will tend to accumulate higher levels of cadmium and mercury in their tissues. The final statement should consider this possibility, indicate the effects on aquatic biota, and describe any human health problems that may arise. Also, if the AEC determines that a serious problem exists, the final statement should describe what corrective steps will be taken. One possibility would be treatment of blowdown water to remove cadmium and mercury.

Air Quality Effects

The draft statement does not discuss the use of auxiliary boilers or diesel engines at the facility. Some of the auxiliary boilers used at nuclear generating stations are large enough to be classified as a point source from an air pollution emission standpoint especially if used occasionally to provide power to the system grid. The final statement should contain information on the extent of their use, the size of the units, type and sulfur content of the fuel, and any other pertinent information necessary to appraise the magnitude of potential emissions from the use of auxiliary boilers and engines at this facility.

The impact of high voltage transmission lines discussed in the draft statement does not mention the production of ozone by the lines. Since little information concerning the production of ozone by high voltage transmission lines is available, the EPA is preparing to study this problem. It would also be desirable for the AEC to provide whatever available information the utility companies may have in the final statement.

Noise Effects

The final impact statement should include an octave band analysis of an area equal distance to the mechanical draft cooling towers from approximately 400 feet south of the Visitor Center extending to approximately 400 feet N.W. of the Vernon Elementary School (along the road). This analysis should include data taken from actual measurements of the mechanical draft cooling towers and data from the turbine generators (predicted data if actual data cannot be obtained). This data should reflect different modes of operation (changes in rpm) as well as operations during different periods of the day.

The data collected should be presented in such a way as to predict possible speech interference levels with particular emphasis being directed to those sound levels received by Vernon Elementary School. This analysis may be of considerable local interest if it became necessary to close the windows of the school to maintain levels below those commonly accepted for speech interference. This situation might require air-conditioning of the school. The External Noise Standards of the Department of Housing and Urban Development for new construction sites state that sound levels should not exceed 45dBA for more than 30 minutes per 24 hours. These criteria should also be applied to the houses in the immediate area of the facility.

COST BENEFIT

The statement has presented a summary of the costs and the benefits of this plant, in which the AEC has concluded, on the basis of their analysis, that the benefits exceed the costs. While EPA is in general agreement with the majority of these listed environmental factors and to some extent in agreement with the tabulation of the benefits, a number of aspects require further clarification and/or modification before we can support fully this conclusion. These aspects are as follows:

1. The benefits derived from the Vermont Yankee Nuclear Power Station are primarily enhanced system reliability reducing the likelihood of power curtailment, and a secondary benefit, the guarantee of a uniform flow through Vernon Dam, for an eventual environmental enhancement. The benefits are not the sales price of the power, particularly when the majority of the power is not urgently needed.

2. The Vermont Yankee Nuclear Power Plant will almost double the generating capacity in the State of Vermont. The majority of this power will be utilized by the New England Power Pool, which will be in an excellent position with respect to reserve

generating capacity (including consideration of unscheduled outages, and maintenance) to the point of achieving a power excess with present demand. This is a case, however, the benefits primarily accrue to a larger segment of society than the environmental costs which are borne by those residing in the locale of the power plant.

3. The draft statement indicates that "The plant should reduce power costs in this area, which would also tend to encourage industry to return." A reduction in the price of power to consumers is a real benefit of this plant that should be considered and quantified. Should industry be enticed to return to the area, however, the environmental costs associated with this industrialization should be considered. Evaluation and further details on this point should be provided in the final statement. In addition, it is stated in the draft statement that tourism would consume a large portion of the power produced by the plant, hence the power would produce more tourism. Justification is needed for such a conclusion.

4. The impacts due to gaseous radioactive release and the thermal discharge will be minimized by the installation of the charcoal bed gas hold-up system, and the closed cycle cooling system. The long term effects, however, of the cooling tower noise and the additional fogging during winter months, should closed cycle cooling be used year-round, requires further discussion to determine their costs to society.

MONITORING AND SURVEILLANCE

As suggested previously, a comprehensive thermal and biological monitoring program should be developed for the Vermont Yankee plant to insure compliance with existing standards and adequate protection of aquatic biota. EPA will be pleased to work with Federal and state agencies in developing general guidelines which can be used by the applicant in preparing a comprehensive and consolidated plan. In our opinion, the plan should include the following:

1) Routine monitoring to judge the impact of thermal discharges, entrainment, and other aspects of plant operation on fish and smaller aquatic organisms. This should include for example, determinations of the effect on populations, population distributions, food sources, and life patterns.

2. Continuous water temperature monitoring at various points in and above Vernon Pond as well as in the river below the dam site.

3. Dissolved oxygen monitoring to insure that receiving waters remain within applicable standards and that levels are sufficient to protect biota.

4. General water quality monitoring to detect concentrations of sulphates, phosphates, toxic metals, chlorine residuals, and other hazardous substances.

5. Provision for providing all monitoring data to appropriate Federal and state agencies for review.

ADDITIONAL COMMENTS

During the review we noted in certain instances that the statement does not present sufficient information to substantiate the conclusions presented. We recognize that much of this information is not of major importance in evaluating the environmental impact of the Vermont Yankee Nuclear Power Station. The cumulative effect, however, could be significant. It would, therefore, be helpful in determining the impact of the plant if the following information were included in the final statement:

1. The draft statement uses different assumptions for calculating: a) the source term for input into the radioactive waste treatment systems; and b) the source term for accident calculations. The primary difference appears to arise because 0.25% failed fuel is assumed in determining the input for the liquid radioactive waste treatment system (even less for gaseous waste); whereas 0.5% failed fuel is assumed for the reactor accident case. Although the difference in the level of risk associated with these two numbers are small, we believe that the values should be the same.

2. The statement should discuss the monitoring of liquid and gaseous discharges in greater detail. Discharges should be analyzed and reported in accordance with the AEC Safety Guide 21. In this manner, meaningful dose estimates can be calculated during operation of the plant. The final statement should also evaluate the amounts of liquid and gaseous radioactivity that could be released undetected and should present estimates of the amount of activity that will

be discharged before monitoring alarms are activated and the discharge terminated.

3. The dose consequences of transportation accidents involving spent fuel should be expanded to include the source terms utilized in the calculations, if this source term is different than that assumed for the general AEC transportation analysis.

4. The statement should discuss the potential leakage of primary coolant water through the residual heat removal (RHR) heat exchangers with subsequent discharge to the environment. The applicant indicates that a radiation monitor is provided for the discharge of the RHR service water system; however, the magnitude of this source was not specified. Leakage may be possible during the shutdown-depressurization mode of the RHR system. The statement should discuss the adequacy of the present system to prevent and control such leakage.

5. The statement should present more information concerning the calculations of offsite doses, for example:

   a. Assumptions for the Sr bioaccumulation factor (BAC) used in calculating the individual dose due to eating fish. A Sr BAC of 150 was used in calculating doses to fish, whereas, a Sr BAC of 15 was used in calculating doses to man. The bases for the difference should be specified.

   b. Table V-6 of the statement should contain whole body dose estimates as well as the presented thyroid dose estimates for the critical pathways of eating fish and drinking water.

c. Doses from accident classes 1, 2, and 4.1 should be presented in the statement.

d. The man-rem doses estimates presented for Vermont Yankee should include contributions from the Yankee Rowe Nuclear Plant.

e. Assumptions for the total radioiodine source term and estimates of the cumulative thyroid dose expressed in thyroid man-rem, including all assumptions and their bases, should be discussed in the final statement.

Non-Radiological

1. The statement should contain additional information in order to allow a more complete assessment of air quality effects. The disposal of non-radioactive solid wastes generated during plant operation with particular attention devoted to combustibles should be addressed. The final statement should also contain a more complete discussion of drift deposits from cooling towers with emphasis on how much land area will be affected, the chemical compounds represented, and the distribution and cumulative biological effect of drift deposits on the land for this facility. The addition of meteorological data such as the annual percentage frequencies of wind direction and speed, supplemented by relevant stability information from the on-site meteorological system, will facilitate our review.

2. The final statement should consider the synergistic and cumulative effects of heat and chemical releases. The combination of residual chlorine, increased mercury and cadmium concentrations, and high water temperatures could significantly increase the effects of the Vermont Yankee Nuclear Power Station on the aquatic biota.

A-85

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

IN REPLY REFER TO:
PWR-ER
May 10, 1972

RECEIVED
MAY 15 1972
U.S. ATOMIC ENERGY COMMISSION
Regulatory
Mail Section

50-271

Mr. Lester Rogers
Director, Division of Radiological
and Environmental Protection
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

This is in response to your letter of April 7, 1972, requesting comments on the AEC's Draft Detailed Statement on the Environmental Considerations Related to the Proposed Issuance of an Operating License to the Vermont Yankee Nuclear Power Corporation for the Vermont Yankee Nuclear Power Station.

The Federal Power Commission's Bureau of Power has commented previously on the need for the Vermont Yankee Nuclear Power Station in a letter dated December 8, 1970, (Reference 4 - page 3 of Draft Detailed Statement) and has submitted more recent comments on the need for this and other nuclear power units in the New England area and the effects of their capacity on the reserves of the New England Power Pool during the 1972 summer and 1972-73 winter peak seasons in a letter to the Chairman of the Atomic Energy Commission dated October 15, 1971 (Reference 2 - page 154 of Draft Detailed Statement). Most recently, in a letter dated March 17, 1972, the need for the facility to serve the area's growing electric demands was reaffirmed (Footnote page 149 - Draft Detailed Statement). The following comments update those made earlier relative to the adequacy and reliability of the electric power systems of the State of Vermont and the New England Power Pool, in which the owner companies of this multi-company enterprise are members. This review is in accordance with the National Environmental Policy Act of 1969 and the Guidelines of the President's Council on Environmental Quality dated April 23, 1971.

The construction of the Vermont Yankee Nuclear Power Station is completed. The AEC issued a license to the Applicant for this unit for fuel loading and lower power testing up to 15.9 megawatts thermal or one percent of full power on March 22, 1972. At this power level no electrical energy will be produced.

<u>Need for the Facilities</u>

This plant was initially scheduled for commercial operation September 1970, but has been delayed due in part, as reported by the Applicant, to environmental considerations and regulatory processes.

Mr. Lester Rogers

In its April 21, 1972 News Release No. 18209, Electric Load-Supply Situation for the Summer of 1972, the FPC did not include the capacity of the Vermont Yankee Plant in the 17.5 percent reserves shown for the New England (NEPEX) area because it is not now considered likely that the plant will be in commercial operation at the time of the summer peak. The 17.5 percent reserve margin shown has since been reduced to 15.4 percent due to the loss of the 250-megawatt Northfield Mountain pumped storage unit when the underground powerhouse was flooded. This area is a winter-peaking area and will necessarily schedule some preventive maintenance during the summer, but its projected margin for the 1972 summer does not allow leeway for extensive maintenance programs.

The projected 1972-73 winter peak for the NEPEX area is 13,477 megawatts, an increase of 1,483 megawatts over the 1972 summer peak. The 540-megawatt Vermont Yankee Plant represents 36.4 percent of this increase in peak demand.

The staff of the Bureau of Power customarily relates its evaluation of the adequacy and reliability of electric bulk power systems to the peak load period immediately following the projected commercial operation of the considered generating unit in order to obtain a measure of the risk when construction schedules are not met. However, large base-load units, such as the Vermont Yankee unit, are expected to provide 35 years or more of economic and reliable service in meeting future demands for electric power.

Transmission Facilities

The station's output is connected directly to the existing New England 345-kilovolt grid. Two new 115-kilovolt lines connect the station's output to the underlying and interconnected Vermont-New Hampshire 115-kilovolt grid. The Bureau of Power staff notes that this transmission arrangement permits the straight-forward and simultaneous support of the EHV system and the lower voltage, parallel, system serving local loads. It is also noted that the construction plans for these lines were reviewed and approved by the Public Service Board of the State of Vermont, and that construction was utilized that minimizes environmental impact.

Alternates to the Proposed Facilities and Costs

The Applicant's decision to construct the Vermont Yankee Nuclear Power Station to provide the system's projected need for base-load capacity was predicated on economic and environmental factors. In making these evaluations, the Applicant used plant costs of $307 per

Mr. Lester Rogers

kilowatt of capacity for nuclear plants and $250 per kilowatt of capacity for a similar-sized plant using oil fuel. It used fuel costs for the nuclear plant of 1.73 mills per kilowatt hour, and for oil-burning plants 6.44 mills per kilowatt hour. The staff of the Bureau of Power has examined these costs with similar costs reported by others and find them to be reasonable.

Conclusions

The staff of the Bureau of Power concludes that it would be prudent to avoid further delay in the commercial operation of the Vermont Yankee Nuclear Power Station, and that matters now delaying that operation be equitably resolved so that the plant be in commercial operation to aid in meeting demands for electric power for the 1972-73 winter peak period and beyond.

Very truly yours,

T. A. Phillips
Chief, Bureau of Power

50-271

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

RECEIVED
MAY 24 1972
U.S. ATOMIC ENERGY COMMISSION
Regulatory
Mail Section

ER-72/421

MAY 19 1972

Dear Mr. Muntzing:

This is in response to Mr. Rogers' letter of April 7, 1972, requesting our comments on the Atomic Energy Commission's draft statement, dated April 7, 1972, on environmental considerations for Vermont Yankee Nuclear Power Station, Vernon, Vermont.

Historical Significance

There do not appear to be any units of the National Park system nor any sites which have been declared eligible for registration as National Historic, Natural or Environmental Education Landmarks affected by construction or operation of this project.

However, the power station is located within the Connecticut River valley corridor, an area which is the subject of pending legislation intended to preserve and promote unusual scenic, ecological, scientific, historic, recreational, and other values contributing to public enjoyment, inspiration and scientific study. The proposed legislation provides for the administration of these units by the National Park Service. The nearest unit is the proposed Mt. Holyoke Unit, near Northampton, Massachusetts, about 32 miles from the Vermont Yankee powerplant.

We are unable to ascertain from the information in the statement if the thermal effects of the project will extend to the Mt. Holyoke Unit of the Connecticut River proposal. We request that the final statement address this question.

Chemical Discharges

It is indicated on page 70 that, since the applicant's limits of detection are relatively insensitive, some trace elements such as mercury and cadmium in the blowdown may be above the permissible limits after concentration. The final environmental statement should indicate that the applicant has adequate monitoring equipment to determine if water quality standards are being met.

We are also concerned for the possible effects these releases will have on the aquatic life. The probable impacts of mercury and cadmium releases are not described on page 70 or in Section V, Environmental Impact of Plant Operation. We think these impacts should be assessed especially since there is a possibility that the water quality standards will be exceeded.

Cooling Tower Effects

According to pages 46 and 70, a maximum of 5000 gpm of water evaporates and drifts from the cooling towers and about 350 tons per year of solids are carried with this water and deposited on the nearby area. According to page 161 most of these solids will be deposited on site. We suggest that the composition of these solids be described and an assessment made of the potential nuisance effects and off-site property damage resulting from these solids.

Outdoor Recreation

The draft statement lacks evidence of full appreciation and consideration of recreational values. According to page 77, construction and operation of the Vermont Yankee Station will have little impact on the present recreational use of the land around the site. We believe that any power project which utilizes natural resources of this magnitude should give serious consideration to the development of recreational facilities. We do not think that the downstream recreational development proposed by the New England Power Company for their FPC Project No. 1904 is a logical substitute for the recreation activities which could be provided in the Vernon Pool. An assessment of the effects on existing and future recreational developments from a physical and esthetic standpoint should be presented in the final environmental statement.

Temperature Monitoring

Based on the discussion on page 81, it appears that continuous temperature recording stations should be installed in Vernon Pond so that both horizontal and vertical temperature profiles can be made for each of the reactor cooling and discharge modes. A correlation between this thermal study and the ecological impact of plant operation should be made in order to isolate the effects of temperature increases to the extent possible.

Entrainment
The experience at the Indian Point Unit 1 Nuclear Plant is described on page 94. In regard to experience at other plants and the proposed intake velocity of 1.0 fps through the trash racks at Vermont Yankee, we recommend that a biological monitoring program be developed and utilized to determine if modification in design or operation of the intake is necessary. We consider that intake velocities greater than 0.5 fps may cause significant damage to fish which become trapped on the intake screens.

Thermal Effects
We suggest that the first sentence, second paragraph, of page 100 be corrected to read as follows: "Since the solubilities of gases, such as dissolved oxygen, in water vary inversely with temperature, increasing the temperature by 20° F will decrease the dissolved oxygen saturation level in the cooling water."

The possible effects of a plant shutdown are recognized on page 98. We suggest that the applicant avoid a sudden shut-down of the cooling system except in an emergency. A gradual shutdown or change of cooling mode procedures should be developed and utilized to the extent possible.

Radiological Effects
The AEC staff concludes, on page 114, that no detectable adverse effect will be produced on the aquatic biota or terrestrial mammals as a result of radionuclides released in the discharge water of the Vermont Yankee Station at the levels given in Section III.D.2. Since the discussion of radiological effects includes animals in addition to mammals, this summary paragraph should include impacts on all animals.

Environmental Impact of Postulated Accidents
The radiological effects of accidents are given only in terms of estimated doses to the population from air borne emissions. However, the environmental effects of releases to water are lacking. We think that the final environmental statement should include estimates of the pathways and quantities of the escaping radionuclides.

We also think that Class 9 accidents resulting in radioactive releases to both air and water should be described and the impact on human life and the remaining environment discussed as long as there is any possibility of occurrence. The consequences of an accident of this severity could have far-reaching effects which last for centuries.

Short-Term Uses and Long-Term Productivity
This section does not address the project's effects on biological productivity. We suggest that the final environmental statement discuss the effects the project will have on the long-term biological productivity of the area.

Irreversible and Irretrievable Commitments of Resources
This section should be expanded and clarified. The last paragraph on page 148 infers that the land directly beneath the reactor buildings may be irreversibly committed; however, these buildings cover only a small part of the 60 acres mentioned. The acreage irreversibly committed should be clarified.

The effects that are expected to make this land irreversibly committed should be described. If leakage of radioactive materials beyond and below the reactor buildings is expected, it should be discussed in the section on the environmental impact of the plant operation, or of postulated accidents.

Potentially serious problems connected with the possible disposition of the site should be discussed in this statement even though the deactivation of the plant would be covered in a future environmental statement. The seriousness of this impact could vary considerably depending on the site location; consequently, it should be considered in the site selection process. Our concern at this site is that long-lived radioactive materials left at the site may eventually affect local ground water or the Connecticut River.

Cost-Benefit Analyses
Table XI-1 on page 165 should be expanded to include benefits from the plant operation and impacts from the transmission lines. Also, the description of the impacts of the intake for the open-cycle operation is not quantitative. The term used, "death of fraction of plankton and fish in Vernon Pond" covers a range from near "0" to near 100%. We suggest that a more accurate description of the impacts expected to occur at the intake be given.

We hope these comments will be useful to you in the preparation of the final environmental statement.

Sincerely yours,

Deputy Assistant Secretary of the Interior

Mr. L. Manning Muntzing
Director of Regulation
Atomic Energy Commission
Washington, D. C. 20545

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

MAILING ADDRESS: U.S. COAST GUARD (WS)
400 SEVENTH STREET SW.
WASHINGTON, D.C. 20590
PHONE: 202-426-2262

9 MAY 1972

50-271

Mr. Lester Rogers, Director
Division of Radiological and
Environmental Protection
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rogers:

This is in response to your letter of 7 April 1972 addressed to Mr. Herbert F. DeSimone, Assistant Secretary for Environment and Urban Systems, Department of Transportation, concerning the revised draft environmental impact statement, environmental report and other pertinent papers on the Vermont Yankee Nuclear Power Station, Vernon, Windham County, Vermont.

The concerned operating administrations and staff of the Department of Transportation have reviewed the material submitted.

Noted in the review of the Federal Railroad Administration is the following:

> "With reference to V.2, transmission line effects, we note no consideration being given to the two railroads that operate in close proximity to the proposed line. High voltage transmission is discussed in Section VIB. The Federal Railroad Administration would like to draw attention to the increasing technological problems created as new and higher voltage transmission lines are built next to railroad rights-of-way. Inductive interference and the more hazardous direct faulting with signal and communication lines are becoming more prevalent. While we do not oppose multiple use of existing rights-of-way, we do feel that this problem must be addressed. 'The 1970 National Power Survey' of the FPC takes cognizance of this problem in Section I-12-7."

The Department of Transportation has no further comments to offer on the draft statement and it is requested that the concern of the Federal Railroad Administration be addressed in the final statement.

This Department has no objection to the proposed nuclear station and the opportunity to review and comment on the environmental impact statement, environmental report and other pertinent papers is appreciated.

Sincerely,

J. M. AUSTIN
Captain, U. S. Coast Guard
Acting Chief, Office of Marine
Environment and Systems

2542

ADVISORY COUNCIL
ON
HISTORIC PRESERVATION
WASHINGTON, D.C. 20240

MAY 10 1972

50-271

Dear Mr. Rogers:

RE: Vermont Yankee Nuclear Power Corporation

This is in response to your request for comments on the environmental impact statement identified by a copy of your cover letter attached to this document. The staff of the Advisory Council has reviewed the submitted impact statement and suggests the following, identified by checkmark on this form:

_____ The final statement should contain (1) a sentence indicating that the National Register of Historic Places has been consulted and that no National Register properties will be affected by the project, <u>or</u> (2) a listing of the properties to be affected, an analysis of the nature of the effects, a discussion of the ways in which the effects were taken into account, and an account of steps taken to assure compliance with Section 106 of the National Historic Preservation Act of 1966 (80 Stat. 915) in accordance with procedures of the Advisory Council on Historic Preservation as they appear in the <u>Federal Register</u>, March 15, 1972.

_____ In the case of properties under the control or jurisdiction of the United States Government, the statement should show evidence of contact with the official appointed by your agency to act as liaison for purposes of Executive Order 11593 of May 13, 1971, and include a discussion of steps taken to comply with Section 2(b) of the Executive Order.

__✓__ The final statement should contain evidence of contact with the Historic Preservation Officer for the State involved and a copy of his comments concerning the effect of the undertaking upon historical and archeological resources.

_____ Specific comments attached.

Comments on environmental impact statements are not to be considered as comments of the Advisory Council in Section 106 matters.

Sincerely yours,

Robert R. Garvey, Jr.

Robert R. Garvey, Jr.
Executive Secretary

2657

cc: Mr. William B. Pinney, SLO, Board of Historic Sites, 7 Landgon St. Montpelier, Vermont 05602 w/inc.

THE COUNCIL is charged by the Act of October 15, 1966, with advising the President and Congress in the field of Historic Preservation, recommending measures to coordinate governmental with private activities, advising on the dissemination of information, encouraging public interest and participation, recommending the conduct of special studies, advising in the preparation of legislation, and encouraging specialized training and education. The Council also has the responsibility to comment on Federal or Federally-assisted undertakings that have an effect on cultural property listed in the National Register.

THE COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF THE ATTORNEY GENERAL
STATE HOUSE • BOSTON 02133

ROBERT H. QUINN
ATTORNEY GENERAL

May 23, 1972

RECEIVED MAY 23 1972

U. S. Atomic Energy Commission
Washington, D.C. 20545

Attention: Director, Division of Radiological and Environmental Protection

Re: Draft Detailed Statement on the Environmental Considerations Related to Vermont Yankee Nuclear Power Station - Docket No. 50-271

Gentlemen:

On April 14, 1972, the Commission published in the Federal Register a notice requesting comments on the above-named statement within thirty days of that date.

Representatives of the Commonwealth of Massachusetts in this proceeding did not receive copies of this statement in time to meet the thirty-day deadline, as our initial copies were apparently lost and we had to request additional from Washington. We respectfully request that the Commission waive the thirty-day requirement as to the Commonwealth and give the same weight to our comments as is given to those received within the thirty-day period. We hope they prove helpful to revision of the Draft Detailed Statement.

Our general comment as to format is that the Draft is either inadequately referenced or poorly organized, or both, so that the factual basis for many of the statements in the Draft is not clear. Special effort should be made to be certain that, in the Final Detailed Statement, no conclusion or judgment is stated without an indication of its source.

As to substance, our major comment is that the matter of benefit-cost analysis and the balancing of benefit and detriment are not well-handled. The staff has in some cases adopted a method of balancing each individual environmental detriment against the total benefit of the plant. It should be obvious that if each

U. S. Atomic Energy Commission
May 23, 1972
Page 2.

detriment were balanced, in a "divide-and-conquer" approach, against the "need for power", then the "need for power" would win the war by a series of small victories. Conversely, if each kilowatt of power generated were balanced against the total environment detriment, then the environment would similarly win out. The National Environmental Policy Act envisions that the total detriment be balanced against the total benefit. Any other balance is meaningless, and such other balances as exist in the draft should be stricken.

The comments provided by the Commonwealth's Division of Fisheries and Game are attached in a letter, verbatim. Additional comments of Massachusetts are listed below, by page and paragraph reference.

Page Reference — Comment, Suggestion, or Question

xvii, par. 5 - It is incumbent upon the Commission, at some point in the Vermont Yankee proceeding, to determine what state law is applicable to the Vermont Yankee facility. It is desirable and appropriate that the Division of Radiological and Environmental Protection now, in the Detailed Statement, detail its conclusions as to what state environmental statutes and regulations govern the plant's operation.

1-2
156, par. 6 - The Draft Detailed Statement nowhere details why the Vermont Yankee plant is or must be located in Vermont.

17, par. 2 - It is suggested that the Division of Radiological and Environmental Protection should be in a position to recommend desired changes in Vermont Yankee operation if the minimum instantaneous flow of the Connecticut River should fall below 1200 cfs.

19, top - The basis does not appear in the Draft Detailed Statement analysis that radionuclides and chemical effluents from the Vermont Yankee plant would be "greatly diluted" and "diluted further" when pumped into Quabbin Reservoir. The Final Detailed Statement should correct this and as well provide information on radiation dispersion or lack of dispersion within the Northfield pumped-storage pond and Quabbin Reservoir to realistically portray dilution of drinking water actually taken from Quabbin.

51-52 – The Draft Detailed Statement provides no analysis of why
79-81 closed cycle operation of the Vermont Yankee plant is not
87 possible or desirable at all times. If the reasons are
157,par.4 economic then the Final Detailed Statement should detail a balancing of the incremental environmental harm from non-closed cycle operation versus economic benefits. Moreover, the Final Detailed Statement should make an analysis of how the plant may be operated in a balanced fashion so that, all environmental factors considered, adverse environmental effects are minimized to the fullest possible extent.

60 – It would be very helpful to these proceedings if the
81 Final Detailed Statement were to provide the best estimate
114 by the Division of Radiological and Environmental Protection as to specific locations within Vernon Pond for the recommended temperature measurement stations.

84,par.2 – To lessen the possible adverse environmental impact of Vermont Yankee, does the Division of Radiological and Environmental Protection have any recommendations for the protection of drinking water supplies downstream on the Connecticut should Vermont Yankee exceed A.E.C. operating strictures for liquid radwaste discharges?

90,par.4 – Given the strength of the opinion of the Division of
92, pars.1,3 Radiological and Environmental Protection on the effect of
145,par.1 heated effluent on anadromous fish, it is suggested that the Final Detailed Statement should specify the conditions it feels necessary, if any, on the Vermont Yankee operating license to protect such interests.

115,par.3 – On the strength of the Draft Detailed Statement's conclusions on the needed limits of temperature increases in Vernon Pond, it appears appropriate that the Division of Radiological and Environmental Protection should recommend an appropriate condition on the operating license eventually issued to Vermont Yankee.

125,par.1 – What is meant by "periodic" biological and river sediment sampling?

125,par.3 – What is the basis for the conclusion that Vermont Yankee "plans to augment the operational radiation monitoring program" in the specified circumstances?

U.S. Atomic Energy Commission
May 23, 1972
Page 4.

138, top - The Final Detailed Statement should specify the "benefits" considered in reaching the conclusion that environmental risks due to postulated radiological accidents at Vermont Yankee constitute a negligible hazard "when compared to the benefits to be gained from the plant operation," how, if at all, this judgment relates to the calculus of the overall benefit-cost analysis in Section XI.B. of the Draft Detailed Statement.

144 (Section VII)
146 (Section VIII)
148 (Section IX) - Please provide, if available, references to subconclusions in other parts of the Draft Detailed Statement which form the basis of the conclusions in these sections on "Unavoidable Adverse Effects," "Short-Term Uses and Long-Term Productivity," and "Irreversible and Irretrievable Commitments of Resources."

148,par.4 - It does not appear from the Draft Detailed Statement what weight is to be accorded the judgment that "commitments" of chemicals and fuels for associated plant equipment are "small" when compared with energy production needs, nor is it clear how this subsidiary judgment is employed in the overall benefit-cost analysis.

151,par.1 - It would be helpful to know whether the 1971-1972 winter experience sheds light on the reliability of past estimates of future electrical power needs, especially for winter 1972-1973.

153,top
and par. 1 -. It does not appear in the Draft Detailed Statement how Vermont's access to additional electrical power from other northeast utilities to meet peak demands is diminished by failure to have an in-state nuclear power plant. It is also suggested that the Final Detailed Statement should specify the other disadvantages, if any, from Vermont being "dependent on importing power to meet its peak electrical energy demands."

156,par.6
157,par.3 - Does the Division of Radiological and Environmental Protection adopt the conclusions of Vermont Yankee as to site selection for the plant and as to a spray pond or cooling pond being "not potentially attractive alternatives" for the cooling system?

Thank you for this opportunity.

Very truly yours,

Gregor I. McGregor

GREGOR I. McGREGOR
Assistant Attorney General
Chief, Division of
Environmental Protection

GIM:JK

Attachment

A-100

The Commonwealth of Massachusetts

Division of Fisheries and Game

Field Headquarters, Westboro 01581

RECEIVED MAY 11 1972 Department of Attorney General

11 May 1972

RECEIVED MAY 26 1972 U.S. ATOMIC ENERGY COMMISSION Mail Section

Mr. Harley Laing
Assistant Attorney General
Department of the Attorney General
State House
Boston, Massachusetts 02133

Dear Mr. Laing:

I have reviewed the "Draft Detailed Statement on the Environmental Considerations Related to the Proposed Issuance of an Operating License to the Vermont Yankee Nuclear Power Station." Basically I find that most areas of concern relating to fisheries and fishery-related problems have been considered to some degree in the report. There are three areas of recommendation which could constitute problems.

1. It is indicated in the report that because unheated river water from upstream will tend to flow along the river bottom and be pulled through the turbines, construction of a skimmer wall (submerged baffle) that would enable the dam to use heated water off the top of the pond for turbine operation would seem to be feasible. It is my opinion that such a recommendation would be extremely hazardous in operating fish passage facilities. In the operation of planned fish passage facilities at the Vernon Dam, the major source of attraction water would emanate from the draft tubes. If this major source was comprised of heated pond surface water, we expect that problems would result in attracting fish to the fishway entrances proposed for construction over the top of the draft tubes.

2. The report indicates that in the event fogging occurs outside of the plant site that the cooling towers be shut down. We would disagree with such a recommendation and conclusion as being impractical if the fishery resource, resident or anadromous, is to be offered full protection.

3. The AEC staff has concluded that thermal impact should not be excessive if the applicant controls the discharge so as to limit the area of the plume to ten acres and its maximum temperature difference from pond temperature to 5° F. (summer) and 10° F. (winter). This

Mr. Harley Laing
11 May 1972
Page 2

appears to be a new concept advanced in the proposed operation of Vermont Yankee. This proposal, I believe, runs contrary to recent permits issued by the Vermont Water Resources Board and the New Hampshire Water Supply and Pollution Control Commission. This third concept now brings us into the area of temperature measurement. It is my understanding that this measurement can be taken at any point or points and the company has agreed that this can be done. It would appear that with the capability of three modes of operation that a closed cycle during the critical months will minimize most fishery problems related to anadromous fish restoration, operation of fish passage facilities, and protection of resident fish.

These are the three areas that I believe should be handled in any reply to the Atomic Energy Commission on their environmental impact statement.

Sincerely yours,

Colton H. Bridges

Colton H. Bridges
Superintendent
Bureau of Wildlife Research & Management

CHB:mb

The State of New Hampshire

ATTORNEY GENERAL
WARREN B. RUDMAN

DEPUTY ATTORNEY GENERAL
WILLIAM F. CANN

Attorney General

Concord

May 11, 1972

CERTIFIED MAIL

Director
U. S. Atomic Energy Commission
Division of Radiological &
Environmental Protection
Washington, D. C. 20545

Dear Sir:

Re: 50-271, In the Matter of Vermont Yankee Nuclear Power Corp.

I enclose herewith comments by the State of New Hampshire, Fish and Game Department concerning the Draft Detailed Statement on the environmental considerations related to the proposed issuance of an operating license to the Vermont Yankee Nuclear Power Station.

You have received under separate cover comments from the New Hampshire Water Supply and Pollution Control Commission, which are intended to be amplified at the time of the environmental hearings before the Atomic Safety and Licensing Board.

Very truly yours,

Donald W. Stever, Jr. (djr)

Donald W. Stever, Jr.
Attorney

DWSJr:djr

Enclosure

A-103

STATE OF NEW HAMPSHIRE

INTER-DEPARTMENT COMMUNICATION

DATE May 2, 1972

ROM Arthur E. Newell, Supervisor
Fisheries Research

AT (OFFICE) Fish and Game Department

JECT Vermont Yankee Draft Impact Statement

TO Donald Stever
Office of Attorney General

The Atomic Energy Commission is to be commended for a very professional job in preparing this statement. There are many points of interest which I believe should be discussed in some detail amongst the various state agencies, previous to the next A.E.C. hearing. I have arranged my comments in what I consider to be logical groups, viz: Chemical Problems, Thermal Problems, Entrainment and Entrapment, and Summary and Recommendations.

Chemical Problems

On page 1 it is indicated that the chlorine concentration in the discharge will be 0.1 ppm. As indicated later in the report, this is sufficient to cause potentially adverse environmental effects.

On page 68, the last paragraph, it is indicated that basically three chemicals will be discharged into Vernon pool in substantial quantities. These are residual chlorine, sodium, and sulfate. A competent biochemist should be consulted to determine the possible affects of these chemicals upon the fish population. In addition, I believe fish are known to refuse to enter water containing excessive amounts of chlorine. This chlorine is bound to be present in the water feeding our fish ladder. It is recommended, therefore, that the effluent be dechlorinated with a treatment of thiosulfate.

On page 70, paragraph 3, it is indicated that certain trace elements, such as mercury and cadmium are presently just below permissable limits in the original water, and that these chemicals will be concentrated by a factor of 2.3. While the Federal tolerance for fish has been established at 0.5 ppm our research in this area has revealed concentrations in fish as high as 0.87 ppm. I believe, therefore, that some effort should be made to remove these chemicals from the discharge.

On page 82 various chemical discharges are discussed. I would suggest that we attempt to take the advice of a competent biochemist relative to this subject, as nobody in our department is qualified. A rather large amount of sodium and sulfate ions will be discharged at rates of 1100 and 90 pounds respectively during open cycle cooling and 170 and 360 pounds per day respectively during closed cycle cooling. Cation and anion units will be regenerated twice per week and will discharge 9000 gallons in each batch at sodium and sulfate concentrations of 1900 and 4100 mg/liter respectively. While it is stated that releases

of these salts are not expected to limit the quality or usability of the river water, I personally would prefer to have other opinions on the matter.

The first paragraph on page 100 is entirely true and we have data of our own to support these statements.

I feel, however, that the possibility of super-saturation of oxygen mentioned in paragraph 4 has not been adequately stressed. It is well known that super-saturation of gasses can cause mortalities in fish. The effects are similar to the commonly known "bends" in divers.

On page 101 chlorine residual in the effluent is discussed. It is pointed out that concentrations far less than those permitted in the discharge have been known to be lethal. We do recommend, therefore, that dechlorination with thiosulfate treatment as recommended on page 102 be applied.

Thermal Problems

On page 11 under the heading "Air Contamination" it is indicated that when fog from the cooling towers extends beyond the site boundaries the operation of the cooling towers will be terminated. If we are to protect our fish population and if the company is to meet established water quality standards this cannot be tolerated. The entire plant must be shut down when such an occasion occurs.

On page v. it is indicated that thermal impact of Vernon Pond will be adequately controlled if the area of the thermal plume is limited to ten acres, and that summer temperatures within this area do not exceed 5°F over ambient and winter temperatures do not exceed 10°F over ambient. While we agree this is an improvement in the original proposal of the mixing zone the temperatures of 5°F and 10°F exceed water quality standards previously established for the states of Vermont and New Hampshire.

On page 51 the temperatures standards adopted by the states of Vermont and New Hampshire are quoted. These are obviously in conflict with the five and ten degree temperature rises recommended by the A.E.C. Perhaps, however, these temperatures can be tolerated if the mixing zone is restricted to ten acres.

In paragraph 2 on page 52 the problem with the point of measurement as established by the state of Vermont is discussed in some detail. It is adequately pointed out that temperatures measured at station 3 approximately .65 miles downstream from Vernon Dam will not adequately reflect the temperature and thermal stratification problems within the Vernon pool. Thus the cooling towers might not be used at times when they are needed to protect the Vernon pool. While it has not been pointed out to any great extent, it should be mentioned at this time that this heated surface water from the Vernon pool is that water which will feed the fish ladder and will consequently cause a rejection by the fish.

Mr. Donald Stever (continued) May 2, 1972

On page 60, paragraph 2, it is indicated that the vertical thickness of the plume will be about 5 feet where it enters the pond and will thin out as it spreads over the remainder of the entire area. Five feet is a rather dense layer of heated water for fish populations to tolerate, especially where they occur immediately upstream of the proposed fish ladder.

Further discussion of cooling tower and fogging effects take place on pages 78 and 79. Again, I believe that rather than shutting down the cooling towers when fogging problems occur the plant itself must be shut down in order to meet water quality requirements if fish and aquatic life are to be maintained.

On page 79 and elsewhere in the report in many places the discussion of open-cycle operation takes place. I fail to see how the plant can be operated at all and water quality standards be complied with. Discharge temperatures will be 20° above ambient and maximum allowable temperature recommended by the states is 5° at any time.

At the top of page 81 it is indicated that the applicant has no definite commitments for detailed thermal plume studies in the pond after the plant begins operation. Such studies are apparently recommended by the A.E.C. and we heartily concur with this recommendation.

In the last paragraph on page 81, it is stated that the staff believes that continuous temperature recording stations should be installed within the Vernon Pond in accordance with the technical specifications for operating the plant, and that temperature profiles in Vernon plant should be measured to define thermal plume after reactor operations begin. With this statement we also concur.

In the same paragraph it is indicated that such stations would provide realistic temperature data on Vernon Pond, where the greatest biological impact is anticipated. While we agree with this statement we feel that perhaps the greatest biological impact will occur within the fish ladder at Vernon Dam.

On page 90 reference is made to other thermal discharges in the Connecticut River which the migrating salmon and shad must contend with. I believe it appropriate to point out that most of these areas do not possess the same problems as exists at Vernon. These areas of discharge are not located immediately above a dam and adequate zones of passage are available: therefore, fish have ample opportunity to pass the effluent either underneath the heated water or on the opposite side of the river, as has been demonstrated by a sonic tagging program at the Conn-Yankee plant.

Mr. Donald Stever (continued) May 2, 1972

In the next to last paragraph on page 90 it is stated that if a fish ladder is built at Vernon heated water from the Vermont Yankee could flow into the ladder and serve as a thermal obstacle to migrating salmon, with which we agree. In addition I would like to state that plans call for this fish ladder to be in operation by 1974. Since the ladder has already been designed and located I do not believe the last sentence in this paragraph is applicable. While I am not an engineer, the only way I could see that the ladder could be modified to circumvent the heated effluent would be to extend it upstream beyond the discharge point. Besides being very costly this form of construction has many other drawbacks. It is known that turbine mortalities of downstream migrating fish exist at Vernon Dam. If it is proven that these mortalities are extensive enough, fish screening will be necessary and the ladder as currently designed will be used to pass the migrating fish downstream in order to eliminate this mortality. A ladder entrance located one-half mile or more upstream could not be used for this purpose.

On page 92, paragraph 3, it is stated, "In summary, the staff concludes that Vermont Yankee could have two potential deleterious effects on the anadromous fish program. One, heated water could flow into the fish ladder and block the progress of ascending fish. Two, smolts migrating to the sea could be killed in the intake." Both of these problems would be eliminated if Vermont Yankee were to operate on a closed cycle from May through December.

In the last paragraph on page 98 it is indicated that winter mortalities will be likely in case of shutdown. With this we heartily agree as we have experienced a similar mortality problem at fossil fuel plants when a forced shutdown occurred during the winter months. It is recommended that all routine maintenance shutdowns be scheduled for the summer months.

On page 114, paragraph 3, again it is recommended that monitoring water temperatures in Vernon pond be conducted. With this we agree and I would like to suggest that our own Water Pollution Department require thermal standards be met at some point within the Vernon pond. Paragraph 4 reiterates the problems with measuring temperatures downstream, as has been proposed by the state of Vermont. With this we are in concurrence.

Page 115, last paragraph, describes what appears to me to be an excellent mixing zone of ten acres within the Vernon pond. I do believe, however, that there should be a shutoff point whereby the plant be prohibited from raising water temperatures more than 1°, as has been indicated in the permits issued by the states of New Hampshire and Vermont. This recommendation again takes place at the bottom of page 162. The matter of radioactive discharges on aquatic life appears to have been treated rather lightly; however, we are not competent to adequately understand these problems and therefore have no comments.

Mr. Donald Stever (continued) May 2, 1972

Entrainment and Entrapment

On page 11 it is indicated that water velocity at the travelling screen will be 1.6 foot per second. This is considerably in excess of the velocities that have been recommended by fishery experts for some time. Water velocity at this point should never exceed one foot per second.

On page 48 it is again indicated that water velocity at travelling screens will be 1.57 foot per second. I repeat, this is bound to cause excessive fish mortalities.

On page 80, paragraph 2, it is indicated that during the months of June, July, August and September the plant is expected to be operated on a closed-cycle. Because of the anadromous fish program I strongly recommend that the plant be operated on closed-cycle from April through December in order to adequately protect upstream and downstream migrating juveniles and adults of both Atlantic salmon and American shad.

In the next to last paragraph on page 80 it is indicated that the plant will probably be operating on open cycles during the months of March, April and May. As previously stated, this cannot be tolerated. Neither can the months of October, November and December be tolerated on an open cycle method of operation, as is indicated in this paragraph.

The problem of losses of phytoplankton and zooplankton entrained in the condenser cooling water are discussed on pages 86 and 87. While it is indicated that past studies have shown high mortalities of these organisms and further that these organisms quickly recover in population further downstream, it should also be remembered that eggs and larvae of many fish species are also planktonic in their early stages and would be subject to the same mortalities. They cannot, however, recover as do the other organisms.

On the bottom of page 88 it is indicated that a difference in abundance and species composition is likely to occur near the outfalls of the water discharge. This type of change is seldom for the better but generally results in the more tolerant, less desireable organisms replacing those that are currently present.

On page 92, paragraph 3, it is stated, "In summary, the staff concludes that Vermont Yankee could have two potential deleterious effects on the anadromous fish program. One, heated water could flow into the fish ladder and block the progress of ascending fish. Two, smolts migrating to the sea could be killed in the intake." Both of these problems would be eliminated if Vermont Yankee were to operate on a closed cycle from May through December.

On page 94, under the subject entitled "Entrainment", it is indicated that experience at Indian Point Nuclear Plant Unit #1 demonstrates that a large number of fish can be killed in cooling water intake structures. The velocity of water entering the intake structure is one of the critical factors. As the velocity at this plant was decreased from 1.20 to 0.85 foot per second a significant decrease in the number of fish killed has been reported. At the Vermont Yankee plant the flow at the intake screen is designed to be 1.6 foot per second.

In the next paragraph it is indicated that the applicant and their consultants have also obtained guidance and recommendations from the states of Vermont, Massachusetts and New Hampshire, as well as the Bureau of Sport Fisheries and Wildlife on the intake structure design. While this is a true statement, it was also indicated at that time that rates of flow as high as 1.6 foot per second at the travelling screen might cause problems, and if so that would have to be corrected. Recent studies such as those cited in the preceding paragraph have indicated that these flows will most likely be excessive. Therefore, I anticipate considerable mortalities through entrainment or entrapment upon the fish screens. Normally I would recommend that the intake structure be redesigned so that the flow at the travelling screen would be somewhere in the neighborhood of 0.5 foot per second. If, however, Vermont Yankee were willing to operate on a closed cycle from April through December the anadromous fish population should receive adequate protection.

On page 98 further results of the Connecticut Yankee plant are discussed in relation to the mortality of nine species of young fish entrained in the condenser cooling water. This further supports my philosophy that the plant should operate on a closed cycle basis from April through December.

On page 98, paragraph 3, the last sentence indicates that the largest number of fish probably would be killed during the fall and winter months when the plant is operating on open cycle and the river flow is low. I fail to see how this plant can operate on open cycle at any season of the year and meet water quality standards which call for a maximum temperature rise of 5°F.

With the conclusions on page 106, we are in basic agreement. However, we should like to point out that we have already proven this section of the river is highly conducive to the spawning of American shad and that entrainment, entrapment and the effects of chemicals upon this species would probably be far greater than that indicated in the report.

<u>Summary and Recommendations</u>

In summary I think the Atomic Energy Commission staff has done an excellent job of preparing a fine environmental impact statement.

Mr. Donald Stever (continued)   May 2, 1972

I would like to suggest that it would probably be to our advantage to attempt to get our own Water Pollution Commission to define the point within Vernon pool where the temperature standards established are to be measured previous to further A.E.C. hearings, and preferably as the ten acre "mixing zone" recommended in the staff report.

It is further recommended that closed-cycle operation be required from April through December.

Lastly, it is recommended that the services of a competent biochemist be sought in order to properly assess the effects of chemical discharges.

A-110

The State of New Hampshire

Water Supply and Pollution Control Commission
Prescott Park
P.O. Box 95—105 Loudon Road
Concord 03301

May 5, 1972

United States Atomic Energy Commission
Attention: Director, Division of Radiological and Environmental Protection
Washington, D. C. 20545

REF. DOCKET NO. 50-271
VERMONT YANKEE NUCLEAR
POWER CORPORATION

Dear Sir:

Subject: DRAFT DETAILED STATEMENT ISSUED APRIL 7, 1972 RE REFERENCE

Assuming the accuracy and correctness of subject statement, it is apparent that the operation of the Vermont Yankee Nuclear Power Corporation's nuclear power station at Vernon, Vermont, will, at times, violate:

(1) the Class B water quality standards assigned by the New Hampshire legislature and approved by the Federal Government to protect the Connecticut River in the vicinity of the nuclear station; and

(2) the conditions of the FINAL PERMIT TO DISCHARGE CERTAIN STATION WASTES FROM THE VERMONT YANKEE NUCLEAR POWER CORPORATION NUCLEAR GENERATING STATION TO THE CONNECTICUT RIVER AT HINSDALE, NEW HAMPSHIRE, granted March 2, 1972, by the New Hampshire Water Supply and Pollution Control Commission.

Substantiating the above is the Commission's highlighted and annotated file copy of subject statement available for review in the Commission offices.

Thank you for making our statement a part of the United States Atomic Energy Commission record re reference, Docket No. 50-271, Vermont Yankee Nuclear Power Corporation.

Sincerely,

Terrence P. Frost
Chief Aquatic Biologist

RECEIVED MAY 9 1972

TPF/mad
CERTIFIED MAIL-RRR

cc: D. W. Stever, Esq., Commission Counsel
R. A. Nylander, Comm. Industrial Wastes Engineer
B. W. Corson, Director, N.H. Fish and Game Dept.

2520

State of Vermont

AGENCY OF ENVIRONMENTAL CONSERVATION
ROBERT B. WILLIAMS, Secretary
Montpelier, Vermont 05602
OFFICE OF THE SECRETARY

*Department of Fish and Game
Department of Forests and Parks
Department of Water Resources
Environmental Board
Division of Environmental Protection
Division of Recreation
*Division of Planning
Natural Resources Conservation Council

RECEIVED MAY 16 1972

May 12, 1972

United States Atomic Energy Commission
Division of Radiological and Environmental
Protection
Washington, D. C. 20545

RE: Docket No. 50-271

Dear Sirs:

This Agency has reviewed the "Draft Detailed Statement on the Environmental Considerations" relative to the proposed operating license for the Vermont Yankee Nuclear Power Station.

The review has been conducted by personnel of the Water Resources Department, Fish and Game Department, Air Pollution Section, and staff of the Planning Division. In addition we have considered inputs from other State agencies and departments, including the Public Service Board and the Department of Health. It is my understanding that no other State agency including the Office of the Attorney General will submit comment on this matter.

1. We concur with the findings of the Atomic Energy Commission, Division of Radiological and Environmental Protection, relative to the necessity for analyzing the impact of thermal releases in Vernon Pond (VB 1 and 2). We agree and also recommend that continuous temperature recording stations should be installed in Vernon Pond and that temperature profiles in Vernon Pond be measured to define the thermal plume after the reactor begins operation. This thermal study should be coordinated with studies documenting the ecological impact of the plant operation. Particular attention should be directed to the possible effect of the flow of heated water in relation to the anadromous fish program.

2. We concur with Commission's opinion in regard to the applicant's lack of commitment as to how the chlorine will be analyzed. Our understanding is that the applicant intends to analyze only the chlorine in the effluent prior to

Page No. 2
U. S. Atomic Energy Commission
May 12, 1972

discharge (Vol. 1, Sec. 3.7.4) and the methodology will not take into consideration constituents of ammonia and nitrogenous materials in the river which may form chloramines. We believe the applicant should measure the "total" residual chlorine (V, C 4.b.(3).

3. We recommend that the applicant should continue biological monitoring to document the effects of plant operation on the ecology of the area in accord with the recommendations outlined in V C 5 Biological Monitoring.

4. We believe that at least one environmental aspect has been overlooked. Despite assurances and findings that the operation of the plant poses no hazard to the safety of the public, we consider it logical to conclude that the operation of an atomic energy facility creates a psychological barrier for at least a portion of the general public in terms of use of the Vernon Pond for recreation. To this extent, there will be an adverse environmental impact that should be noted.

Sincerely,

Robert B. Williams

ROBERT B. WILLIAMS, Secretary of
Environmental Conservation

RBW:mss

VERMONT YANKEE NUCLEAR POWER CORPORATION
SEVENTY SEVEN GROVE STREET
RUTLAND, VERMONT 05701

REPLY TO:
ENGINEERING OFFICE
TURNPIKE ROAD
WESTBORO, MASSACHUSETTS 01581
TELEPHONE 617-366-9011

May 15, 1972

U. S. Atomic Energy Commission
Washington, D. C. 20545

MAY 17 1972

Attention: Director, Division of Radiological and Environmental Protection

Re: Staff Draft Detailed Statement on the Environmental Considerations related to the proposed issuance of the operating license to the Vermont Yankee Nuclear Power Station--AEC Docket No. 50-271

Dear Sir:

On April 14, 1972 the Commission published a notice in the Federal Register announcing the availability of the above Draft Detailed Statement and requesting comments thereon to be filed within thirty days thereafter.

The Applicant, Vermont Yankee Nuclear Power Corporation, has reviewed the Draft Detailed Statement issued by the Commission's Regulatory Staff and offers the following comments:

1. The "Brief Summary and Preliminary Conclusions", appearing on pages i through v, contains some inconsistencies with the substantive content of the text itself and also reflects some erroneous statements of fact contained in the text. For example, on page i, it is stated that "chlorine is sufficiently concentrated (0.1 ppm) in the effluents to cause potentially adverse effects", whereas on page v, it is stated that

chlorine will have a chemical impact only if it exceeds 0.1 ppm and in the text, at pages 101 through 106, the Staff discusses the chemical impact of the effluents and concludes that the anticipated chlorine concentration after minimum dilution "is harmless according to the predominance of the evidence" and that the chlorine "at times may cause fish to move from the vicinity of the discharge area or may damage less mobile organisms in a localized area". There is also a statement on pages ii and v that Applicant will refrain from operating its cooling towers under certain fogging conditions which is unsupported on the record as explained in comment 12 below. In addition, there are other statements which, because of their capsule form, fail to convey fully their relative importance. For example, on page i the Staff refers to "temperature increase . . . in a 10-acre area of the Pond", while as pointed out in comment 7 below, the Staff has presented no cost-benefit evaluation of this arbitrary imposition of a mixing zone. Further, the reference to the "planned restoration of salmon" does not accurately reflect the status of that program and the reference to "traffic" does not evaluate that effect in the perspective of what traffic would be for any other facility.

The Applicant believes that the Detailed Statement, and in particular the summary which will be widely read, should be a careful and reasoned exposition of the data and evaluation process which the Staff has gone through in considering the environmental aspects of the proposed licensing so that all parties

to the proceeding and the public in general can appraise the result.

2. There appears to remain some misunderstanding of the precise nature of the Applicant's facility in relation to the rest of the New England area. The Applicant is a generating company which will sell the output of its facility to its ten owners which are investor-owned electric utilities. The Applicant has no "system" of its own (see erroneous statements on page 1, line 11 and on page 149, line 2). Similarly, the New England Power Pool is a vehicle for joint generation and transmission in New England which does not constitute a "system" (see erroneous statement on page 1, line 11). Similarly, Velco is a <u>transmission</u> company in the State of Vermont rather than a "distribution" company (see page 45, line 11). In this connection, a better description of the New England power picture would be helpful to avoid such erroneous statements in the Detailed Statement, such as: "The Vermont Yankee plant will provide about one-half of Vermont's power requirements" (page 39); "the electric power . . . would probably be largely consumed by the tourism industry" (page 146); and "industry and population will increase in the vicinity of the plant" (page 148).

3. <u>Page 2</u>. The discussion in the second paragraph on page 2 implies that little or no consideration was given to population distributions. In fact, the Gibbs and Hill Site Study of October 1965 states the following criterion on page II-5, which would have to be met for any site:

"Sufficient remoteness from populated areas to meet safety requirements of AEC and land area sufficient to meet exclusion area requirements."

It is abundantly clear that Vernon is an acceptable site from the standpoint of population density as evidenced by DRL's approval of it. Further, comparison with other approved sites will show that the population distribution around Vernon is lower than for many other nuclear power stations. As a consequence of these considerations, Vermont Yankee considers that the wording of the particular paragraph is misleading and the implications contained in it should be eliminated.

4. Page 17, line 13 under heading 2. The Applicant's commitment to the Commission and to the Vermont Water Resources Board, and its contractual arrangements with New England Power Company, contemplate a minimum flow through the Vernon Dam of 1200 cfs at all times. The textual reference to stabilizing pond elevations which appears to qualify that minimum flow commitment is without foundation.

5. Page 39. The last three sentences of the first paragraph under "B. Transmission Lines" would be more accurate if changed to read as follows:

"The connection of Vermont Yankee to the 345 kv New England grid is made in the Vermont Yankee switchyard. The 345 kv grid loops from western Massachusetts northerly to the Vermont Yankee switchyard and then easterly through New Hampshire. The two 345 kv grid transmission lines into the Vermont Yankee switchyard are not considered to be required as a result of the construction of the Vermont Yankee plant, as they would have been required to supply purchased power to the State of Vermont if the plant had not been built at the Vernon site. The added facilities required are two 115 kv lines that connect the plant to the interconnected Vermont, New Hampshire 115 kv grid."

6. Page 45. The sentence beginning "Another transmission line . . ." which starts on line 14 should be deleted because it refers to a proposed line which was never constructed.

7. Page 51. The Staff's discussion of the dispersion of heat from the plant, which begins on this page, results ultimately in the Staff's recommendation on page 115 that specified temperature limitations be imposed upon operation of the plant and that only "a discharge area of 10 acres will be exempted from this restriction". As the text of the Draft Detailed Statement reveals, the logic which leads to this result is elusive and that factual support and evaluation process which underlies the Staff's conclusion is nonexistent. In reaching this position the Staff disregards the results of the Applicant's dye studies, while relying upon a mathematical model selected by the Staff. In addition, the Staff discounts the value of monitoring temperature rise downstream from Vernon Dam. The Applicant strongly opposes the arbitrary imposition of the Staff's recommendation as set forth below.

The Applicant submits that dye studies are an entirely acceptable tool for analyzing heat dispersion. Although the dye studies at Vermont Yankee used unheated water and were conducted to determine the hydraulic and diffusive properties of Vernon Pond, the results of the dye studies can be used to estimate effects of a heated discharge released into Vernon Pond.

The results of the Applicant's study showed the presence of circulatory currents in Vernon Pond during nightly periods of low flow (1270 cfs) and stronger currents directed toward Vernon Dam during daily periods of higher flows (5000 cfs). The dye became well mixed with the receiving water throughout the Pond, indicating a relatively high degree of ambient turbulence during the period in which the dye studies were performed. These changing currents and ambient turbulence tend to increase both horizontal and vertical mixing of the heated discharge with the receiving water.

In fact, the results of the mathematical analysis conducted by the AEC indicates that the Applicant's "dye dispersion studies are in approximate agreement with the results from the mathematical model at both low flow conditions tested". (Page 60, first paragraph)

The heated water layer and ambient turbulence have been related through the densiometric froude number which is a measure of the ability of a body of water to sustain a two layered, or stratified condition. The froude number for the maximum average allowable temperature rise of 4°F. on Vernon Pond is approximately 1 during flows of 1200 cfs and increases to approximately 4 during flows of 5000 cfs. Field experiments have shown that flow separation occurs when the froude number is less than 1 over pi. (Orlob, GT, and Selna, LG, "Mathematical simulations of thermal stratification in deep

reservoirs", ASCE Specialty Conference on Water Quality, Portland, Oregon, January, 1968.)

It is, therefore, unlikely that Vernon Pond can support a stratified condition outside of the initial mixing area if the temperature rise criteria are adhered to.

The dye dispersion studies indicate that ambient turbulence in the Pond will overcome the buoyant effects of the heated discharge.

These original judgments regarding the mixing from the discharge in addition to the supporting information obtained in the dye study indicate that the Pond will be mixed and will not have a stratification similar to those predicted by the mathematical models. The supposition that the heated water would stratify on the Vernon Pond is not supported in any way other than by a mathematical model which the Staff concedes "was not considered entirely appropriate for Vernon Pond" (Page 60). On the other hand, the Applicant's dye dispersion study does indicate that there would be substantial mixing in Vernon Pond. Therefore, the mathematical models used by the Staff have obviously presented an inaccurate representation of the three-dimensional aspects of the thermal dispersion in Vernon Pond.

The arbitrary delineation of a 10-acre area which is to be exempt from the Staff recommendation is of real concern to Vermont Yankee. As is readily demonstrated by the tables on

pages 54 through 59, the position of the plume will constantly change as river flows change. As may be seen in Webster-Martin's Report, Section C, the river flows change significantly on a daily basis. With this constant change in flow, the river is seldom in a steady state condition and thus neither is the thermal plume. Therefore, it would be extremely difficult to assure compliance with such a standard. It is clear from the foregoing discussion that there can be no assurance, without extensive post-operational field studies, that the thermal plume will be as predicted in the Staff's figures on pages 56 and 57 and therefore, there is no justification for arbitrarily fixing a mixing zone on the basis of these predictions.

Furthermore, as indicated by the Staff's discussion on page 51, both the Vermont Water Resources Board and the New Hampshire Water Supply and Pollution Control Commission have issued permits to Vermont Yankee establishing thermal limitations upon discharge which are less restrictive than the Staff recommendations. The Applicant would note that the Water Resources Board Order was developed through extensive hearings, at which testimony was presented by the Vermont Fish and Game Department, the States of New Hampshire and Massachusetts, and the Connecticut River Fisheries Committee on Technical Management, all of which are agencies concerned with the restoration of anadromous fish. The Water Resources Board Order which specifically prohibits any operation which endangers that

restoration program, sets limits for mixed temperatures of the condenser cooling water and the Connecticut waters that are adequate to protect the biota and indigenous fishes of that area of the Connecticut River. The Staff provides no discussion of its reasons for disregarding the considered recommendations of the state agencies most intimately concerned with the river and the restoration programs. In this connection, it should be pointed out that the Staff recommendation would inevitably necessitate increased operation of the cooling towers which, the Staff concedes (page 115), creates some adverse effect on the environment.

Finally, the Applicant must emphasize that the Draft Detailed Statement completely fails to provide any cost-benefit analysis of the new standard which the Staff is proposing. There is no evaluation of the physical damage to the environment which is presumably to be obviated by the more rigorous standard imposed by the Staff. There is no balancing of benefits of that undefined "benefit" to the environment against the economic cost and environmental harm to be incurred by the operating regime necessitated by the Staff standard. There is no justification for the reduction of the areas predicted by their mathematical model (see page 53) to only 10 acres and no evaluation of the environmental impact of this arbitrary reduction. Implicit in the Staff approach is the concept of minimizing a particular effect without evaluating

the costs involved. The Applicant submits that a true balancing of costs and benefits does not support the imposition of the Staff recommendation. The final statement should include such a discussion.

The Staff has also expressed its doubt as to the relevance of temperature data monitored below the Vernon Dam and implied that the monitoring sites were selected solely upon physical features (page 81). As is pointed out in the Webster-Martin report the sites for installation of the monitors were selected with the cooperation of the Vermont Department of Water Resources. They were chosen with a view to positioning the upstream monitor (Station 7) above the effects of the plant's cooling water discharge and the downstream monitor (Station 3) below the zone for mixing of river water and cooling water discharge. The results of the downstream measurements would be adjusted to compensate for any temperature drop resulting from the location of the monitoring station in order to demonstrate compliance with the Vermont thermal requirements. These measurements were not intended to determine the thermal plume configuration in Vernon Pond.

Nevertheless, Vermont Yankee does intend to study the temperature distribution pattern of circulating water discharges in the area of the Vernon Pond. These studies will include vertical profiles and cross-river transects to identify any stratification or channelling of the thermal discharge (Environmental Report, Page 5.6-7). Vermont Yankee submits

that permanent monitors in the mixing zone would be almost meaningless due to changing river flows, wind directions and velocities and other changing parameters (Tr. page 2758). The data provided by the Applicant's proposed monitoring program, where probes can be moved as results are accumulated, offers far more reliable information on thermal patterns in the Vernon Pond. In addition, the post-operational field studies and environmental monitoring by the Applicant will provide real data upon which a considered decision can be made as to the environmental impact of the plant.

Until such information has been assembled and evaluated, the Applicant submits that there is no basis for imposing the rigorous standard suggested by the Staff and in the interim the continuing jurisdiction of the Commission provides adequate safeguards.

8. Page 60. In the second paragraph, the Staff recommends the installation of a skimmer wall to enable Vernon Dam "to use heated water off the top of the pond for turbine operation". There is no explanation of the reasoning behind this suggestion. The Staff appears to rely heavily on its assumptions that marked stratification will occur in Vernon Pond above the dam and that the turbines will not draw a cross-section of the water impounded above the dam. The supposition that the heated water would stratify on the Vernon Pond is not supported in any way other than by a mathematical model which the Staff concedes "was not considered entirely appropriate for Vernon Pond" (page 60). On

the other hand, the dye dispersion study does indicate that there would be substantial mixing in Vernon Pond. See discussion in Comment 7 above. Furthermore, the Applicant believes there is no evidence to suggest that the turbines do not draw from the entire water column behind the dam. Once again the Applicant would note that there is no cost-benefit evaluation of the consequences of the Staff's recommendation.

9. Page 68. It is stated that after installation of the off-gas system modification that total iodine will be reduced to less than 0.6 curies/year. This value is not comparable to the figure of 1.7 curies/year of I-131 shown on Table III-2 (page 69) for the early stages of operation. It is recommended that the figures be stated on a consistent basis and since the pasture-cow-milk-child thyroid chain in the pathway of significance, I-131 values rather than total iodine are the significant quantities and should be used as the basis for comparison.

In addition, Figre III-16 (page 67) accruately shows the presence of a charcoal filter in the existing off-gas system discharge path. The text does not indicate whether or not the presence of this filter has been considered in the I-131 release estimate of 53.9×10^{-3} uCi/second during the period of operation prior to modification of the off-gas system. (Although a complete discussion of source term assumptions has not been provided, it appears to Vermont Yankee that the filter was not considered to remove iodine.) It is suggested that this subject be addressed in the final statement.

10. Page 70. The Applicant is not aware of any basis for the Staff's estimate (in the fourth full paragraph) of solids to be deposited from drift from the cooling towers. If the Staff "feels" a more conservative estimate than the Applicant's is required, some factual basis for that estimate should be provided. The Applicant submits that the "conservative estimate" by the Staff is grossly exaggerated: it assumes a capacity factor of 100%, whereas in reality a lower capacity factor will result from annual refueling and maintenance shutdowns; it assumes a solids concentration of 230 ppm continuously, whereas that level would be reached only during closed cycle operation and would be reduced by a factor of 2.3 during helper cycle operation; it is premised upon a continuous solids concentration in the river water of 142 ppm (the highest level recorded by Vermont Yankee), whereas the average solids concentration of the river was 100 ppm; and it assumes closed cycle operation of the cooling towers throughout the year which is unrealistic.

11. Page 77. The first sentence of the third paragraph under the heading "General Effects" is in error. The exclusion area does not include the boat ramp on the New Hampshire side (see Applicant's Exhibit No. 14, which map indicates the extent of the exclusion zone and the location of the ramp). Furthermore, the exclusion zone will be "controlled" by Vermont and New Hampshire officials under the provisions of the emergency plans of those states.

12. Page 78, "Cooling Tower Effects". The Applicant has supplied various data with respect to fogging which the Staff has evaluated here and at pages 160-161. Without explanation, the Staff has erroneously concluded (see pages ii and v) that operation of the cooling tower will be terminated whenever fog is carried beyond the site. This conclusion is inconsistent with statements about off-site fogging on page 160. The confusion, no doubt, arose from a provision contained in the Amended Order of Permit, dated November 26, 1971, issued by the Vermont Water Resources Board. This Order was discussed at the licensing hearing and the possibility of its modification was then disclosed (Tr. 3169-71). On May 8, 1972 a Motion was filed by Vermont Yankee seeking a change in that Order and the Staff will be notified as that proceeding progresses.

13. Page 84. In the last paragraph on page 84 and again in the second paragraph on page 86, the Staff suggests that the minimum flow of 1200 cfs may stabilize the aquatic environment and waterfowl conditions in Vernon Pond. The Applicant's consultants believe any such effect would be minimal and that the final statement should not imply that significant value has been attributed to this phenomenon.

14. Page 94, "Entrainment". There is no justification for burdening the discussion of the Vermont Yankee Station with a gratuitous reference to the Indian Point Unit 1 experience with the implication of similarity. There are many distinguishing factors which are not discussed by the Staff. This discussion should be limited to the anticipated impact of the Vermont

Yankee Station.

15. Page 98, "Thermal". As noted in the previous comment, any comparison of the Vermont Yankee Station with another plant should, in the interest of providing a fair and objective evaluation, also note distinguishing factors. The reference to experience at Connecticut Yankee with "river species of young fish" (unnamed in the Staff's statement) should reflect the extent to which these species are present in Vernon Pond.

16. Page 92, "Effects on Fish Populations". Throughout the report there are generalized words used to refer to potential effects on fish, such as "large number" and "certain number" as on page 94. On page 98, the report refers to "many". These are terms which may imply an exaggerated notion of the magnitude of the effects. It would be better if some more exact numbers were used to indicate the orders of magnitude so that some evaluation can be made. There is also a lot of speculation without evaluation, such as the statement on page 98, at the end of the first paragraph, that the sudden rise of temperature "may not be lethal" but that physiological shock "may cause" greater susceptibility to predation. On page 105, in the discussion of white perch, again general terms are used that could be misleading. The report states that "a noticeable number of white perch may be killed" and that "a major adverse effect . . . is not expected". These two speculations are not reconciled. Similarly, on pages 89 to 92, assertions are made concerning impacts upon restored salmon runs without any

evaluation of the prospects or timing of such events. It is suggested that the final statement attempt a more objective discussion which can permit a reader to perform his own evaluation of the material.

17. Page 101, paragraph 3 under "Chemical". The text appears to ignore the chlorine analyzer which the Applicant has installed. The versatility of the chlorine analyzer/controller permits the adjustment of the residual chlorine coming from the condenser so that the concentration of chlorine going into the river will be in the order of 0.1 ppm.

18. Page 102, last sentence. The Staff here states its belief that postoperational biological monitoring should include chemical analyses of aquatic organisms for sodium and sulfate. The Applicant would point out that the daily and seasonal variations in chemical concentrations in the river, as reported in the Webster-Martin study (cited in note 21 on page 37), have substantially greater impact than the concentrations of chemicals being discharged by Vermont Yankee. Since aquatic organisms are subjected to the natural range of concentrations of metals in the Connecticut River there seems to be no logical basis for chemical monitoring of organisms in the plume if the blowdown concentrations do not exceed the maximum natural concentrations observed in the river. Therefore, Vermont Yankee proposes to routinely monitor cooling tower blowdown for those metals which, because of the 2.3 concentration factor, may exceed maximum values naturally present in the

Connecticut River. If this blowdown monitoring program does indicate that any metal concentrations exceed the maximum natural value, then aquatic organisms in the plume area will be analyzed for these metals by sensitive chemical methods.

The analytical procedures used for certain metals in the 1969-70 survey were less sensitive than are practicable by current procedures and this resulted in uncertainty as to the concentrations of these substances in blowdown. Newer instrumentation and analytical procedures will permit a much lower limit of detection for these substances in the water quality monitoring program to be conducted when the plant becomes operational.

19. Page 106, "Biological Monitoring". The Applicant proposes to implement the following post-operational studies:

1. Operational profiles of the thermal plume in all dimensions for each of the cooling water modes and river flows. These data will be correlated with the continuous temperature monitors to provide data to evaluate thermal impacts on Vernon Pond.
2. Studies of the phytoplankton, periphyton and zooplankton will continue in a similar manner as in the preoperational studies which were primarily on a seasonal basis in the vicinity of the plant and at the two permanent sampling stations. Operational studies data on species diversity and population numbers will be compared with preoperational data.

3. Collections of benthic fauna in Vernon Pond and the Connecticut River below the dam will continue at the stations that were studied before Vermont Yankee became operational.

4. Aquatic vascular plants below the discharge area and above the intake will be investigated for changes in species composition due to thermal and other effects.

5. Fish collections will continue in all areas that were studied in the preoperational period with additional emphasis in the intake and discharge areas. Physical examination of these fish as well as weight and length and scale samples will be evaluated. Radionuclide concentrations will be determined in various species as in the preoperational studies. In addition, a log will be kept at frequent intervals of the material removed from the intake screen. This record will record the dead fish and other organisms along with pertinent information relative to time of year and water temperatures.

6. Entrainment studies will be conducted during the time of year of open-cycle operation. Such studies will include evaluation of plankton and larval forms of insects and fish. These studies will be oriented to entrainment mortalities. The applicant proposes to contract the services of Aquatec, Inc. (Former Biology Division of Webster-Martin) in conjunction with these studies, the outline of which is attached.

7. Water Quality studies will be conducted for selected water quality parameters in a similar manner as in the preoperational program. Operation as well as the data reduction from the Honeywell monitors at Stations 3 and 7 will continue. D.O. and Temperature studies at selected stations will be repeated.

8. All areas will be studied each year to some degree and the various programs will be kept flexible enough to accommodate any indicated need for a change in emphasis.

The discussion on this subject in the final statement should reflect this information.

The Applicant would also point out that there is no reason to perform the terrestial organism monitoring referred to in the last paragraph on page 107 until the monitoring of plant effluents indicates that an impact on such organisms is plausible and the Applicant would only then expect to perform such monitoring.

20. Page 121, third full paragraph. The Applicant would respectfully suggest that until the design objectives of Appendix I are finally formulated, it is not possible to make the statement that the presently planned modifications will meet those objectives. Nevertheless, it is the Applicant's present expectation that such will be the case and, of course, it will comply with Appendix I when it becomes effective. In this connection, it should be noted that the statement on page 145 that

the Applicant "will have to meet the limits proposed" (emphasis added) in Appendix I is likewise inaccurate. The Applicant will have to meet the limits contained in Appendix I as ultimately adopted.

21. Page 141. The Applicant believes it is misleading to discuss the results of accidental criticality during the transportation of cold fuel without first enumerating the many precise events which must occur coincidentally before such criticality can occur.

22. Page 144. In the last paragraph on this page and again at the top of page 147 reference is made to adjusting operation "to minimize adverse effects". The Applicant must take issue with this approach as being wholly contrary to the Commission's regulations. The purpose of the detailed statement is to analyze the costs and benefits of a proposed course of action and its alternatives and to determine which course of action is justified. Inherent in this approach is a weighing of the costs and benefits attributable to each. Any suggestion that an effect is to be "minimized" abandons this balancing approach by totally disregarding costs and risks carrying environmental measures to the point where costs exceed the benefits. The final statement should clearly demonstrate the favorable cost-benefit comparison for any course of action it propounds.

23. Page 149. The discussion of "Need for Power" is entirely out of date and therefore does not accurately portray the power situation in New England. It relies upon sources which

are six months to six years old. It also, understandably, does not reflect the recent serious changes resulting from the flooding accident at the Northfield Pumped Storage Station on April 22, 1972, which has delayed 1000 mw of anticipated capacity for a substantial period of time. When this incident has been fully evaluated, the Applicant will supply the Staff with further information.

24. Page 155. With respect to the "Cost-Benefit Analysis", the Applicant believes the following points should be corrected:

(a) A discount rate of 8.75% per year is used throughout without any justification for the selection of that rate. The final statement should explain the basis for this figure.

(b) On page 164, a statement is made that "tourist activity might initially elicit a negative response", whereas the Staff previously states that "tourism is a very important industry in Vermont" and the Brattleboro area near the plant "is significantly dependent on tourism" (page 146).

(c) The present worth values for the oil-fired alternative have been incorrectly computed. (See page 146.) It appears that the present worth was calculated on the basis of 25 years. However, since the 25 years would start to run five years hence, they should be present-worthed for an additional five years to bring them to present value at the time of the report. The result, of course, would be to reduce the present value of the cost of the oil-fired alternative, but it does not change any of the relationships. The correct numbers should now be as follows: in the table on page 165 under the column labeled Alternative Oil Burning Plant, the second line should read 75-121 in place of 162-209. The fourth line should read 321-367 in place of 408-455. On page 166, the next to the last paragraph, the present worth of the cost of fuel oil shown as $233 million should be changed to $153 million and the present worth of operations should be changed from $19 million to $12.5 million. In the last paragraph on page 166, the present worth of fuel costs should be changed from $280 million to

$199 million. This latter change also represents discounting of the 25 years of fuel cost including the 2 percent per year fuel price increase for 30 years, starting at the present time, and then discounting for the five years from time of plant start up to the present. Finally, there seems to be a slight error in the calculation of the present worth of the benefits shown on page 167. The benefit value should be $825 million rather than $835 million.

(d) The figure at the end of the second full paragraph on page 167 should be $825,000,000.

25. Finally, there are several typographical errors which should be noted to remove any ambiguities which may have been created:

(a) Page 11, line 24 - "initiation" should be "irritation".

(b) Page 17, line 20 - "flow over" should read "flow passed".

(c) Page 33, line 3 under heading 7 - the word "relative" should be inserted before the word "abundance". The Applicant's study did not attempt a census of the fish population but only made an evaluation of their relative abundance by weight.

(d) Page 24, line 21 - the word "complete" should read "exhaustive". The report referred to is "complete" in the sense that it has been finalized and sets forth all the data assembled by Webster-Martin as of its date. It is not "exhaustive" in the sense that it does not purport to cover every conceivable aspect of the Connecticut River.

(e) Page 33, line 14 under heading 7 - the "black crappie" should be deleted, since a specimen of this species was caught in the Applicant's study.

(f) Page 36, Note 9 - this reference should be to the "Order dated July 31, 1970 of the Federal Power Commission, approving the Indenture between New England Power Company and Vermont Yankee Nuclear Power Corporation, relating to use of lands and reservoir of Project No. 1904". Compare reference 3 on page 73.

(g) Page 66, paragraph 3, line 4 - the "reactor building vent stack" should read the "main station stack". There is only a single vent stack at the facility.

(h) Page 72, line 4 under heading E - the figure "500 lb." should read "680 lb."

(i) Page 82 - in the second sentence of the fifth paragraph under the heading "Chemical Discharges" the word "hydroxide" should be "hypochloride".

(j) Page 144, line 3 - to be consistent with the periods considered in the Cost-Benefit Analyses, the life of the plant should be deemed to be 30 years.

(k) Page 149, table - the last figures in the third and fourth columns of the table should be identical.

The foregoing comments have been submitted by the Applicant to assist in correcting the content of the final statement. The Applicant would be happy to meet with the Staff to discuss any of these comments and to provide whatever additional material may be required.

Very truly yours,

VERMONT YANKEE NUCLEAR POWER CORPORATION

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May 17, 1972

RECEIVED MAY 22 1972

Director
U. S. Atomic Energy Commission
Division of Radiological and
Environmental Protection
Washington, D. C. 20545

Dear Sir:

Re: 50-271, In the Matter of Vermont Yankee Nuclear Power Corp.

I enclose herewith comments by New England Coalition on Nuclear Pollution concerning the Draft Detailed Statement on the environmental considerations related to the proposed issuance of an operating license to the Vermont Yankee Nuclear Power Station.

Very truly yours,

Anthony Z. Roisman

AZR/pq

Encl.

2708

BEFORE THE
UNITED STATES OF AMERICA
ATOMIC ENERGY COMMISSION

In the Matter of

VERMONT YANKEE NUCLEAR POWER CORP.) Docket No. 50-271

COMMENTS ON ENVIRONMENTAL IMPACT STATEMENTS

The following comments on the Vermont Yankee Power Plant Draft Detailed Statement are submitted by the New England Coalition on Nuclear Pollution in accordance with the notice in 37 FR 7423, April 13, 1972 and the provisions of the National Environmental Policy Act.

Reference is made to the New England Coalition on Nuclear Pollution submission of a Detailed Analysis of the Draft Statement issued February 18, 1971 and the accompanying 202 questions which we considered critical to the thorough preparation of an impact statement. Although the Draft Detailed Statement of April 7, 1972 is a substantial improvement over the Draft submitted a year ago, we find that a number of matters still remain to be considered.

A. Site Selection

The statement indicates that of the 23 potential sites considered, the Vernon site was the "least favorable site from a population density standpoint". (p.2) There is no discussion of the factors considered to be of greater importance to the

Applicant than impact on population, although we can surmise that economics was a large factor. Thus the public has no way of knowing whether the increased risk to health and safety of persons living near the plant is outweighed by other considerations.

B. Site Location

The Vermont Yankee site is unusual in that it incorporates a section of the Connecticut River within its exclusion area. The NECNP commented in its Detailed Analysis on the February 18, 1971 Statement that there should be discussion of this appropriation of property by the Applicant. None appears in the Draft Detailed Statement. It troubles us that a private company can assert control over a public resource, and in so doing not only deprive the public of its use of the resource, but pose difficulties for state administrations concerned with preserving resource quality.

C. Land Use

(1) Dairies and Crops - In the discussion of land use the statement notes that much of the land around the plant is devoted to agriculture and dairying. However, no maps are included to point out the location of fields and dairies, and the information concerning the use of milk and crops is severely limited. How much local milk is pooled, and what is the effect of this on iodine concentrations? How many children consume milk that has been pooled, and how many drink milk from the family cow? Since the grass-cow-milk chain is one of the most

critical concentration pathways for radiation, it should not be dismissed as an insignificant pathway at the Vernon site without a more detailed discussion of the justification for such a conclusion. Realistic dose estimates for the local population depend on the availability of such information.

(2) Flora and Fauna - In our previous submission New England Coalition on Nuclear Pollution recommended that an analysis be completed of the plant property in terms of impact upon wild animals and plants. The Staff chose not to undertake an independent study of this, but relied instead on the Applicant's ecological studies, although, as noted, except for the Applicant's studies, "very little information is available on the acquatic biota". The Webster-Martin Studies, commissioned by the Applicant, do not offer a complete evaluation of the effects of the plant on the ecosystem. For example, the survey did not include a survey of fish larvae and fry in the Connecticut River near Vernon. The plankton sampling program described is not an adequate substitute since the sampling techniques for fish larvae are quite different. In addition, the Webster-Martin fish sampling program did not include sampling during the winter months, when the warm water at the discharge point is likely to be most attractive to fish, or sampling in the mixing zone, the area of greatest impact.

The affect on water quality, fish and other acquatic organisms of the chemicals, particularly chlorine, to be discharged into Vernon Pond is not adequately discussed. We are in agreement with

the comments submitted by the State of New Hampshire on this subject. We join in their recommendation that a competent bio-chemist be consulted to ascertain the impact on fish of these chemicals. We also recommend treatment of the effluents to reduce amounts of chlorine, and the trace elements of mercury and cadmium.

Support for the conclusion that discharge of salts will not impair water quality should be given since the amounts to be discharged are substantial.

The matter of fish mortalities, and the impact of radio-active materials on acquatic biota has been treated lightly. Since the Department of the Interior plans to undertake a major anadromous fish restoration program for the river, impact on fish should be reduced to an absolute minimum. Rather than simply acknowledging loss of fish life, steps should be taken now to prevent this.

The Applicant's studies do not include an analysis of the terrestrial environment. In lieu of an independent and thorough evaluation of this aspect of the Vermont Yankee site, the statement offers a list of animals found in the state of Vermont, not all of which are found at the Yankee site. Such a listing cannot take the place of an analysis of the impact of the plant on flora and fauna at the site. In relying on the Applicant's data, rather than gathering its own, the Staff is slighting the public's in-terest in the maintenance and well being of plants and animals.

D. Meterology

Meterologic data about the plant site was collected by the Applicant at one station during a one year period from August, 1967 through July, 1968. It is questionable that the information received from this severely limited sampling is an adequate basis for accurate judgments about weather and wind conditions in the Vernon area. Sampling should reflect a period of years.

In addition, there is no information on the monitoring program itself, nor a discussion of the site characteristics - primarily the presence of a valley - which contribute to meterologic conditions.

E. Groundwater/Wells and Springs

Within a five mile radius of the plant water for private use is supplied by wells and springs. As shown in Figure II - 11 most of the wells are concentrated around the plant site. From the discussion of geology and groundwater it is clear that water in this area is close to the surface and contained in relatively shallow deposits. In light of this, and the fact that the water table fluctuates with changes in the level of the Connecticut River, there is a potential for contamination of the groundwater, and the wells and springs, by the leaching of radioactive materials from the plant's liquid wastes. Obviously, if groundwater becomes contaminated, vegetation and animals consuming that vegetation will be as well. Other than acknowledging that the Staff had considered the possible impact of plant operation on drinking

water supplies, the statement fails to address this problem in any depth. A thorough discussion, including plans for monitoring should be included.

F. Direct Radiation

One of the largest problems posed by the Vermont Yankee site is the direct radiation dose to children attending the Vernon Elementary School which is located 1500 feet from the turbine building. The estimates of 20 mr per year from ^{16}N gamma shine, assuming an occupancy factor of 0.2 at the school is not supported. The statement contains no details of how the calculation of 20 mr was made, whether it was based on data from the Vermont Yankee site or extrapolated using data from another site. In fact, according to the AEC Staff, data from Oyster Creek was used to predict the gamma shine dose at Vermont Yankee. The public not only needs to know this, but to know whether 20 mr per year of direct radiation is an acceptable dose for the small children and pregnant women who will be present at the school building.

G. Thermal Discharge

The problem of thermal pollution of Vernon Pond raised by the State of Vermont following the 1971 Draft Statement, has not yet been solved. There is no information in the statement to indicate that Vermont Yankee will be able to comply with Vermont water quality standards, using a closed-open-helper cycle system to regulate discharge of heated water. No analysis is presented of the increase in the temperature of Vernon Pond during each of

these modes. Furthermore, we find the evaluation of impact on fish and other acquatic incomplete. Supporting data for the discussion on pages 114 and 115 should be provided.

H. Transmission Lines

The statement notes that herbicides were used by the Applicant to "reduce the impact of the transmission lines on the environment" (P. 45) There is no indication that alternative methods of land clearing were considered and abandoned, nor is there information on the kind of herbicide used and its affects on non-target plants and animals. Some discussion of the total amount of animal habitual destroyed by the lines and the use of herbicides would also be in order.

I. Exposures During Transportation

The exposures to truck drivers hauling irradiated fuel and solid wastes away from the plant (page 139) seem excessively high when compared to the 5 rem per year limit for radiation workers in plants, and the proposed 5 mr Appendix I guide for exposure at a site boundary. An explanation of how these estimates were derived is in order. In addition, a substantial effort should be devoted to their reduction.

J. Need for Power

We feel that the scope of the investigation of the need for power is not adequate. The AEC is relying on information about projected growth rates and future demands supplied to the Federal Power Commission by the power companies. The FPC does no

independent analysis to determine whether these figures are correct, or even to ascertain what they mean. In the same vein, the AEC accepts the Applicant's view of the need for the plant.

The supposed "need for power" has been used by companies to justify permitting plant operations without a true examination of the alternatives to operating the plant. Ways of reducing demand are not analyzed. Nor is there an analysis of the harm or benefit which will occur if the alleged need for electricity is not met. The Staff assumes that because money will be made and jobs created by the operation of the plant, this is a benefit which requires no further analysis. The same benefits would flow from operation of any industry. The real benefits depend upon the particular industry and the benefits flowing from the products produced by that industry. The principle of <u>NRDC</u> v. <u>Morton</u> should be applied; the impact of the whole fuel cycle should be examined.

Unless a independent, factual analysis is done of the power situation in the NE Pool, there is no basis for the conclusions in the need for power section.

The New England Coalition on Nuclear Pollution will address these and other comments to the Applicant and the Commission in the hearings on the environmental impact of Vermont Yankee to be held after the Final Impact Statement is filed. Our comments here are not complete, and we do not mean to limit our further