NorthStar

NorthStar Nuclear Decommissioning Co., LLC
Vermont Yankee Nuclear Power Station
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Corey R. Daniels
ISFSI Senior Manager

10 CFR 50.36a

BVY 23-011

May 10, 2023

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: 2022 Radiological Effluent Release Report
Vermont Yankee Nuclear Power Station
Docket No. 50-271
License No. DPR-28

Dear Sir or Madam:

In accordance with 10 CFR 50.36a and the Vermont Yankee (VY) Off-site Dose Calculation Manual, please find in Enclosure 1 a copy of the Annual Radiological Effluent Release Report for 2022.

In addition, the VY Off-site Dose Calculation Manual (ODCM) requires that changes made during the reporting period to the ODCM be identified in the next Radiological Effluent Release Report. Accordingly, Enclosure 2 provides Revision 42 of the ODCM that occurred during 2022. The changes associated with Revision 42 to the ODCM are discussed within the ODCM.

The VY Renewed Facility Operating License Condition 3.E.10 requires that similar information to that contained within the subject report be provided to the Massachusetts Metropolitan District Commission (MDC). However, since the MDC is currently part of the Massachusetts Department of Conservation and Recreation (DCR), this report is being provided to the DCR to satisfy License Condition 3.E.10.

This letter contains no new regulatory commitments.

Should you have any questions concerning this letter, or require additional information, please contact Mr. Thomas B. Silko at (802) 451-5354, Ext 2506.

Sincerely,

CRD/tbs

Enclosure 1: Annual Radiological Effluent Release Report for 2022.
Enclosure 2: Off-site Dose Calculation Manual (ODCM), Revision 42

cc: Regional Administrator, Region 1
U.S. Nuclear Regulatory Commission
475 Allendale Road, Suite 102
King of Prussia, PA 19406-1415

Commissioner
Vermont Department of Public Service
112 State Street – Drawer 20
Montpelier, Vermont 05602-2601

Massachusetts Department of Public Health
Director, Radiation Control Program
529 Main Street, Suite 1 M2A
Charlestown, MA 02129

Commissioner
Massachusetts Department of Conservation and Recreation
251 Causeway Street
Boston, MA 02114

Enclosure 1

Vermont Yankee Nuclear Power Station

Annual Radiological Effluent Release Report for 2022
(52 pages excluding this cover sheet)

Vermont Yankee Nuclear Power Station

Annual Radiological Effluent Release Report

January - December 2022

NorthStar – Vermont Yankee
Vermont Yankee Nuclear Power Station
320 Governor Hunt Road
Vernon, Vermont 05354

Docket No. 50-271

License No. DPR-28

VERMONT YANKEE
ANNUAL RADIOACTIVE EFFLUENT RELEASE REPORT
FOR 2022

Reviewed By: ______________________ / 05/09/2023
Andy Miller, RP Manager Plant — Date

Approved By: ______________________ / 5.9.2023
Scott Dorval, RP Manager, ISFSI — Date

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List of Tables

1.0 INTRODUCTION

Tables 1 through 3 list the recorded radioactive liquid and gaseous effluents and solid waste shipments for 2022, with data summarized on a quarterly basis for both liquids and gases. Table 4A summarizes the estimated radiological dose commitments from all radioactive liquid and gaseous effluents released during 2022, to the maximally exposed individual member of the public, in responseto the ALARA objectives of 10 CFR 50, Appendix I. Table 4B presents the estimate of direct dose from fixed station sources along the limiting west site boundary line. Tables 5A through 6G present the cumulative joint frequency distributions of wind speed, wind direction, and atmospheric stability for the 5-year period, 2012 through 2016. Radioactive effluents reported in Tables 1 and 2 were used to determine the dose to the maximum exposed individual member of the public for 2022.

Dose commitments resulting from the release of radioactive materials in liquids and gases during the reporting period were estimated in accordance with the plant's Off-Site Dose Calculation Manual (ODCM), Section 10.1 (Reference 1). These dose estimates were made using a "Method I" analysis as described in the ODCM, and as reported in Tables 4A and 4B of this report. A conservative "Method I" analysis incorporates the methodology of Regulatory Guide 1.109 (Reference 2) and uses nuclide specific dose factors. Dose factors are the dose per Ci released for the age group and organ receiving the highest dose. This method is conservative since the age and organ receiving the highest dose differs from one nuclide to another.

As required by ODCM Section 10.1, this report shall also include an assessment of the radiation doses from radioactive effluents to member(s) of the public due to allowed recreational activities inside the site boundary during the year. As discussed in Section 3.5, there were no such recreational activities permitted and, therefore, there is no associated dose assessment.

An assessment of radiation doses (including direct radiation) to the likely most exposed real member(s) of the public for the calendar year for the purposes of demonstrating conformance with 40 CFR 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," is also required to be included in this report if the conditions indicated in ODCM 3/4.4, "Total Dose," have been exceeded during the year. Since the conditions indicated in the action statement under ODCM 3/4.4 were not entered into during the year, no additional radiation dose assessment is required. However, Table 4B does provide the combination of off-site doses and dose commitments from plant effluents and direct radiation sources for the limiting member of the public as a demonstration of compliance with the dose standards of 40 CFR 190.

All calculated dose estimates for members of the public at the site boundary or beyond for the 2022 annual reporting period are below the dose criteria of 10 CFR 50, Appendix I, and 40 CFR 190.

Appendices B through J indicate the status of reportable items per the requirements of ODCM Section 10.1.

2.0 METEOROLOGICAL DATA

The scope of possible accidents is significantly reduced with all spent fuel in dry cask storage. The potential for any off-site consequences from radiological accidents are also substantially reduced. No reasonably conceivable beyond design basis event can result in a radiological release that exceeds Environmental Protection Agency (EPA) Protective Actions Guidelines. During the final decommissioning and dismantling phases, administrative controls over radiological source accumulation will preempt any significant radiological release to the environment. As a result, there is no need for continued on-site meteorological data accumulation or real time dose assessment. Conservative atmospheric dispersion factors have been developed from the 2012 through 2016 joint frequency data to provide both short term dose assessment and for assessment in the annual average dose from facility routine releases. There are no planned or existing Emergency Action Levels in the defueled state that could result in the need for real time accident release assessment with other than previously determined conservative atmospheric dispersion factors.

Actual measured meteorological data for the five-year period, 2012 through 2016, were analyzed to determine all the values and locations of the maximum off-site long-term average atmospheric dispersion and deposition factors. The highest offsite dispersion and deposition factors at any location beyond the site boundary, regardless of whether it was an actual location of a residence or food production, was used to calculate “Method I” dose factors for each nuclide. Each dose and dose rate calculation presented in the current Revision 41 of the ODCM incorporate the maximum applicable off-site long-term average atmospheric dispersion and deposition factors, and maximum organ dose to any age group from each nuclide.

Updated five-year average dispersion factors and deposition factors developed from 2012 through 2016 on-site meteorological hourly data and the nuclide specific dose factors can be used to assess either routine releases or estimate conservative off-site consequences from any on-site radiological event. As such, there is no need to continue to collect on-site meteorological data for either accessing routine releases or potential emergency events. Collection of data from on-site meteorological tower was terminated in November 2018.

The five-year aggregate joint frequency distribution tables for ground level releases are presented in Tables 5A through 5G. The five-year aggregate joint frequency distribution tables for elevated releases are presented in Tables 6A through 6G.

3.0 DOSE ASSESSMENT

3.1 Doses from Liquid Effluents

ODCM 3/4.2.2 limits total body doses (1.5 mrem per quarter, and 3 mrem per year) and organ doses (5 mrem per quarter, and 10 mrem per year) from liquid effluents to a member of the public to those specified in 10 CFR 50, Appendix I. By implementing the requirements of 10 CFR 50, Appendix I, ODCM 3/4.2.2 assures that the release of radioactive material in liquid effluents will be kept "as low as reasonably achievable."

There were no continuous or batch routine liquid radioactive waste discharges during 2022. Dose estimates of tritium-contaminated groundwater released from the site are based on Protected Area Boundary monitoring well data collected throughout 2022 and hydrological modeling of groundwater movement. The groundwater discharge rates from the developed portion of the site to the river are estimated using a streamtube approach based on Darcy's Law. Using a conservative estimate of groundwater flow through the affected area toward the river on a quarterly basis, an estimate of the total potential tritium released from the site during each quarter of 2022 was generated and reported in Table 2A. The quantity of tritium released from the site by groundwater in each quarter was then converted to dose by using the calculated dose conversion factors presented in ODCM Table 1.1.11.

The resulting quarterly doses are presented in Table 4A.

ODCM Control 3.2.1 states, in part, that groundwater flowing to the Connecticut River from the site in radioactive concentrations above background (Unrestricted Areas for liquids is at the point of discharge from the plant discharge in Connecticut River) shall be limited to 10 times the concentrations specified in Appendix B to 10 CFR 20.1001 – 20.2402, Table 2, Column 2. The tritium quarterly average concentrations discharged from the plant ranged from 0.011% to 0.014% of this limit.

3.2 Doses from Noble Gases

The dose limits specified in ODCM 3/4.3.2 have been deleted from Revision 40 of the ODCM. Noble gases were not produced or detected in releases from the Reactor Building Exhaust in 2022.

3.3 Dose from Radionuclides in Particulate Form and Tritium

ODCM 3/4.3.3 limits the organ dose to a member of the public from tritium and radionuclides in particulate form in gaseous effluents released from the site to areas at and beyond the site boundary to those specified in 10 CFR 50, Appendix I (7.5 mrem per quarter and 15 mrem per year). By implementing the requirements of 10 CFR 50, Appendix I, ODCM 3/4.3.3 assures that the releases of any tritium and particulates in gaseous effluents will be kept "as low as is reasonably achievable."

There were no non-routine gaseous releases or batch releases in 2022.

Continuous sampling of the plant reactor building exhaust for tritium, per ODCM Table 4.3.1, was performed by using silica gel cartridges in 2022. The cartridges were analyzed monthly. Based upon the reactor building exhaust flow rate and sample flow rates, the average release rate in µCi/sec and total release in Ci for each quarter was calculated. Tritium released to the Turbine Building 228' level during the Torus cutting project was analyzed in the same manner. The quantity of tritium released from the site by the reactor building exhaust in each quarter was then converted to dose by using the calculated dose conversion factors presented in ODCM Table 1.1.12.

Continuous sampling of the reactor building exhaust for particulates, per ODCM Table 4.3.1, was performed in 2022. These samples are analyzed weekly for principle gamma emitters. Cobalt-60 was identified on the reactor building ventilation exhaust particulate filters in each quarter in 2022. Cesium-137 was also identified on the reactor building ventilation exhaust particulate filters in the third and fourth quarters in 2022. CO-60 was also released through the Turbine Building West Hatch in the fourth quarter. The quantity of Cobalt 60 and Cs-137 did not exceed any dose limits. The doses from Co-60 and Cs-137 were combined with H-3 and are presented in Table 4A.

3.4 Whole Body Doses in Unrestricted Areas from Direct Radiation

As opposed to prior years before the permanent shut down when the majority of the dose in the unrestricted area consisted of direct and skyshine radiation from N-16 decay in the Turbine Building steam cycle during power operations, there was no such source during 2022 due to the elimination of itsproduction and its short half-life.

The other fixed sources of direct and scatter radiation to the site boundary are the Independent Spent Fuel Storage Installation (ISFSI) and old turbine rotors and casings in the Turbine Storage Facility. All spent fuel has been transferred to the ISFSI since August 2018. The method to assess the direct radiation dose in unrestricted areas has been agreed upon with the State of Vermont. Site boundary TLDs are changed out monthly. The net dose at the location of TLD DR-53A has been chosen to assess direct radiation dose to unrestricted areas.

Table 4B lists the combination of the direct radiation dose at the limiting site boundary location and the maximum offsite dose from gaseous and liquid effluents for the purpose of demonstrating compliance with the dose standards contained in 40 CFR 190. For 2022, this annual dose was below the 25 mrem total body and organ limit, as well as the 75 mrem thyroid limit, of 40 CFR 190.

3.5 On-Site Recreational Activities

During 2022, no access to the on-site boat launching ramp located north of the intake structure was permitted for employees, their families, and guests. As such, there was no associated dose impact to members of the public due to any recreational activities on-site.

REFERENCES

1. Off-Site Dose Calculation Manual (ODCM), Revision 42, effective February 17, 2022.

2. Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Release of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," U. S. Nuclear Regulatory Commission, Office of Standards Development, Revision l, October 1977.

3. Safety Guide 1.23, "Onsite Meteorological Programs," U.S. Atomic Energy Commission, February 17, 1972.

4. Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," U.S. Nuclear Regulatory Commission, Office of Standards Development, March 1976.

5. Meteorology and Atomic Energy, 1968, Section 5-3.2.2, "Cloud Depletion," page 204, U. S. Atomic Energy Commission, July 1968.

6. Regulatory Guide 1.21, "Measuring, Evaluating, and Reporting Radioactive Material in Liquidand Gaseous Effluents and Solid Waste," U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, Revision 2, June 2009.

Table 1A - Gaseous Effluents -Summation of All Releases

	Units	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Est. Total Error, %
A. Fission and Activation Gases						
1. Total release	Ci	ND	ND	ND	ND	
2. Average release rate for period	µCi/sec	ND	ND	ND	ND	
3. Percent of ODCM limit (1)	%	NA	NA	NA	NA	
B. Iodines						
1. Total Iodine	Ci	ND	ND	ND	ND	
2. Average release rate for period	µCi/sec	ND	ND	ND	ND	
3. Percent of ODCM limit (1)	%	NA	NA	NA	NA	
C. Particulates						
1. Particulates with T-1/2>8 days	Ci	2.56E-6	2.00E-6	7.61E-5	9.45E-5	1.80E+01
2. Average release rate for period	µCi/sec	9.48E-3	2.72E-3	2.63E-3	3.06E-3	
3. Percent of ODCM limit (2)	%	2.43E-3	6.95E-4	1.85E-2	2.35E-2	
4. Gross alpha radioactivity	Ci	ND	ND	ND	ND	
D. Tritium						
1. Total release	Ci	2.84e-1	1.15E-01	9.23E-02	9.46E-02	1.80E+01
2. Average release rate for period	µCi/sec	3.63E-02	1.39E-02	2.62E-03	2.58E-03	
3. Percent of ODCM limit (2)	%	2.61E-02	1.06E-02	8.50E-03	8.71E-03	
E. Carbon-14						
1. Total release	Ci	ND	ND	ND	ND	
2. Percent of ODCM limit (1)	%	NA	NA	NA	NA	

ND = Not Detected NA = Not Applicable

(1) There is no ODCM Control for Iodines, C-14 and Fission and Activation Gases. All spentfuel is in casks on the ISFSI pads.

(2) ODCM Control 3.3.3 for dose from Tritium and radionuclides in particulate form. The values in row D.3 are based upon the total particulate and Tritium activity in each quarter.

Table 1B - Gaseous Effluents -Elevated Releases

		Continuous Mode			
		Quarter			
Nuclides Released	**Units**	**1**	**2**	**3**	**4**
1. Fission Gases					
Krypton-85	Ci	ND	ND	ND	ND
Unidentified	Ci	ND	ND	ND	ND
Total for Period	**Ci**	**ND**	**ND**	**ND**	**ND**
2. Iodines	**Ci**	ND	ND	ND	ND
3. Particulates					
Strontium-90	Ci	ND	ND	ND	ND
Cesium-134	Ci	ND	ND	ND	ND
Cesium-137	Ci	ND	ND	ND	ND
Manganese-54	Ci	ND	ND	ND	ND
Cobalt-57	Ci	ND	ND	ND	ND
Cobalt-60	Ci	ND	ND	ND	ND
Zinc-65	Ci	ND	ND	ND	ND
Total for Period	**Ci**	**ND**	**ND**	**ND**	**ND**

ND Not Detected at the plant stack (The Plant Stack was no longer in service as of the last week in the first quarter of 2021.)

Table 1B - Gaseous Effluents -Elevated Releases
(Continued)

		Batch Mode			
		Quarter			
Nuclides Released	**Units**	**1**	**2**	**3**	**4**
1. Fission Gases					
Krypton-85	Ci				
Unidentified	Ci				
Total for Period	**Ci**	(1)	(1)	(1)	(1)
2. Iodines	**Ci**				
3. Particulates					
Strontium-90	Ci				
Cesium-134	Ci				
Cesium-137	Ci				
Manganese-54	Ci				
Cobalt-57	Ci				
Cobalt-60	Ci				
Zinc-65	Ci				
Total for Period	**Ci**	(1)	(1)	(1)	(1)

(1) There were no batch mode gaseous releases for this reporting period. (The Plant Stack was no longer in service as of the last week in the first quarter of 2021.)

Table 1C – Gaseous Effluents Ground Level Releases

		Continuous Mode			
		Quarter			
Nuclides Released	**Units**	**1**	**2**	**3**	**4**
1. Fission Gases					
Krypton-85	Ci				
Unidentified	Ci				
Total for Period	**Ci**	(1)	(1)	(1)	(1)
2. Iodines	**Ci**	(1)			
3. Particulates					
Strontium-90	Ci	(1)			
Cesium-134	Ci	(1)			
Cesium-137	Ci	(1)	(1)	7.53E-05	8.89E-05
Manganese-54	Ci	(1)			
Cobalt-57	Ci	(1)			
Cobalt-60	Ci	2.56E-6	2.00E-6	8.56E-07	5.75E-6
Zinc-65	Ci	(1)			
Total for Period	Ci	2.56E-6	2.00E-6	7.62E-5	9.46E-5

(1) No releases of this type.

Table 1C – Gaseous Effluents Ground Level Releases
(Continued)

		Batch Mode			
		Quarter			
Nuclides Released	**Units**	**1**	**2**	**3**	**4**
1. Fission Gases					
Krypton-85	Ci				
Unidentified	Ci				
Total for Period	**Ci**	(1)	(1)	(1)	(1)
2. Iodines	**Ci**				
3. Particulates					
Strontium-90	Ci				
Cesium-134	Ci				
Cesium-137	Ci				
Manganese-54	Ci				
Cobalt-57	Ci				
Cobalt-60	Ci				
Zinc-65	Ci				
Total for Period	**Ci**	(1)	(1)	(1)	(1)

(1) There were no batch ground level gaseous releases for this reporting period.

Table 1D - Gaseous Effluents – Non-routine Releases

		Quarter			
Nuclides Released	**Units**	**1**	**2**	**3**	**4**
1. Fission Gases					
Krypton-85	Ci				
Unidentified	Ci				
Total for Period	**Ci**	(1)	(1)	(1)	(1)
2. Iodines	**Ci**				
3. Particulates					
Strontium-90	Ci				
Cesium-134	Ci				
Cesium-137	Ci				
Manganese-54	Ci				
Cobalt-57	Ci				
Cobalt-60	Ci				
Zinc-65	Ci				
Total for Period	**Ci**	(1)	(1)	(1)	(1)

(1) There were no non-routine gaseous releases for this reporting period.

Table 2A - Liquid Effluents - Summation of All Releases

There were continuous non-routine (groundwater flow to the Connecticut River) liquid releases during this reporting period. The data in this table is based upon monitoring well data collected throughout 2022 and hydrological modeling of groundwater movement.

Nuclides Released	Units	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Est. Total Error, %
A. Fission and Activation Products						
Total Release (not including tritium, gases, alpha)	Ci	ND	ND	ND	ND	
Average diluted concentration during period	µCi/ml	ND	ND	ND	ND	
Percent of applicable limit (2)	%	NA	NA	NA	NA	
B. Tritium						
Total Release	Ci	2.61E-03	3.14E-03	3.10E-03	2.53E-03	1.8E+01
Average diluted concentration during period	µCi/ml	1.06E-06	1.23E-06	1.43E-06	1.27E-06	
Percent of applicable limit (2)	%	4.51E-05	5.42E-05	5.35E-05	4.36E-05	
C. Dissolved and Entrained Gases						
Total Release	Ci	ND	ND	ND	ND	
Average diluted concentration during period	µCi/ml	ND	ND	ND	ND	
Percent of applicable limit (1)	%	NA	NA	NA	NA	
D. Gross Alpha Radioactivity						
Total release	Ci	ND	ND	ND	ND	
E. Volume of Waste Released (prior to dilution)	Liters	(3)	(3)	(3)	(3)	NA
F. Volume of Dilution Water Used During Period	Liters	3.62E+06	3.67E+06	3.71E+06	3.71E+06	(4)

ND = Not Detected NA = Not Applicable

(1) All spent fuel is in casks on the ISFSI pads. Release of Dissolved and Entrained Gases is not possible.

(2) The percent of limit is based on the ODCM Control 3.2.2 limiting dose (1.5 mrem/quarter to the total body) from liquid effluents and is related to the abnormal leakage of tritiated plant water into the underground environment.

(3) Leakage of contaminated plant water to subsurface areas was stopped in February 2010. The release of contaminated groundwater to the Connecticut River is based on site boundary monitoring well data collected during 2022 and reported in Section B.

(4) Dilution due to groundwater flow through the affected subsurface plume area toward the Connecticut River was estimated to be 7.38 gpm (times the number of days per quarter) during 2022. An estimated total error is not applicable.

Table 2B - Liquid Effluents - Routine Releases

		Continuous Mode			
		Quarter			
Nuclides Released	**Units**	**1**	**2**	**3**	**4**
Strontium-89	Ci				
Strontium-90	Ci				
Cesium-134	Ci				
Cesium-137	Ci				
Iodine-131	Ci				
Cobalt-58	Ci				
Cobalt-60	Ci				
Iron-59	Ci				
Zinc-65	Ci				
Manganese-54	Ci				
Chromium-51	Ci				
Zirconium-Niobium-95	Ci				
Molybdenum-99	Ci				
Technetium-99m	Ci				
Barium-Lathanium-140	Ci				
Cerium-141	Ci				
Others-	Ci				
	Ci				
Unidentified	Ci				
Total for period (above)	**Ci**	(1)	(1)	(1)	(1)
Kr-85	Ci				
Xe-133	Ci				

(1) There were no continuous routine releases in this reporting period, only continuous non-routine liquid releases. See Table 2A.

Table 2B - Liquid Effluents - Routine Releases
(Continued)

		Batch Mode			
		Quarter			
Nuclides Released	**Units**	**1**	**2**	**3**	**4**
Strontium-89	Ci				
Strontium-90	Ci				
Cesium-134	Ci				
Cesium-137	Ci				
Iodine-131	Ci				
Cobalt-58	Ci				
Cobalt-60	Ci				
Iron-59	Ci				
Zinc-65	Ci				
Manganese-54	Ci				
Chromium-51	Ci				
Zirconium-Niobium-95	Ci				
Molybdenum-99	Ci				
Technetium-99m	Ci				
Barium-Lathanium-140	Ci				
Cerium-141	Ci				
Others-	Ci				
	Ci				
Unidentified	Ci				
Total for period (above)	**Ci**	(1)	(1)	(1)	(1)
Kr-85	Ci				
Xe-133	Ci				

(1) There were no batch routine releases in this reporting period, only continuous non-routine liquid releases. See Table 2A.

Table 3 – Solid Waste and Irradiated Fuel Shipments

A. Solid Waste Shipped Off-Site for Burial or Disposal (not Irradiated Fuel)

1. Type of Waste

Shipped from VY for Burial	Unit	Quarters 1 & 2	Est. Total Error %
a.Spent resins, filter sludges, etc.	m^3	1.79E+01	±25%
	Ci	8.20E+01	±25%
b.Dry Compressible Waste, equipment, etc.	m^3	1.55E+03	±25%
	Ci	6.06E00	±25%
c. Irradiated components, control rods, etc.	m^3	1.71E+02	±25%
	Ci	3.66E+03	±25%
d.Other	m^3	2.65E+03	±25%
	Ci	9.10E00	±25%

Shipped from Processor(s) for Burial	Unit	Quarters 1 & 2	Est. Total Error %
a.Spent resins, filter sludges, etc.	m^3	0	N/A
	Ci	0	N/A
b.Dry Compressible Waste, equipment, etc.	m^3	0	N/A
	Ci	0	N/A
c. Irradiated components, control rods, etc.	m^3	0	N/A
	Ci	0	N/A
d.Other	m^3	0	N/A
	Ci	0	N/A

2. Estimate of Major Nuclide Composition (By Type of Waste)

Spent resins, filter sludges		Dry Compressible Waste, equipment, etc.		Irradiated components, control rods, etc.		Other Waste	
Nuclide	Percent(1)	Nuclide	Percent(1)	Nuclide	Percent(1)	Nuclide	Percent(1)
Fe-55	39.6	Fe-55	30.92	Fe-55	20.89	H-3	12.99
Co-60	44.73	Co-60	58.06	Co-60	68.45	Co-60	1.03
Ni-63	15.47	Ni-63	4.53	Ni-63	10.58	Cs-137	85.71
		Cs-137	5.92				

(1) Includes only those nuclides that are greater than 0.1% of the total activity

3. Disposition of Solid Waste Shipments (1st & 2nd Quarters)

No. of Shipments	From VY	From Processor	Mode	To Processor	To Burial
55	55	0	Rail	0	55
6	6	0	Truck	0	6

B. Irradiated Fuel Shipments (Disposition): None

C. Additional Data (1st & 2nd Quarters)

Supplemental Information	VY to Processor	VY to Burial	Processors to Burial
Class of Solid Waste Shipped	N/A	A/B/C	N/A
Type of Containers Used	N/A	GDC/IP-1/IP-2/Type B	N/A
Solidification Agent or Absorbent Used	N/A	None	N/A

GDC = General Design Container

Table 3 – Solid Waste and Irradiated Fuel Shipments (Continued)

A. Solid Waste Shipped Off-Site for Burial or Disposal (not Irradiated Fuel)

1. Type of Waste

Shipped from VY for Burial	Unit	Quarters 3 & 4	Est. Total Error %
a.Spent resins, filter sludges, etc.	m^3	1.79E+01	±25%
	Ci	8.20E+01	±25%
b.Dry Compressible Waste, equipment, etc.	m^3	1.55E+03	±25%
	Ci	6.06E00	±25%
c. Irradiated components, control rods, etc.	m^3	1.71E+02	±25%
	Ci	3.66E+03	±25%
d.Other	m^3	2.65E+03	±25%
	Ci	9.10E00	±25%

Shipped from Processor(s) for Burial	Unit	Quarters 3 & 4	Est. Total Error %
a.Spent resins, filter sludges, etc.	m^3	0	N/A
	Ci	0	N/A
b.Dry Compressible Waste, equipment, etc.	m^3	0	N/A
	Ci	0	N/A
c. Irradiated components, control rods, etc.	m^3	0	N/A
	Ci	0	N/A
d.Other	m^3	0	N/A
	Ci	0	N/A

A. Estimate of Major Nuclide Composition (By Type of Waste)

Spent resins, filter sludges		Dry Compressible Waste, equipment, etc.		Irradiated components, control rods, etc.		Other Waste	
Nuclide	Percent(1)	Nuclide	Percent(1)	Nuclide	Percent(1)	Nuclide	Percent(1)
Fe-55	39.6	Fe-55	30.92	Fe-55	20.89	H-3	12.99
Co-60	44.73	Co-60	58.06	Co-60	68.45	Co-60	1.03
Ni-63	15.47	Ni-63	4.53	Ni-63	10.58	Cs-137	85.71
		Cs-137	5.92				

(2) Includes only those nuclides that are greater than 0.1% of the total activity

B. Disposition of Solid Waste Shipments (3rd & 4th Quarters)

No. of Shipments	From VY	From Processor	Mode	To Processor	To Burial
56	56	N/A	Rail	N/A	56
6	6	N/A	Truck	N/A	6

A. Irradiated Fuel Shipments (Disposition): None

B. Additional Data (1st & 2nd Quarters)

Supplemental Information	VY to Processor	VY to Burial	Processors to Burial
Class of Solid Waste Shipped	N/A	A/B/C	N/A
Type of Containers Used	N/A	GDC/IP-1/IP-2/Type B	N/A
Solidification Agent or Absorbent Used	N/A	None	N/A

GDC = General Design Container

Table 4A – Off-Site Doses from Liquid and Gaseous Releases
(10CFR50, Appendix I)

	Dose (mrem)				
Source	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Year
Liquid Effluents					
Total Body Dose	5.38E-07	6.44E-07	6.38E-07	5.21E-07	2.34E-06
Percent of Limit (1.5 mrem)	3.59E-05	4.29E-05	4.25E-05	3.47E-05	1.56E-04
Footnotes	(a)	(a)	(a)	(a)	
Organ Dose	5.38E-07	6.44E-07	6.38E-07	5.21E-07	2.34E-06
Percent of Limit (5 mrem)	1.08E-05	1.29E-05	1.28E-05	1.04E-05	4.68E-05
Footnotes	(a)	(a)	(a)	(a)	
Airborne Effluents					
Iodines, H-3, C-14 and Particulates	1.99E-03	8.19E-04	1.99E-03	2.32E-03	7.12E-03
Percent of Limit (7.5 mrem)	2.66E-02	1.09E-02	2.65E-02	3.09E-02	9.49E-02
Footnotes	(b)	(b)	(b)	(b)	
Noble Gases					
Beta Air (mrad)	--	--	--	--	--
Footnotes	(c)	(c)	(c)	(c)	
Gamma Air (mrad)	--	--	--	--	--
Footnotes	(c)	(c)	(c)	(c)	

(a) The critical age group/organ for the Maximum Exposed Individual (MEI) is the Adult/Total Body and all organs (except Bone) from the release of H-3 to groundwater.

(b) These doses are based upon the maximum offsite X/Qs and D/Qs. The doses are the maximum organ dose when the Vegetable, Meat, Cow Milk, and Inhalation pathways are summed.

(c) There were no noble gas releases in this quarter.

Table 4B – Annual Off-Site Doses from Liquid, Gaseous and Direct Radiation
(40 CFR 190)

Pathway	Total Body (mrem)	Maximum Organ (mrem)	Thyroid (mrem)
Direct External (a) (b)	7.255	7.255	7.255
Liquids (c)	2.95E-06	2.95E-06	2.95E-06
Gases (c)	1.36E-02	1.36E-02	1.36E-02
Annual Total (d)	7.269	7.269	7.269

The location of the projected maximum individual doses from combined direct radiation plus liquid and gaseous effluents correspond to residences at the southwest boundary relative to the Turbine Hall.

(a) No residential shielding credit or occupancy time fraction (i.e., occupancy is assumed to be 100%) is used. Expected direct external radiation doses would be reduced by approximately 54% with a realistic residential shielding credit and occupancy time (i.e., by using a 0.7 shielding factor from Regulatory Guide 1.109 (Reference 2) and an annual occupancy time of 6760 hours).

(b) The direct dose reported here was calculated by summing the net monthly doses at TLD location DR-53A and represents the dose to the former nearest residence, which was located in the South sector at 385 meters from the stack prior to the vacancy of this residence in 2008 and the purchase of land by Vermont Yankee. Doses are driven by the casks on the ISFSI.

(c) Maximum dose to any organ over all age groups for each release.

(d) Annual dose limits contained in 40 CFR 190 are 25 mrem to the total body and any organ, and 75 mrem to the thyroid for any real member of the public.

Table 4C – Receptor Locations

Sector	Site Boundary [(1)] (meters)	Nearest Resident [(2)] (meters)
N	529	1400
NNE	468	1384
NE	448	1255
ENE	477	966
E	499	933
ESE	482	1915
SE	512	1963
SSE	555	2044
S	419	644
SSW	575	576
SW	505	505
WSW	418	451
W	402	628
WNW	528	1062
NW	917	2253
NNW	831	1738

(1) Site boundary locations are taken from the Reactor Building column in Table 6.10.2 of the ODCM.
(2) The location(s) given are based on information from the Vermont Yankee 2016 Land Use Census and Table 7.1 of the ODCM and are relative to the Reactor Building. Gardens are assumed to be present at all resident locations.

Table 4D - Usage Factors for Environmental Pathways

Age Group	Fish (kg/yr)	Potable Water (l/yr)	Veg. (kg/yr)	Leafy Veg. (kg/yr)	Milk (l/yr)	Meat (kg/yr)	Inhalation (m3/yr)
Adult	21	730	520	64	310	110	8,000
Teen	16	510	630	42	400	65	8,000
Child	6.9	510	520	26	330	41	3,700
Infant	0	330	0	0	330	0	1,400

Data from Regulatory Guide 1.109, Table E-5 (Reference 2).

Table 4E - Environmental Parameters for Gaseous Effluents

		Vegetables		Cow Milk		Goat Milk		Meat	
Variable		Stored	Leafy	Pasture	Stored	Pasture	Stored	Pasture	Stored
YV	Agricultural Productivity (kg/m^2)	2	2	0.70	2	0.70	2	0.70	2
P	Soil Surface Density (kg/m^2)	240	240	240	240	240	240	240	240
T	Transport Time to User (hrs)	--	--	48	48	48	48	480	480
TB	Soil Exposure Time[(a)](hrs)	131,400	131,400	131,400	131,400	131,400	131,400	131,400	131,400
TE	Crop Exposure Time to Plume (hrs)	1,440	1,440	720	1,440	720	1,440	720	1,440
TH	Holdup After Harvest (hrs)	1,440	24	0	2,160	0	2,160	0	2,160
QF	Animals Daily Feed (kg/day)	--	--	50	50	6	6	50	50
FP	Fraction of Year on Pasture	--	--	(b)	--	(b)	--	(b)	--
FS	Fraction Pasture Feed When on Pasture[(c)]	--	--	1	--	1	--	1	--

Note: Footnotes on following page.

Table 4E - Environmental Parameters for Gaseous Effluents
(Continued)

	Variable	Vegetables		Cow Milk		Goat Milk		Meat	
		Stored	**Leafy**	**Pasture**	**Stored**	**Pasture**	**Stored**	**Pasture**	**Stored**
FG	Fraction of Stored Vegetables Grown in Garden	0.76	--	--	--	--	--	--	--
FL	Fraction of Leafy Vegetables Grown in Garden	--	1.0	--	--	--	--	--	--
FI	Fraction Elemental Iodine = 0.5	--	--	--	--	--	--	--	--
H	Absolute Humidity = 5.6[(d)]	--	--	--	--	--	--	--	--

(a) For Method II dose/dose rate analyses of identified radioactivity releases of less than one year, the soil exposure time for that release may be set at 8,760 hours (one year) for all pathways.

(b) For Method II dose/dose rate analyses performed for releases occurring during the first or fourth calendar quarters, the fraction of time animals are assumed to be on pasture is zero (non-growing season). For the second and third calendar quarters, the fraction of time on pasture (FP) will be set at 1.0. FP may also be adjusted for specific farm locations if this information is so identified and reported as part of the land use census.

(c) For Method II analyses, the fraction of pasture feed while on pasture may be set to less than 1.0 for specific farm locations if this information is so identified and reported as part of the land use census.

(d) For all Method II analyses, an absolute humidity value equal to 5.6 (gm/m3) shall be used to reflect conditions in the Northeast (Reference: Health Physics Journal, Volume 39 (August), 1980; Pages 318-320, Pergammon Press).

Table 4F - Environmental Parameters for Liquid Releases (Tritium) Via Groundwater

Variable Name (Units)	**Potable Water**	**Aquatic Food**	**Stored Veg.**	**Leafy Veg.**	**Meat**	**Cow Milk**
Mixing Ratio	5.94E-06	1.27E-03	5.94E-06	5.94E-06	5.94E-06	5.94E-06
Transit Time (hrs)*	12	24	0	0	0	0
Water Uptake** (animal) (L/day)	--	--	--	--	50.0	60.0
Feed Uptake** (animal) (kg/day)	--	--	--	--	50.0	50.0

* Values are from Regulatory Guide 1.109, Table E-15 (Reference 2)

** Values are from Regulatory Guide 1.109, Table E-3 (Reference 2)

Tables 5A-5G - Frequency Distribution Tables for Ground Level Releases

Table 5A

Five Year Aggregate 35-foot
PASQUILL A

	Class 1 Calms	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	
Wind mph	0.95	3	7	12	18	24	>24	TOTAL
N	15	11	30	32	7	2	0	97
NNE	1	2	9	3	0	0	0	15
NE	0	5	10	0	0	0	0	15
ENE	0	5	11	1	0	0	0	17
E	0	12	41	11	0	0	0	64
ESE	1	7	36	32	1	0	0	77
SE	0	3	12	16	0	0	0	31
SSE	1	0	7	23	4	0	0	35
S	0	1	2	9	2	0	0	14
SSW	0	0	0	4	0	0	0	4
SW	0	1	2	4	0	0	0	7
WSW	0	4	2	3	0	0	0	9
W	0	1	3	2	5	0	0	11
WNW	0	0	0	1	6	1	1	9
NW	0	0	11	11	3	1	0	26
NNW	1	10	35	60	19	5	0	130
TOTALS	19	62	211	212	47	9	1	561

Table 5B

Five Year Aggregate 35-foot
PASQUILL B

	Class 1 Calms	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	
Wind mph	0.95	3	7	12	18	24	>24	TOTAL
N	2	10	65	36	5	1	0	119
NNE	0	12	15	9	0	0	0	36
NE	0	7	23	0	0	0	0	30
ENE	0	7	22	0	0	0	0	29
E	1	9	56	7	0	0	0	73
ESE	1	5	65	28	1	0	0	100
SE	0	2	39	22	0	0	0	63
SSE	0	4	31	65	8	1	0	109
S	0	3	15	29	11	1	0	59
SSW	0	0	6	4	0	0	0	10
SW	0	0	1	3	0	0	0	4
WSW	0	0	2	3	0	0	0	5
W	0	0	5	15	14	3	0	37
WNW	0	3	6	12	10	0	0	31
NW	0	2	17	18	14	7	0	58
NNW	1	5	64	72	45	6	0	193
TOTALS	5	69	432	323	108	19	0	956

Table 5C

Five Year Aggregate 35-foot
PASQUILL C

	Class 1 Calms	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	
Wind mph	0.95	3	7	12	18	24	>24	TOTAL
N	2	19	103	68	6	0	0	198
NNE	1	31	31	13	0	0	0	76
NE	0	19	23	2	0	0	0	44
ENE	0	22	56	2	0	0	0	80
E	0	28	111	2	0	0	0	141
ESE	6	25	128	25	1	0	0	185
SE	0	14	94	21	0	0	0	129
SSE	0	6	74	99	11	0	0	190
S	0	2	30	63	8	0	0	103
SSW	0	5	12	9	1	0	0	27
SW	0	5	8	7	0	0	0	20
WSW	0	3	8	10	0	0	0	21
W	1	1	5	37	22	1	0	67
WNW	0	4	14	38	33	2	1	92
NW	1	11	63	53	44	4	0	176
NNW	0	9	123	109	49	6	1	297
TOTALS	11	204	883	558	175	13	2	1846

Table 5D

Five Year Aggregate 35-foot
PASQUILL D

	Class 1 Calms	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	
Wind mph	0.95	3	7	12	18	24	>24	TOTAL
N	33	418	666	514	107	3	0	1741
NNE	21	244	203	58	2	0	0	528
NE	21	232	99	14	1	0	0	367
ENE	31	243	111	2	0	0	0	387
E	51	288	240	24	0	0	0	603
ESE	96	303	474	89	2	0	0	964
SE	102	349	901	101	7	0	0	1460
SSE	79	358	1167	583	48	3	0	2238
S	31	282	493	435	96	3	0	1340
SSW	5	206	177	92	6	0	0	486
SW	27	167	144	94	2	0	0	434
WSW	7	133	205	125	6	0	0	476
W	6	183	412	788	277	13	0	1679
WNW	3	235	370	908	471	42	1	2030
NW	10	400	895	713	359	39	2	2418
NNW	33	521	1440	1181	385	52	1	3613
TOTALS	556	4562	7997	5721	1769	155	4	20764

Table 5E

Five Year Aggregate 35-foot
PASQUILL E

	Class 1 Calms	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	
Wind mph	0.95	3	7	12	18	24	>24	TOTAL
N	51	197	161	43	15	0	0	467
NNE	19	111	23	4	0	0	0	157
NE	14	89	9	1	1	0	0	114
ENE	14	71	7	0	0	0	0	92
E	13	91	36	1	0	0	0	141
ESE	25	156	74	7	0	0	0	262
SE	71	216	277	15	0	0	0	579
SSE	77	346	428	100	8	1	0	960
S	46	529	278	125	32	3	0	1013
SSW	34	676	101	17	2	0	0	830
SW	38	912	98	12	1	0	0	1061
WSW	19	827	214	13	0	1	0	1074
W	19	797	342	150	22	2	0	1332
WNW	21	640	396	144	36	0	0	1237
NW	21	601	577	148	29	1	0	1377
NNW	27	407	711	239	49	3	1	1437
TOTALS	509	6666	3732	1019	195	11	1	12133

Table 5F

Five Year Aggregate 35-foot
PASQUILL F

	Class 1 Calms	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	
Wind mph	0.95	3	7	12	18	24	>24	TOTAL
N	8	78	12	0	0	0	0	98
NNE	7	31	3	0	0	0	0	41
NE	5	25	0	0	0	0	0	30
ENE	5	27	1	0	0	0	0	33
E	6	27	5	0	0	0	0	38
ESE	14	26	7	0	0	0	0	47
SE	17	75	13	0	0	0	0	105
SSE	19	136	39	1	1	0	0	196
S	30	344	59	1	0	0	0	434
SSW	50	501	56	0	0	0	0	607
SW	36	1061	68	0	0	0	0	1165
WSW	29	990	47	1	0	0	0	1067
W	11	677	78	1	0	0	0	767
WNW	12	349	69	2	0	0	0	432
NW	13	198	84	2	0	1	0	298
NNW	23	94	70	6	0	0	0	193
TOTALS	285	4639	611	14	1	1	0	5551

Table 5G

Five Year Aggregate 35-foot
PASQUILL G

	Class 1 Calms	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	
Wind mph	0.95	3	7	12	18	24	>24	TOTAL
N	7	36	4	0	0	1	0	48
NNE	11	18	1	0	0	0	0	30
NE	4	16	0	0	0	0	0	20
ENE	1	10	0	0	0	0	0	11
E	6	22	0	0	0	0	0	28
ESE	10	22	5	0	0	0	0	37
SE	10	27	2	0	0	0	0	39
SSE	10	52	6	0	0	0	0	68
S	22	96	12	0	0	0	0	130
SSW	21	133	15	0	0	0	0	169
SW	7	198	28	0	0	0	0	233
WSW	8	205	8	0	0	0	0	221
W	4	140	17	1	0	0	0	162
WNW	7	90	15	0	0	0	0	112
NW	6	57	26	2	0	0	0	91
NNW	5	38	25	3	0	0	0	71
TOTALS	139	1160	164	6	0	1	0	1470

Tables 6A-6G - Frequency Distribution Tables for Elevated Releases

Table 6A

Five Year Aggregate 297-foot
PASQUILL A

	Class 1 Calms	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	
Wind mph	0.95	3	7	12	18	24	>24	TOTAL
N	11	1	1	6	0	0	0	19
NNE	1	5	1	1	0	0	0	8
NE	0	1	1	1	0	0	0	3
ENE	0	1	2	0	0	0	0	3
E	0	1	0	0	0	0	0	1
ESE	0	3	2	3	1	0	0	9
SE	0	2	5	1	0	0	0	8
SSE	0	4	4	1	2	0	0	11
S	0	1	2	0	0	0	0	3
SSW	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0
WSW	0	0	0	1	0	0	0	1
W	0	1	0	0	2	0	0	3
WNW	0	0	2	0	0	0	0	2
NW	0	1	0	3	0	0	0	4
NNW	1	2	3	3	3	0	0	12
TOTALS	13	23	23	20	8	0	0	87

Table 6B

Five Year Aggregate 297-foot
PASQUILL B

	Class 1 Calms	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	
Wind mph	0.95	3	7	12	18	24	>24	TOTAL
N	0	1	8	14	2	0	0	25
NNE	0	0	2	5	2	0	0	9
NE	0	1	1	6	0	0	0	8
ENE	0	0	2	3	0	0	0	5
E	0	1	1	3	1	0	0	6
ESE	1	4	13	26	4	0	0	48
SE	0	3	6	5	3	0	0	17
SSE	0	1	1	3	2	0	0	7
S	0	0	0	0	5	0	0	5
SSW	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0
WSW	0	0	0	1	1	0	0	2
W	0	0	0	3	1	1	0	5
WNW	0	0	3	0	2	2	3	10
NW	0	1	1	2	2	0	0	6
NNW	0	3	9	24	18	9	4	67
TOTALS	1	15	47	95	43	12	7	220

Table 6C

Five Year Aggregate 297-foot
PASQUILL C

	Class 1 Calms	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	
Wind mph	0.95	3	7	12	18	24	>24	TOTAL
N	0	6	25	36	26	1	0	94
NNE	0	2	11	16	4	0	0	33
NE	0	2	7	7	2	0	0	18
ENE	0	3	14	8	0	0	0	25
E	0	4	16	9	1	0	0	30
ESE	0	7	51	47	3	0	0	108
SE	0	9	21	31	7	1	0	69
SSE	0	4	2	38	13	0	0	57
S	1	1	3	9	14	7	2	37
SSW	0	0	0	0	0	1	0	1
SW	0	0	1	4	0	0	0	5
WSW	0	0	1	2	3	0	0	6
W	0	0	0	5	3	9	1	18
WNW	0	0	2	7	7	8	0	24
NW	1	1	10	11	15	8	2	48
NNW	0	3	31	71	62	47	11	225
TOTALS	2	42	195	301	160	82	16	798

Table 6D

Five Year Aggregate 297-foot
PASQUILL D

	Class 1 Calms	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	
Wind mph	0.95	3	7	12	18	24	>24	TOTAL
N	18	269	442	565	426	131	10	1861
NNE	3	182	145	127	55	4	1	517
NE	2	191	125	62	21	1	2	404
ENE	2	186	131	32	5	0	0	356
E	8	238	251	66	18	3	0	584
ESE	7	271	505	192	47	3	0	1025
SE	17	355	878	458	57	10	1	1776
SSE	10	243	811	1092	206	24	3	2389
S	13	102	395	1047	628	136	18	2339
SSW	5	72	124	220	71	8	1	501
SW	7	43	93	171	57	1	0	372
WSW	11	50	73	216	92	7	2	451
W	16	53	101	623	695	175	12	1675
WNW	3	82	138	689	901	285	28	2126
NW	2	173	344	430	564	229	52	1794
NNW	54	358	1172	1527	1240	512	153	5016
TOTALS	178	2868	5728	7517	5083	1529	283	23186

Table 6E

Five Year Aggregate 297-foot
PASQUILL E

	Class 1 Calms	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	
Wind mph	0.95	3	7	12	18	24	>24	TOTAL
N	27	524	467	222	46	7	0	1293
NNE	8	354	66	27	5	0	0	460
NE	9	294	41	2	0	0	1	347
ENE	5	282	33	1	0	2	0	323
E	9	397	70	8	0	0	0	484
ESE	15	457	226	27	3	0	0	728
SE	25	474	747	171	6	1	0	1424
SSE	10	277	718	372	30	4	2	1413
S	6	160	281	306	144	23	3	923
SSW	2	90	118	114	40	8	0	372
SW	3	61	87	63	16	0	0	230
WSW	2	61	111	109	20	2	0	305
W	4	57	132	299	186	9	1	688
WNW	4	97	146	284	108	12	1	652
NW	1	206	361	258	83	13	1	923
NNW	21	441	1536	944	305	58	10	3315
TOTALS	151	4232	5140	3207	992	139	19	13880

Table 6F

Five Year Aggregate 297-foot
PASQUILL F

	Class 1 Calms	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	
Wind mph	0.95	3	7	12	18	24	>24	TOTAL
N	9	217	176	19	6	0	0	427
NNE	2	161	24	3	0	0	0	190
NE	2	130	6	0	0	0	0	138
ENE	3	115	16	2	0	0	0	136
E	7	165	42	0	0	0	0	214
ESE	5	140	125	14	0	0	0	284
SE	8	188	343	81	0	0	0	620
SSE	5	149	296	79	0	1	0	530
S	2	76	172	51	8	0	0	309
SSW	3	63	60	29	4	0	0	159
SW	1	52	73	19	2	0	0	147
WSW	0	40	67	20	1	0	0	128
W	1	44	81	70	7	0	0	203
WNW	2	66	91	64	3	0	0	226
NW	2	115	154	40	4	0	0	315
NNW	3	167	429	184	9	0	0	792
TOTALS	55	1888	2155	675	44	1	0	4818

Table 6G

Five Year Aggregate 297-foot
PASQUILL G

	Class 1 Calms	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	
Wind mph	0.95	3	7	12	18	24	>24	TOTAL
N	0	18	19	3	1	0	0	41
NNE	0	6	2	0	0	0	0	8
NE	0	10	3	0	0	0	0	13
ENE	0	9	2	0	0	0	0	11
E	1	9	3	0	0	0	0	13
ESE	0	12	7	2	0	0	0	21
SE	0	19	48	19	0	0	0	86
SSE	0	19	50	18	0	0	0	87
S	1	14	39	14	4	1	0	73
SSW	0	8	19	12	2	0	0	41
SW	0	11	22	17	0	0	0	50
WSW	0	15	29	15	0	0	0	59
W	0	8	32	26	2	0	0	68
WNW	0	11	24	25	3	0	0	63
NW	1	20	23	20	0	0	0	64
NNW	0	21	37	19	0	0	0	77
TOTALS	3	210	359	190	12	1	0	775

APPENDIX A – SUPPLEMENTAL INFORMATION

1. MEASUREMENTS AND APPROXIMATIONS OF TOTAL RADIOACTIVITY

Provided below are the methods used to measure or approximate the total radioactivity in effluents and the methods used to determine radionuclide composition.

Tritium

ODCM Table 4.3.l requires that a continuous sample of Reactor Building ventilation effluents be collected for H-3 and analyzed monthly. The error involved in this sample is approximately ±18 percent. This sampling was initiated at the reactor building exhaust in the second quarter of 2021 when the stack was abandoned prior to demolition.

Particulates

ODCM Table 4.3.l requires that a continuous sample of Reactor Building ventilation effluents be collected andanalyzed weekly for principal gamma emitters. The error involved in this sample is approximately ±18 percent. This sampling was initiated at the reactor building exhaust in the second quarter of 2021 when the stack was abandoned prior to demolition.

2. BATCH RELEASES

There were no routine liquid or gaseous batch releases during the reporting period.

3. ABNORMAL RELEASES

a. Liquid

VY had installed 32 groundwater wells to monitor the 2010 leak event or to monitor additional at-risk structures, systems or components (SSCs) that could cause a release of licensed material to the groundwater. One well (GZ-08) has been dry since installation and no samples were collected from it in 2021. A second well, GZ-24 was compromised by excavation activity in 2014 and is no longer able to be sampled. Due to the current condition of the facility a groundwater expert panel was convened to evaluate the status of the groundwater sampling wells. Based upon the plant configuration (removal of piping/components) and status of the plume it was prudent to reduce the number of active wells in the program. A summary of the sample results for the remaining wells are presented in Table A-1. There are only two (2) wells that had detectable activity (>MDC) in 2021 and all these sample results are well below the EPA limit of 20,000 pCi/L for drinking water. None of the wells in this program supply drinking water, and no drinking water wells on site or adjacent to VY have shown tritium at detectable levels in regular surveillance samples.

b. Gaseous

There were no non-routine gaseous releases (measured) during the reporting period.

Table A-1: VY Groundwater Tritium Summary - 2022

Groundwater well Sampled	Number of analyses performed	Mean Concentration[1]	Concentration Range[1]	
			Min	Max
GZ-01	1	< 574	< 574	< 574
GZ-03	1	< 604	< 604	< 604
GZ-04	2	< 600	< 600	< 600
GZ-05	1	< 598	< 598	< 598
GZ-13	1	< 630	< 630	< 630
GZ-13D	2	< 624	< 617	< 630
GZ-14	1	< 616	< 594	< 637
GZ-14D	4	**1237**	762	1780
GZ-18	1	< 625	< 625	< 625
GZ-18D	1	< 627	< 627	< 627
GZ-19	1	< 576	< 576	< 576
GZ-19D	1	< 566	< 566	< 566
GZ-22D	12	**1232**	833	1870
GZ-23	9	< 624	< 620	< 628
GZ-25	1	< 573	< 573	< 573
GZ-26	1	< 572	< 572	< 572
GZ-27	1	< 572	< 572	< 572

Notes:

1. All concentrations are in units of pCi/L
2. Required LLD for tritium = 2,000 pCi/L
3. “<” denotes minimum detectable value for the analytical period
4. **Bold** values denote positive results (greater than minimum detectable values)

APPENDIX B – LIQUID HOLDUP TANKS

Requirement	With the quantity of radioactive material in any outside tank exceeding the limit of Section 4 of the Defueled Safety Analysis Report, describe the events leading to this condition in the next Radioactive Effluent Release Report.
Response	The limits for any outside tank were not exceeded during this reporting period.

APPENDIX C - RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION

The requirements for radioactive liquid effluent monitoring instrumentation channels in ODCM Table 3.1.1 were removed in ODCM Revision 40.

APPENDIX D - RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION

Requirement	Radioactive gaseous effluent monitoring instrumentation channels are required to be functional in accordance with ODCM Table 3.1.2. If a non-functional, gaseous effluent monitoring instrumentation is not returned to functional status within 30 days pursuant to Note 5 of Table 3.1.2, an explanation in the next annual Radioactive Effluent Release Report of the reason(s) for the delay in correcting the inoperability is required per ODCM Section 10.1. The plant stack was removed from service in March 2021. The release path was relocated to reactor building exhaust path in the overhead of the 280 foot level.
Response	There was a loss of ~49 hours of sample time in 2022 due to the sampler on the RB 280 being de-energized. This issue is documented in CR-2022-0098.

APPENDIX E – RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

This Appendix is no longer required by the ODCM as of Revision 40. This Appendix is retained as a placeholder to allow this report to be consistent with previous reports.

APPENDIX F – LAND USE CENSUS

Requirement	A land use census is conducted in accordance with ODCM Control 3/4.5.2. With a land use census identifying a location(s) that yields at least a 20 percent greater dose or dose commitment than the values currently being calculated pursuant to ODCM Control 4.3.3, the new location(s) must be identified in the next Annual Radioactive Effluent Release Report.
Response	The Land Use Census was completed during the third quarter of 2022. No locations were identified which yielded a 20 percent greater dose or dose commitment than the values currently being calculated pursuant to ODCM Control 4.3.3. See Table 4C for a listing of nearest residents in the site area as determined in the 2022 Land Use Census.

APPENDIX G – PROCESS CONTROL PROGRAM

<u>Requirement</u>	ODCM Section 10.1 requires that licensee-initiated changes to the Process Control Program (PCP) be submitted to the Commission in the annual Radioactive Effluent Release Report for the period in which the change(s) was made.
<u>Response</u>	There were no changes made to the Process ControlProgram during this reporting period.

APPENDIX H – OFF-SITE DOSE CALCULATION MANUAL

<u>Requirement</u>	ODCM Section 10.1 requires that licensee-initiated changes to the Off-Site Dose Calculation Manual (ODCM) be submitted to the Commission in the annual Radioactive Effluent Release Report for the period in which the change(s).
<u>Response</u>	There was one revision (Rev. 42) to the Offsite Dose Calculation Manual (ODCM) during 2022. The ODCM is included as Enclosure 2 to the letter forwarding this report. A description of the changes associated with Revision 41 to the ODCM are included within the Revision Summary portion of the ODCM.

APPENDIX I – RADIOACTIVE LIQUID, GASEOUS, AND SOLID WASTE TREATMENT SYSTEMS

Requirement	ODCM Section 10.5 requires that licensee-initiated major changes to the radioactive waste systems (liquid, gaseous, and solid) be reported to the Commission in the annual Radioactive Effluent Release Report for the period in which the evaluation was reviewed by the Independent Safety Review Committee.
Response	There were no licensee-initiated major changes to the radioactive waste systems during this reporting period.

APPENDIX J – ON-SITE DISPOSAL OF SEPTIC/SILT/SOIL WASTE

Requirement	The Off-Site Dose Calculation Manual included Appendices B, F and I which required that the dose impact due to on-site disposal of septic waste, cooling tower silt, and sand/soil type materials during the reporting year and from previous years be reported to the Nuclear Regulatory Commission in the Annual Radioactive Effluent Release Report if disposals occur during the reporting year. In 2021 (BVY 21-025) Vermont Yankee notified the NRC that there will no longer be any alternate disposal material on site. The subject letter notified the NRC that the referenced approvals for alternate disposal of material on site will no longer be utilized/authorized and the subject documents will cease to be incorporated into the ODCM. As such, this appendix will no longer be included in future submittals.
Response	There was no on-site disposal spreading during 2022.

Enclosure 2

Vermont Yankee Nuclear Power Station

Off-site Dose Calculation Manual (ODCM), Revision 42
(140 pages excluding this cover sheet)

VERMONT YANKEE NUCLEAR POWER STATION

OFF-SITE DOSE CALCULATION MANUAL

REVISION 42

Effective Date: 2/17/2022

Originator:	Michael Pletcher Print/Sign	12/7/22 Date
Reviewed:	John Geyster Print/Sign (Independent Safety Review)	2/8/22 Date
Approved:	Corey Daniels Print/Sign (ISFSI Senior Manager)	2/10/22 Date

REVISION SUMMARY

DATE	REVISION	DESCRIPTION
9/23/10	33	Three sections of the ODCM were modified with minor changes to incorporate recommendations made in the 2009 RETS/REMP QA audit: - A typographical error in ODCM Table 6.10.1.was corrected. The table listed a distance of 26,500 meters for the highest undepleted X/Q for skin dose calculations. The correct value is 2,650 meters. This table is descriptive in nature and is not used for calculation of doses. - The error in distance measurement in the first paragraph on page 2 of 12 of Section 7 of the ODCM was corrected. The distance of 0.5 miles was revised to 0.75 miles. This value is descriptive in nature and is not used for calculation of doses. - ODCM Table 3.5.1 provided distances in miles whereas other sections of this table contained distances in kilometers. Additionally, there was no explanation as to why some "inner" ring TLDs are located further from the plant than some "outer" ring TLDs. This table was changed to include both kilometers and miles where distances are required. Additionally, the table footnotes were revised to explain the method used to determine proper location for the inner and outer ring TLDs in each of the 16 compass sectors. - Footnote "e" to ODCM Table 4.5.1 did not fully explain how the determination of Barium/Lanthanum 140 activity is determined using daughter ingrowth. Additional information was provided in footnote "e" to provide the reader with a better explanation. - Table 7.1 was revised to clearly indicate the TLDs designated as "control" location TLDs.

REVISION SUMMARY (Continued)

7/08/2011	34	Four main sections of the ODCM were modified with significant changes to incorporate the contaminated groundwater discharge pathway to the Connecticut River: o Section 3 / 4 was revised to include the subsurface groundwater pathway in the Liquids Discharge description. Groundwater monitoring wells used to determine the extent of these releases are listed. The Southwest Well was added as Ground (Potable Drinking) Water sample location in the REMP description of Section 3 / 4. o Section 5 was revised to include a description of the determination of plant generated radionuclide concentrations in groundwater discharges. o Section 6 was revised to include methods for calculating radiation dose from plant generated radionuclides in groundwater discharges. o Section 9 was revised to include the method for determination of groundwater flows in the 17 identified streamtubes flowing from the plant site to the Connecticut River. In addition to revisions of four main sections of the ODCM, the Table of Contents, Definitions and References Sections of the ODCM were revised to reflect the additional subsections, figures, tables, definitions and references in the ODCM.
10/09/14	35	o Section 3/4 was revised to delete a reference requirement to Note 5 in Section 2 of Table 3.1.2 (Gaseous Effluent Monitoring Instrumentation). It was determined that Note 5 was in conflict with Note 2 for Section 2 and therefore should be removed as a requirement for Section 2 (CR-VTY-2013-04078 CA-0002). o Also, in Sections 2, 3/4, 6, 8 and 10, the word “operable” was found to be inappropriate and should be replaced by the word “functional”. Additionally, the word “inoperable” by the word “non-functional” and the word “operability” was replaced by “functionality” (EN-OP-104 and NRC Inspection Guide 9900) (CR-VTY-2013-04078 CA-0002). o In the tables of Section 7 of the Offsite Dose Calculation Manual, it was determined that the out-of-business dairy farms which had provided milk for the REMP but were no longer functional, should be eliminated from the description (WT-WTVTY-2011-00116). Section 9 of the Offsite Dose Calculation Manual was revised to eliminate the references to the Off Gas “30 minute” delay line. This was previously evaluated under CR-VTY-2010-1676 and it was determined that the reference to the “30 minute” should be removed. (WT-WTVTY-2009-00009 CA-0010)

02/03/16	36	o Section 3/4.2.1 was changed to add intercepted groundwater releases to Surveillance 4.2.1.a to clarify that controls on liquid releases also apply to intercepted groundwater being released. o Section 3/4.2.1, Table 4.2.1 was changed to add intercepted groundwater requirements to Table 4.2.1. This establishes sampling and analysis protocols that are as rigorous as liquid waste releases and consistent with subsurface groundwater analysis. These protocols provide data sufficient to support dose estimates and assignments and allows comparison between interception wells and other subsurface groundwater. o Section 3/4.2.1, Table 4.2.1 Notation (e) was revised to provide the same analytical specifications for intercepted groundwater and subsurface groundwater, enabling comparison of results for all groundwater samples. o Section 3/4.2.1, Surveillance 4.2.1.a was revised to ensure that the ODCM limit of 10 times 10CFR20 Appendix B applies to all water released to the Connecticut River. o Section 3/4.6 was revised to ensure that liquid effluent instrumentation is not required for intercepted groundwater releases. o Section 5.1 was revised to include groundwater intercept release tank(s) as a potential release point and to clarify that intercepted groundwater releases are undiluted. o Section 5.2.1 was revised to include intercepted groundwater tanks to the list of tanks from which batch releases are made. Additionally, this section recognizes alternate sample point(s) other than the radwaste sample sink are acceptable for collecting samples for analysis prior to release. o Section 5.2.4 is added to describe the new release pathway for intercepted groundwater and to describe it's use in a manner consistent with liquid waste treatment systems and subsurface groundwater. o Section 6.2 is revised to add dose calculation from intercepted groundwater and ensure it is performed the same as subsurface groundwater. This clarifies that total body dose estimates are only required prior to liquid waste releases. o Table 6.2.1 is revised to add a footnote clarifying that the mixing ratio is based on a 20,000 gpm flow. o Section 6.2.1, Equation 6-1 is revised to add a flow correction term. This allows dose factors DFL to be adjusted for release flow rates if the flow rate is different than the rate used for Table 1.1.11. o Section 6.2.2, Equation 6-2 is revised to add a flow correction term. This allows dose factors DFL to be adjusted for release flow rates if the flow rate is different than the rate used for Table 1.1.11. o Section 6.3.1, Equation 6-3 is revised to add a flow correction term. This allows dose factors DFL to be adjusted for release

		flow rates if the flow rate is different than the rate used for Table 1.1.11. o Section 6.3.2, Equation 6-4 is revised to add a flow correction term. This allows dose factors DFL to be adjusted for release flow rates if the flow rate is different than the rate used for Table 1.1.11. o Section 7.2 and Table 7.1 were revised to delete non-required control stations from the REMP Sample Station listing for airborne, waterborne, mixed grasses, milk and sileage.
12/01/16	37	o Delete Steam Jet Air Ejector (SJAE) Monitoring from Table 1.1.1 o Delete "iodines" from Table 1.1.1 o Delete Thyroid dose from Table 1.1.1 o Delete "iodines" from Table 1.1.4 o Delete iodine and N-16 terms from Table 1.1.6 o Delete direct radiation calculations from Table 1.1.6 and replace with TLD readings from site boundary o Delete reference to North Warehouse from Table 1.1.6 o Delete SJAE requirements from Table 1.1.7 o Delete Total body calculation for noble gas from Table 1.1.7 o Remove I-131, I-133 and SJAE from Table 1.1.8 o Delete all nuclides other than Kr-85 from Table 1.1.10 o Delete all nuclides other than Kr-85 from Table 1.1.10A o Delete nuclides with short half-life from Table 1.1.11 o Delete nuclides with short half-life from Table 1.1.12 o Delete Gaseous Radwaste Treatment system, Hot Standby and Refueling Outage definitions from Table 2.1.1 o Delete variables from Table 2.1.2 that are no longer applicable o Delete iodines from Table 2.1.2 o Delete SJAE and AOG terms from Table 2.1.2 o Delete SJAE and AOG requirements from Table 3.1.2 o Delete Notes 2,3,6,8 & 9 from Table 3.1.2 o Delete references to Tech Spec 3.8.K and 3.8.J o Delete SJAE and AOG requirements from Table 4.1.2 o Delete SJAE and AOG monitor Notes from Table 4.1.2 o Delete I-131 analysis and LLD from Table 4.2.1 o Delete I-131, Ba-140 & La-140 from Table 4.2.1 Note (e) o Delete iodine requirements from 3/4.3.1 o Delete SJAE, I-131 and short-lived noble gas requirements from Table 4.3.1 o Delete start-up, shutdown, power change requirements, SJAE noble gas sample and short-lived gamma emitter list from Table 4.3.1 Notation o Delete iodines from 3/4.3.3 o Delete 3/4.3.4 and Revise Figure 9.2 to reflect change o Delete AOG requirements from 3/4.3.5 o Delete 3/4.3.6

		○ Delete 3/4.3.7 ○ Reduce the number of REMP air sample stations due to reduced risk of release and remove iodine canisters ○ Reduce REMP TLDs to site boundary and offsite controls ○ Delete Table 3.5.1 4.a. Milk sampling ○ Delete Table 3.5.1 Notation (g) ○ Delete I-131, Ba-140, La-140 and Notation (d) from Table 3.5.2 ○ Delete I-131, Ba-140, La-140, milk and Notes (e) and (g) from Table 4.5.1 ○ Delete requirement to identify location of nearest milk animal in each meteorological sector from the land use census. ○ Delete infant thyroid dose from 3/4.6 Basis 3.3.1 ○ Delete iodine dose from 3/4.6 Basis 3.3.3 ○ Delete 3/4.6 Basis 3.3.4 ○ Delete AOG from 3/4.6 Basis 3.3.5 ○ Delete 3/4.6 Basis 3.3.6 ○ Delete 3/4.6 Basis 3.3.7 ○ Delete reference to multiple reactor site from 3/4.6 Basis 3.4.1 ○ Revise wording in 3/4.6 Basis 3.5.1 to indicate the cessation of milk sampling. ○ Revise wording in 3/4.6 Basis 3.5.2 to indicate the cessation of milk sampling. ○ Revise wording of 5.2.1 Sample Tank Pathway to reflect current operational status. ○ Delete Section 5.2.3, Circulating Water Pathway ○ Revise Section 6.1 to delete discussion of burning waste oil ○ Section 6.2.2, reformat to align terms correctly (editorial) ○ Delete thyroid dose from Section 6.3 ○ Re-format terms under Equation 6-3 (editorial) ○ Revise 6.4.1 Method I to remove SJAE calculations and calculate based on stack gas grab samples. Due to decay, remove summation and calculate based solely on Kr-85 for stack and ground calculations ○ Revise 6.4.2 Method I equations to be specific for Kr-85 and remove reference to SJAE and AOG ○ Delete references to AOG and SJAE and make Section 6.5.1 Method I specific to Kr-85 ○ Revise 6.5.2 Method I to make Kr-85 specific (delete summation in Eq 6-8, 6-9, 6-12, 6-13, 6-7, 6-37, 6-38 and make all D and Q terms specific for Kr-85 ○ Section 6.5.2 Basis for Method I delete references to the North Warehouse as a designated ground level release point and the waste oil burner. Designate the Reactor Building as a ground level release point. ○ Delete iodine from Section 6.6 ○ Delete references to the North Warehouse waste oil burner and designate the Reactor Building as a ground level release point in Section 6.6

		o Delete Section 6.7; beta air dose is bounding based on Kr-85 o Revise Section 6.8 due to decay, remove summation and calculate based solely on Kr-85 for stack and ground calculations; make all D and Q terms specific for Kr-85 o Section 6.8.2 Basis for Method I delete references to the North Warehouse as a designated ground level release point and the waste oil burner. Designate the Reactor Building as a ground level release point. o Delete iodine from Section 6.9 o Delete milk pathway, iodines and noble gas gamma air dose from Section 6.10 o Revise the stack flow rate in Section 6.10 o Table 6.10.1 was revised to include new atmospheric dispersion factors for the Reactor Building o Revise Table 6.10.2 to show distances to site boundary from the Reactor Building o Delete Section 6.11.1 due to no dose from N-16 o Delete Section 6.11.2 o Delete Section 6.11.3 due to the Low Level Waste Pad being demolished o Delete calculation of ISFSI direct dose and measure dose using REMP TLDs o Revise Section 6.11.4 to replace calculations of direct dose with REMP TLDs o Delete Section 6.11.5 o Revise Section 7.2 Airborne Pathway to delete sampling in nearby communities o Revise Section 7.3 to replace Turbine Building with Reactor Building for distances to sample stations o Delete reference to Tech Spec 3.8.K.1 and SJAE in Section 8.2 o Delete AOG from Section 8.2.1 o Delete AOG from Section 8.2.1.1 o Delete total body setpoint equation; beta skin dose is limiting for noble gas o Revise Section 8.2.1.2 to add Kr-85 values for Sg, revise the stack flow and make the example specific for Kr-85 and make set point based on Kr-85 skin dose o Revise Section 8.2.1.3 to remove reference to AOG and SJAE, make specific to Kr-85 and remove basis for total body set point o Delete Section 8.2.2, SJAE Noble Gas Activity Monitors o Revise Section 9.2 to delete references to equipment no longer in service (AOG, recombiner system, charcoal absorber system, gland seal system) o Delete met tower reporting requirement from Section 10.1 o Revise Section 10.2 to delete milk sample reference. o Revise Section 10.4.2 to delete iodine from gaseous effluents

02/06/17	38	o Table 4.2.1: change “Perimeter” wells to “Monitoring” wells in the table, consistent with the function of the well as defined in site procedures. o Table 4.2.1 Notation g.: change “Perimeter” wells to “Monitoring” wells, consistent with the function of the well as defined in site procedures. o Table 4.2.1, Add Notation i. to provide basis for sampling intervals in Table 4.2.1. o Table 4.2.1, Add Notation j. to provide basis for sampling intervals in Table 4.2.1.
03/05/18	39	o Delete Liquid Radwaste Monitor from Table 1.1.1 o Delete Liquid Radwaste Monitor and set points from Table 1.1.7 o Revise Definition 7 in Table 2.1.1 (Liquid Waste Discharge) o Revise Definition 8 in Table 2.1.1 (ODCM) o Revise definitions of dilution flow and discharge flow rates and delete set point and efficiency terms in Table 2.1.2 o Delete Liquid Radwaste Monitor and Flow Rate Measurement Devices from Table 3.1.1 o Delete Note 1 and Note 3 in Table 3.1.1 o Delete Liquid Radwaste Monitor from Table 4.1.1 o Revise Control 3/4.2.1 to allow intercepted groundwater release through liquid waste effluent line o Revise Table 4.2.1 to institute requirements for release without liquid radwaste monitor deleted from Table 3.1.1 Note 1. o Add Note (k) to Table 4.2.1 implement Table 3.1.1 requirements for release without liquid radwaste monitor o Revise 3/4.6 Bases 3.1.1 to pertain to flow rate meter and delete language on release frequency o Revise 3/4.6 Bases 3.2.1 to allow intercepted groundwater release through liquid waste effluent line o Revise Cpi term in 5.1 to remove names of SSCs to reflect SAFSTOR configuration o Revise 5.2.1 Sample Tank Pathway to reflect SAFSTOR configuration o Revise 5.2.4 Intercepted Groundwater Pathway to allow intercepted groundwater release through liquid waste effluent line o Delete 8.1.1 Liquid Radwaste Discharge Monitor (RM-17-350) o Revise Section 9.1 to reflect SAFSTOR configuration o Revise Figure 9-1 to reflect SAFSTOR configuration

10/23/18	40	o Add definitions for X/Q and D/Q o Changed Reactor Building release to Ground Release throughout and eliminated elevated throughout. Put notes under Table 1.1.12 and Table 6.10.1 that Reactor Building releases are considered ground releases. Changed ground level vents to ground level releases throughout. o Remove North Warehouse throughout document. o Delete references to noble gas controls and calculations, and ventilation exhaust treatment system for AOG and waste building from Table 1.1.1 Summary of Radiological Effluent Controls and Implementing Equations and equations 6-21 and 6-23 in Note 2 o Delete noble gas requirements from Table 1.1.2 Summary of Methods to Calculate Unrestricted Area Liquid Concentrations o Delete the following direct noble gas dose calc terms from TABLE 1.1.4 Summary of Methods to Calculate Dose Rates Eq. No. Title o 6-5 Total Body Dose Rate from Noble Gases Released from Stack o 6-39 Total Body Dose Rate from Noble GasesReleased from Ground o 6-7 Skin Dose Rate from Noble Gases Released from Stack o 6-38 Skin Dose Rate from Noble Gases Released from Ground o 6-21 Gamma Dose to Air from Noble Gases Released from Stack o 6-41 Gamma Dose to Air from Noble Gases Released from Ground Level o 6-23 Beta Dose to Air from Noble Gases Released from Stack o 6-43 Beta Dose to Air from Noble Gases Released from Ground Level o 6-27b Direct Dose o 6-27c Direct Dose o 6-27d Direct Dose o Gaseous Effluents: o Plant Stack (RR-108-1A, RR-108-1B) Noble Gas Activity Monitors o 8-10 Skin o Delete TABLE 1.1.5 Summary of Methods to Calculate Doses to Air from Noble Gases entirely o Delete Table 1.1.6 reference to direct dose from main steam line radiation monitor associated with N-16 o Delete Table 1.1.7 Summary of Methods for Setpoint o Determinations, stack monitoring consists of grab and composite sampling o Delete items from Table 1.1.8 that no longer apply associated

		with noble gases and primary gas treatment systems o Delete TABLE 1.1.10 Dose Factors Specific for Vermont Yankee for Noble Gas Releases o Delete TABLE 1.1.10A Combined Skin Dose Factors Spe if for Vermont Yankee Ground Level Noble Gas Releases. o Modify Table 1.1.12 values incorporating new meteorology and dispersion factors. o Delete the Noble Gas effluent release and dose calculation terms from TABLE 2.1.2 Summary of Variables, added new terms as applicable to coincide with methodology changes. o Modify 3/4.1.2 and Table 2.1.2 to recognize the removal of the gaseous monitor channel for noble gases o Delete Notes 7 and 10 from TABLE 3.1.2 NOTATION along with removal of noble gas requirements o Delete iodine sampler cartridge and Noble Gas Activity o Monitor (RM 17 156, RM 17 157) from Table 3.1.2. o Delete 3/4.1.1 Radioactive Liquid Effluent Instrumentation since Service Water Discharge Monitor (RM 17 351) is removed from service. o Delete Table 3.1.1 Service Water Discharge Monitor (RM 17 351) will be removed from Service. o Delete Table 4.1.1 and Notations Service Water Discharge Monitor (RM 17 351) will be removed from Service. o Delete noble gas activity monitor from Table 4.1.2 o Add Service Water weekly grab sample and quarterly composite to Table 4.2.1 Radioactive Liquid Sampling and Analysis Program o Delete 3/4.6 EFFLUENT AND ENVIRONMENTAL CONTROL BASES INSTRUMENTATION Liquid Effluent Instrumentation (3.1.1) o Revise 5.2.2 Service Water Pathway to eliminate continuous monitoring and require routine sampling. o Delete Section 8.1.2 Service Water Discharge Monitor (RM o 17 351) o Delete reference to noble gases in 3/4.2.1 o Delete reference to dissolved noble gases in Table 4.2.1 o Add weekly storm drain grab sample to Table 4.2.1. o Change MDC to LLD in Table 4.2.1 Note j. o Delete the Noble Gas requirements from Section 3/4.3.1 Gaseous Effluents Dose Rate o Delete Section 3/4.3 RADIOACTIVE GASEOUS EFFLUENTS for noble gases o Delete 3/4.Ventilation exhaust treatment system is no longer needed to maintain doses below 0.3 mrem to any organ over one month during decommissioning. o Delete monthly stack grab sample. Change to continuous tritium sample analyzed monthly. o Delete Control 4.3.2 in 3/4.4.1 noble gas controls no longer applicable.

		o Modified wording explaining the REMP direct radiation monitoring sites to be consistent with the 10 chosen locations. o Modify note b in Table 3.5.1 to coincide with number of direct radiation monitoring stations. o Change from weekly to Monthly the frequency for change out of particulate sampling (weekly sampling was originally based on radioiodine sampling requirements). o Remove statements from 3/4.6 basis (for 3.2.1 and 3.3.2) related to noble gas dose and dose rate limits, no longer applicable. o Delete reference to ventilation exhaust treatment system, systems supported by this system are no longer in service or needed per NUREG-0473 o Delete Table 4.5.1 Note (b). No longer used in the table. o Typo, repeat paragraph in 3/4.6 after discussion of Interlaboratory Comparison Program basis statement. o Delete the noble gas terms from Section 5.0 METHOD TO CALCULATE OFF SITE LIQUID CONCENTRATIONS o Delete References to noble gases in Section 6.1 on introductory concepts to dose calculations o Delete release release in fourth paragraph of 6.1 Introductory Concepts o Delete sections 6.4, 6.5 and 6.8 related to methods associated with noble gas dose and dose rate calculations o In Section 6.6.2, remove statement referring to Section 6.4.3 since that section has been deleted. o Modify Section 6.6 for tritium and particulates to present calculational methods that are comparable and consistent with NUREG-0133 "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants o Changed reference for equation 6-19 from 6.8 to 6-44 which is the ground release equation. o Revise equation 6-19 to use ground release terms Rcog, QiGLP and DFGgico o Delete references to noble gas doses, air, and skin doses in Section 6.10 and 6.10.1 o In section 6.10.2 change the computer code used to calculate dispersion factors to the NRC sponsored code XOQDOQ o In Section 6.10.2 deleted discussion on effective stack height being above 100 m, XOQDOQ program code was run with a stack height less than 100 meters. Also changed basis for depleted X/Q and calculated D/Q from Regulatory Guide 1.111 to NRC approved software XOQDOQ. o Changed date range for meteorological data to 2012 to 2016. o In Section 6.10 add in ingestion of milk since this is still an o exposure pathway that will contribute to dose from particulate radionuclides. o Table 6.10.1 was modified to remove atmospheric dispersion data applicable to noble gases and incorporate the new factors

		determined from the XOQDOQ program code with the updated meteorological data. o Revised 6.11.4 and reference H to reflect 58 Spent Fuel Dry Storage Casks and the 10 CFR 72.104 study of direct radiation dose rates. o Renumbered section after 6.11.4. 6.11.4 was used twice. o Deleted control 3.3.2 related to noble gases from statement in Section 6.12. o Added in information on the change in meteorological data wind frequencies as compared to original plant data in Sector 7.1. o In Table 7.1 added in four additional REMP direct radiation monitoring sites to account for the committed number of 10 in Table 3.5.1. These added sites include those associated with the ISFSI siting. o Deleted silage as an exception in note 2 of Table 7.1 o Delete radioiodine sampling from Table 7.1 Radiological Environmental Monitoring Stations o Updated Figure 7.4 to include all REMP direct radiation monitoring sites. o Delete section 8.1 Liquid Effluent Instrumentation Setpoints because there is no liquid effluent instrumentation and there are no liquid effluent releases occurring. All water is being shipped off site for disposal. o Delete Section 8.2.1 on setpoint determination for the noble gas monitor, no longer required. o Modified Figure 9.2 to show current configuration of gaseous effluent pathway and monitoring. o Delete Section 10.1 Annual Meteorological Report Requirements o Changed outside tank limit location in 6th paragraph from Techs Specs to DSAR section 4. o Fixed typo in Section 10.3 where radioactive was misspelled. o Modified Section 10.4.2 to remove reference to reporting for noble gases and the abandonment of the primary vet gas and AOG treatment systems. o In Reference Section item B Change computer code for calculating dispersion coefficients to the NRC program XOQDOQ which formed the basis for the AEOLUS-2 computer code

7/1/21	41	o Deleted proprietary statement on the cover page. o Modified references to the Technical Specifications throughout the ODCM. The reference information is now contained in the Vermont Yankee Nuclear Power Station Quality Assurance Program Manual (QAPM). o Table 1.1.1, Note 2. Removed reference to Equation 6-21 and 6-23 as the equations related to noble gas releases which had been removed in the previous revision to the ODCM. o Deleted 3.3.2.a and 3.3.2.b from 3/4.4.1 action statement, the information was deleted in Rev. 40 of the ODCM. o Table 3.5.1, Removed the composite sampling requirement for the downstream river sample. Vermont Yankee is no longer discharging to the river continuously. This sample requirement has been changed to a monthly grab sample. o Table 3.5.1, Notation – Note f. was deleted, it was a reference to composite sampling. o Table 4.2.1, Deleted Service Water sampling, service water system has been abandoned. o 5.2.2, Service Water Pathway, section deleted because service water system has been abandoned. o 6.10.1, Added back in the remaining Atmospheric Dispersion Factor that had been inadvertently left out of the previous version of the ODCM. o 6.11.4, Modified the location description of the ISFSI Pad based upon current site configuration. o 9.3.1, typo correction – steam should be stream. o 10.1, typo correction – correct spelling of "functional". o Revised the entire document such that it is Revision (Rev) 41. o Corrected minor typographical errors such as references to formally deleted sections, tables or figures. o Deleted definition #16 from Table 2.1.1 "Ventilation Exhaust Treatment System." This is a legacy removal as the use of this definition and the corresponding equations were removed during Revision 40.
2/17/22	42	o Delete Appendices B, F, H, I, &J associated with NRC approvals for alternate disposal of materials on site. Also reference BVY 21-025 associated with this action. (LIC 21-07) o Deleted Appendices C, D, E & G as they are historical and no longer material to the facility (LIC 21-08) o Table 1.1.3, Deleted Equation 6-16 (Stack Effluent Pathway no longer exists). (LIC 21-02) o Deleted proprietary statement on the cover page. o Modified references to the Technical Specifications throughout the ODCM. The reference information is now contained in the Vermont Yankee Nuclear Power Station Quality Assurance Program Manual (QAPM).

		o Table 1.1.1, Note 2. Removed reference to Equation 6-21 and 6-23 as the equations related to noble gas releases which had been removed in a previous revision to the ODCM. o Deleted 3.3.2.a and 3.3.2/b from 3/4.4.1 action statement, the information was deleted in a Rev. 40 of the ODCM. o Table 3.5.1, Removed the composite sampling requirement for the downstream river sample. Vermont Yankee is no longer discharging to the river continuously. This sample requirement has been changed to a monthly grab sample. o Table 3.5.1, Notation – Note f. was deleted, it was a reference to composite sampling. o Table 4.2.1, Deleted Service water sampling, service water system has been abandoned. o 5.2.2, Service Water Pathway, section deleted because service water system has been abandoned. o 6.10.1, Added back in the remaining Atmospheric Dispersion Factor that had been in advertantly left out of a previous version of the ODCM. o 6.11.4., Modified the location description of the ISFSI Pad based upon current site configuration. o 9.3.1, typo correction - steam should be stream. o 10.1, typo correction – corrected spelling of “functional”.

ABSTRACT

The VYNPS ODCM (Vermont Yankee Nuclear Power Station Off-Site Dose Calculation Manual) contains the effluent and environmental control limits, and approved methods to estimate the maximum individual doses and radionuclide concentrations occurring at or beyond the boundaries of the plant due to normal plant operation. The effluent dose models are based on the U.S. NRC Regulatory Guide 1.109. Revision 1.

With initial approval by the U.S. Nuclear Regulatory Commission and the VYNPS Plant Management and approval of subsequent revisions by the manager responsible for overall operational activities (as per the VY Quality Assurance Program Manual) the methods contained in the ODCM are suitable to demonstrate compliance with effluent controls.

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1.0 INTRODUCTION

The ODCM (Off-Site Dose Calculation Manual) provides formal and approved methods for the calculation of off-site concentration, off-site doses, and effluent monitor setpoints in order to comply with the Vermont Yankee Control Limits which implement the program requirements of Quality Assurance Program Manual (QAPM), Appendix D, Section 2.5.B. The ODCM forms the basis for plant procedures and is designed for use by the procedure writer. In addition, the ODCM will be useful to the writer of periodic reports required by the NRC on the dose consequences of plant operation. The dose methods contained herein follow accepted NRC guidance for calculation of doses necessary to demonstrate compliance with the dose objectives of Appendix I to 10 CFR 50 (Regulatory Guide 1.109) unless otherwise noted in the text.

Demonstration of compliance with the dose limits of 40 CFR 190 (see Control 3.4.1) will be considered as demonstrating compliance with the 0.1 rem limit of 10 CFR 20.1301(a)(1) for members of the public in unrestricted areas (Reference 56 FR 23374, third column.)

It shall be the responsibility of the RP/Chemistry Manager to ensure that the ODCM is used in the performance of the surveillance requirements of the appropriate portions of ODCM Controls.

All changes to the ODCM must be reviewed by the Independent Safety Review and approved by the manager responsible for overall operational activities, in accordance with QAPM Appendix D, prior to implementation. All approved changes shall be submitted to the NRC for their information in the Radioactive Effluent Release Report for the period in which the change(s) was made effective. The plant's Document Control Center (DCC) shall maintain the current version of the ODCM and issue under controlled distribution all approved changes.

1.1 Summary of Methods, Dose Factors, Limits, Constants, and Radiological Effluent Control Cross-References

This section summarizes the dose calculation methods. The concentration and setpoint methods are also summarized in Table 1.1.2 through Table 1.1.4 and Table 1.1.6, as well as the Method I Dose equations. Where more accurate dose calculations are needed use the Method II for the appropriate dose as described in Sections 6.2, 6.3, 6.6, 6.9 and 6.11. The dose factors used in the equations are in Tables 1.1.11 and 1.1.12 and the Regulatory Limits are summarized in Table 1.1.1.

A cross-reference of old Technical Specification sections to the new ODCM sections containing the equivalent Controls is presented in Table 1.1.8.

Special definitions and equation variables used in the ODCM are in Tables 2.1.1 and 2.1.2.

TABLE 1.1.1
Summary of Radiological Effluent Controls and Implementing Equations

	Control	Category	Method [1]	Limit
3.2.1	Liquid Effluent Concentration	Sum of the Fractions of Effluent Concentration Limits [Excluding Noble Gases]	Eq. 5-1	≤10
3.2.2	Liquid Effluent Dose	Total Body Dose Organ Dose	Eq. 6-1 Eq. 6-3	≤1.5 mrem in a qtr. ≤3.0 mrem in a yr. ≤5 mrem in a qtr. ≤10 mrem in a yr.
3.2.3	Liquid Radwaste Treatment Operability	Total Body Dose Organ Dose	Eq. 6-1 Eq. 6-3	≤0.06 mrem in a mo. ≤0.2 mrem in a mo.
3.3.1	Gaseous Effluents Dose Rate	Organ Dose Rate from Tritium and Particulates with $T_{1/2}$>8 Days	Eq. 6-40	≤1500 mrem/yr.
3.3.3	Gaseous Effluents Dose from Tritium and Particulates	Organ Dose from Tritium and Particulates with T1/2 >8 Days	Eq. 6-44	≤ 7.5 mrem in a qtr. ≤15 mrem in a yr.
3.4.1	Total Dose (from All Sources)	Total Body Dose	Footnote (2)	≤25 mrem in a yr.
		Organ Dose	No Thyroid	≤25 mrem in a yr.

(1) More accurate methods may be available (see subsequent chapters).

(2) Effluent Control 3.4.1 requires this evaluation only if twice the limit of Equations 6-1 or 6-3, is reached. If this occurs a Method II calculation shall be made considering available information for pathways of exposure to real individuals from liquid, gaseous, and direct radiation sources.

TABLE 1.1.2

Summary of Methods to Calculate Unrestricted Area Liquid Concentrations

Equation Number	Category	Equation	Reference Section
5-1	Sum of the Fractions of Combined Effluent Concentrations in Liquids [Except Noble Gases]	$F_{l}^{ENG} = \sum_{i} \frac{Cpi}{ECL_{i}} \leq 10$	5.1

TABLE 1.1.3

Summary of Methods to Calculate Off-Site Doses from Liquid Concentrations

Equation Number	Category	Equation	Reference Section
6-1	Total Body Dose	$D_{tb}(\text{mrem}) = \sum_i Q_i \, DFL_{itb}$	6.2.1
6-3	Maximum Organ Dose	$D_{mo}(\text{mrem}) = \sum_i Q_i \, DFL_{imo}$	6.3.1

TABLE 1.1.4

Summary of Methods to Calculate
Dose Rates

Equation Number	Category	Equation	Reference Section
6-40	Critical Organ Dose Rate from Ground Level Release of Tritium and Particulates with $T_{1/2}$ >8 Days	$\dot{R}_{cog}\left(\frac{mrem}{yr}\right) = \sum_i \dot{Q}_i^{GLP} DFG'_{gico}$	6.6.1

TABLE 1.1.5

Summary of Methods to Calculate Doses to Air from Noble Gases

Deleted

TABLE 1.1.6

Summary of Methods to Calculate Dose to an Individual from Tritium, Iodine, and Particulates in Gas Releases and Direct Radiation

Equation Number	Category	Equation	Reference Section
6-44	Dose to Critical Organ from Ground Level Release of Tritium and Particulates	$D_{cog}(mrem) = \sum_i Q_i^{GLP} DFG_{gico}$	6.9.1
	Deleted		

TABLE 1.1.7

Summary of Methods for Setpoint Determinations

Deleted

TABLE 1.1.8

Effluent and Environmental Controls Cross-Reference

Control Topic	Original Technical Specification Section	Revised ODCM Control Section
INSTRUMENTATION		
Radioactive Liquid Effluent Instrumentation	3/4.9.A	3/4.1.1
Effluent instrumentation list	Table 3.9.1	Table 3.1.1
Instrument surveillance requirements	Table 4.9.1	Table 4.1.1
Radioactive Gaseous Effluent Instrumentation	3/4.9.B	3/4.1.2
Effluent instrumentation list	Table 3.9.2	Table 3.1.2
Instrumentation requirements	Table 4.9.2	Table 4.1.2
RADIOACTIVE LIQUID EFFLUENTS		
Concentration	3/4.8.A	3/4.2.1
Liquid waste sampling & analysis program	Table 4.8.1	Table 4.2.1
Dose – Liquids	3/4.8.B	3/4.2.2
Liquid Radwaste Treatment	3/4.8.C	3/4.2.3
RADIOACTIVE GASEOUS EFFLUENTS		
Dose Rate	3/4.8.E	3/4.3.1
Gaseous waste sampling & analysis program	Table 4.8.2	Table 4.3.1
Dose from Tritium and Radionuclides in Particulate Form	3/4.8.G	3/4.3.3
TOTAL DOSE		
Total Dose	3/4.8.M	3/4.4.1

TABLE 1.1.8 (Continued)

RADIOLOGICAL ENVIRONMENTAL MONITORING		
Radiological Environmental Monitoring Program	3/4.9.C	3/4.5.1
Listing of required monitoring criteria	Table 3.9.3	Table 3.5.1
Reporting levels for radioactivity in samples	Table 3.9.4	Table 3.5.2
Detector capability for environmental analysis	Table 4.9.3	Table 4.5.1
Land Use Census	3/4.9.D	3/4.5.2
Intercomparison Program	3/4.9.E	3/4.5.3
EFFLUENT CONTROL BASES	Bases: 3.8 & 3.9	3/4.6
UNIQUE REPORTING REQUIREMENTS		
Annual Radioactive Effluent Release Report	6.7.C.1	10.1
Environmental Radiological Monitoring	6.7.C.3	10.2
Special Reports	6.7.C.2	10.3
Major Changes to Radioactive Liquid, Gaseous, and Solid Waste Treatment Systems	6.14	10.4

TABLE 1.1.9

(Deleted)

TABLE 1.1.10
Dose Factors Specific for Vermont Yankee for Noble Gas Releases

Deleted

TABLE 1.1.10A

Combined Skin Dose Factors Specific for Vermont Yankee Ground Level Noble Gas Releases

Deleted

TABLE 1.1.11

Dose Factors Specific for Vermont Yankee for Liquid Releases

Radionuclide	Total Body Dose Factor $DFL_{itb}\left(\frac{mrem}{Ci}\right)$	Maximum Organ Dose Factor $DFL_{imo}\left(\frac{mrem}{Ci}\right)$
H-3	2.06E-04	2.06E-04
Mn-54	2.08E-01	3.00E+00
Fe-55	4.18E-02	2.54E-01
Co-60	2.13E-01	1.28E+00
Zn-65	8.06E+00	1.64E+01
Sr-90	4.23E+01	1.67E+02
Zr-95	4.21E-04	1.36E-01
Ag-110m	6.90E-03	7.02E-01
Sb-125	7.52E-03	1.15E-01
Cs-134	1.28E+02	1.60E+02
Cs-137	7.58E+01	1.21E+02

TABLE 1.1.12
Dose and Dose Rate Factors Specific for Vermont Yankee
for Tritium and Particulate Releases

			Ground(1)	
Nuclide			**Dose mrem/Ci**	**Dose Rate mrem/yr per µCi/sec**
H-3			6.90E-03	2.18E-01
C-14			7.29E+00	2.30E+02
Mn-54			3.25E+00	1.03E+02
Fe-55			3.37E+00	1.06E+02
Co-60			1.24E+01	3.92E+02
Ni-59			5.69E-01	1.79E+01
Ni-63			1.71E+02	5.39E+03
Zn-65			3.39E+01	1.07E+03
Sr-90			5.81E+03	1.83E+05
Tc-99			1.64E+01	5.19E+02
Sb-125			5.76E+00	1.82E+02
I-129			5.86E+03	1.85E+05
Cs-134			1.44E+02	4.55E+03
Cs-137			1.79E+01	5.64E+02
Sm-151			1.60E+00	5.05E+01
Eu-152			6.59E+00	2.08E+02
Eu-154			1.50E+01	4.74E+02
Eu-155			2.66E+01	8.40E+02
Pu-238			1.52E+04	4.79E+05
Pu-239			1.75E+04	5.52E+05
Pu-241			3.79E+02	1.19E+04
Am-241			1.79E+04	5.65E+05
Cm-242			6.77E+02	2.13E+04
Cm-243			1.21E+04	3.81E+05
Cm-244			9.33E+03	2.94E+05

NOTE 1 -Releases from the Reactor Building are considered ground releases.

These dose and dose rate factors apply to the maximum offsite X/Qs and D/Qs. Releases from the Reactor Building are ground releases. The dose and dose rate factors or for the maximum organ dose when the Vegetable, Meat, Cow Milk, and Inhalation pathways are summed.

2.0 DEFINITIONS

This section lists definitions (Table 2.1.1) and dose equation variable names (Table 2.1.2) which are utilized in the VY ODCM.

TABLE 2.1.1
Definitions

1. Deposition Coefficient - DOQ or D/Q (i.e., deposition factor); is the average relative deposition per unit area at a given point in a given sector of an effluent species (particulate or radioiodine) considering depletion of a plume during transport by dry deposition and radioactive decay (See RG 1.109 and RG 1.111), units are in 1/m2.

2. Dispersion Coefficient - XOQ or X/Q (i.e., dispersion factor); is the annual average effluent concentration (corrected as necessary for radioactive decay) at a specified distance and sector normalized by source strength (see RG 1.109 and RG 1.111), units are in sec/m3 .

3. Groundwater – For purposes of the ODCM, groundwater is defined as subsurface water which is either shallow, deep or in bedrock layers. Shallow and deep groundwater wells are sampled to determine the flow rate and contamination concentrations of groundwater flowing to the Connecticut River above or on the bedrock layer. Bedrock groundwater wells, utilized for drinking water purposes both on and off the plant site, are monitored for radioactive contamination as part of the REMP.

4. Immediate - Immediate means that the required action will be initiated as soon as practicable considering the safe operation of the unit and the importance of the required action.

5. Instrument Calibration - An instrument calibration means the adjustment of an instrument signal output so that it corresponds, within acceptable range and accuracy, to a known value(s) of the parameter which the instrument monitors. Calibration shall encompass the entire instrument including actuation, alarm, or trip. Response time as specified is not part of the routine instrument calibration but will be checked once per operating cycle.

6. Instrument Check - An instrument check is qualitative determination of acceptable operability by observation of instrument behavior during operation. This determination shall include, where possible, comparison of the instrument with other independent instruments measuring the same variable.

7. Instrument Functional Test - An instrument functional test shall be:

    a. Analog channels - the injection of a signal into the channel as close to the sensor as practicable to verify operability including alarm and/or trip functions.

    b. Bistable channels - the injection of a signal into the sensor to verify the functionality including alarm and/or trip functions.

TABLE 2.1.1 (Continued)

8. Intercepted Groundwater – For the purposes of the ODCM, intercepted groundwater is defined as groundwater which has infiltrated Turbine Building sumps or trenches which have no contact with water from plant systems and groundwater removed from the saturated zone soil adjacent to or underlying structures, equipment, excavations, etc. to reduce groundwater infiltration.

9. Liquid Waste Discharge – For the purposes of the ODCM, liquid waste discharges are plant process water treated with the liquid radwaste system and discharged through the liquid radwaste effluent outfall, using the installed flow monitor and pre-discharge grab sample results.

10. Off-Site Dose Calculation Manual (ODCM) – A manual containing the current methodology and parameters used in the calculation of off-site doses due to radioactive gaseous and liquid effluents, in the calculation of gaseous effluent monitoring alarm/trip setpoints, and in the conduction of the environmental radiological monitoring program. The ODCM shall also contain (1) the Radioactive Effluent Controls (including the Radiological Environmental Monitoring) Program required by QAPM Appendix D, Section 2.5.B and (2) descriptions of the information that should be included in the annual Radioactive Effluent Release Report and Annual Radiological Environmental Operating Report required by QAPM Appendix D, Section 2.4.A and 2.4.B, respectively.

11. Site Boundary – The site boundary is shown in Plant Drawing 5920-6245.

12. Source Check - The qualitative assessment of channel response when the channel sensor is exposed to a radioactive source.

13. Streamtube(s) – Defined as flows of subsurface groundwater (having discrete width, depth and flow rate characteristics) in either the shallow or deep layers of permeable soils above the bedrock layer at the plant site. Streamtube flows are from west to east, towards the Connecticut River, and are assumed to discharge into the Connecticut River.

14. Surveillance Frequency - Unless otherwise stated in these specifications, periodic surveillance tests, checks, calibrations, and examinations shall be performed within the specified surveillance intervals. These intervals may be adjusted plus 25%. The operating cycle interval is considered to be 18 months and the tolerance stated above is applicable.

15. Surveillance Interval - The surveillance interval is the calendar time between surveillance tests, checks, calibrations, and examinations to be performed upon an instrument or component when it is required to be functional. These tests unless otherwise stated in these specifications may be waived when the instrument,

TABLE 2.1.1 (Continued)

component, or system is not required to be functional, but these tests shall be performed on the instrument, component, or system prior to being required to be functional.

16. Deleted.

17. Vent/Purging – Vent/purging is the controlled process of discharging air or gas from the primary containment to control temperature, pressure, humidity, concentration or other operating conditions.

TABLE 2.1.2

Summary of Variables

Variable		Definition	Units
C_{di}	=	Concentration of radionuclide "i" at the point of liquid discharge to an unrestricted area.	$\frac{\mu Ci}{ml}$
C_i	=	Concentration of radionuclide "i."	$\frac{\mu Ci}{cc}$
C_{pi}	=	Concentration, exclusive of noble gases, of radionuclide "i" from tank "p" at point of discharge to an unrestricted area.	$\frac{\mu Ci}{ml}$
C_{mi}	=	Concentration of radionuclide "i" in mixture at the monitor.	$\frac{\mu Ci}{ml}$
D_{cog}	=	Dose to the critical organ from ground level release.	mrem
D_{mo}	=	Dose to the maximum organ.	mrem
D^S	=	Dose to skin from beta and gamma.	mrem
D_{tb}	=	Dose to the total body.	mrem
DF	=	Dilution factor.	ratio
DF_{min}	=	Minimum allowable dilution factor.	ratio
DFB_i	=	Total body gamma dose factor for nuclide "i."	$\frac{mrem - m^3}{pCi - yr}$
DFB_c	=	Composite total body dose factor.	$\frac{mrem - m^3}{pCi - yr}$
DFL_{itb}	=	Site-specific, total body dose factor for a liquid release of nuclide "i."	$\frac{mrem}{Ci}$
DFL_{imo}	=	Site-specific, maximum organ dose factor for a liquid release of nuclide "i."	$\frac{mrem}{Ci}$
DFG_{gico}	=	Site-specific, critical organ dose factor for a ground level gaseous release of nuclide "i."	$\frac{mrem}{Ci}$

TABLE 2.1.2 (Continued)

Variable		Definition	Units
DFG'_{gico}	=	Site-specific, critical organ dose rate factor for a ground level gaseous release of nuclide "i."	$\frac{mrem - sec}{\mu Ci - yr}$
$\dot{R}_{cog}$	=	Critical organ dose rate due to particulates released from ground.	$\frac{mrem}{yr}$
D/Q	=	Deposition factor for dry deposition of particulates.	$\frac{1}{m^2}$
F_d	=	Dilution Flow rate.	gpm
F_W	=	Waste Flow rate from liquid waste processing sample tank.	gpm
F_1^{ENG}	=	Sum of the fractions of combined effluent concentrations in liquid pathways (excluding noble gases).	fraction
ECL_i	=	Annual average effluent concentration limit for radionuclide "i" (10 CFR 20.1001-20.2401, Appendix B, Table 2, Column 2)	$\frac{\mu Ci}{cc}$
Q_i	=	Release for radionuclide "i" from the point of interest.	curies
$\dot{Q}_i$	=	Release rate for radionuclide "i" at the point of interest.	$\frac{\mu Ci}{sec}$
$\dot{Q}_i^{GLP}$	=	The tritium and particulate radionuclide "i" release rate from ground level.	$\frac{\mu Ci}{sec}$
Q_i^{GL}	=	The release of noble gas radionuclide "i" from ground level.	curies
Q_i^{GLP}	=	The release of tritium and particulate radionuclide "i" from ground level.	curies
X/Q_g		Annual or long-term average undepleted atmospheric dispersion factor for ground level release.	$\frac{sec}{m^3}$

3/4.0 EFFLUENT AND ENVIRONMENTAL CONTROLS

This section includes the effluent and environmental controls that were originally part of the Vermont Yankee Technical Specifications. These controls were relocated into the ODCM without any substantial changes, in accordance with NRC Generic Letter 89-01. Text and tables were reformatted to the style of the ODCM. The various controls were renumbered from the original numbering scheme of the Technical Specifications. A cross-reference of the old Technical Specifications section to the new ODCM section is presented in Table 1.1.8.

3/4.1 INSTRUMENTATION

3/4.1.1 Liquid Effluent Monitoring Instrumentation

Deleted.

TABLE 3.1.1

Liquid Effluent Monitoring Instrumentation

Deleted

TABLE 3.1.1 NOTATION

NOTE 1 - Deleted

NOTE 2 - Deleted

NOTE 3 - Deleted

NOTE 4 - Deleted

TABLE 4.1.1

Deleted

TABLE 4.1.1 NOTATION

Deleted

3/4.1 INSTRUMENTATION

3/4.1.2 Radioactive Gaseous Effluent Instrumentation

CONTROLS

3.1.2 The gaseous process and effluent monitoring instrumentation channels shall be functional in accordance with Control Table 3.1.2.

APPLICABILITY:

As shown in Table 3.1.2.

ACTION:

b. With less than the minimum number of radioactive gaseous effluent monitoring instrumentation channels functional, take actions noted in Table 3.1.2.

SURVEILLANCE REQUIREMENTS

4.1.2.a Each gaseous process or effluent monitoring instrumentation channel shall be tested and calibrated as indicated in Table 4.1.2.

TABLE 3.1.2

Gaseous Effluent Monitoring Instrumentation

Instrument	Minimum Channels Functional	Notes
3. Reactor Building Ventilation Exhaust		
a. Particulate Sampler Filter	1	4, 5
b. Sampler Flow Integrator	1	1, 5

TABLE 3.1.2 NOTATION

NOTE 1 - With the number of channels functional less than required by the minimum channels functional requirement, effluent releases via this pathway may continue provided the flow rate is estimated at least once per 4 hours.

NOTE 2 - Deleted

NOTE 3 - Deleted

NOTE 4 - With the number of channels functional less than required by the minimum channels functional requirement, effluent releases via the affected pathway may continue provided samples are continuously collected with auxiliary sampling equipment.

NOTE 5 - With the number of channels functional less than required by the minimum channels functional requirement, exert reasonable efforts to return the instrument(s) to functional status within 30 days.

NOTE 6 - Deleted

NOTE 7 - Deleted

NOTE 8 - Deleted

NOTE 9 - Deleted

NOTE 10 - Deleted

TABLE 4.1.2

Gaseous Effluent Monitoring Instrumentation Surveillance Requirements

Instrument	Instrument Check	Source Check	Instrument Calibration	Instrument Functional Test
3. Reactor Building Ventilation Exhaust				
a. Sampler Flow Integrator	Once each week	Not Applicable	Once each 18 months	Not Applicable

TABLE 4.1.2 NOTATION

(1) Deleted

(2) Deleted

(3) Deleted

(4) Deleted

3/4.2 RADIOACTIVE LIQUID EFFLUENTS

3/4.2.1 Liquid Effluent Concentration

CONTROLS

3.2.1 The concentration of radioactive material in liquid effluents released in liquid waste effluents, intercepted groundwater released via liquid waste effluent line, storm drain or groundwater flowing to the Connecticut River from the site in radioactive concentrations above background (Unrestricted Areas for liquids is at the point of discharge from the plant discharge in Connecticut River) shall be limited to 10 times the concentrations specified in Appendix B to 10 CFR Part 20.1001 – 20.2402, Table 2, Column 2.for radionuclides other than noble gases.

APPLICABILITY:

At all times.

ACTION:

With the concentration of radioactive material in liquid effluents released to Unrestricted Areas exceeding the limits of Control 3.2.1, immediately take action to decrease the release rate of radioactive materials and/or increase the dilution flow rate to restore the concentration to within the above limits.

SURVEILLANCE REQUIREMENTS

4.2.1.a Radioactive material in liquid waste, intercepted groundwater releases, and subsurface groundwater flows to the Connecticut River shall be sampled and analyzed in accordance with requirements of Table 4.2.1.

4.2.1.b The results of the analyses shall be used in accordance with the methods in the ODCM to assure that the concentrations at the point of release to Unrestricted Areas are limited to the values in Control 3.2.1.

TABLE 4.2.1

Radioactive Liquid Sampling and Analysis Program

Liquid Release Type	Sampling Frequency	Minimum Analysis Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (uCi/ml) [(a)]
Batch Waste Processing Sample Tanks [(b)(k)]	Prior to each release Each Batch	Prior to each release Each Batch	Principal Gamma Emitters [(d)]	5×10^{-7}
	Prior to each release Each Batch	Once per month Composite [(c)]	H-3	1×10^{-5}
			Gross Alpha	1×10^{-7}
	Prior to each release Each Batch	Once per quarter Composite [(c)]	Sr-90	5×10^{-8}
			Fe-55	1×10^{-6}
Groundwater Interception Release Tanks [(b)]	Prior to each release Each Batch	Prior to each release Each Batch	Principal Gamma Emitters [(d)] H-3	Activity Analysis LLDs [(e)]
	Prior to each release Each Batch	Once per month Composite [(c)]	H-3[(e)] Gross Alpha	Activity Analysis LLDs [(e)]
	Prior to each release Each Batch	Once per quarter Composite [(c)]	H-3[(e)] Gamma Emitters(e) Ni-63(e) Fe-55(e) Sr-90[(e)] Alpha Spec[(e)]	Activity Analysis LLDs [(e)]

Liquid Release Type	Sampling Frequency	Minimum Analysis Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (uCi/ml) [(a)]
Storm Drain	Weekly Grab	Weekly	H-3	Activity Analysis LLDs [(e)]
Subsurface Groundwater Flows to the Connecticut River[(f)]	Monitoring Wells – according to the Groundwater Monitoring Plan [(g)(i)] Sentinel Wells- according to the Groundwater Monitoring Plan [(h)(j)]	Monitoring Wells – Annual[(i)] Sentinel Wells – Annual[(j)]	H-3[(e)] Gamma Emitters[(e)] Ni-63[(e)] Fe-55[(e)] Sr-90[(e)] Alpha Spec[(e)]	Activity Analysis LLDs [(e)]

TABLE 4.2.1 NOTATION

a. The LLD is the smallest concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system (which may include radiochemical separation):

$$LLD = \frac{4.66 * S_b}{E * V * K * Y * e^{-\lambda * \Delta t}}$$

where:

LLD = the lower limit of detection as defined above (microcuries or picocuries/unit mass or volume)

S_b = the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (counts/minute)

E = the counting efficiency (counts/disintegration)

V = the sample size (units of mass or volume)

K = 2.22×10^6 disintegrations/minute/microcurie or 2.22 disintegration/minute/picocurie as applicable

Y = the fractional radiochemical yield (when applicable)

λ = the radioactive decay constant for the particular radionuclide (/minute)

Δt = the elapsed time between sample collection and analysis (minutes)

Typical values of E, V, Y and Δt can be used in the calculation. In calculating the LLD for a radionuclide determined by gamma-ray spectrometry, the background shall include the typical contributions of other radionuclides normally present in the samples.

Analysis shall be performed in such a manner that the stated LLDs will be achieved under routine conditions. Occasionally, background fluctuations, unavoidably small sample sizes, the presence of interfering nuclides, or other uncontrollable circumstances may render these LLDs unavailable.

It should be recognized that the LLD is defined as a "before the fact" limit representing the capability of a measurement system and not as an "after the fact" limit for a particular measurement. This does not preclude the calculation of an "after the fact" LLD for a particular measurement based upon the actual parameters for the sample in question and appropriate decay correction parameters such as decay while sampling and during analysis.

TABLE 4.2.1 NOTATION
(Cont'd)

b. A batch release is the discharge of liquid wastes of a discrete volume. Prior to sampling for analysis, each batch shall be isolated and then thoroughly mixed to assure representative sampling.

c. A composite sample is one in which the quantity of liquid sampled is proportional to the quantity of liquid waste discharged and in which the method of sampling employed results in a specimen which is representative of the liquids released. Prior to analyses, all samples taken for the composite shall be thoroughly mixed in order for the composite sample to be representative of the effluent release.

d. The principal gamma emitters for which the LLD specification will apply are exclusively the following radionuclides: Mn-54, Co-60, Zn-65, Cs-134, Cs-137 and Ce-144. This list does not mean that only these nuclides are to be detected and reported. Other peaks which are measurable and identifiable, together with the above nuclides, shall also be identified and reported. Nuclides which are below the LLD for the analyses should not be reported as being present at the LLD level, but as "not detected." When unusual circumstances result in LLDs higher than required, the reasons shall be documented in the Radioactive Effluent Release Report.

e. At a minimum, each subsurface groundwater sample shall be analyzed for the following analytes. Lower Limit of Detection for each analyte is as follows:

STANDARD RADIONUCLIDES	LLD (PCI/L)
^{3}H	2000
^{54}Mn	15
^{60}Co	15
^{65}Zn	30
^{95}Zr	30
^{134}Cs	15
^{137}Cs	18

TABLE 4.2.1 NOTATION
(Cont'd)

If tritium or plant-generated gamma activity is positively detected, then a sample should be further analyzed for the presence of the following Hard-To-Detect (HTD) radionuclides, as a minimum, using the associated LLD values:

HTD RADIONUCLIDES	LLD (PCI/L)
^{55}Fe	110
^{63}Ni	530
^{90}Sr	3.5
Alpha Emitters	15

f. ODCM Section 9.3 further defines the location and determination of flow through the plant site groundwater streamtubes.

g. Monitoring wells used to measure flow and concentration of contaminants in streamtubes: GZ-1s, GZ-3s, GZ-4s, GZ-5s, GZ-13s, GZ-13d, GZ-14s, GZ-14d, GZ-18s, GZ-18d, GZ-19s and GZ-19d.

h. Sentinel used to measure flow and concentration of contaminants in streamtubes: GZ-27s, GZ-26s, GZ-25s, GZ-23s and GZ-22d.

i. The Groundwater Monitoring Plan is used to determine sample frequency of Monitoring wells based on analysis trends and risk of SSCs being monitored.

j. The Groundwater Monitoring Plan is used to determine sample frequency of Sentinel wells. Sentinel wells with analysis results >LLD are sampled monthly and wells with analysis results < LLD are sampled according to the guidance in the procedure.

k. At least two independent samples are analyzed in accordance with Control 4.2.1, and at least two technically qualified members of the Facility Staff independently verify the release rate calculations and discharge line valve line-up.

3/4.2 RADIOACTIVE LIQUID EFFLUENTS

3/4.2.2 Dose - Liquids

CONTROLS

3.2.2 The dose or dose commitment to a member of the public from radioactive materials in liquid effluents released to Unrestricted Areas shall be limited to the following:

a. During any calendar quarter:

less than or equal to 1.5 mrem to the total body, and
less than or equal to 5 mrem to any organ, and

b. During any calendar year:

less than or equal to 3 mrem to the total body, and
less than or equal to 10 mrem to any organ.

APPLICABILITY:

At all times.

ACTION:

With the calculated dose from the release of radioactive materials in liquid effluents exceeding any of the above limits, prepare and submit to the Commission within 30 days, pursuant to ODCM Section 10, a Special Report that identifies the cause(s) for exceeding the limit(s) and defines the corrective actions that have been taken to reduce the releases and the proposed corrective actions to be taken to assure that subsequent releases will be in compliance with the above limits.

SURVEILLANCE REQUIREMENTS

4.2.2 Cumulative dose contributions shall be determined in accordance with the methods in the ODCM at least once per month if releases during the period have occurred.

3/4.2 RADIOACTIVE LIQUID EFFLUENTS

3/4.2.3 Liquid Radwaste Treatment

CONTROLS

3.2.3 The liquid radwaste treatment system shall be used in its designed modes of operation to reduce the radioactive materials in the liquid waste prior to its discharge when the projected doses due to the liquid effluents released to Unrestricted Areas, when averaged with all other liquid releases over the last month, would exceed 0.06 mrem to the total body, or 0.2 mrem to any organ.

APPLICABILITY:

At all times.

ACTION:

With radioactive liquid waste being discharged without treatment and in excess of the above limits and any portion of the Liquid Radwaste Treatment System not in operation, prepare and submit to the Commission within 30 days, a Special Report that includes the information detailed in ODCM Section 10.4.1.

SURVEILLANCE REQUIREMENTS

4.2.3.a See Control 4.2.2.

4.2.3.b The liquid radwaste treatment system schematic is shown in ODCM Figure 9.1.

3/4.3 RADIOACTIVE GASEOUS EFFLUENTS

3/4.3.1 Gaseous Effluents Dose Rate

CONTROLS

3.3.1 The dose rate due to radioactive materials released in gaseous effluents from the site to areas at and beyond the site boundary shall be limited to the following:

b. For tritium and radionuclides in particulate form with half-lives greater than 8 days; less than or equal to 1,500 mrem/yr to any organ.

APPLICABILITY:

At all times.

ACTION:

With the dose rate(s) exceeding the above limits, immediately take action to decrease the release rate to within the limits of Control 3.3.1.

SURVEILLANCE REQUIREMENTS

4.3.1.b The dose rate due to tritium and radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents shall be determined to be within the limits of Control 3.3.1 in accordance with the methods in the ODCM by obtaining representative samples and performing analyses in accordance with the sampling and analysis program specified in Table 4.3.1.

TABLE 4.3.1

Radioactive Gaseous Waste Sampling And Analysis Program

Gaseous Release Type	Sampling Frequency	Minimum Analysis Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (uCi/ml) [(a)]
Deleted				
C. Reactor Building Ventilation Exhaust	Continuous Sample	Once per month	H-3	1×10^{-6}
	Continuous [(e)]	Once per week [(b)] Particulate Sample	Principal Gamma Emitters [(d,g)]	1×10^{-11}
	Continuous [(e)]	Once per month Composite Particulate Sample	Gross Alpha	1×10^{-11}
	Continuous [(e)]	Once per quarter Composite Particulate Sample	Sr-90	1×10^{-11}

TABLE 4.3.1 NOTATION

a. See footnote a. of Table 4.2.1.

b. Samples shall be changed at least once per 7 days and analyses shall be completed within 48 hours after removal from samplers.

c. Deleted

d. The principal gamma emitters for which the LLD specification will apply are exclusively the following radionuclides: Mn-54, Co-60, Zn-65, Cs-134, Cs-137 and Ce-144 for particulate emissions. This list does not mean that only these nuclides are to be detected and reported. Other peaks which are measurable and identifiable, together with the above nuclides, shall also be identified and reported. Nuclides which are below LLD for the analyses should not be reported as being present at the LLD level for that nuclide, but as "not detected." When unusual circumstances result in LLDs higher than required, the reasons shall be documented in the Radioactive Effluent Release Report.

e. The ratio of the sample flow rate to the sampled stream flow rate shall be known for the time period covered by each dose or dose rate calculation made in accordance with Controls 3.3.1 and 3.3.3.

f. Deleted

g. Lower Limit of Detection (LLD) applies only to particulate form radionuclides identified in Table Notation d. above.

3/4.3 RADIOACTIVE GASEOUS EFFLUENTS

3/4.3.2 Deleted

CONTROLS

3.3.2 Deleted

APPLICABILITY:

Deleted

ACTION:

Deleted

SURVEILLANCE REQUIREMENTS

4.3.2 Deleted

3/4.3 RADIOACTIVE GASEOUS EFFLUENTS

3/4.3.3 Dose –Radioactive Material in Particulate Form and Tritium

CONTROLS

3.3.3 The dose to a member of the public from tritium and radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents released from the site to areas at and beyond the site boundary shall be limited to the following:

a. During any calendar quarter:

less than or equal to 7.5 mrem to any organ, and

b. During any calendar year:

less than or equal to 15 mrem to any organ.

APPLICABILITY:

At all times.

ACTION:

With the calculated dose from the release of tritium and radionuclides in particulate form with half-lives greater than 8 days, in gaseous effluents exceeding any of the above limits, prepare and submit to the Commission within 30 days, pursuant to ODCM Section 10.4.2, a Special Report that identifies the cause(s) for exceeding the limit(s) and defines the corrective actions that have been taken to reduce the releases and the proposed corrective actions to be taken to assure that subsequent releases will be in compliance with the above limits.

SURVEILLANCE REQUIREMENTS

4.3.3 Cumulative dose contributions for the total time period shall be determined in accordance with the methods in the ODCM at least once every month.

3/4.3 RADIOACTIVE GASEOUS EFFLUENTS

3/4.3.4 Deleted

3/4.3.5 Deleted

3/4.3.6 Deleted

3/4.3.7 Deleted

3/4.4 TOTAL DOSE

3/4.4.1 Total Dose (40 CFR 190)

CONTROLS

3.4.1 The dose or dose commitment to a member of the public* in areas at and beyond the Site Boundary from all station sources is limited to less than or equal to 25 mrem to the total body or any organ over a calendar year.

APPLICABILITY:

At all times.

ACTION:

With the calculated dose from the release of radioactive materials in liquid or gaseous effluents exceeding twice the limits of Controls 3.2.2.a, 3.2.2.b, 3.3.3.a, or 3.3.3.b, calculations should be made, including direct radiation contributions from the station to determine whether the above limits of Control 3.4.1 have been exceeded. If such is the case, prepare and submit to the Commission within 30 days a Special Report that includes the information detailed in ODCM Section 10.4.3.

SURVEILLANCE REQUIREMENTS

4.4.1.a Cumulative dose contributions from liquid and gaseous effluents shall be determined in accordance with Controls 4.2.2 and 4.3.3.

4.4.1.b Cumulative dose contributions from direct radiation from plant sources shall be determined in accordance with the methods in the ODCM. This requirement is applicable only under conditions set forth in Control 3.4.1 Action Statement.

* Note: For this Control, a member of the public may be taken as a real individual accounting for ones actual activities.

3/4.5 RADIOLOGICAL ENVIRONMENTAL MONITORING

3/4.5.1 Environmental Monitoring Program

CONTROLS

3.5.1 The radiological environmental monitoring program shall be conducted as specified in Table 3.5.1.

APPLICABILITY:

At all times.

ACTION:

a. With the radiological environmental monitoring program not being conducted as specified in Tables 3.5.1 or 4.5.1, prepare and submit to the Commission, in the Annual Radiological Environmental Monitoring Report (per ODCM Section 10.2), a description of the reasons for not conducting the program as required and the plans for preventing a recurrence.

b. With the level of radioactivity as the result of plant effluents in an environmental sampling media at one or more locations specified in Control Table 3.5.1 exceeding the reporting levels of Control Table 3.5.2, prepare and submit to the Commission a Special Report within 30 days from receipt of the laboratory analysis (per ODCM Section 10.4.4).

SURVEILLANCE REQUIREMENTS

4.5.1 The radiological environmental monitoring samples shall be collected pursuant to Table 3.5.1 from the locations given in the ODCM and shall be analyzed pursuant to the requirements of Table 3.5.1 and the detection capabilities required by Table 4.5.1.

TABLE 3.5.1

Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Number of Sample Locations [a]	Sampling and Collection Frequency	Type and Frequency of Analysis
1. AIRBORNE a. Particulates	Samples from 3 locations: 1 sample from up valley, within 4 miles (~6.4 km) of Site Boundary. (major wind direction) 1 sample from down valley, within 4 miles(~6.4 km) of Site Boundary. (major wind direction) 1 sample from a control location.	Continuous operation of sampler with sample collection monthly or more frequently as required by dust loading.	Particulate sampler: Gross beta radioactivity analysis on each sample following filter change. [c] Composite (by location) for gamma isotopic [d] at least once per quarter.

TABLE 3.5.1
(Cont'd)

Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Number of Sample Locations [(a)]	Sampling and Collection Frequency	Type and Frequency of Analysis
2. DIRECT RADIATION[(b)]	Routine monitoring stations as follows: 10 REMP stations (in representative meteorological sectors on land) located along the site boundary; Additional stations to be placed in special interest areas and control station areas.	Quarterly.	Gamma dose, at least once per quarter. Incident response TLDs de-dose only quarterly unless gaseous release Controls were exceeded in period.

TABLE 3.5.1
(Cont'd)

Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Number of Sample Locations [a]	Sampling and Collection Frequency	Type and Frequency of Analysis
3. WATERBORNE			
a. Surface [e]	1 sample upstream.	Monthly grab sample.	Gamma isotopic analysis [d] of each sample. Tritium analysis of composite sample at least once per quarter.
	1 sample downstream.	Monthly grab sample.	Gamma isotopic analysis [d] of each sample. Tritium analysis of composite sample at least once per quarter.
b. Ground (potable – drinking water from bedrock wells)	1 sample from within 8 km (5 miles) distance.	Quarterly.	Gamma isotopic[d] and tritium analyses of each sample.
	1 sample from a control location.	Quarterly.	Gamma isotopic[d] and tritium analyses of each sample.
c. Sediment from Shoreline	1 sample from downstream area with existing or potential recreational value.	Semiannually.	Gamma isotopic analysis [d] of each sample.
	1 sample from north storm drain outfall.	Semiannually.	Gamma isotopic analysis [d] of each sample.

TABLE 3.5.1
(Cont'd)

Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Number of Sample Locations [(a)]	Sampling and Collection Frequency	Type and Frequency of Analysis
4. INGESTION			
a. Deleted			
b. Fish	1 sample of two recreationally important species in vicinity of plant discharge area.	Semiannually.	Gamma isotopic analysis [(d)] on edible portions.
	1 sample (preferably of same species) in areas not influenced by plant discharge.	Semiannually.	Gamma isotopic analysis [(d)] on edible portions.
c. Vegetation	1 grass sample at each air sampling station.	Quarterly when available.	Gamma isotopic analysis [(d)] of each sample.
	1 silage sample at each former milk sampling station (as available).	Quarterly when available.	Gamma isotopic analysis [(d)] of each sample.

TABLE 3.5.1 NOTATION

a Specific parameters of distance and direction sector from the centerline of the reactor and additional descriptions where pertinent, shall be provided for each and every sample location in Table 3.5.1 in a table and figure(s) in the ODCM (Section 7). Deviations are permitted from the required sampling schedule if specimens are unobtainable due to hazardous conditions, seasonal unavailability, malfunction of automatic sampling equipment and other legitimate reasons. If specimens are unobtainable due to sampling equipment malfunction, every reasonable effort shall be made to complete corrective action prior to the end of the next sampling period. All deviations from the sampling schedule shall be documented in the Annual Radiological Environmental Operating Report pursuant to ODCM Section 10.2. It is recognized that, at times, it may not be possible or practicable to continue to obtain samples of the media of choice at the most desired location or time. In these instances, suitable alternative media and locations may be chosen for the particular pathway in question and appropriate substitutions made within 30 days in the radiological environmental monitoring program. In lieu of a Licensee Event Report and pursuant to ODCM Section 10.1, identify the cause of the unavailability of samples for that pathway and identify the new location(s) for obtaining replacement samples in the next Radioactive Effluent Release Report and also include in the report a revised figure(s) and table for the ODCM reflecting the new location(s).

b One or more instruments, such as a pressurized ion chamber, for measuring and recording dose rate continuously may be used in place of, or in addition to, integrating dosimeters. For the purposes of this table, a Thermoluminescent Dosimeter (TLD) is considered to be one phosphor; two or more phosphors in a packet are considered as two or more dosimeters. Film badges shall not be used as dosimeters for measuring direct radiation. The 10 stations is not an absolute number. The frequency of analysis or readout for TLD systems will depend upon the characteristics of the specific system used and should be selected to obtain optimum dose information with minimal fading.

c Airborne particulate sample filters shall be analyzed for gross beta radioactivity 24 hours or more after sampling to allow for radon and thorium daughter decay. If gross beta activity in air particulate samples is greater than ten times the yearly mean of control samples, gamma isotopic analysis shall be performed on the individual samples.

d Gamma isotopic analysis means the identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents from the facility.

e The "upstream sample" shall be taken at a distance beyond significant influence of the discharge. The "downstream" sample shall be taken in an area beyond but near the mixing zone.

f Deleted.

g Deleted.

h Deleted.

TABLE 3.5.2

Reporting Levels For Radioactivity Concentrations In Environmental Samples[a]
Reporting Levels

Analysis	Water (pCi/1)	Airborne Particulate or Gases (pCi/m3)	Fish (pCi/Kg, wet)	Vegetation (pCi/Kg, wet)	Sediment (pCi/Kg, dry)
H-3	2×10^{4}[b]				
Mn-54	1×10^{3}		3×10^{4}		
Co-60	3×10^{2}		1×10^{4}		3×10^{3}[c]
Zn-65	3×10^{2}		2×10^{4}		
Zr-95	4×10^{2}				
Cs-134	30	10	1×10^{3}	1×10^{3}	
Cs-137	50	20	2×10^{3}	2×10^{3}	

(a) Reporting levels may be averaged over a calendar quarter. When more than one of the radionuclides in Table 3.5.2 are detected in the sampling medium, the unique reporting requirements are not exercised if the following condition holds:

$$\frac{\text{concentration (1)}}{\text{reporting level (1)}} + \frac{\text{concentration (2)}}{\text{reporting level (2)}} + \ldots \quad < 1.0$$

When radionuclides other than those in Table 3.5.2 are detected and are the result of plant effluents, the potential annual dose to a member of the public must be less than or equal to the calendar year limits of Controls 3.2.2 and 3.3.1.

(b) Reporting level for drinking water pathways. For nondrinking water pathways, a value of 3×10^{4} pCi/l may be used.

(c) Reporting level for individual grab samples taken at North Storm Drain Outfall only.

(d) Deleted

TABLE 4.5.1

Detection Capabilities For Environmental Sample Analysis(a)(c)

Analysis(d)	Water (pCi/1)	Airborne Particulate or Gas (pCi/m3)	Fish (pCi/Kg, wet)	Vegetation (pCi/Kg, wet)	Sediment (pCi/Kg, dry)
Gross beta	4	0.01			
H-3	2000(h)				
Mn-54	15		130		
Co-60	15		130		
Zn-65	30		260		
Zr-95	15				
Cs-134	15	0.05	130	60	150
Cs-137	18	0.06	150	80	180

TABLE 4.5.1 NOTATION

(a) See Footnote (a) of Table 4.2.1.

(b) Deleted

(c) If the measured concentration minus the 5 sigma counting statistics is found to exceed the specified LLD, the sample does not have to be analyzed to meet the specified LLD.

(d) This list does not mean that only these nuclides are to be considered. Other peaks that are identifiable, together with those of the listed nuclides, shall also be analyzed and reported in the Annual Radiological Environmental Operating Report pursuant to QAPM, Appendix D, Section 2.4.B and ODCM Section 10.2.

(e) Deleted

(f) Deleted.

(g) Deleted

(h) If no drinking water pathway exists, then a value of 3000 picocuries per liter may be used.

3/4.5 RADIOLOGICAL ENVIRONMENTAL MONITORING

3/4.5.2 Land Use Census

CONTROLS

3.5.2 A land use census shall be conducted to identify the location of the nearest residence in each of the 16 meteorological sectors within a distance of five miles.

APPLICABILITY:

At all times.

ACTION:

a. With a land use census identifying one or more locations which yield a calculated dose or dose commitment (via the same exposure pathway) at least 20 percent greater than at a location from which samples are currently being obtained in accordance with Control 3.5.1, add the new location(s) to the radiological environmental monitoring program within 30 days if permission from the owner to collect samples can be obtained, and sufficient sample volume is available. The sampling location(s), excluding the control station location, having the lowest calculated dose or dose commitment (via the same exposure pathway) may be deleted from this monitoring program after October 31 of the year in which this land use census was conducted.

b. With the land census not being conducted as required above, prepare and submit to the Commission within 30 days a Special Report that includes information detailed in ODCM Section 10.4.5.

SURVEILLANCE REQUIREMENTS

4.5.2 The land use census shall be conducted at least once per year between the dates of June 1 and October 1 by either a door-to-door survey, aerial survey, or by consulting local agricultural authorities. The results of the land use census shall be included in the Annual Radiological Environmental Operating Report pursuant to QAPM, Appendix D, Section 2.4.B and ODCM Section 10.2.

3/4.5 RADIOLOGICAL ENVIRONMENTAL MONITORING

3/4.5.3 Interlaboratory Comparison Program

CONTROLS

3.5.3 Analyses shall be performed on referenced radioactive materials supplied as part of an Interlaboratory Program which has been approved by NRC.

APPLICABILITY:

At all times.

ACTION:

With analysis not being performed as required above, report the corrective actions taken to prevent a recurrence to the Commission in the Annual Radiological Environmental Operating Report pursuant to ODCM Section 10.2

SURVEILLANCE REQUIREMENTS

4.5.3 A summary of the results of analyses performed as part of the above required Interlaboratory Program shall be included in the Annual Radiological Environmental Operating Report. NRC-approved interlaboratory programs utilized by environmental laboratories in processing Vermont Yankee samples shall be identified in the ODCM.

3/4.6 EFFLUENT AND ENVIRONMENTAL CONTROL BASES

INSTRUMENTATION

Gaseous Effluent Instrumentation (3.1.2)

The radioactive gaseous effluent instrumentation is provided to monitor and control, as applicable, the releases of radioactive materials in gaseous effluents during actual or potential releases of gaseous effluents.

RADIOACTIVE EFFLUENTS

Liquid Effluents: Concentration (3.2.1)

This Control is provided to ensure that at any time the concentration of radioactive materials released in liquid waste effluents, intercepted groundwater released via liquid waste effluent line, storm drain or groundwater flowing to the Connecticut River from the site in radioactive contamination concentrations above background (Unrestricted Area for liquids is at the point of discharge from the plant discharge into Connecticut River) will not exceed 10 times the concentration levels specified in 10 CFR Part 20.1001-20.2402, Appendix B, Table 2, Column 2. These requirements provide operational flexibility, compatible with considerations of health and safety, which may temporarily result in releases higher than the absolute value of the concentration numbers in Appendix B, but still within the annual average limitation of the Regulation. Compliance with the design objective doses of Section II.A of Appendix I to 10 CFR Part 50 assure that doses are maintained ALARA, and that annual concentration limits of Appendix B to 10 CFR 20.1001-20.2402 will not be exceeded.

3/4.6 EFFLUENT AND ENVIRONMENTAL CONTROL BASES (cont.)

Liquid Effluents: Dose (3.2.2)

This Control is provided to implement the requirements of Sections II.A, III.A, and IV.A of Appendix I, 10 CFR Part 50. The Limiting Condition for Operation implements the guides set forth in Section II.A of Appendix I. The requirements provide operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in liquid effluents will be kept "as low as is reasonably achievable." The Surveillance Requirements implement the requirements in Section III.A of Appendix I, i.e., that conformance with the guides of Appendix I be shown by calculational procedures based on models and data such that the actual exposure of an individual through appropriate pathways is unlikely to be substantially underestimated. In addition, there is reasonable assurance that the operation of the facility will not result in radionuclide concentrations in potable drinking water that are in excess of the requirements of 40 CFR 141. No drinking water supplies drawn from the Connecticut River below the plant have been identified. The appropriate dose equations for implementation through requirements of the Specification are described in the Vermont Yankee Off-Site Dose Calculation Manual. The equations specified in the ODCM for calculating the doses due to the actual release rates of radioactive materials in liquid effluents were developed from the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I", Revision 1, October 1977 and Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I", Revision 1, April 1977.

3/4.6 EFFLUENT AND ENVIRONMENTAL CONTROL BASES (cont.)

Liquid Radwaste Treatment (3.2.3)

The requirement that the appropriate portions of this system as indicated in the ODCM be used, when specified, provides assurance that the releases of radioactive materials in liquid effluents will be kept "as low as is reasonably achievable." This specification implements the requirements of 10 CFR Part 50.36a and the design objective given in Section II.D of Appendix I to 10 CFR Part 50. The specified limits governing the use of appropriate portions of the liquid radwaste treatment system were specified as a suitable fraction of the dose design objectives set forth in Section II.A of Appendix I, 10 CFR Part 50, for liquid effluents.

Gaseous Effluents: Dose Rate (3.3.1)

The specified limits as determined by the methodology in the ODCM, restrict, at all times, the corresponding organ dose rate to <1500 mrem/yr to any organ. This instantaneous dose rate limit allows for operational flexibility when off normal occurrences may temporarily increase gaseous effluent release rates from the plant, while still providing controls to ensure that licensee meets the dose objectives of Appendix I to 10 CFR 50.

Gaseous Effluents: Dose from Noble Gases (3.3.2)

Deleted

3/4.6 EFFLUENT AND ENVIRONMENTAL CONTROL BASES (cont.)

Gaseous Effluents: Dose from Tritium and Radionuclides in Particulate Form (3.3.3)

This Control is provided to implement the requirements of Section II.C, III.A, and IV.A of Appendix I, 10 CFR Part 50. The Limiting Condition for Operation are the guides set forth in Section II.C of Appendix I. The requirements provide operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive materials in gaseous effluents will be kept "as low as is reasonably achievable." The Surveillance Requirements implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data such that the actual exposure of a member of the public through appropriate pathways is unlikely to be substantially underestimated. The equations specified in the ODCM for calculating the doses due to the actual release rates of the subject materials were also developed using the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977 and Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water Cooled Reactors," Revision 1, July 1977. These equations also provide for determining the actual doses based upon the historical average atmospheric conditions. The release rate specifications for tritium and radionuclides in particulate form with half-lives greater than 8 days are dependent on the existing radionuclide pathways to man, in areas at and beyond its site boundary. The pathways which were examined in the development of these specifications were: 1) individual inhalation of airborne radionuclides, 2) deposition of radionuclides onto green leafy vegetation with subsequent consumption by man, 3) deposition onto grassy areas where milk animals and meat producing animals graze with consumption of the milk and meat by man, and 4) deposition on the ground with subsequent exposure of man.

3/4.6 EFFLUENT AND ENVIRONMENTAL CONTROL BASES
(cont.)

Gaseous Radwaste Treatment (3.3.4) Deleted

Ventilation Exhaust Treatment (3.3.5) Deleted

Primary Containment (MARK I) (3.3.6) Deleted

Steam Jet Air Ejector (SJAE) (3.3.7) Deleted

Total Dose (40 CFR 190) (3.4.1)

This Control is provided to meet the dose limitations of 40 CFR Part 190 to Members of the Public in areas at and beyond the Site Boundary. The specification requires the preparation and submittal of a Specific Report whenever the calculated doses from plant radioactive effluents exceed twice the design objective doses of Appendix I. The Special Report will describe a course of action that should result in the limitation of the annual dose to a Member of the Public to within the 40 CFR Part 190 limits. For the purposes of the Special Report, it may be assumed that the dose commitment to the Member of the Public is estimated to exceed the requirements of 40 CFR Part 190, the Special Report with a request for a variance (provided the release conditions resulting in violation of 40 CFR Part 190 have not already been corrected), in accordance with the provisions of 40 CFR Part 190.11 and 10 CFR Part 20.2203(a)(4), is considered to be a timely request and fulfills the requirements of 40 CFR Part 190 until NRC staff action is completed. The variance only relates to the limits of 40 CFR Part 190, and does not apply in any way to the other requirements for dose limitation of 10 CFR Part 20. An individual is not considered a Member of the Public during any period in which he/she is engaged in carrying out any operation that subjects them to occupational exposures. For individuals in controlled areas who are considered Members of the Public per 10 CFR 20, the dose limits of 10 CFR 20.1301 apply since the licensee has the authority to control and limit access to these areas.

3/4.6 EFFLUENT AND ENVIRONMENTAL CONTROL BASES (cont.)

Radiological Environmental Monitoring Program (3.5.1)

The radiological monitoring program required by this Control provides measurements of radiation and of radioactive materials in those exposure pathways and for those radionuclides which lead to the highest potential radiation exposures of member(s) of the public resulting from the station operation. This monitoring program implements Section IV.B.2 of Appendix I to 10 CFR Part 50 and thereby supplements the radiological effluent monitoring program by verifying that the measurable concentrations of radioactive materials and levels of radiation are not higher than expected on the basis of the effluent measurements and modeling of the environmental exposure pathways.

Ten years of plant operation, including the years prior to the implementation of the Augmented Off-Gas System, have amply demonstrated via routine effluent and environmental reports that plant effluent measurements and modeling of environmental pathways are adequately conservative. In all cases, environmental sample results have been two to three orders of magnitude less than expected by the model employed, thereby representing small percentages of the ALARA and environmental reporting levels. This radiological environmental monitoring program has therefore been modified as provided for by Regulatory Guide 4.1 (C.2.b), Revision 1, April 1975. Evaluation of plant gaseous effluents, meteorological conditions and potential accident scenaria have concluded that milk sampling is no longer required and silage and grass sampling have been instituted as an indicator of radionuclide deposition. Because of this change, the frequency of silage collection has been increased from annual to quarterly.

The detection capabilities required by Table 4.5.1 are considered optimum for routine environmental measurements in industrial laboratories. It should be recognized that the LLD is defined as a before-the-fact limit representing the capability of a measurement system and not as an after-the-fact limit for a particular measurement. This does not preclude the calculation of an after-the-fact LLD for a particular measurement based upon the actual parameters for the sample in question.

3/4.6 EFFLUENT AND ENVIRONMENTAL CONTROL BASES (cont.)

Land Use Census (3.5.2)

This Control is provided to ensure that changes in the use of areas at and beyond the site boundaries are identified and that modifications to the monitoring program are made if required by the results of this census. This census satisfies the requirements of Section IV.B.3 of Appendix I to 10 CFR Part 50. The requirement of a garden census has been eliminated along with the food product monitoring requirement due to the substantial and widespread occurrence of dairy farming in the surrounding area which dominates the food uptake pathway.

The addition of new sampling locations to Control 3.5.1, based on the land use census, is limited to those locations which yield a calculated dose or dose commitment greater than 20 percent of the calculated dose or dose commitment at any location currently being sampled. This eliminates the unnecessary changing of the environmental radiation monitoring program for new locations which, within the accuracy of the calculation, contributes essentially the same to the dose or dose commitment as the location already sampled. The substitution of a new sampling point for one already sampled when the calculated difference in dose is less than 20 percent, would not be expected to result in a significant increase in the ability to detect plant effluent related nuclides. Due to the decay of I-131 and limited source terms available after permanent shutdown, milk sampling was discontinued, but sampling of vegetation and air sampling have remained in place.

Interlaboratory Comparison Program (3.5.3)

The requirement for participation in an intercomparison program is provided to ensure that independent checks on the precision and accuracy of the measurements of radioactive material in environmental sample matrices are performed as part of a quality assurance program for environmental monitoring in order to demonstrate that the results are reasonably valid for the purposes of Section IV.B.2 of Appendix I to 10 CFR Part 50.

Deleted

5.0 METHOD TO CALCULATE OFF-SITE LIQUID CONCENTRATIONS

Chapter 5 contains the basis for plant procedures that the plant operator requires to meet ODCM Control 3.2.1 which limits the total fraction of combined effluent concentration in liquid pathways, excluding noble gases, denoted here as, F_1^{ENG} at the point of discharge at any time (see Figure 9-1). F_1^{ENG} is limited to less than or equal to ten, i.e.,

$$F_1^{ENG} \leq 10$$

Evaluation of F_1^{ENG} and C_1^{NG} is required concurrent with the sampling and analysis program in Control Table 4.2.1.

5.1 Method to Determine F_1^{ENG}

Determine the total fraction of combined effluent concentrations at the point of discharge in liquid pathways (excluding noble gases), denoted F_1^{ENG}, as follows:

$$F_1^{ENG} = \sum_i \frac{C_{pi}}{ECL_i} \leq 10 \qquad (5\text{-}1)$$

$$\left(\frac{\mu Ci/ml}{\mu Ci/ml}\right)$$

where:

F_1^{ENG} = Total sum of the fractions of each radionuclide concentration in liquid effluents (excluding noble gases) at the point of discharge to an unrestricted area, divided by each radionuclide's ECL value.

C_{pi} = Concentration at point of discharge to an unrestricted area of radionuclide "i", except for dissolved and entrained noble gases, from any tank or other significant source, p, from which a discharge may be made (including the liquid waste sample tank, groundwater interception release tanks and any other significant source from which a discharge can be made) (μCi/ml). This concentration can be calculated from: $C_{pi} = C_{TK1} \times F_{TK}/[F_{DIL} + F_{TK}]$ where: C_{TK1} equals the concentration of radionuclide i in the tank to be discharged (μCi/ml); F_{DIL} is equal to the dilution flow provided by the waste dilution pumps, if used; F_{TK} equals the liquid waste discharge pump flow rate which regulates the rate at which liquid from a waste collection tank is discharged (gpm).

ECL_i = Annual average effluent concentration limits of radionuclide "i", except for dissolved and entrained noble gases, from 10 CFR 20.1001-20.2402, Appendix B, Table 2, Column 2 (μCi/ml).

5.2 Method to Determine Radionuclide Concentration for Each Liquid Effluent Pathway

5.2.1 Sample Tanks Pathways

C_{pi} is determined for each radionuclide above LLD from the activity in a representative grab sample of any of the sample tanks and the predicted flow at the point of discharge to an unrestricted area.

Most periodic batch releases are made from the waste sample tank. This tank serves to hold all the liquid wastes after they have been processed by ion exchange. Other periodic batch releases may also come from the intercepted groundwater tank. A batch release tank can be any collection device (e.g. bladder, pillow tank, etc.) that meets the discharge requirements of Table 4.2.1 Notation b.

The liquid waste sample tank is sampled and the contents analyzed for water quality and radioactivity. If the sample meets all the requirements, the contents of the tank may be re-used in the spent fuel pool or torus. If the sample does not meet all the requirements, the contents are recycled through the radwaste system or discharged. The groundwater intercept tank is sampled from the tank recirculation system, and the contents analyzed for water quality and radioactivity. If the sample meets the requirements for discharge, it may be discharged to the storm drain system.

Prior to discharge each sample tank is analyzed for tritium and dissolved and suspended gamma emitters.

5.2.2 Deleted

5.2.3 Deleted

5.2.4 Intercepted Groundwater Concentrations in Flowpaths to the Connecticut River

In order to minimize radioactive liquid waste, groundwater intruding into basement structures is intercepted from sub-slab groundwater wells. This water is environmentally derived and captured under basements to prevent additional cross contamination from plant systems and structures. The intercepted ground water is tanked, sampled and released via the liquid waste effluent line or to the storm system with outfalls to the Connecticut River. The Intercepted Groundwater Collection and Release System is isolated from all other plant systems containing liquids in order to prevent cross contamination and contains water collected from the plant environs, therefore continuous release monitoring is not required . Intercepted groundwater tanks are sampled and released as described in 5.2.1 Sample Tank Pathway.

5.2.5 Subsurface Contaminated Groundwater Concentrations in Flowpaths to the Connecticut River

The overall direction of groundwater flow at Vermont Yankee (VY) is towards the Connecticut River (west to east). Based on this understanding of site hydrogeologic conditions, the groundwater discharge rates from the developed portion of the site to the river are estimated using a streamtube approach based on Darcy's Law (see Section 9).

To estimate the groundwater concentration in each of the designated streamtubes, samples will be collected and analyzed according to requirements specified in Section 3 /4, Table 4.2.1. The concentrations shall then be determined using methods provided in Section 5.1.

6.0 OFF-SITE DOSE CALCULATION METHODS

Chapter 6 provides the basis for plant procedures required to meet the 10 CFR 50, Appendix I, ALARA dose objectives, and the 40 CFR 190 total dose limits to members of the public in unrestricted areas, as stated in the Radiological Effluent Controls (implementing the requirements of QAPM Appendix D, Section 2.5.B). A simple, conservative method (called Method I) is listed in Tables 1.1.2 to 1.1.4 and Table 1.1.6 for each of the Control requirements. Each of the Method I equations is presented, along with their bases in Sections 6.2, 6.3, 6.6, 6.9 and Section 6.11. In addition, reference is provided to more sophisticated but still conservative methods (called Method II) for use when more accurate results are needed. This chapter provides the methods, data, and reference material with which the operator can calculate the needed doses and dose rates. Setpoint methods for effluent monitor alarms are described in Chapter 8.

Demonstration of compliance with the dose limits of 40 CFR 190 is considered to be a demonstration of compliance with the 0.1 rem limit of 10 CFR 20.1301(a)(1) for members of the public in unrestricted areas (Reference 56 FR 23374, 3rd column).

6.1 Introductory Concepts

The Radiological Effluent Controls Program (QAPM Appendix D, Section 2.5.B) either limit dose or dose rate. The term "Dose" for ingested or inhaled radioactivity means the dose commitment, measured in mrem, which results from the exposure to radioactive materials that, because of uptake and deposition in the body, will continue to expose the body to radiation for some period of time after the source of radioactivity is stopped. The time frame over which the dose commitment is evaluated is 50 years. The phrases "annual Dose" or "Dose in one year" then refers to the fifty-year dose commitment from one year's worth of releases. "Dose in a quarter" similarly means a fifty-year dose commitment from one quarter's releases. The term "Dose," with respect to external exposures, refers only to the doses received during the actual time period of exposure to the radioactivity released from the plant. Once the source of the radioactivity is removed, there is no longer any additional accumulation to the dose commitment.

Gaseous effluents from the plant are also controlled such that the maximum "dose rates" at the site boundary <u>at any time</u> are limited to 1500 mrem/year to any organ from tritium and radionuclides in particulate form. This instantaneous dose rate limit allows for operational flexibility when off normal occurrences may temporarily increase gaseous effluent release rates from the plant, while still providing controls to ensure that licensees meet the dose objectives of Appendix I to 10 CFR 50.

The quantities D and $\dot{R}$ are introduced to provide calculable quantities, related to off-site dose, or dose rate which demonstrates compliance with the effluent controls.

The dose D is the quantity calculated by the Chapter 6 dose equations. The D calculated by "Method I" equations is not necessarily the actual dose received by a real individual but usually provides an upper bound for a given release because of the conservative margin built into the dose factors and the selection and definition of critical receptors. The radioisotope specific dose factors in each "Method I" dose equation represent the greatest dose to any organ of any age group accounting for existing or potential pathways of exposure. The critical receptor assumed by "Method I" equations is typically a hypothetical individual whose behavior - in terms of location and intake - results in a dose which is expected to be higher than any real individual. The Method I equations employ five-year historical average atmospheric dispersion factors to define receptors of maximum impact. Method II allows for a more exact dose calculation for real individuals, if necessary, by considering only existing pathways of exposure, or actual concurrent meteorology with the recorded release (e.g., wind direction from on-site wind sock, representative off-site wind direction, or meteorology source, etc.).

$\dot{R}$ is the quantity calculated in the Chapter 6 dose rate equations. It is calculated using the plant's effluent monitoring system reading and an annual average or long-term atmospheric dispersion factor. Dispersion factors based on actual concurrent meteorology during effluent releases can also be used via Method II, if necessary, to demonstrate compliance with off-site dose rate limits.

Each of the methods to calculate dose or dose rate are presented in separate sections of Chapter 6, and are summarized in Tables 1.1.1 to 1.1.4 and Table 1.1.6. Each method has two levels of complexity and are called Method I and Method II. Method I is the simplest; generally a linear equation. Method II is a more detailed analysis which allows for use of site-specific factors and variable parameters to be selected to best fit the actual release conditions, within the bounds of the guidance provided.

The plant has a ground level gaseous release point from the Reactor Building. The elevated release point (i.e. Stack) has been demolished. Therefore, total dose calculations for whole body, and the critical organ from gaseous releases will be from ground level doses only.

6.2 Method to Calculate the Total Body Dose from Liquid Releases

Effluent Control 3.2.2 limits the total body dose commitment to a Member of the Public from radioactive material in liquid effluents to 1.5 mrem per quarter and 3 mrem per year. Control 3.2.3 requires liquid radwaste treatment when the total body dose estimate exceeds 0.06 mrem in any month. Control 3.4.1 limits the total body dose commitment to any real member of the public from all station sources (including liquids) to 25 mrem in a year. Dose evaluation is required at least once per month. If the liquid radwaste treatment system is not being used, dose evaluation is required before each release.

Use Method I first to calculate the maximum total body dose from a liquid release to the Connecticut River as it is simpler to execute and more conservative than Method II.

Use Method II if a more accurate calculation of total body dose is needed (i.e., Method I indicates the dose is greater than the limit), or if Method I cannot be applied.

If the radwaste system is not operating, the total body dose must be estimated prior to a release (Control 3.2.3). To evaluate the total body dose, use Equation 6.1 to estimate the dose from the planned release and add this to the total body dose accumulated from prior releases during the month.

To assess the dose contribution from subsurface groundwater contaminated with plant-generated radionuclides, a dose evaluation shall be performed using Method I on a monthly basis. Radionuclide concentration averages and groundwater streamtube average flow rates shall be utilized to estimate the total plant-generated radioactive contaminants released for the previous monthly period.

6.2.1 Method I

The increment in total body dose from a liquid release is:

$$D_{tb} = FC \sum_{i} Q_i \, DFL_{itb} \qquad (6\text{-}1)$$

$$(\text{mrem}) \quad (\text{Ci}) \left(\frac{\text{mrem}}{\text{Ci}}\right)$$

where:

FC = Flow Correction calculated by dividing the flow at the unrestricted area release point in gpm divided 20,000 gpm or release flow in ft^3/sec divided by 44.6 ft^3/sec.

DFL_{itb} = Site-specific total body dose factor (mrem/Ci) for a liquid release. See Table 1.1.11.

Q_i = Total activity (Ci) released for radionuclide "i." (For strontiums and Fe 55, use the most recent measurement available.)

Equation 6-1 can be applied under the following conditions (otherwise, justify Method I or consider Method II):

1. Normal operations (not emergency event),

2. Liquid releases were to the Connecticut River, and

3. Any continuous or batch release over any time period.

6.2.2 Basis for Method I

This section serves three purposes: (1) to document that Method I complies with appropriate NRC regulations, (2) to provide background and training information to Method I users, and (3) to provide an introductory user's guide to Method II.

Method I may be used to show that the effluent Controls which limit off-site total body dose from liquids (3.2.2 and 3.2.3) have been met for releases over the appropriate periods. Control 3.2.2 is based on the ALARA design objectives in 10 CFR 50, Appendix I Subsection II A. Control 3.2.3 is an "appropriate fraction," determined by the NRC, of that design objective (hereafter called the Objective). Control 3.4.1 is based on Environmental Standards for Uranium Fuel Cycle in 40 CFR 190 (hereafter called the Standard) which applies to direct radiation as well as liquid and gaseous effluents.

Exceeding the Objective or the Standard does not immediately limit plant operation but requires a report to the NRC within 30 days. In addition, a waiver may be required.

Method I was developed such that "the actual exposure of an individual ... is unlikely to be substantially underestimated" (10 CFR 50, Appendix I). The definition, below, of a single "critical receptor" (a hypothetical individual whose behavior results in an unrealistically high dose) provides part of the conservative margin to the calculation of total body dose in Method I. Method II allows that actual individuals, with real behaviors, be taken into account for any given release. In fact, Method I was based on a Method II analysis for the critical receptor with maximum exposure conditions instead of any real individual. That analysis was called the "base case;" it was then reduced to form Method I.

The steps performed in the Method I derivation follow. First, in the base case, the dose impact to the critical receptor (in the form of dose factors DFL_{itb}, mrem/Ci) for a 1 curie release of each radioisotope in liquid effluents was derived. The base case analysis uses the methods, data and assumptions in Regulatory Guide 1.109 (Equations A-2, A-3, A-7, A-13 and A-16, Reference A). The liquid pathways identified as contributing to an individual's dose are the consumption of fish from the Connecticut River, the ingestion of vegetables and leafy vegetation which were irrigated by river water, the consumption of milk and meat from cows and beef cattle who had river water available for drinking as well as having feed grown on irrigated land, and the direct exposure from the ground plane associated with activity deposited by the water pathway. A plant discharge flow rate of 44.6 ft^3/sec was used with a mixing ratio of 0.0356 which corresponds to a minimum regulated river flow of 1250 cfs at the Vernon Dam just below the plant discharge outfall.* Tables 6.2.1 and 6.2.2 outline human consumption and environmental parameters used in the analysis. The resulting, site-specific, total body dose factors appear in Table 1.1.11.

For any liquid release, during any period, the increment in annual average total body dose from radionuclide "i" is:

$$\Delta D_{tb} = FC\, Q_i\, DFL_{itb} \qquad (6\text{-}2)$$

$$(\text{mrem})\ (\text{Ci}) \left(\frac{\text{mrem}}{\text{Ci}}\right)$$

where:

FC = Flow Correction calculated by dividing the flow at the unrestricted area release point in gpm divided 20,000 gpm or release flow in ft^3/sec divided by 44.6 ft^3/sec

DFL_{itb} = Site-specific total body dose factor (mrem/Ci) for a liquid release. See Table 1.1.11.

Q_i = Total activity (Ci) released from radionuclide "i."

* An Mp equal to 1.0 for the fish pathway is assumed between the discharge structure and the dam.

Method I is conservative because it is based on dose factors DFL_{itb} which were chosen from the base case to be the highest of the four age groups for each radionuclide, as well as assuming minimum river dilution flow.

6.2.3 Method II

If Method I cannot be applied, or if the Method I dose exceeds the limit or if a more exact calculation is required, then Method II should be applied. Method II consists of the models, input data and assumptions in Regulatory Guide 1.109, Rev. 1 (Reference A), except where site-specific models, data or assumptions are more applicable, such as the use of actual river flow at the time of actual discharge as opposed to the minimum river flow of 1,250 cfs that is assumed in the Method I dose factors (except for the fish pathway). The base case analysis, documented above, is a good example of the use of Method II. It is an acceptable starting point for a Method II analysis.

TABLE 6.2.1

Environmental Parameters for Liquid Effluents at Vermont Yankee
(Derived from Reference A)

VARIABLE			POTABLE WATER	AQUATIC FOOD	SHORELINE ACTIVITY	FOOD GROWN WITH CONTAMINATED WATER: VEGETABLES	LEAFY VEG.	MEAT	COW MILK
MP	Mixing Ratio		-	1.0	0.0356	0.0356	0.0356	0.0356	0.0356
TP	Transit Time	(HRS)	-	24.0	0.000	0.0000	0.0000	480.0	48.0
YV	Agricultural Productivity	(KG/M^2)				2.0	2.0	2.0	2.0
P	Soil Surface Density	(KG/M^2)				240.0	240.0	240.0	240.0
IRR	Irrigation Rate	($L/M^2/HR$)				0.152	0.152	0.152	0.152
TE	Crop Exposure Time	(HRS)				1440.0	1440.0	1440.0	1440.0
TH	Holdup Time	(HRS)				1440.0	24.0	2160.0	2160.0
QAW	Water Uptake Rate for Animal	(L/D)						50.0	60.0
QF	Feed Uptake Rate for Animal	(KG/D)						50.0	50.0
FI	Fraction of Year Crops Irrigated					0.5	0.5	0.5	0.5
	Location of Critical Receptor		Connecticut River Below Vernon Dam						

TABLE 6.2.2

Usage Factors for Various Liquid Pathways at Vermont Yankee
(From Reference A, Table E-5. Zero Where No Pathway Exists)

AGE	VEG.	LEAFY VEG.	MILK	MEAT	FISH	INVERT.	POTABLE WATER	SHORELINE
	(KG/YR)	(KG/YR)	(LITER/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(LITER/YR)	(HR/YR)
Adult	520.00	64.00	310.00	110.00	21.00	0.00	0.00	12.00
Teen	630.00	42.00	400.00	65.00	16.00	0.00	0.00	67.00
Child	520.00	26.00	330.00	41.00	6.90	0.00	0.00	14.00
Infant	0.00	0.00	330.00	0.00	0.00	0.00	0.00	0.00

6.3 Method to Calculate Maximum Organ Dose from Liquid Releases

Effluent Control 3.2.2 limits the maximum organ dose commitment to a Member of the Public from radioactive material in liquid effluents to 5 mrem per quarter and 10 mrem per year. Control 3.2.3 requires liquid radwaste treatment when the maximum organ dose estimate exceeds 0.2 mrem in any month. Control 3.4.1 limits the maximum organ dose commitment to any real member of the public from all station sources (including liquids) to 25 mrem in a year. Dose evaluation is required at least once per month if releases have occurred. If the liquid radwaste treatment system is not being used, dose evaluation is required before each release.

Use Method I first to calculate the maximum organ dose from a liquid release to the Connecticut River as it is simpler to execute and more conservative than Method II.

Use Method II if a more accurate calculation of organ dose is needed (i.e., Method I indicates the dose is greater than the limit), or if Method I cannot be applied.

If the radwaste system is not operating, the maximum organ dose must be estimated prior to a release (Control 3.2.3). To evaluate the maximum organ dose, use Equation 6-3 to estimate the dose from the planned release and add this to the maximum organ dose accumulated from prior releases during the month.

To assess the dose contribution from subsurface groundwater contaminated with plant-generated radionuclides, a dose evaluation shall be performed using Method I on a monthly basis. Radionuclide concentration averages and groundwater streamtube average flow rates shall be utilized to estimate the total plant-generated radioactive contaminants released for the monthly period.

6.3.1 Method I

The increment in maximum organ dose from a liquid release is:

$$D_{mo} = \sum_i FC \; Q_i \; DFL_{imo} \qquad (6\text{-}3)$$

$$(\text{mrem}) = (\text{Ci}) \left(\frac{\text{mrem}}{\text{Ci}}\right)(FC)$$

where:

FC = Flow Correction calculated by dividing the flow at the unrestricted area release point in gpm divided 20,000 gpm or release flow in ft^3/sec divided by 44.6 ft^3/sec.

DFL_{imo} = Site-specific maximum organ dose factor (mrem/Ci) for a liquid release. See Table 1.1.11.

Q_i = Total activity (Ci) released for radionuclide "i." (For strontiums and Fe-55, use the most recent measurement available.)

Equation 6-3 can be applied under the following conditions (otherwise, justify Method I or consider Method II):

1. Normal operations (not emergency event),
2. Liquid releases were to the Connecticut River, and
3. Any continuous or batch release over any time period.

6.3.2 Basis for Method I

This section serves three purposes: (1) to document that Method I complies with appropriate NRC regulations, (2) to provide background and training information to Method I users, and (3) to provide an introductory user's guide to Method II. The methods to calculate maximum organ dose parallel the total body dose methods (see Section 6.2.2). Only the differences are presented here.

For each radionuclide, a dose factor (mrem/Ci) was determined for each of seven organs and four age groups. The largest of these was chosen to be the maximum organ dose factor (DFL_{imo}) for that radionuclide.

For any liquid release, during any period, the increment in annual average dose from radionuclide "i" to the maximum organ is:

(6-4)

$$\Delta D_{mo} = FC \; Q_i \, DFL_{imo}$$

$$\text{(mrem)} \quad \text{(Ci)} \left(\frac{\text{mrem}}{\text{Ci}}\right)(FC)$$

where:

FC = Flow Correction calculated by dividing the flow at the unrestricted area release point in gpm divided 20,000 gpm or release flow in ft^3/sec divided by 44.6 ft^3/sec

DFL_{imo} = Site-specific maximum organ dose factor (mrem/Ci) for a liquid release. See Table 1.1.11.

Q_i = Total activity (Ci) released for radionuclide "i".

Because of the assumptions about receptors, environment, and radionuclides; and because of the low Objective and Standard, the lack of immediate restriction on plant operation, and the adherence to 10 CFR 20 concentrations (which limit public health consequences) a failure of Method I (i.e., the exposure of a real individual being underestimated) is improbable and the consequences of a failure are minimal.

6.3.3 Method II

If Method I cannot be applied, or if the Method I dose exceeds the limit or if a more exact calculation is required, then Method II should be applied. Method II consists of the models, input data and assumptions in Regulatory Guide 1.109, Rev. 1 (Reference A), except where site-specific models, data or assumptions are more applicable. The base case analysis, documented above, is a good example of the use of Method II. It is an acceptable starting point for a Method II analysis.

6.4 Method to Calculate the Total Body Dose Rate From Noble Gases

Deleted

6.4.1 Method I

Deleted

6.4.2 Basis for Method I

Deleted

6.4.3 Method II

Deleted

6.5 Method to Calculate the Skin Dose Rate from Noble Gases

Deleted

6.5.1 Method I

Deleted

6.5.2 Basis For Method I

Deleted

6.5.3 Method II

Deleted

6.6 Method to Calculate the Critical Organ Dose Rate from Tritium and Particulates with $T_{1/2}$ Greater Than 8 Days

Effluent Control 3.3.1.b limits the dose rate to any organ, denoted $\dot{R}_{co}$, from all release sources of H-3 and radionuclides in particulate form with half lives greater than 8 days to 1500 mrem/year to any organ. The peak release rate averaging time in the case of particulates is commensurate with the time the particulate samplers are in service between changeouts (typically a week).

Use Method I first to calculate the critical organ dose rate from ground level release points to the atmosphere. The dose rate limit of Control 3.3.1.b is the total contribution of releases occurring during the period of interest. Method I applies at all release rates.

Use Method II if Method I predicts a dose rate greater than the Control limits (i.e., use of actual meteorology over the period of interest) to determine if, in fact, Control 3.3.1.b had actually been exceeded during the sampling period.

6.6.1 Method I

For ground releases the critical organ dose rate from Tritium and Particulates with T 1/2 greater than 8 days is calculated as follows:

$$\dot{R}_{cog} = \sum_i \dot{Q}_i^{GLP} \quad DFG'_{gico} \qquad (6\text{-}40)$$

where:

$\dot{Q}_i^{GLP}$ = Ground activity release rate determination of radionuclide "i" (particulates with half-lives greater than 8 days, and tritium) in µCi/sec. For i = Sr-90, Fe-55 or tritium, use the best estimates (such as most recent measurements).

DFG'_{gico} = Site specific critical organ dose rate factor $\left(\frac{\text{mrem - sec}}{\mu\text{Ci - yr}}\right)$ for a ground level gaseous release. See Table 1.1.12.

The critical organ dose rate for the site is equal to $\dot{R}_{cos} + \dot{R}_{cog}$.

Equation 6-40 can be applied under the following conditions (otherwise, justify Method I or consider Method II):

1. Normal operations (not emergency event), and

2. Tritium and particulate releases via ground level releases to the atmosphere.

6.6.2 Basis for Method I

The methods to calculate critical organ dose rate parallel the total body dose rate methods. Only the differences are presented here.

Method I may be used to show that the Control limit for organ dose rate from tritium and radionuclides in particulate form with half lives greater than 8 days (hereafter called Particulates or P) released to the atmosphere (Control 3.3.1.b) has been met for the peak P release rate.

The equation for $\dot{R}_{cos}$ and $\dot{R}_{cog}$ is derived by modifying former Equation 6-25 from Section 6.9 as follows:

$$\dot{D}_{cos} = \sum_i Q_i \; DFG_{ico} \qquad (6\text{-}17)$$

$$(\text{mrem}) \qquad (\text{Ci}) \left(\frac{\text{mrem}}{\text{Ci}}\right)$$

applying the conversion factor, 31.54 (Ci-sec/μCi-yr) and converting Q to $\dot{Q}$ in μCi/sec as it applies to the plant stack yields:

$$\dot{R}_{cos} = 31.54 \sum_i \dot{Q}_i^{STP} \; DFG_{sico} \qquad (6\text{-}18)$$

$$\left(\frac{\text{mrem}}{\text{yr}}\right) \left(\frac{\text{Ci-sec}}{\mu\text{Ci-yr}}\right) \left(\frac{\mu\text{Ci}}{\text{sec}}\right) \left(\frac{\text{mrem}}{\text{Ci}}\right)$$

Equation 6-44 is written in the form:

$$\dot{R} = 31.54 \sum_i \dot{Q}_i^{STP} \; DFG_{sico} \tag{6-19}$$

$$\left(\frac{mrem}{yr}\right) \quad \left(\frac{Ci-sec}{\mu Ci-yr}\right) \quad \left(\frac{\mu Ci}{sec}\right) \left(\frac{mrem}{Ci}\right)$$

DFG'_{sico} and DFG'_{gico} ground releases incorporates the conversion constant of 31.54 and has assumed that the shielding factor (SF) applied to the direct exposure pathway from radionuclides deposited on the ground plane is equal to 1.0 in place of the S_F value of 0.7 assumed in the determination of DFG_{sico} and DFG_{gico} for the integrated doses over time.

The selection of critical receptor (based on the combination of exposure pathways which include direct dose from the ground plane, inhalation and ingestion of vegetables, meat, and milk) which is outlined in Section 6.10 is inherent in Method I, as are the maximum expected off-site atmospheric dispersion factors based on past long-term site-specific meteorology.

The calculation of ground level release dispersion parameters are based on the location of the Reactor Building with respect to the site boundary that would experience the highest exposure.

Should Method II be needed, the analysis for critical receptor critical pathway(s) and atmospheric dispersion factors may be performed with actual meteorologic and latest land use census data to identify the location of those pathways which are most impacted by these type of releases.

6.6.3 Method II

If Method I cannot be applied, or if the Method I dose exceeds the limit, then Method II may be applied. Method II consists of the models, input data and assumptions in Regulatory Guide 1.109, Rev. 1 (Reference A), except where site-specific models, data or assumptions are more applicable. The base case analysis, documented above, is a good example of the use of Method II. It is an acceptable starting point for a Method II analysis.

6.7 Deleted

6.8 Deleted

6.9 Method to Calculate the Critical Organ Dose from Tritium and Particulates

Effluent Control 3.3.3 limits the critical organ dose to a Member of the Public from all release sources of Tritium and particulates with half-lives greater than 8 days (hereafter called "P") in gaseous effluents to 7.5 mrem per quarter and 15 mrem per year.

Use Method I first to calculate the critical organ dose from ground level vent releases. The total critical organ dose limit of Control 3.3.3 is the total contribution from ground level releases occurring during the period of interest.

Use Method II if a more accurate calculation of critical organ dose is needed (i.e., Method I indicates the dose is greater than the limit).

6.9.1 Method I

The critical organ dose is calculated for ground level releases as follows:

$$D_{cog} = \sum_i Q_i^{GLP} \; DFG_{gico} \qquad (6\text{-}44)$$

$$(\text{mrem}) \qquad (\text{Ci}) \left(\frac{\text{mrem}}{\text{Ci}}\right)$$

Q_i^{GLP} = Total activity (Ci) released from ground level releases to the atmosphere of radionuclide "i" during the period of interest. For tritium, strontiums, and Fe-55 use the most recent measure.

DFG_{gico} = Site-specific critical organ dose factor for a ground level release of nuclide "i" (mrem/Ci). For each radionuclide it is the age group and organ with the largest dose factor. See Table 1.1.12.

The critical organ dose for the site is equal to $D_{cos} + D_{cog}$.

Equation 6-44 can be applied under the following conditions (otherwise, justify Method I or consider Method II):

1. Normal operations (not emergency event),
2. P releases via the ground releases (e.g., Reactor Building) to the atmosphere, and
3. Any other ground level continuous or batch release over any time period.

6.9.2 Basis for Method I

This section serves three purposes: (1) to document that Method I complies with appropriate NRC regulations, (2) to provide background and training information to Method I users, and (3) to provide an introductory user's guide to Method II.

Method I may be used to show that the Control limit for off-site organ dose from gaseous releases in particulate form, including tritium (3.3.3) has been met for releases over the appropriate periods.

Method I was developed such that "the actual exposure of an individual ... is unlikely to be substantially underestimated" (10 CFR 50, Appendix I). The use below of a single "critical receptor" provides part of the conservative margin to the calculation of critical organ dose in Method I. Method II allows that actual individuals, with real behaviors, be taken into account for any given release. In fact, Method I was based on a Method II analysis of the critical receptor for the annual average conditions. For purposes of complying with the Control 3.3.3, maximum annual average atmospheric dispersion factors are appropriate for batch and continuous releases. That analysis was called the "base case"; it was then reduced to form Method I. The base case, the method of reduction, and the assumptions and data used are presented below.

The steps performed in the Method I derivation follow. First, in the base case, the dose impact to the critical receptor in the form of dose factors (mrem/Ci) of 1 curie release of each P radionuclide to gaseous effluents was derived. Then Method I was determined using simplifying and further conservative assumptions. The base case analysis uses the methods, data and assumptions in Regulatory Guide 1.109 (Equations C-2, C-4 and C-13 in Reference A). Tables 6.9.1 and 6.9.2 outline human consumption and environmental parameters used in the analysis. It is conservatively assumed that the critical receptor lives at the "maximum off-site atmospheric dispersion factor location" as defined in Section 6.10. However, the individual is exposed, conservatively, to all pathways (see Section 6.10). The resulting site-specific dose factors are for the maximum organ and the age group with the highest dose factor for that organ. These critical organ, critical age dose factors are given in Table 1.1.12.

For any gas release, during any period, the increment in annual average dose from radionuclide "i" is:

$$\Delta D_{ico} = Q_i DFG_{ico} \qquad (6\text{-}26)$$

where DFG_{ico} is the critical dose factor for radionuclide "i" and Q_i is the activity of radionuclide "i" released in curies.

Method I is more conservative than Method II in the region of the effluent dose Control limit because it is based on the following reduction of the base case. The dose factors DFG_{ico} used in Method I were chosen from the base case to be the highest of the set for that radionuclide. In effect each radionuclide is conservatively represented by its own critical age group and critical organ.

6.9.3 METHOD II

If Method I cannot be applied, or if the Method I dose exceeds the Control limit or if a more exact calculation is required, then Method II should be applied. Method II consists of the models, input data and assumptions in Regulatory Guide 1.109, Rev. 1 (Reference A), except where site-specific models, data or assumptions are more applicable. The base case analysis, documented above, is a good example of the use of Method II. It is an acceptable starting point for a Method II analysis.

TABLE 6.9.1

Environmental Parameters for Gaseous Effluents at Vermont Yankee
(Derived from Reference A)*

Variable			Vegetables		Cow Milk		Goat Milk		Meat	
			Stored	Leafy	Pasture	Stored	Pasture	Stored	Pasture	Stored
YV	Agricultural Productivity	(Kg/m^2)	2	2	0.70	2	0.70	2	0.70	2
P	Soil Surface Density	(Kg/m^2)	240	240	240	240	240	240	240	240
T	Transport Time to User(5)	(Hrs)			48	48	48	48	480	480
TB	Soil Exposure Time(1)	(Hrs)	131400	131400	131400	131400	131400	131400	131400	131400
TE	Crop Exposure Time to Plume	(Hrs)	1440	1440	720	1440	720	1440	720	1440
TH	Holdup After Harvest	(Hrs)	1440	24	0	2160	0	2160	0	2160
QF	Animals Daily Feed	(Kg/Day)			50	50	6	6	50	50
FP	Fraction of Year on Pasture(2)				0.50		0.50		0.50	
FS	Fraction Pasture When on Pasture(3)				1		1		1	
FG	Fraction of Stored Veg. Grown in Garden		0.76							
FL	Fraction of Leafy Veg. Grown in Garden			1						
FI	Fraction Elemental Iodine = 0.5									
A	Absolute Humidity = 5.6 (gm/m^3)(4)									

*Regulatory Guide 1.109, Revision 1.

TABLE 6.9.1 (Continued)

Notes:

(1) For Method II dose/dose rate analyses of identified radioactivity releases of less than one year, the soil exposure time for that release may be set at 8760 hours (1 year) for all pathways.

(2) For Method II dose/dose rate analyses performed for releases occurring during the first or fourth calendar quarters, the fraction of time animals are assumed to be on pasture is zero (nongrowing season). For the second and third calendar quarters, the fraction of time on pasture (FP) will be set at 1.0. FP may also be adjusted for specific farm locations if this information is so identified and reported as part of the land use census.

(3) For Method II analyses, the fraction of pasture feed while on pasture may be set to less than 1.0 for specific farm locations if this information is so identified and reported as part of the land use census.

(4) For all Method II analyses, an absolute humidity value equal to 5.6 (gm/m^3) shall be used to reflect conditions in the Northeast (Reference: Health Physics Journal, Vol. 39 (August), 1980; Page 318-320, Pergamon Press).

(5) Variable T is a combination of variables TF and TS in Regulatory Guide 1.109, Revision 1.

TABLE 6.9.2

Usage Factors for Various Gaseous Pathways at Vermont Yankee
(from Regulatory Guide 1.109, Table E-5)

Age Group	Vegetables (kg/yr)	Leafy Vegetables (kg/yr)	Milk (1/yr)	Meat (kg/yr)	Inhalation (m^3/yr)
Adult	520.00	64.00	310.00	110.00	8000.00
Teen	630.00	42.00	400.00	65.00	8000.00
Child	520.00	26.00	330.00	41.00	3700.00
Infant	0.00	0.00	330.00	0.00	1400.00

6.10 Receptor Point and Long-Term Average Atmospheric Dispersion Factors for Important Exposure Pathways

The gaseous effluent dose methods have been simplified by assuming an individual whose behavior and living habits inevitably lead to a higher dose than anyone else. The following exposure pathways to gaseous effluents listed in Regulatory Guide 1.109 (Reference A) have been considered for tritium, and particulates with half lives greater than 8 days:

1. Direct exposure to contaminated ground;
2. Inhalation of air;
3 Ingestion of vegetables;
4. Ingestion of meat.
5. Ingestion of milk.

Beta air doses have also been considered for noble gases in plant effluents along with whole body and skin dose rate calculations.

Section 6.10.1 details the selection of important off-site locations and receptors. Section 6.10.2 describes the atmospheric model used to convert meteorological data into atmospheric dispersion factors. Section 6.10.3 presents the maximum atmospheric dispersion factors calculated at each of the off-site receptor locations.

6.10.1 Receptor Locations

Distances to the site boundary from the evaluated gaseous release pathway (the Reactor Building) are provided in Table 6.10.2. Two important off-site receptor locations are considered in the dose and dose rate equations for gaseous radioactive effluents from the release pathway. They are:

1. The point of maximum ground level air concentration (maximum depleted X/Q) of particulates for determining critical organ dose from inhalation; and

2. The point of maximum deposition (maximum D/Q) of particulates for determining critical organ dose from ingestion.

The ground release pathway (e.g., Reactor Building) was evaluated as a ground level release using the meteorological period-of-record (2012-2016). The highest long-term atmospheric dispersion factors at the site boundary were determined (see Table 6.10.1) and doses and dose rates to the critical off-site receptor were calculated assuming the highest site boundary atmospheric dispersion factors all occurred at the same location.

6.10.2 Vermont Yankee Atmospheric Dispersion Model

The long-term average atmospheric dispersion factors are computed for routine releases XOQDOQ Computer Code (Reference B). XOQDOQ is based, in part, on the constant mean wind direction model discussed in Regulatory Guide 1.111 (Reference C). Since XOQDOQ is a straight-line steady-state model, site-specific recirculation correction factors were developed for each release pathway to adjust the XOQDOQ results to account for temporal variations of atmospheric transport and diffusion conditions. The applicable recirculation correction factors are listed in Table 6.10.3.

XOQDOQ produces the following average atmospheric dispersion factors for each location:

1. Depleted X/Q dispersion factors for evaluating ground level concentrations of particulates;

2. D/Q deposition factors for evaluating dry deposition of elemental particulates.

The ground release (e.g., Reactor Building) depleted X/Q and D/Q factors were derived using Nuclear Regulatory Commission approved software XOQDOQ.

6.10.3 Long-Term Average Atmospheric Dispersion Factors for Receptors

Actual measured meteorological data for the five-year period, 2012 through 2016, were analyzed to determine all the values and locations of the maximum off-site long-term average atmospheric dispersion factors. Each dose and dose rate calculation incorporates the maximum applicable off-site long-term average atmospheric dispersion factor. The values used and their locations are summarized in Table 6.10.1. Table 6.10.1 also indicates which atmospheric dispersion factors are used to calculate the various doses or dose rates of interest.

TABLE 6.10.1

Atmospheric Dispersion Factors

Release Pathway	Dispersion Factor	Dose to Individual		
		Total Body	Skin	Critical Organ
Deleted				Deleted
				Deleted
Reactor Building	X/Q Depleted (sec/m^3)			4.0E-05 (402m NE)
	D/Q ($1/m^2$)			9.53E-08 (402m SSE)

TABLE 6.10.1 NOTATION

NOTE 1 – Releases from the Reactor Building are considered ground releases.

TABLE 6.10.2

Site Boundary Distances

Downwind Sector	Ground Releases
N	529 m
NNE	468 m
NE	448 m
ENE	477 m
E	499 m
ESE	482 m
SE	512 m
SSE	555 m
S	419 m
SSW	575 m
SW	505 m
WSW	418 m
W	402 m
WNW	528 m
NW	917 m
NNW	831 m

TABLE 6.10.3

Recirculation Correction Factors

A. Deleted

B. Ground (e.g., Reactor Building) Release

Sector	0.5 Mi	1.5 Mi	2.5 Mi	3.5 Mi	4.5 Mi	7.5 Mi
N	1.1	1.1	1.1	1.1	1.1	1.0
NNE	1.2	1.2	1.2	1.1	1.1	1.0
NE	1.1	1.2	1.1	1.1	1.0	1.0
ENE	1.2	1.3	1.4	1.4	1.4	1.3
E	1.1	1.3	1.4	1.4	1.4	1.2
ESE	1.1	1.1	1.2	1.1	1.1	1.0
SE	1.0	1.1	1.1	1.1	1.1	1.1
SSE	1.2	1.2	1.2	1.2	1.2	1.2
S	1.0	1.0	1.0	1.0	1.0	1.0
SSW	1.0	1.1	1.0	1.0	1.0	1.0
SW	1.2	1.3	1.2	1.0	1.0	1.0
WSW	1.1	1.1	1.0	1.0	1.0	1.0
W	1.2	1.2	1.1	1.0	1.0	1.0
WNW	1.2	1.4	1.3	1.2	1.2	1.0
NW	1.1	1.1	1.0	1.0	1.0	1.0
NNW	1.1	1.2	1.2	1.2	1.2	1.1

6.11 Method to Calculate Direct Dose From Plant Operation

Effluent Control 3.4.1 (40 CFR 190) restricts the dose to the whole body or any organ to any member of the public from all station sources (including direct radiation from fixed sources on-site) to 25 mrem in a calendar year.

6.11.1 Deleted

6.11.2 Deleted

6.11.3 Deleted

6.11.4 Independent Spent Fuel Storage Installation Dose Contribution

The Independent Spent Fuel Storage Installation (ISFSI) has been constructed to provide a secure location for the long term storage of spent nuclear fuel bundles and Greater Than Class C waste. This installation is located just north of the previous power block, within the Vermont Yankee Protected Area. The vendor, Holtec International, has prepared a study report to satisfy the requirements of 10 CFR 72.104 and this document is included as Reference H. The facility stores 58 Spent Fuel Dry Storage Casks (DSCs). An additional GTCC cask will be added when segmentation of the reactor internals is complete. The shielding analysis of the Independent Spent Fuel Storage Installation is provided in Reference H. The report analyzes the dose generated from a single cask as well as the dose generated from the 58 casks. The dose from each cask to the west site boundary (DR-53A Location) is monitored with REMP TLDs.

6.11.5 Total Direct Dose Summary

Estimates of direct exposure above background in areas at and beyond the site boundary can be determined from measurements made by environmental TLDs located as shown in Table 7.1 and Figure 7.4 that are part of the Radiological Environmental Monitoring Program. Alternatively, direct dose calculations from identified fixed sources on site can be used to estimate the off-site direct dose contribution where TLD information may not be applicable.

6.11.6 Deleted

6.12 Cumulative Doses

Cumulative Doses for a calendar quarter and a calendar year must be maintained to demonstrate a compliance with Controls 3.2.2 and 3.3.3 (10 CFR 50, Appendix I dose objectives). In addition, if the requirements of the Action Statement of Control 3.4.1 dictate, cumulative doses over a calendar year must be determined (demonstration of compliance with total dose, including direct radiation per requirements of 40 CFR 190). To ensure the limits are not exceeded, a running total must be kept for each release.

Demonstration of compliance with the dose limits of 40 CFR 190 is considered as demonstrating compliance with the 0.1 rem limit of 10 CFR 20.1301(a)(1) for members of the public in unrestricted areas.

7.0 ENVIRONMENTAL MONITORING PROGRAM

The radiological environmental monitoring stations are listed in Table 7.1. The locations of the stations with respect to the Vermont Yankee plant are shown on the maps in Figures 7-1 to 7-6.

7.1 Intercomparison Program

All routine radiological analyses for environmental samples are performed at offsite environmental laboratories. The laboratories participate in several commercial inter-comparison programs in addition to an internal QC sample analysis program and the analysis of client-introduced QC sample programs. The external programs may include the Department of Energy – Mixed Analyte Performance Evaluation Program (MAPEP), Analytics Cross-Check Program - Environmental Inter-laboratory Cross-Check Program, and Environmental Resources Association - Environmental Radioactivity Performance Evaluation Program or other NRC-approved sources.

7.2 Airborne Pathway Monitoring

The environmental sampling program is designed to achieve several major objectives, including sampling air in predominant up-valley and down-valley wind directions and at proper control locations, while maintaining continuity with two years of preoperational data and all subsequent years of operational data (post 1972.) The chosen air sampling locations are discussed below.

To assure that an unnecessarily frequent relocation of samplers will not be required due to short-term or annual fluctuations in meteorology, thus incurring needless expense and destroying the continuity of the program, long term, site specific ground level D/Qs (five-year averages - 1978 through 1982) were evaluated in comparison to the existing air monitoring locations to determine their adequacy in meeting the above-stated objectives of the program and the intent of the NRC general guidance. The long-term average meteorological data base precludes the need for an annual re-evaluation of air sampling locations based on a single year's meteorological history.

The Connecticut River Valley in the vicinity of the Vermont Yankee plant has a pronounced up- and down-valley wind flow. Based on five years of meteorological data, wind blows into the 3 "up-valley" sectors (N, NNW, and NW) 27 percent of the time, and the 4 "down-valley" sectors (S, SSE, SE, and ESE) 40 percent of the time, for a total "in-valley" time of 67 percent. This compares reasonably with the updated meteorological data (2012 – 2016) where upper wind data frequencies for the up-valley sectors (WNW, NW, NNW, N) account for 37 percent of the time, and the down-valley sectors (ESE, SE, SSE, S) account for 33 percent of the time.

Station AP/CF-12 (NNW, 3.6 km) in North Hinsdale, New Hampshire, monitors the up-valley sectors. It is located in the sector that ranks fourth overall in terms of wind frequency (i.e., in terms of how often the wind blows into that sector), and is approximately 0.75 miles from the location of the calculated maximum ground level D/Q (i.e., for any location in any sector, for the entire Vermont Yankee environs). This station provides a second function by its location in that it also monitors North Hinsdale, New Hampshire, the community with the second highest ground level D/Q for surrounding communities, and it has been in operation since the preoperational period.

The down-valley direction is monitored by the River Station Number 3-3 (AP/CF-11, SSE, 1.9 km). This station resides in the sector with the maximum wind frequency and they bound the down-valley point of calculated maximum ground level D/Q (the second highest overall ground level D/Q for any location in any sector). Station AP/CF-11 is approximately one mile from this point, between it and the plant. This station has been in operation since the preoperational period.

The control air sampler was located at Spofford Lake (AP/CF-21, NNE, 16.4 km) due to its distance from the plant and the low frequency for wind blowing in that direction based on the long-term (five-year) meteorological history. Sectors in the general west to southwest direction, which would otherwise have been preferable due to lower wind frequencies, were not chosen since they approached the region surrounding the Yankee Atomic plant in Rowe, Massachusetts.

7.3 Distances and Directions to Monitoring Stations

It should be noted that the distances and directions for direct radiation monitoring locations in Table 7.1, as well as the sectors shown in Figures 7-5 and 7-6, are keyed to the center of the Reactor Building due to the critical nature of the Reactor Building-to-TLD distance for close-in stations. For simplicity, all other radiological environmental sampling locations use the historical plant stack location (a.k.a. “plant stack”) as the origin.

Control Table 3.5.1, Footnote a, specifies that in the Annual Radiological Environmental Operating Report and ODCM, the reactor shall be used as the origin for all distances and directions to sampling locations. Vermont Yankee interprets “the reactor” to mean the reactor site which includes the plant stack and the Reactor Building. The distances to the plant stack and Reactor Building will, therefore, be used in the Annual Radiological Environmental Operating Reports and ODCM for the sampling and TLD monitoring stations, respectively.

Table 7.1

Radiological Environmental Monitoring Stations(1)

Exposure Pathway and/or Sample Direction(5)	Sample Location and Designated Code(2)		Distance (km)(5)	
1. AIRBORNE (Particulate)				
	AP-11	River Station No. 3-3	1.88	SSE
	AP-12	N. Hinsdale, NH	3.61	NNW
	AP-21	Spofford Lake(9)	16.36	NNE
2. WATERBORNE				
a. Surface	WR-11	River Station No. 3-3	1.88	Downriver
	WR-21	Rt. 9 Bridge(9)	11.83	Upriver
b. Ground	WG-11	Plant Well	0.24	On-Site
	WG-12	Vernon Nursing Well	2.13	SSE
	WG-22	Copeland Well(9)	13.73	N
c. Sediment From Shoreline	SE-11	Shoreline Downriver	0.57	SSE
	SE-12	North Storm Drain Outfall(3)	0.13	E
3. INGESTION				
a. Deleted				
b. Mixed Grasses	TG-11	River Station No. 3-3	1.88	SSE
	TG-12	N. Hinsdale, NH	3.61	NNW
	TG-21	Spofford Lake(9)	16.36	NNE
c. Silage	TC-11	Miller Farm	0.82	W
	TC-18	Blodgett Farm	3.60	SE
	TC-22	Franklin Farm(9)	9.73	WSW
d. Fish	FH-11	Vernon Pond	(6)	(6)
	FH-21	Rt. 9 Bridge(9)	11.83	Upriver

TABLE 7.1 (Continued)

Exposure Pathway and/or Sample Direction(5)	Sample Location and Designated Code(2)		Distance (km)(5)	
4. DIRECT RADIATION				
	DR-1	River Station No. 3-3	1.61	SSE
	DR-2	N. Hinsdale, NH	3.88	NNW
	DR-5	Spofford Lake(9)	16.53	NNE
	DR-6	Vernon School	0.52	WSW
	DR-7	Site Boundary	0.28	W
	DR-8	Site Boundary	0.25	SSW
	DR-43	Site Boundary	0.44	SSE
	DR-45	Site Boundary	0.12	NE
	DR-46	Site Boundary	0.28	NNW
	DR-53A	West Cornfield	0.39	WSW

(1) Sample locations are shown on Figures 7.1 to 7.6.

(2) Station Nos. 10 through 19 are indicator stations. Station Nos. 20 through 29 are control stations (except the direct radiation stations).

(3) To be sampled and analyzed semiannually.

(4) Deleted

(5) Distance and direction from the center of the Reactor Building for direct radiation monitors; from the plant stack for all others.

(6) Fish samples are collected from anywhere in Vernon Pond, which is adjacent to the plant (see Figure 7-1).

(7) Deleted.

(8) Deleted.

(9) Control stations

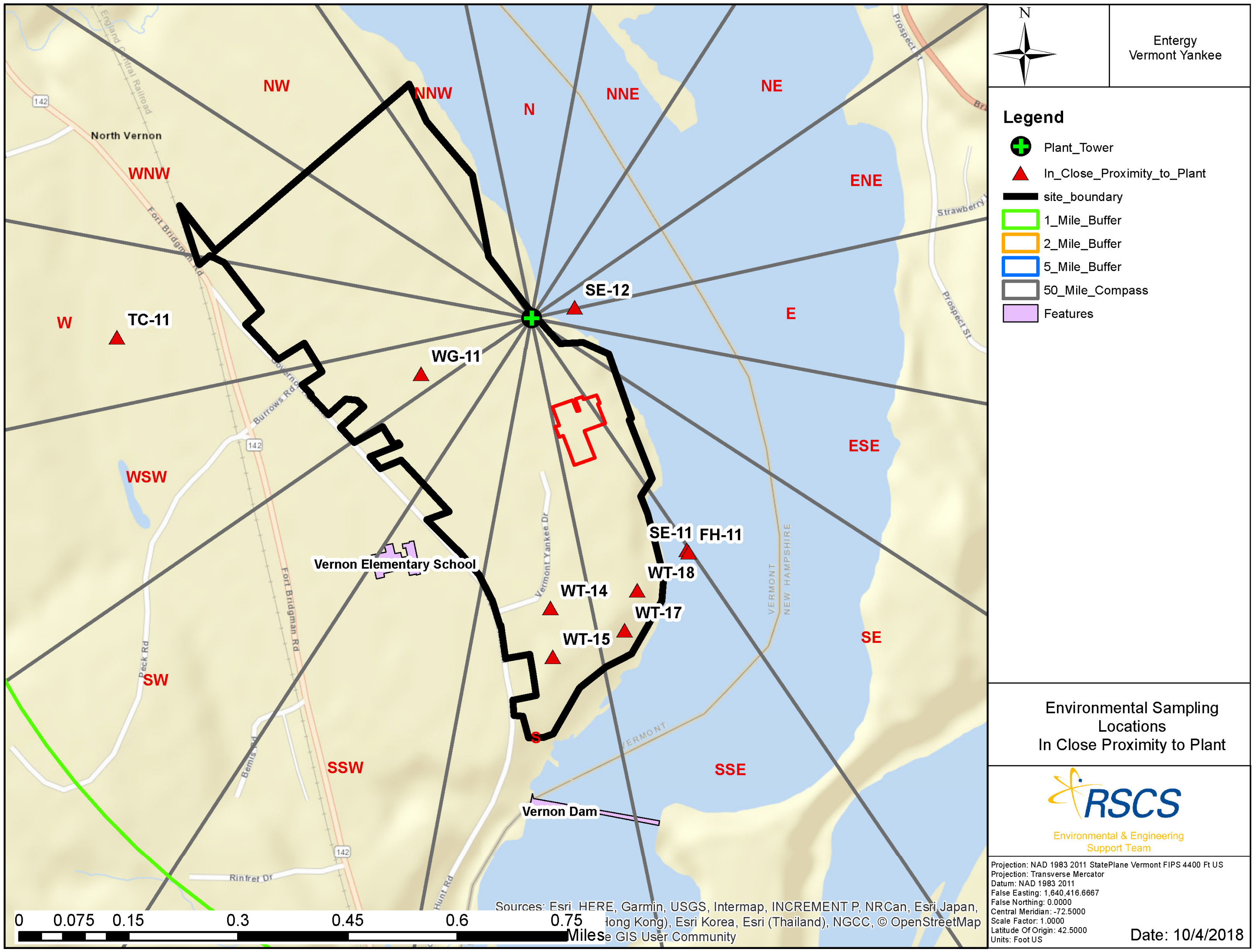

Figure 7-1 Environmental Sampling Locations in Close Proximity to the Plant

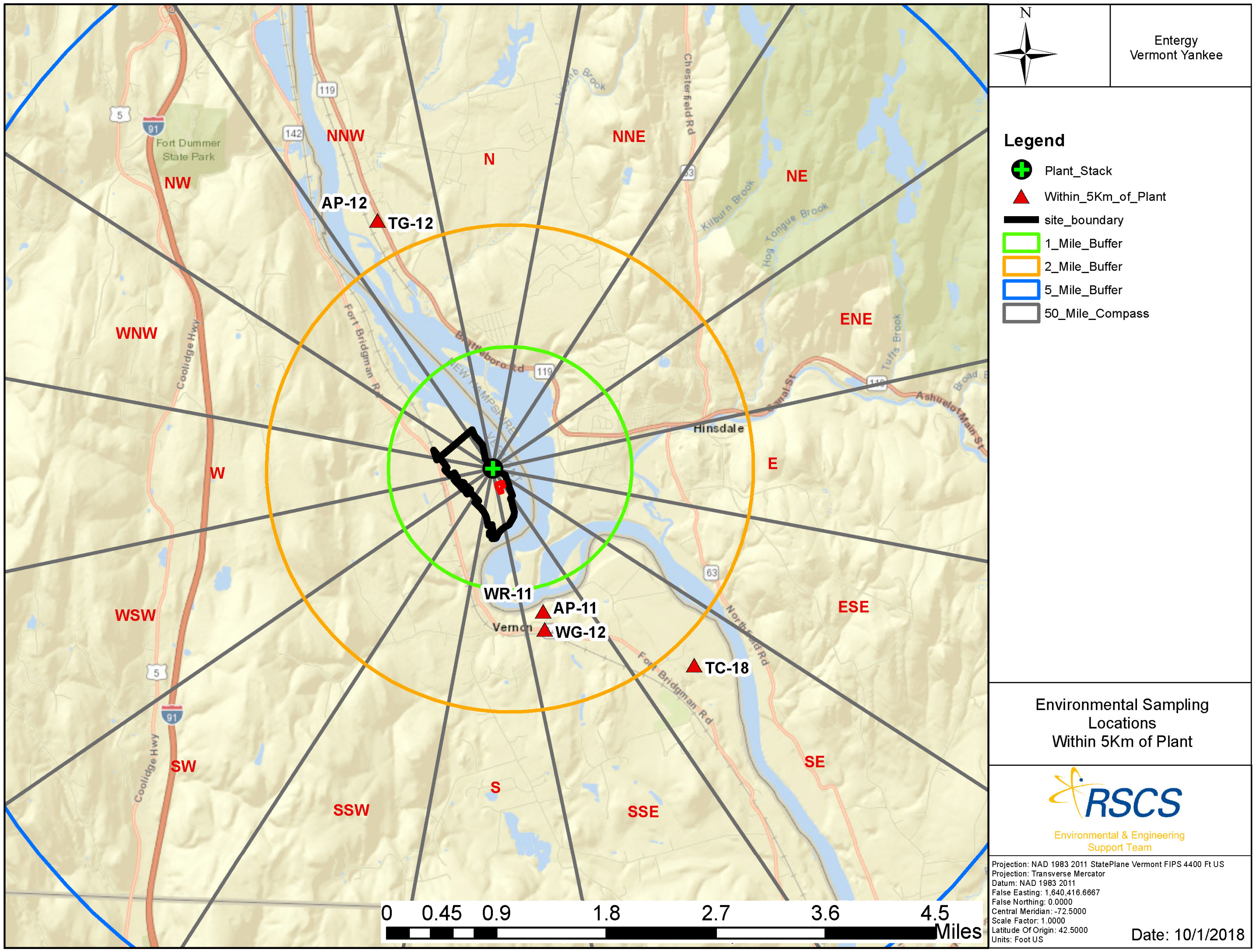

Figure 7-2 Environmental Sampling Locations Within 5 Km of Plant

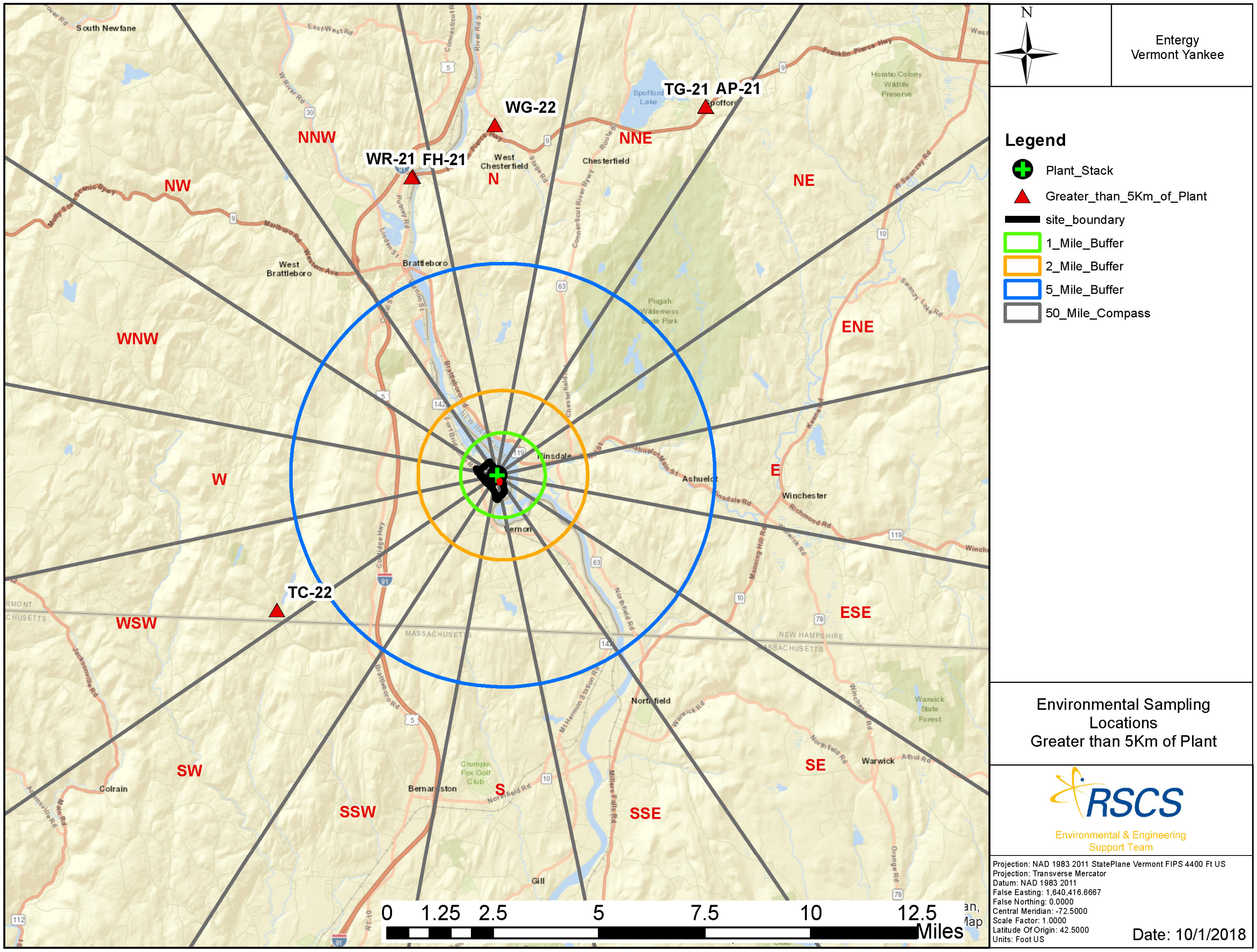

Figure 7-3 Environmental Sampling Locations Greater than 5 Km from Plant

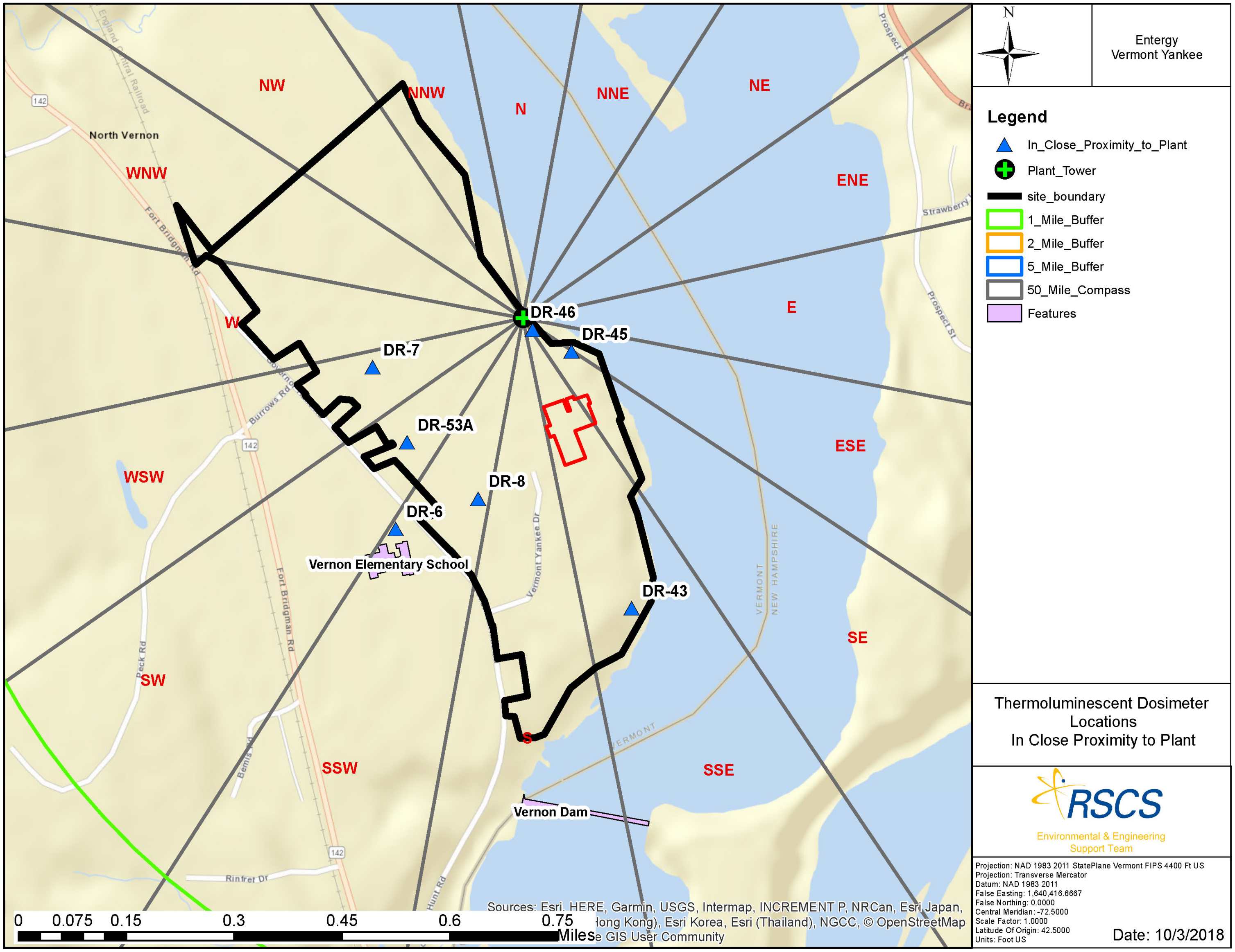

Figure 7-4 TLD Locations in Close Proximity to Plant

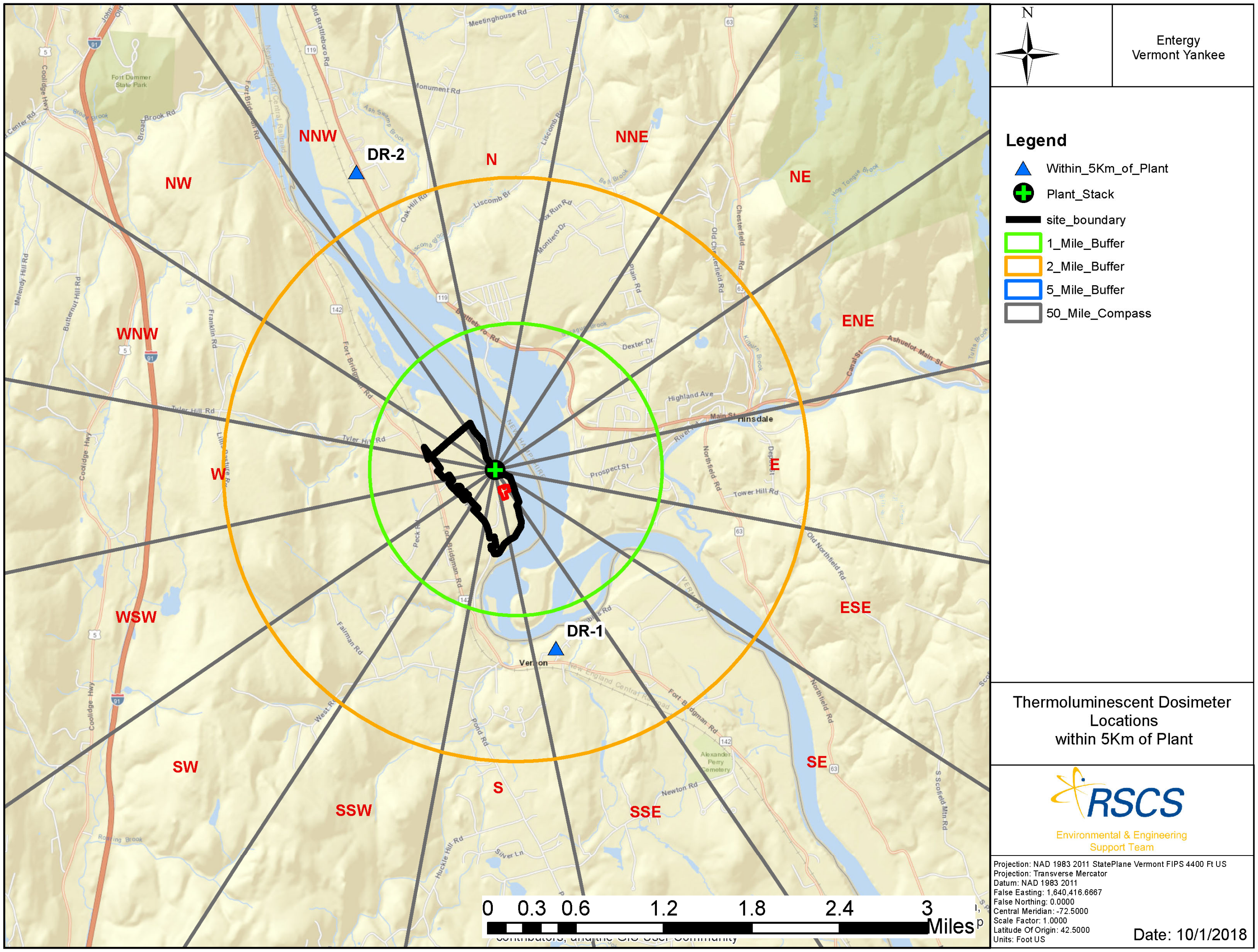

Figure 7-5 TLD Locations Within 5 Km of Plant

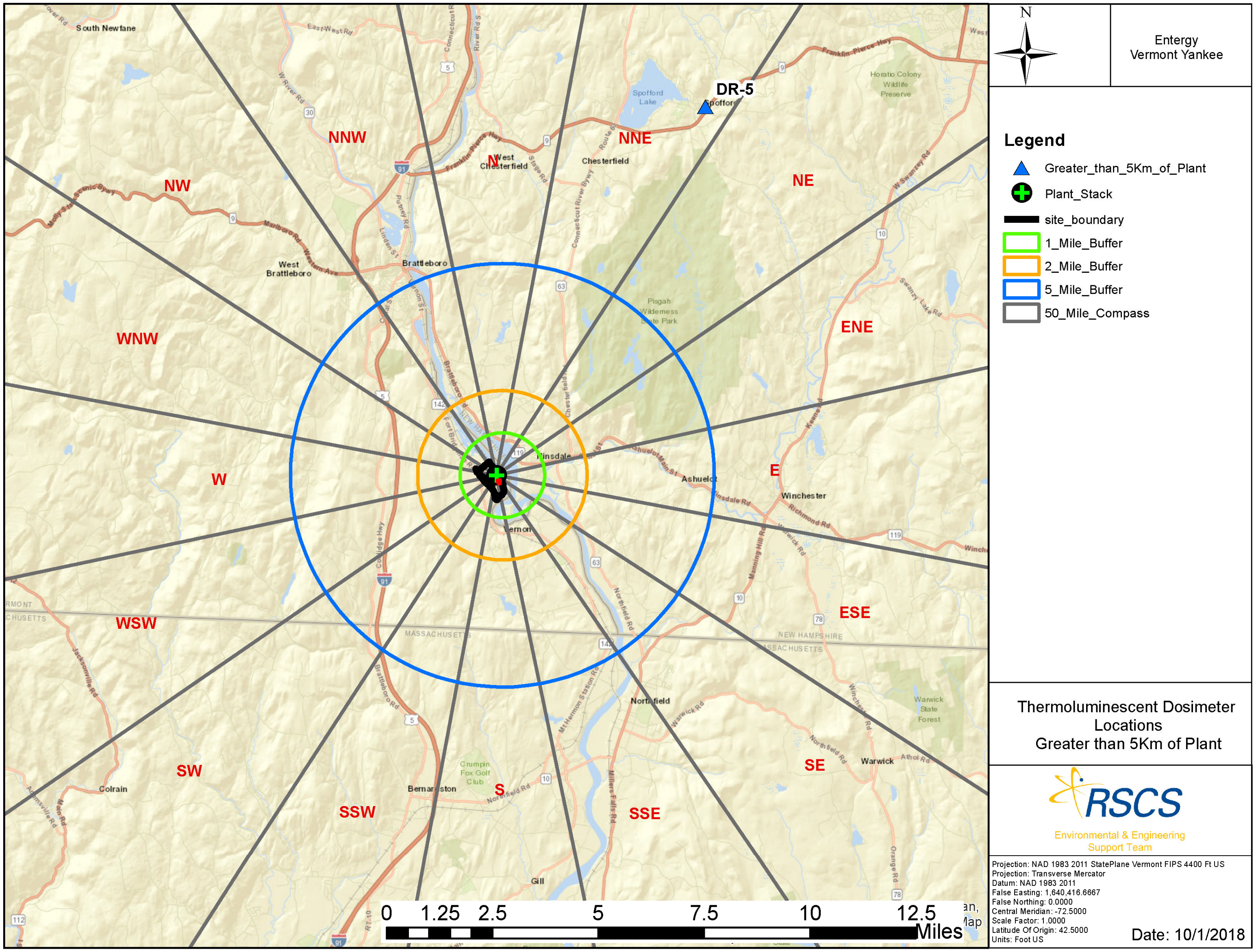

Figure 7-6 TLD Locations Greater Than 5 Km from Plant

8.0 Deleted

8.1 Deleted

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9.0 LIQUID AND GASEOUS EFFLUENT STREAMS, RADIATION MONITORS AND RADWASTE TREATMENT SYSTEMS

Figure 9-1 shows the normal (design) radioactive liquid effluent streams, radiation monitors, and the appropriate Liquid Radwaste Treatment System. Figure 9-2 shows the normal (design) gaseous effluent systems, radiation monitors, and the appropriate Gaseous Radwaste Treatment System. Figure 9-3 shows the normal subsurface shallow groundwater stream tube configuration for the plant site. Figure 9-4 shows the normal subsurface deep groundwater stream tube configuration for the plant site.

9.1 In-Plant Radioactive Liquid Effluent Pathways

The Liquid Radwaste System has been modified for the permanently shutdown and defueled SAFSTOR configuration. The installed plant Liquid Radwaste System has been permanently isolated from the Liquid Waste Discharge line and replaced by a Liquid Waste Processing System as shown in Figure 9-1. The Liquid Waste Processing System consists of particulate filter(s) and demineralizers, a sample tank and pump with recirculation, neutralization and sampling capabilities. The sample tank is filled from the Torus and/or Turbine Building Intercepted Groundwater. Typically, water is processed through particulate filters and/or demineralizers prior to filling the sample tank. The liquid wastes collected in the Sample Tank are handled on a batch basis. Prior to discharge, the Sample Tank is recirculated and sampled as required by Table 4.2.1 and the contents analyzed for radioactivity and water purity. A release is allowed once it is determined that the activity in the liquid wastes will not exceed control release limits. The Sample Tank is isolated from all inputs when discharging through the Liquid Waste Discharge Line.

A discharge from the Sample Tank is accomplished by first isolating inputs, starting the pump and opening the necessary valves. The release rate in the discharge line is between 0 and 100 gpm (typically 70 gpm) and discharge volume is monitored by the Liquid Waste Flow Meter.

During discharge the Sample Tank is isolated from the Torus, Intercepted Groundwater and processing system demineralizers and filters preventing the possibility of discharging uncharacterized liquid wastes. The Liquid Waste Discharge Monitor (RM-17-350) has been removed from service since pre-discharge sampling requirements and controls equivalent to those required when the monitor was out of service have been permanently implemented. The monitor is no longer required due to the low radioactivity of SAFSTOR liquids and the simplified Liquid Waste Processing configuration. Discharge occurs to outfall S/N-001 in the Connecticut River via the existing or a replacement liquid waste discharge line.

The Circulating Water System has been removed from service and permanently isolated from the Discharge Structure preventing the possibility of a liquid release from this system. The Circulating Water System Radiation Monitor (RM-17-359) has been removed from service.

9.2 In-Plant Radioactive Gaseous Effluent Pathways

The gaseous radwaste system includes subsystems that dispose of gases from the station ventilation exhausts.

9.3 Subsurface Groundwater Pathways to the Connecticut River

9.3.1 Overview

As presented in the Hydrogeologic Investigation Report prepared by GZA GeoEnvironmental, Inc. (See ODCM Reference Section) the overall direction of groundwater flow at the Vermont Yankee plant site is towards the Connecticut River. Based on this understanding of site hydrogeologic conditions, the groundwater discharge rates from the developed portion of the site to the river, has been estimated using a steam tube approach based on Darcy's Law.

9.3.2 Geology

The site geology consists of a discontinuous layer of engineered fill material underlain by glaciolacustrine/glaciofluvial deposits. The total overburden thickness varies from approximately 30 to 80 feet. The upper-most soil deposit is fill, generally consisting of silty sand. Directly underlying the fill is an upper sand unit which consists of fine to medium sand with various amounts of silt. This unit is underlain by a confining silt layer which appears fairly continuous in areas east of the AOG Building (approximately 1 to 16 feet thick) but pinches out towards the north. Groundwater flux towards the river through this silt unit is likely to be negligible due to its low permeability. Consequently, the silt layer was not included in the groundwater flux calculation presented herein. Below the silt layer and in the vicinity of the Connecticut River, is a finer-grained lower sand unit. This lower sand deposit appears to be of limited lateral extent, extending from approximately the intake structure southerly to the discharge structure.

The bedrock below the overburden is reported to be biotite gneiss. Pre-construction seismic testing of the bedrock indicates that it is generally hard and massive. The depth of bedrock in the release area, east of the AOG building, is approximately 55 to 80 feet below the plant grade of approximately 251.5 ft NGVD, with bedrock generally sloping towards the river. Groundwater movement through the bedrock in the vicinity of the river appears to be in an upward direction, toward the river.

9.3.3 Streamtube Method

To estimate the groundwater flow through the developed area of the site containing systems, structures and components (SSCs) which may carry radionuclides, a series of twelve streamtubes in the shallow overburden and five streamtubes in the deep overburden were delineated. The streamtubes show groundwater flow direction and were drawn perpendicular to the groundwater contours, which were developed from synoptic groundwater elevation data collected on December 15, 2010. The boundaries of the streamtubes represent groundwater flow lines, with groundwater flow generally parallel to these lines within the streamtubes. Based on frequent groundwater level measurements recorded in the monitoring wells at the site, the overall groundwater flow pattern and hydraulic gradients do not vary significantly at the site, and thus the location and shape of the streamtubes are anticipated to be relatively stable. The location and configuration of these streamtubes are shown on Figures 9-3 and 9-4. In the shallow overburden, stream-tubes were generally centered on individual downgradient monitoring wells (perimeter wells) extending across the site from the off-gas stack (well GZ-27) southerly to approximately the area of the discharge structure (well GZ-5). In the deep overburden, streamtubes extend over the lateral extent of the lower sand deposit (from well GZ-18D southerly to well GZ-19D), and were centered on the deep downgradient wells.

9.3.4 Cross Sectional Flow Area

The cross sectional area (A) of flow for each streamtube is based on the streamtube width and the thicknesses of the saturated transmissive overburden units within the streamtube. For the shallow overburden streamtubes, the saturated thickness is estimated based on the difference between the measured groundwater table elevation and the elevation of the bottom of the upper sand unit depending on the specific geological conditions present within the screened portion of the well. If a significant thickness of saturated fill is present, the cross sectional area must also include the thickness of any saturated upper sand present under the fill. For the deep overburden stream-tubes, the flow area was computed using the thickness of the fully saturated lower sand unit.

9.3.5 Hydraulic Conductivity

As presented in the GZA's May 2011 Hydrogeologic Investigation report, hydraulic conductivity (K) testing was performed in monitoring wells at the Site to characterize the hydrogeologic properties of the overburden soils. Based on this data, the geometric mean K for each major hydrogeologic unit is presented in Table 5.2 of the GZA report. These values, combined with other input parameters presented herein, are used to calculate groundwater flow rates through each streamtube. A summary of the geometric mean K values for each major hydrogeologic unit is presented below.

Hydrogeologic Unit		Geometric Mean K (ft/day)
Shallow Overburden	Fill	0.3
	Upper Sand (East of Power Block)	4
	Upper sand (North of Power Block)	12
Deep Overburden	Lower Sand	1.2

9.3.6 Streamtube Parameters

A summary of selected streamtube parameters used to calculate groundwater flow rates (as discussed further below) is presented in the following table:

Streamtube	Key Well within Streamtube	Approximate Width (ft)	Hydrogeologic Unit(s) Present within Streamtube	K (ft/day)
Shallow Overburden Streamtubes				
ST-1S	GZ-27S	76	Upper Sand – (North of Power Block)	12
ST-2S	GZ-26S	215	Upper Sand – (North of Power Block)	12
ST-3S	GZ-25S	260	Upper Sand – (North of Power Block)	12
ST-4S	GZ-1S	200	Upper Sand – (North of Power Block)	12
ST-5S	GZ-18S	160	Fill	0.3
ST-6S	GZ-13S	50	Fill	0.3
			Upper Sand – (East of Power Block)	4
ST-7S	GZ-23S	85	Fill	0.3
			Upper Sand – (East of Power Block)	4
ST-8S	GZ-3S	85	Fill	0.3
			Upper Sand – (East of Power Block)	4
ST-9S	GZ-14S	105	Fill	0.3
			Upper Sand – (East of Power Block)	4
ST-10S	GZ-4S	90	Fill	0.3
			Upper Sand – (East of Power Block)	4
ST-11S	GZ-19S	95	Fill	0.3
			Upper Sand – (East of Power Block)	4
ST-12S	GZ-5S	125	Fill	0.3
			Upper Sand – (East of Power Block)	4
Deep Overburden Streamtubes				
ST-1D	GZ-18D	75	Lower Sand	1.2
ST-2D	GZ-13D	100	Lower Sand	1.2
ST-3D	GZ-22D	110	Lower Sand	1.2
ST-4D	GZ-14D	110	Lower Sand	1.2
ST-5D	GZ-19D	150	Lower Sand	1.2

9.3.6 Hydraulic Gradient

For each streamtube, average hydraulic gradients (i) are calculated based on quarterly groundwater elevation contours developed from quarterly groundwater level measurements in the monitoring wells.

9.3.7 Calculated Groundwater Flow Rate

Based on the above parameter estimates, the quarterly groundwater flow in each streamtube is computed using the following form of the Darcy's equation for fluid flow through porous media:

$$Q = KiA$$

Where:

Q	= flow (ft^3/day)
K	= hydraulic conductivity (ft/day)
i	= hydraulic gradient (ft/ft)
A	= cross-sectional area of flow (width times depth) (ft^2)

The quarterly groundwater flow rates are utilized to determine monthly estimates of flow rate for the dose calculations required in Section 6 of the ODCM. The quarterly groundwater flow rates are also averaged over the reporting year to account for variations in seasonal precipitation, and thus the associated seasonal variation groundwater flux to estimate annual radiation doses. To conservatively account for potential uncertainties and the heterogeneity inherent in geologic materials such as those at the plant site, a factor of safety may be applied to the estimated flow to provide a more conservative estimate for the groundwater flow through the subsurface.

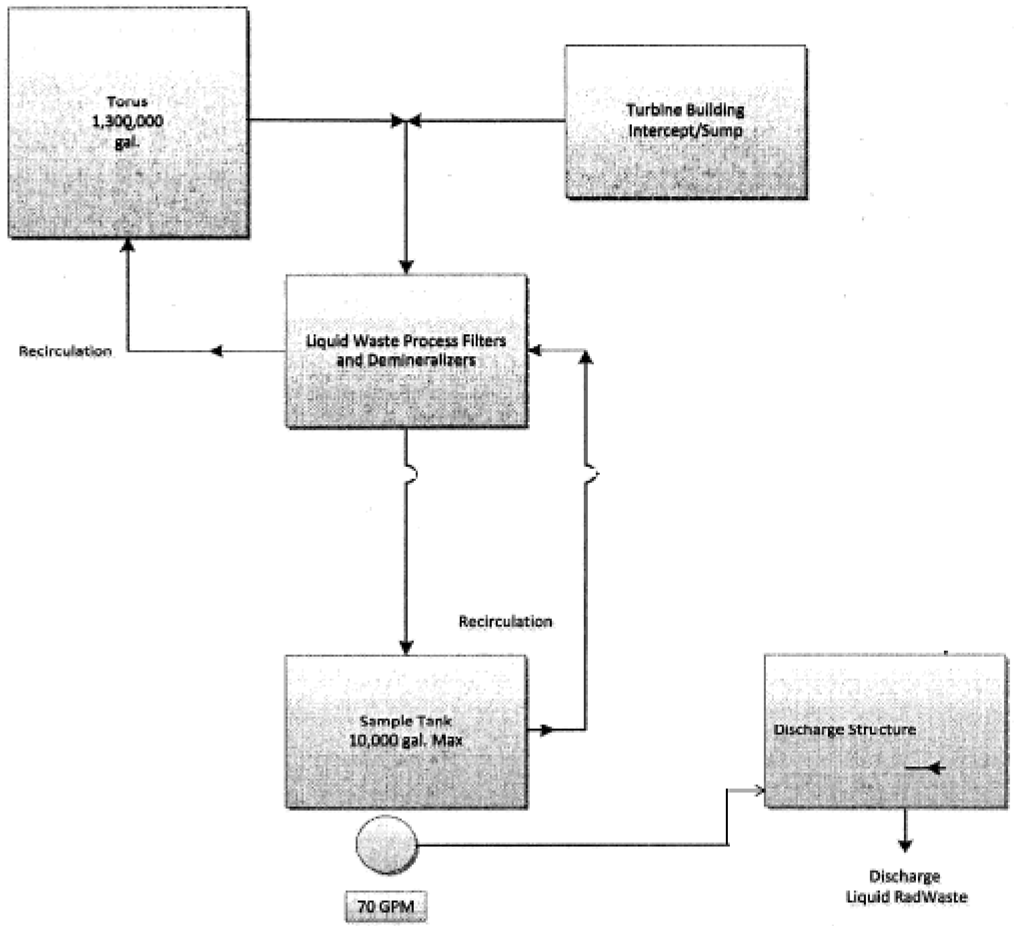

Figure 9.1: Radioactive Liquid Effluent Streams, Radiation Monitors, and Radwaste Treatment System at Vermont Yankee*

* Normal (design) radioactive process streams only are shown.

Figure 9.2: Deleted

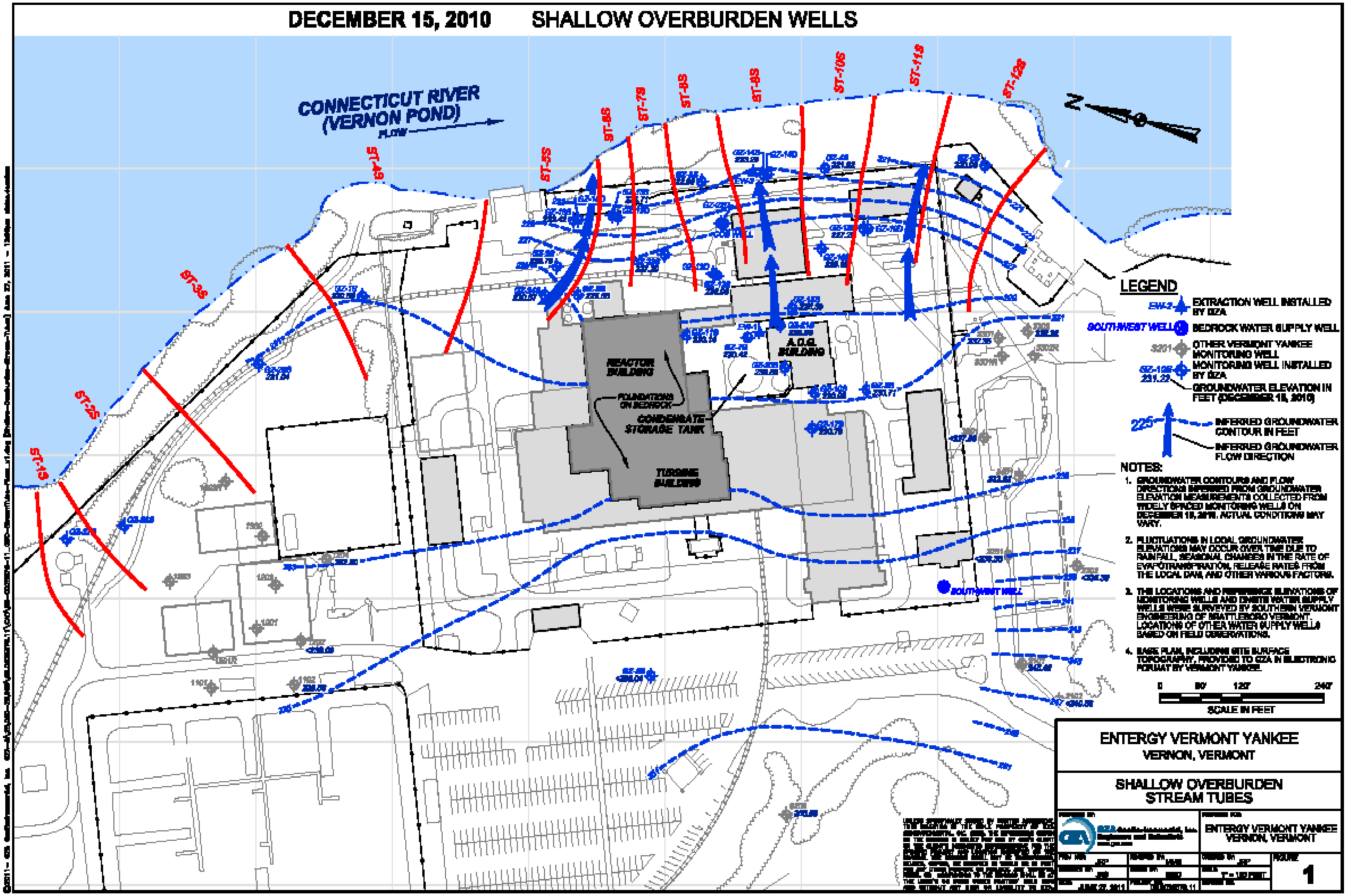

Figure 9.3: Subsurface Shallow Groundwater Streamtubes from the Plant Site to the Connecticut River

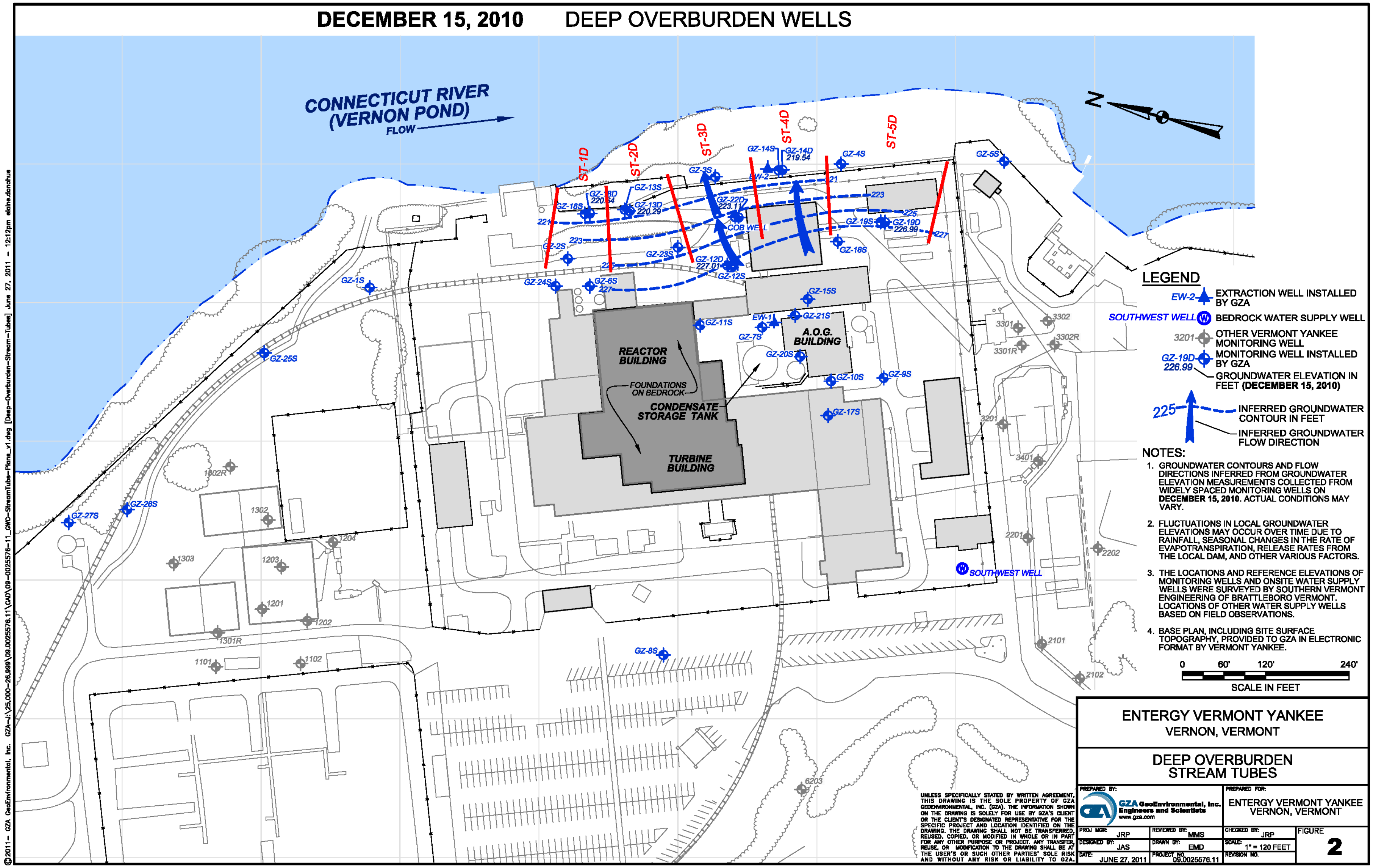

Figure 9.4: Subsurface Deep Groundwater Streamtubes from the Plant Site to the Connecticut River

10.0 UNIQUE REPORTING REQUIREMENTS

10.1 Annual Radioactive Effluent Release Report

In accordance with 10 CFR 50.36a, the Radioactive Effluent Release Report covering the operation of the unit shall be submitted by May 15 of each year.

The Radioactive Effluent Release Report shall include a summary of the quantities of radioactive liquid and gaseous effluents and solid waste released from the unit as outlined in Regulatory Guide 1.21, Revision 1, June 1974, "Measuring, Evaluating and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants," with data summarized on a quarterly basis following the format of Appendix B thereof. For solid wastes the format for Table 3 in Appendix B of Regulatory Guide 1.21 shall be supplemented with three additional categories: class of solid wastes (as defined by 10 CFR Part 61), type of container (e.g., LSA, Type A, Type B, Large Quantity), and solidification agent or absorbent, if any.

In addition, the Radioactive Effluent Release Report shall include an annual summary of hourly meteorological data collected over the previous year. This annual summary may be either in the form of an hour-by-hour listing on magnetic tape of wind speed, wind direction, atmospheric stability, and precipitation (if measured), or in the form of joint frequency distributions of wind speed, wind direction, and atmospheric stability. This same report shall include an assessment of the radiation doses due to the radioactive liquid and gaseous effluents released from the unit during the previous calendar year. The Radioactive Effluent Release Report shall also include an assessment of the radiation doses from radioactive effluents to member(s) of the public due to any allowed recreational activities inside the site boundary during the previous calendar year. All assumptions used in making these assessments (e.g., specific activity, exposure time and location) shall be included in these reports. The assessment of radiation doses shall be performed in accordance with the Off-Site Dose Calculation Manual (ODCM).

With the limits of Control 3.4.1 being exceeded during the calendar year, the Radioactive Effluent Release Report shall also include an assessment of radiation doses to the likely most exposed real member(s) of the public from reactor releases (including doses from primary effluent pathways and direct radiation) for the previous calendar year to show conformance with 40 CFR 190, Environmental Radiation Protection Standards for Nuclear Power Operation.

The Radioactive Effluent Release Report shall include a list and description of unplanned releases from the site to site boundary of radioactive materials in gaseous and liquid effluents made during the reporting period.

With the quantity of radioactive material in any outside tank exceeding the limit of Section 4 of the Defueled Safety Analysis Report, describe the events leading to this condition in the next Radioactive Effluent Release Report.

If non-functional gaseous effluent monitoring instrumentation is not returned to functional status within 30 days pursuant to Note 5 of Control Table 3.1.2, explain in the next Radioactive Effluent Release Report the reason(s) for delay in correcting the inoperability.

With a land use census identifying one or more locations which yield at least a 20 percent greater dose or dose commitment than the values currently being calculated in Control 4.3.3, identify the new location(s) in the next Radioactive Effluent Release Report.

Changes made during the reporting period to the Process Control Program (PCP) and to the Off-Site Dose Calculation Manual (ODCM), shall be identified in the next Radioactive Effluent Release Report.

10.2 Environmental Radiological Monitoring

The Annual Radiological Environmental Operating Report covering the operation of the unit during previous calendar year shall be submitted by May 15th of each year.

The report shall include summaries, interpretations, and an analysis of trends of the results of the radiological environmental surveillance activities for the report period. The material provided shall be consistent with the objectives outlined in the ODCM and in 10 CFR 50, Appendix I, Sections IV.B.2, IV.B.3, and IV.C.

The Annual Radiological Environmental Operating Report shall include summarized and tabulated results of all radiological environmental samples taken during the report period pursuant to Table 7-1 and Figures 7-1 through 7-6. In the event that some results are not available for inclusion with the report, the report shall be submitted noting and explaining the reasons for the missing results. The missing data shall be submitted as soon as possible in a supplementary report.

With the level of radioactivity in an environmental sampling media at one or more of the locations specified in Control Table 3.5.1 exceeding the reporting levels of Control Table 3.5.2, the condition shall be described in the next Annual Radiological Environmental Operating Report only if the measured level of radioactivity was not the result of plant effluents. With the radiological environmental monitoring program not being conducted as specified in Control Table 3.5.1, a description of the reasons for not conducting the program as required and the plans for preventing a recurrence shall be included in the next Annual Radiological Environmental Operating Report.

The Annual Radiological Environmental Operating Report shall also include the results of the land use census required by Control 3.5.2. A summary description of the radiological environmental monitoring program including a map of all sampling locations keyed to a table giving distances and directions from the reactor shall be in the reports. If new environmental sampling locations are identified in accordance with Control 3.5.2, the new locations shall be identified in the next Annual Radiological Environmental Operating Report.

The reports shall also include a discussion of all analyses in which the LLD required by Control Table 4.5.1 was not achievable.

The results of license participation in the intercomparison program required by Control 3.5.3 shall be included in the reports. With analyses not being performed as required by Control 3.5.3, the corrective actions taken to prevent a recurrence shall be reported to the Commission in the next Annual Radiological Environmental Operating Report.

10.3 ISFSI Reporting Requirements

In accordance with 10 CFR 72.44(d)(3), the Annual Independent (Interim) Spent Fuel Storage Installation Radioactive Effluent Control Program Report (AISFSIRECPR) will be generated and issued by February 28th of each year.

Since it has been determined by Holtec International in their Final Safety Analysis Report (Reference I) that the Holtec HI-STORM 100 Cask System does not create any radioactive materials or have any radioactive waste treatment systems, specific operating procedures for the control of radioactive effluents are not required. Specification 3.1.1, Multi-Purpose Canister (MPC), provides assurance that there are no radioactive effluents from the SFSC.

In light of the information presented in the previous paragraphs, the AISFSIRECPR, to be issued by February 28th of each year, shall state that no radioactive effluents were discharged from the Independent (Interim) Spent Fuel Storage Installation and therefore no ISFSI-specific monitoring program is in place at Vermont Yankee and there are no ISFSI-specific data to report for the previous calendar year reporting period.

10.4 Special Reports

Special reports shall be submitted to the NRC Document Control Desk and Regional Office within the time period specified for each report.

10.4.1 Liquid Effluents (Controls 3.2.2 and 3.2.3)

With the calculated dose from the release of radioactive materials in liquid effluents exceeding any of the limits of Control 3.2.2, prepare and submit to the Commission within 30 days a special report which identifies the cause(s) for exceeding the limit(s) and defines the corrective actions taken to assure that subsequent releases will be in compliance with the limits of Control 3.2.2.

With liquid radwaste being discharged without processing through appropriate treatment systems and estimated doses in excess of Control 3.2.3, prepare and submit to the Commission within 30 days a special report which includes the following information:

(1) explanation of why liquid radwaste was being discharged without treatment, identification of any non-functional equipment or subsystems, and the reasons for the non-functionality;

(2) action(s) taken to restore the non-functional equipment to functional status; and

(3) summary description of action(s) taken to prevent a recurrence.

10.4.2 Gaseous Effluents (Control 3.3.3)

With the calculated dose from the release of tritium and/or radionuclides in particulate form exceeding any of the limits of Control 3.3.3, prepare and submit to the Commission within 30 days a special report which identifies the cause(s) for exceeding the limit(s) and the corrective action(s) taken to assure that subsequent releases will be in compliance with the limits of Control 3.3.3.

10.4.3 Total Dose (Control 3.4.1)

With the calculated dose from the release of radioactive materials in liquid or gaseous effluents exceeding the limits of Control 3.4.1, prepare and submit to the Commission within 30 days a special report which defines the corrective action(s) to be taken to reduce subsequent releases to prevent recurrence of exceeding the limits of Control 3.4.1 and includes the schedule for achieving conformance with these limits. This special report, required by 10 CFR Part 20.2203(a)(4), shall include an analysis that estimates the radiation exposure (dose) to a member of the public from station sources, including all effluent pathways and direct radiation, for the calendar year that includes the release(s) covered by this report. It shall also describe levels of radiation and concentrations of radioactive material involved, and the cause of the exposure levels or concentrations. If the estimated doses exceed any of the limits of Control 3.4.1, and if the release condition resulting in violation of 40 CFR Part 190 has not already been corrected, the special report shall include a request for a variance in accordance with the provisions of 40 CFR Part 190. Submittal of the report is considered a timely request, and a variance is granted until staff action on the request is complete.

10.4.4 Radiological Environmental Monitoring (Control 3.5.1)

With the level of radioactivity as the result of plant effluents in an environmental sampling media at one or more of the locations specified in Control Table 3.5.1 exceeding the reporting levels of Control Table 3.5.2, prepare and submit to the Commission within 30 days from the receipt of the Laboratory Analyses a special report which includes an evaluation of any release conditions, environmental factors or other factors which caused the limits of Control Table 3.5.2 to be exceeded. This report is not required if the measured level of radioactivity was not the result of plant effluents, however, in such an event, the condition shall be reported and described in the Annual Radiological Environmental Operating Report.

10.4.5 Land Use Census (Control 3.5.2)

With a land use census not being conducted as required by Control 3.5.2, prepare and submit to the Commission within 30 days a special report which identifies the reasons why the survey was not conducted, and what steps are being taken to correct the situation.

10.5 Major Changes to Radioactive Liquid, Gaseous, and Solid Waste Treatment Systems

Licensee-initiated major changes to the radioactive waste systems (liquid, gaseous, and solid):

A. Shall be reported to the commission in the Radioactive Effluent Release Report for the period in which the evaluation was reviewed by the Independent Safety Review (ISR). The discussion of each change shall contain:

1. A summary of the evaluation that led to the determination that the change could be made in accordance with 10 CFR Part 50.59;

2. Sufficient detailed information to support the reason for the change without benefit of additional or supplemental information;

3. A detailed description of the equipment, components, and processes involved and the interfaces with other plant systems;

4. An evaluation of the change, which shows the predicted releases of radioactive materials in liquid and gaseous effluents and/or quantity of solid waste that differ from those previously predicted in the license application and amendments thereto;

5. An evaluation of the change, which shows the expected maximum exposures to member(s) of the public at the site boundary and to the general population that differ from those previously estimated in the license application and amendments thereto;

6. A comparison of the predicted releases of radioactive materials, in liquid and gaseous effluents and in solid waste, to the actual releases for the period prior to when the changes are to be made;

7. An estimate of the exposure to plant operating personnel as a result of the change; and

8. Documentation of the fact that the change was reviewed and found acceptable by ISR.

B. Shall become effective upon review and acceptance by ISR and approval by the manager responsible for overall operational activities.

REFERENCES

A. Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I," U.S. Nuclear Regulatory Commission, Revision 1, October 1977.

B. XOQDOQ: Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Plants, NUREG/CR-2919, 1982.

C. Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water Cooled Reactors," U.S. Nuclear Regulatory Commission, Rev. 1, July 1977.

D. National Bureau of Standards, "Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure," Handbook 69, June 5, 1959.

E. Slade, D. H., "Meteorology and Atomic Energy - 1968, USAEC, July 1968.

F. Lowder, W. M., P. D. Raft, and G. dePlanque Burke, "Determination of N-16 Gamma Radiation Fields at BWR Nuclear Power Stations," Health and Safety Laboratory, Energy Research and Development Administration, Report No. 305, May 1976.

G. Letter from Charles L. Miller of the United States Nuclear Regulatory Commission to John F. Schmidt of the Nuclear Energy Institute, dated December 26, 1995.

H. "Dose vs Distance From HI-STORM 100S Containing MPC-68 and MPC-68M for Vermont Yankee ISFSI" Holtec Report No: HI-2146076, Holtec Project No: 2347, Approved on 04/13/2017. (VY-RPT-17-0002)

I. Certificate of Compliance, Holtec International, Final Safety Analysis Report, Amendment 2, 06/07/05. (HI-STORM 1-13)

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