UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION I
475 ALLENDALE ROAD
KING OF PRUSSIA, PA 19406-1415

September 20, 2011

Mr. Michael Colomb
Site Vice President
Entergy Nuclear Operations, Inc.
Vermont Yankee Nuclear Power Station
185 Old Ferry Road
P.O. Box 500
Brattleboro, VT 05302-0500

SUBJECT: VERMONT YANKEE NUCLEAR POWER STATION – GROUNDWATER MONITORING INSPECTION REPORT 05000271/2011010

Dear Mr. Colomb:

On August 30, 2011, the U.S. Nuclear Regulatory Commission (NRC) completed a groundwater monitoring and radioactive effluents inspection at the Vermont Yankee Nuclear Power Station. Based on the results of this inspection, no findings were identified. The enclosed inspection report documents the results of our inspection. The inspection results were discussed with you, and other members of your staff, on August 30, 2011. This inspection was conducted from May 9 to August 30, 2011 and included an office review of your Conceptual Site Model (CSM) report entitled "Hydrogeologic Investigation of Tritium in Groundwater" (received May 2011), and a revised Offsite Dose Calculation Manual (received July 2011). The purpose of the inspection was to assess your performance relative to the continued monitoring and remediation of residual onsite groundwater contamination of a previous Advanced Off-Gas pipe tunnel leak. The inspectors: (1) reviewed your actions to establish a groundwater monitoring program and protocols to monitor and assess the residual contaminant plume condition; (2) reviewed your development of a CSM on which to base your Long-Term Groundwater Monitoring Program (LTGWMP), including remediation activities; and (3) examined the methods applied to assess and calculate the radiological groundwater effluent release and dose consequence to members of the public.

The inspectors examined activities conducted under your license as they relate to safety and compliance with the Commission's rules and regulations, and with the conditions of your license. The inspection involved field walkdowns; observations of monitoring wells and groundwater sampling activities; examination of selected procedures, calculations and examination of records; interviews with station personnel; and detailed technical discussions with your staff and contractor on the field monitoring data and its analysis including numerical simulations of the groundwater system and scenarios.

NRC inspectors confirmed that Entergy Nuclear-Vermont Yankee (ENVY): effectively evaluated the contaminated groundwater with respect to off-site effluent release limits; properly evaluated the resultant radiological impact to the public's health and safety; and complied with all applicable regulatory requirements and standards pertaining to radiological effluent monitoring, dose assessment, and radiological evaluation. Based on completion of these inspection activities, the NRC has determined that the exit criteria contained in the April 5, 2010, Deviation

Memorandum (ADAMS Accession No. ML100960321) regarding Vermont Yankee groundwater inspection activities, have been met and our inspection efforts in this area will return to those described in the Reactor Oversight Process (ROP) baseline inspection program. In addition, in our May 20, 2010, inspection (IR No. 05000271/2010006, ADAMS Accession No. ML101400040) conducted in accordance with Temporary Instruction (TI) 2515/173, "Review of the Implementation of the Industry Groundwater Protection Voluntary Initiative," we assessed whether your groundwater protection program implemented the elements of the voluntary industry Groundwater Protection Initiative (NEI 07-07) and determined that you had not implemented all of the necessary procedures and processes elements to respond to a leak or spill of radioactive material to groundwater. Since the time of that inspection, we have found that you have now installed all of the necessary procedures and process elements, and fully implemented the voluntary industry Groundwater Protection Initiative.

While it was determined to not be an issue of regulatory import, the inspectors did assess the efficacy and potential benefits of sampling the construction office building (COB) well. This is discussed in the report details.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice," a copy of this letter, its enclosure, and your response (if any) will be available electronically for the public inspection in the NRC Public Docket Room or from the Publicly Available Records component of NRC's document system Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

Christopher G. Miller, Director
Division of Reactor Safety

Docket No. 50-271
License No. DPR-28

Enclosure:
Inspection Report 05000271/2011010
w/Attachments: Supplemental Information

cc w/Encl.: Distribution via ListServ

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/RA/

Christopher G. Miller, Director
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*see previous concurrences

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U. S. NUCLEAR REGULATORY COMMISSION

REGION I

Docket No.:	50-271
License No.:	DPR-28
Report No.:	05000271/2011010
Licensee:	Entergy Nuclear Operations, Inc.
Facility:	Vermont Yankee Nuclear Power Station
Location:	320 Governor Hunt Road Vernon, Vermont 05354-9766
Dates:	May 9 – August 30, 2011
Inspectors:	J. Noggle, CHP, Senior Health Physicist, Team Leader T. Nicholson, Sr. Technical Advisor for Radionuclide Transport Office of Nuclear Regulatory Research (RES) T. Mack, Supervisory Hydrogeologist, U.S. Geological Survey (USGS)
Approved by:	Pamela J. Henderson, Chief Plant Support Branch 2 Division of Reactor Safety

SUMMARY OF FINDINGS

IR 05000271/2011010; 05/09/2011 – 08/30/2011; Vermont Yankee Nuclear Power Station; Contaminated Groundwater Monitoring and Effluent Controls Inspection.

The report covers both the event and follow-up activities related to the tritium groundwater contamination condition at Vermont Yankee Nuclear Power Station that was previously reported in IR No. 05000271/2010010, January 7, 2011; and the effluent monitoring and controls program. The NRC's program for overseeing the safe operation of commercial nuclear power reactors is described in NUREG-1649, "Reactor Oversight Process," Revision 4, dated December 2006.

This report also covers the licensee's follow-up actions to address gaps that were identified in their implementation of the voluntary Industry Groundwater Protection Initiative (Nuclear Energy Initiative 07-07).

No findings were identified.

EXECUTIVE SUMMARY

Background:

On January 7, 2010, Entergy Nuclear -Vermont Yankee (ENVY) representatives informed the NRC that tritium was detected in a groundwater monitoring well (GZ-3) at an initial concentration of approximately 17,000 picocuries per liter (pCi/L). ENVY initiated a prompt investigation to identify the source of the tritium. The investigation included mapping of the groundwater tritium plume and investigating potential structures, systems, and components, such as buried pipes and tanks, to determine possible sources and causes of the contamination. As a result of this effort, ENVY successfully identified the cause (an underground pipe tunnel that contained leaking components associated with the Advanced Off-Gas (AOG) system) and subsequently terminated the source of the contamination in February 2010.

On January 25, 2010, Region I initiated an inspection of this abnormal release event to examine the licensee's performance, and determine if the contaminated groundwater affected, or could affect, public health and safety. This inspection included the combined efforts of Region I-based inspectors, as well as a hydrogeologist from NRC's Office of Nuclear Regulatory Research (RES), and the U.S. Geological Survey's (USGS) New Hampshire/Vermont Office. The inspection included continuing review and assessment of ENVY's performance and response to the groundwater contamination event, including the licensee's actions to monitor and assess the on-site groundwater contamination condition sufficiently to assure public health and safety, and protection of the environment.

Status of ENVY's Groundwater Contamination Monitoring:

As reported in the licensee's Conceptual Site Model (CSM) "Hydrogeologic Investigation of Tritium in Groundwater at Vermont Yankee Nuclear Power Station" report, analysis of the characterization and monitoring data indicate that the direction of groundwater flow is toward the Connecticut River. On-site drinking water sources and off-site drinking water sources in Vernon, Vermont are upgradient of the tritium plume and would not be affected. Similarly, off-site drinking water sources in Hinsdale, New Hampshire are upgradient and would not be affected. Based on review of all available information and data to date, there continues to be reasonable assurance that public health and safety has not been, nor is expected to be, adversely affected by the current on-site groundwater contaminant plume condition.

ENVY's hydrogeological investigations and groundwater flow and transport measurements and methods were reasonable and accurate in establishing an estimate of the total groundwater effluent released to the Connecticut River, and the resulting public dose impacts of these releases for 2009 and 2010. The calculational method and estimates have been verified by the NRC to also be reasonable and accurate. Dose calculations were reviewed and independently verified by the NRC, and determined to be a small fraction of the "As Low As is Reasonably Achievable" dose objective specified in 10 CFR Part 50, Appendix I for liquid effluent releases (i.e., significantly less than 3 mrem in a year). NRC verified that ENVY appropriately and accurately reported the abnormal groundwater effluent releases for 2009 and 2010, and thus was in compliance with applicable NRC regulatory requirements.

NRC Evaluation of ENVY's Groundwater Monitoring Performance:

- Inspectors determined that there has been no impact to public health and safety due to the groundwater contamination event. Plant-related radioactivity, including tritium has not been detected in any on-site or off-site drinking water well (except in the Construction Office Building (COB) well, which was removed from use in January 2010 when the tritium release was detected in a nearby well GZ-3) or at any off-site environmental monitoring location.

- Inspectors concluded that ENVY is continuing to implement groundwater and environmental monitoring protocols to provide on-going radiological oversight and assessment of the on-site contaminated groundwater condition to confirm that public health and safety is not, nor is expected to be, adversely affected.

- Inspectors determined that the licensee implemented actions that conformed to the radiological survey requirements of 10 CFR 20.1501 to ensure compliance with dose limits for individual members of the public as specified in 10 CFR 20.1302.

- Inspectors determined that ENVY's May 2011 CSM report "Hydrogeologic Investigation of Tritium in Groundwater at the Vermont Yankee Nuclear Power Station," provides an effective technical basis for determining groundwater flow and transport parameters to support on-site groundwater effluent release determinations.

- Inspectors found that ENVY has significantly enhanced its on-site groundwater monitoring since the initial discovery of the tritium plume. ENVY has completed its Long-Term Groundwater Monitoring Program (LTGWMP), including updating the licensing basis in the Final Safety Analysis Report (FSAR); and its revision of the Offsite Dose Calculation Manual (ODCM), to include the current characterization of the hydrologic flow and transport conditions and processes related to tritium migration. The CSM, LTGWMP, and ODCM provide tools for assessing future abnormal releases involving radionuclide transport, groundwater monitoring locations and sampling frequencies, and a method for calculating public dose based upon site-specific data.

Status of ENVY's Response to NEI 07-07:

In a previous inspection (IR No. 05000271/2010006) in accordance with TI 2515/173, the NRC identified a number of gaps in Entergy's implementation of the voluntary Industry Groundwater Protection Initiative as specified in Nuclear Energy Institute (NEI) 07-07 "Industry Groundwater Protection Initiative – Final Guidance Document" issued August 2007. Since the Spring of 2010, ENVY conducted a significant amount of hydrogeologic investigative work and program improvements to implement NEI 07-07 at the site. The NRC reviewed these actions and determined that ENVY has now fully implemented the voluntary Industry Groundwater Protection Initiative.

REPORT DETAILS

2. RADIATION SAFETY

Cornerstone: Occupational/Public Radiation Safety (PS)

2RS6 Radioactive Gaseous and Liquid Effluent Treatment (71124.06)

a. Inspection Scope (1 Sample)

The licensee's program was evaluated against the requirement to provide adequate protection of the public from effluent releases resulting from normal operations of the plant by maintaining the dose to the maximally exposed member of the public as far below the dose limits in 10 CFR Part 20 and 40 CFR Part 190, as is reasonably achieveable (ALARA). General Design Criterion 60 in 10 CFR Part 50, Appendix A, requires the control and appropriate mitigation of radioactive materials released as plant effluents. In addition, Paragraph 50.34a (and the associated Appendix I) to 10 CFR Part 50 provides dose based design criteria to ensure the effectiveness of plant effluent processing systems in maintaining effluent releases to the plant environs ALARA.

Event Report and Effluent Report Reviews

The inspector reviewed the ENVY 2009 and 2010 Annual Radiological Effluent Release Reports. Both of these reports included documentation of groundwater effluent releases to the Connecticut River and commensurate doses to the "maximally exposed member of the public" (a child) with comparison to regulatory limits. The inspector determined that the reports were submitted as required by the Off-site Dose Calculation Manual (ODCM)/Technical Specifications. The inspector identified radioactive effluent monitor operability issues reported by the licensee as provided in effluent release reports, and determined that the issues were entered into the corrective action program and adequately resolved.

ODCM and FSAR Reviews

The inspector reviewed changes to the ODCM made by the licensee since the last inspection, against the guidance in NUREG-1301, 1302, and 0133, and Regulatory Guides 1.109, 1.21, and 4.1. The inspector determined that the licensee had not identified any non-radioactive systems that had become contaminated as disclosed either through an event report or are documented in the ODCM since the last inspection. The ODCM and Final Safety Analysis Report (FSAR) were revised to include groundwater pathway effluent calculations and more detailed description of the site groundwater flow and transport parameters. Of note, the ODCM Revision 34, (which is discussed in detail in Section 4OA3.3 of this report) contains a groundwater, well-specific, groundwater flux calculation methodology that specifies the basis for the current groundwater effluent calculations, as well as providing a basis for any future subsurface leak from other locations at the plant.

Groundwater Protection Initiative (GPI) Program

The inspector reviewed the reported groundwater monitoring results, and changes to the licensee's written program for identifying and controlling contaminated spills/leaks to groundwater. In a previous inspection (IR No. 05000271/2010006) using Temporary Instruction (TI) 2515/173, the NRC identified a number of gaps in Entergy's implementation of the voluntary industry GPI as specified in Nuclear Energy Institute (NEI) 07-07 "Industry Groundwater Protection Initiative – Final Guidance Document" issued August 2007. Since the Spring of 2010, ENVY has conducted a significant amount of hydrogeologic investigative work at the site, including the installation of 29 additional monitoring wells, determination of site-specific groundwater flow and transport conditions and parameters, and establishment of a site-specific groundwater monitoring program. The licensing basis has recently been revised that includes the ODCM and the FSAR. In addition, a management oversight group was established to review the site-specific groundwater monitoring program and procedures. These program improvements were reviewed during the Spring and Summer of 2011, with respect to the criteria set forth in NEI 07-07. The review determined that ENVY has now fully implemented the voluntary industry Groundwater Protection Initiative.

Walkdowns and Observations

The inspector walked down selected components of the gaseous and liquid discharge systems to verify that equipment configuration and flow paths align with the FSAR documented descriptions, and reviewed and assessed equipment material conditions. For equipment or areas associated with the systems cited above that were not readily accessible due to radiological conditions, the inspector reviewed the licensee's material condition surveillance records. The inspector walked down those filtered ventilation systems whose test results were reviewed during the inspection. The inspector verified that there were no conditions, such as degraded high efficiency particulate air (HEPA)/charcoal banks, improper alignment, or system installation issues that would impact the performance, or the effluent monitoring capability of the effluent system. The inspector determined that the licensee had not made any significant changes to their effluent release points.

The inspector observed the routine processing and discharge of effluents (including sample collection and analysis). The inspector verified that appropriate effluent treatment equipment was being used and that untreated groundwater effluent was designated as an abnormal liquid effluent, and its discharge into the Connecticut River was appropriately calculated and reported in accordance with ODCM specifications, and in accordance with 10 CFR Part 50, Appendix I regulatory limits.

Sampling and Analyses

The inspector selected effluent sampling activities and verified that adequate controls had been implemented to ensure representative samples are obtained (e.g. provisions for sample line flushing, vessel recirculation, composite samplers, etc.). The inspector determined that the facility was not routinely relying on the use of compensatory

sampling, in lieu of adequate system maintenance, based on the frequency of compensatory sampling since the last inspection.

The inspector reviewed the results of the inter-laboratory comparison program to verify the quality of the radioactive effluent sample analyses. The inspector verified that the inter-laboratory comparison program include hard-to-detect radioisotopes as appropriate. Groundwater sample measurements included selected back-up measurement comparison from an outside commercial laboratory to provide lower limits of detection than onsite laboratory tritium measurements, and to confirm laboratory quality control.

Instrumentation and Equipment

Effluent Flow Measuring Instruments

The inspector reviewed the methodology that the licensee uses to determine the effluent stack and vent flow rates. The inspector verified that the flow rates are consistent with radiological effluents technical specifications (RETS)/ODCM or FSAR values, and that differences between assumed and actual stack and vent flow rates do not affect the results of the projected public doses.

Air Cleaning Systems

The inspector verified that surveillance test results since the previous inspection for Technical Specification required that ventilation effluent discharge systems (High Efficiency Particulate Air (HEPA) and charcoal filtration) meet Technical Specification acceptance criteria.

Dose Calculations

The inspector reviewed one gaseous waste discharge permit. The inspector verified that the projected dose to members of the public were accurate and based on representative samples of the discharge path. The inspector evaluated the methods used to determine the isotopes in the source term to ensure all applicable radionuclides were included, within detectability standards. The inspector reviewed the current 10 CFR Part 61 analyses to ensure hard-to-detect radionuclides were included in the source term.

The inspector reviewed changes in the licensee's offsite dose calculations since the last inspection. The inspector verified that the changes were consistent with the ODCM and Regulatory Guide 1.109. The inspector reviewed meteorological dispersion and deposition factors used in the ODCM and effluent dose calculations to ensure appropriate factors were being used for public dose calculations. The inspector reviewed the latest Land Use Census and verified that changes have been factored into the dose calculations.

GPI Implementation

The inspector reviewed the identified leakage or spill events, and the ENVY entries recorded in their decommissioning file as required by paragraph 50.75 (g) in 10 CFR Part 50. The inspector verified that the January 7, 2010, Advanced Off-Gas (AOG) leak event was documented in the decommissioning file, which also included records of trace contaminants besides tritium, that were detected in soil around the prior AOG leak location and in soil samples taken during on-site well drilling operations.

The inspector verified that on-site groundwater sample results and a description of any significant on-site leaks/spills into groundwater for each calendar year were documented in the Annual Radiological Environmental Operating Report (AREOR) for radiological environmental monitoring program (REMP) or the Annual Radiological Effluent Release Report (ARERR) for the RETS.

Problem Identification and Resolution

The inspector verified that problems associated with the effluent monitoring and control program were being identified by the licensee at an appropriate threshold and were properly addressed for resolution in the licensee corrective action program.

b. Findings and Observations

No findings were identified.

4. OTHER ACTIVITIES

4OA2 Problem Identification and Resolution

Background

In January 2010, following the licensee's detection of on-site groundwater tritium contamination, the NRC inspection team determined that the licensee's subsurface Conceptual Site Model (CSM) of the Vermont Yankee (VY) site, which had been developed in response to the NEI 07-07 GPI, was not sufficiently detailed. The NRC team found the initial CSM did not: (1) provide sufficient specificity to identify the source area for the H-3 (tritium) leak; (2) include fundamental definition of the groundwater flow and transport units (e.g., depths and extents); and (3) include the hydraulic and transport relationships and parameters. Based upon hydrogeologic investigations begun in response to the tritium leak, ENVY significantly updated the CSM to account for site-specific groundwater flow and transport processes, properties and conditions as documented in their May 2011 report "Hydrogeologic Investigation of Tritium in Groundwater."

The initial detection of the tritium leak was in monitoring well GZ-3 (see Attachment A, Figure 1) located on the Connecticut River bank. The source of the contamination was not readily discernable due to an absence of monitoring wells adjacent to the plant systems, structures and components (SSC) that contain radioactive fluids, as

recommended in the NEI 07-07 Groundwater Protection Initiative. Subsequently, ENVY examined numerous candidate SSCs for possible sources of the leak, and then installed a series of groundwater monitoring wells to aid in identifying the tritium leak source. By February 6, 2010, monitoring well GZ-10 was installed next to the AOG building where subsurface pipes within a pipe tunnel conveyed fluids carrying radionuclides. The GZ-10 monitoring data was instrumental in determining the specific leak location which was the underground concrete pipe tunnel associated with the AOG system. The initial tritium concentration at GZ-10 was approximately 2.5 million pCi/L. By November 15, 2010, the licensee completed installation of 29 new groundwater monitoring wells to identify the extent of the tritium plume and its behavior (i.e., flow directions and rates).

a. Inspection Scope

The licensee initiated Condition Report, CR-VTY-2010-0541, on February 8, 2010, to assess and correct gaps in their implementation of the NEI Industry Groundwater Protection Initiative, NEI 07-07, based on findings from an NEI peer review on January 25, 2010; and the subsequent identification of deficiencies by an NRC inspection conducted in accordance with TI 2515-173. The status of this condition report was previously reviewed and documented in Inspection Report No. 05000271/2010006 issued on May 20, 2010 (ADAMS Accession No. ML101400040).

During the current inspection, the NRC inspection team reviewed the remaining groundwater monitoring program elements which were incomplete at the time of the earlier inspection. The NRC inspection focus was to confirm and assess ENVY's actions relative to the establishment, implementation, and maintenance of a Long-Term Groundwater Monitoring Program (LTGWMP). The LTGWMP was designed to oversee and assess the current groundwater contamination conditions, and have the capability to detect new or changed groundwater conditions and potential future releases.

b. Findings and Observations

No findings were identified.

The NRC team determined that the licensee did establish a set of site-specific groundwater monitoring program procedures. Administrative Procedure PP-GPP-7605, "Groundwater Protection Program," established a station management review group, *the Groundwater Protection Expert Panel* (GPEP), to oversee and approve the groundwater monitoring program processes and procedures to include: (1) contamination risk profile, including the assessment of station work practices that may adversely affect groundwater contamination; (2) site-specific groundwater monitoring plan; and (3) the updating of the groundwater-related licensing documents, such as the FSAR, to reflect current hydrogeology information and analyses, and the ODCM, to indicate groundwater monitoring locations and frequencies, and a groundwater effluent pathway dose calculation methodology.

The GPEP approved the current set of groundwater monitoring procedures; the groundwater monitoring plan; a revision to FSAR Section 2.4 to update the hydrogeology description of the site; and Revision No. 34 of the ODCM, which captures the

groundwater effluent release calculation methodology. NRC has determined that ENVY has satisfactorily completed the previous outstanding items in CR-VTY-2010-0541.

4OA3 Event Follow-up (IP 71153 – 1 sample)

.1 Groundwater Tritium Contamination

a. Inspection Scope

The scope of this inspection included a continuing review of ENVY's groundwater monitoring program to assess the residual on-site groundwater tritium contamination conditions and ENVY's remediation efforts, as well as the licensee's actions to complete their LTGWMP to effectively assess the current groundwater conditions, and their ability to detect any future leaks that may impact the groundwater both onsite and offsite. In addition to NRC health physics specialists and NRC hydrogeologists, a U.S. Geological Survey (USGS) supervisory hydrogeologist from the USGS New Hampshire/Vermont Office also participated in this inspection.

During this inspection effort, the inspectors met and discussed groundwater, geophysical survey, and tritium migration issues with ENVY technical and management personnel and contractors; reviewed data, records, technical drawings, and procedures; observed monitoring well activities including remedial extractions and processing; and conducted direct inspection and observed the licensee's and their contractor's performance over the course of several on-site visits. NRC inspectors also reviewed ENVY's remedial actions to extract contaminated groundwater from the highest concentration center of the plume, which began on March 25, 2010.

NRC inspectors reviewed ENVY's investigations; numerous site hydrogeology, geophysical and radionuclide survey activities; measurement of groundwater gradients in the overburden and bedrock hydrogeologic units; estimates of hydraulic and transport parameters; numerical simulation studies of groundwater flow at the site for a variety of pumping well scenarios; and ENVY's determination of the extent of radionuclide release. The inspectors also reviewed the use of this information to support the calculation of radiological liquid effluent releases from the previous AOG tunnel leakage via the groundwater pathway, and calculation of the corresponding safety impact of radiation dose to the public due to this abnormal groundwater effluent release.

b. Findings and Observations

No findings were identified.

Tritium Contamination Measurement

After the AOG pipe leak was terminated on February 15, 2010, the monitoring well sample results tracked the tritium contamination movement east across the site towards the Connecticut River. Based on ENVY's hydrogeologic investigations which included well hydraulic tests, soils closest to the AOG pipe leak were more porous with higher hydraulic conductivity that allowed for more rapid groundwater flow and subsequent

tritium migration over a few months (e.g., GZ-10, GZ-20, and GZ-15), while the less porous soils to the east, were less conductive (lower hydraulic conductivity) to groundwater flow and subsequently, the tritium contamination transport slowed as the plume progressed further east to the river bank, with a migration time interval on the order of one to two years (e.g., GZ-14, GZ-3, and GZ-4). Trend plots of the tritium plume migration demonstrating this response are included in Attachment A of this report. The groundwater monitoring well data continues to support the CSM of predicted groundwater flow in the overburden and shallow water table units.

Near the end of 2010, monitoring well GZ-24 indicated measurable tritium contamination which peaked in early 2011 at about 9,000 pCi/L (below the Environmental Protection Agency (EPA) drinking water standard for tritium of 20,000 pCi/L). Subsequently, another nearby monitoring well, GZ-6, also revealed trace levels of tritium (plots of these results are provided in Attachment A). The CSM does not account for this discovery based on the existing tritium plume migration, and ENVY promptly initiated an investigation to identify its source. The monitoring frequency of these two wells was increased to several times per week. Weekly status calls with the NRC and the State of Vermont were held to discuss these investigation results. Five subsurface pipe lines were identified in the immediate area of these two wells. One of these was an AOG passive drain line which was determined by ENVY to be unnecessary for continued plant operations. This line was subsequently permanently removed from service. Other parallel efforts, that are ongoing at the time of this inspection report, include tracer gas injection and leak detection monitoring of the other four subsurface pipe lines. Based on the prompt retiring of the AOG drain line, samples from monitoring wells GZ-24 and GZ-6 since early April 2011, have returned to less than detectable radioactivity thus exhibiting no indication of a continuing leak to groundwater. Although the original cause of the tritium activity has not been concluded at this time, the actions taken by ENVY to respond to the tritium activity detected in GZ-24 and GZ-6, by initiating an investigation to address the potential leak, was a practical demonstration of the recently completed LTGWMP (groundwater monitoring program) in action, and appears to have successfully minimized a groundwater effluent release.

Hydrogeology Assessment

1.0 Conceptual Site Model (CSM)

ENVY's "Hydrogeologic Investigation of Tritium in Groundwater at Vermont Yankee Nuclear Power Station" (CSM) was completed in May 2011. The development and testing of the CSM was reviewed during this inspection. Although not an NRC regulatory requirement, the development and testing of a CSM was identified in NEI-07-07, "Industry Groundwater Protection Initiative – Final Guidance Document," dated August 2007, which directs nuclear plant operators to: "Perform hydrogeologic and geologic studies to determine predominant groundwater flow characteristics and gradients." The CSM provides detailed information derived from site and regional groundwater studies conducted between January and December 2010. This study included a review of previous site hydrogeological information; the installation of 29 additional onsite groundwater monitoring wells outfitted with pressure transducers to determine groundwater gradients and flow directions; and down-hole geophysical surveys and

measurements conducted in six onsite and offsite bedrock aquifer drinking water wells. This work followed an iterative investigative approach to determine the location and extent of the tritium plume and its behavior including well specific concentrations and gradients. The study further investigated the vertical depth of the tritium plume in the overburden (soil overlaying the bedrock), and limited investigation of the bedrock aquifer. The CSM provided effective horizontal definition and spatial relationships in the overburden but did not determine the depth of tritium plume penetration into the bedrock aquifer down gradient of the plant.

To investigate the vertical extent of the tritium plume, ENVY developed six deep overburden monitoring wells that terminated just above the bedrock interface (specifically wells GZ-12D, GZ-13D, GZ-14D, GZ-18D, GZ-19D, and GZ-22D). Subsequent groundwater samples showed a wide range of tritium concentrations with some of these wells indicating less than 2,000 pCi/L. This range along with groundwater transducer data indicating an upward and horizontal flow to the Connecticut River, implies the potential for very little downward migration to the underlying bedrock interface. However, sample results from two wells (GZ-12D and GZ-22D), indicated concentrations of 65,000 and 500,000 pCi/L respectively, suggesting the potential for downward migration to the underlying bedrock aquifer if local groundwater gradients and diffusion favor it. Limited packer testing was conducted in the COB well using a series of packed off intervals corresponding to interpreted fracture locations from the down-hole geophysical surveys. Sampling only was conducted in the lowest two intervals of the well. Initially, ENVY expressed concern that there may be a vertical leak path from the overlying tritium plume in the overburden unit to the bedrock aquifer by way of the COB well annulus and around the bottom of the steel well casing. Therefore ENVY directed that further testing and sampling cease. Since that time, ENVY refurbished the COB well to prevent potential leakage past the well casing, and to establish the COB well as a potential environmental monitoring well. ENVY has indicated that there are technical reasons why low-flow sampling would not be feasible to collect representative samples, and that sampling may create downward migration of the tritium into the bedrock aquifer. However, inclusion of the COB well in ENVY's LTGWMP could serve as a sentinel well to provide an early indicator of contaminant migration to the bedrock aquifer, and detailed information for consideration in remediation decisions.

NRC and USGS scientists are confident that there are existing methods to collect sufficient volumes at appropriate well depth locations for water sampling in the retrofitted COB well. Based upon details provided on the COB retrofitting in the ENVY CSM report, sampling in the present COB well would not lead to vertical migration around the well casing into the bedrock aquifer. The sand pack around the inside PVC may well attenuate tritium emanating from one of the contributing fractures but would not preclude confidence in detecting tritium in high concentrations (above the Lower Limit of Detection) in the retrofitted COB well. There are existing industry methods that would be suitable for sampling the COB well for hydraulic gradients and the presence of tritium.

2.0 Remediation Program

ENVY implemented a remediation program on March 25, 2010, to extract contaminated groundwater in the highest concentration center of the plume using well EW-1A. This activity was suspended on November 8, 2010, after removal of the targeted 307,000 gallons of tritiated groundwater. Following discussions with Vermont State officials, this remedial activity was restarted on December 30, 2010, from GZ-14 and GZ-22D, which at that time represented the groundwater well locations with the highest tritium concentrations. The initial extraction activity removed approximately 300 mCi or approximately 10 percent of the total tritium activity, and assisted in decreasing the plume's concentration and extent in and around the AOG concrete pipe tunnel. The objective of the licensee's remediation program is to minimize releases of tritium to the Connecticut River. Based on the very low radiation dose hazard associated with the residual groundwater tritium plume, there are no NRC requirements for active remediation.

3.0 Long-Term Groundwater Monitoring Program

The "Vermont Yankee Groundwater Monitoring Plan" was approved by the GPEP on June 28, 2011. In this document, each monitoring well is described, categorizing each as either a sentinel or perimeter well. These well categories are related to the "streamtube groundwater model" in the ODCM. The perimeter wells are close to the "perimeter" (boundary) of the Vermont Yankee site, and are located near the shoreline of the Connecticut River bank, where the sampled tritium concentrations are used as representative values for each defined "stream tube" in effluent release calculations. Sentinel wells are close to potential subsurface sources of radioactivity such as underground pipes or tanks, and are designated for monthly sampling frequency, while the perimeter wells are designated for quarterly sampling frequency. Based on the groundwater transport conditions as described in the CSM, these sampling frequencies appear reasonable and support the required quarterly effluent release calculations.

Annual licensee review of the groundwater monitoring program, and continued ongoing review of water table measurement results to confirm the validity of the CSM provide reasonable assurance of the efficacy of the established groundwater monitoring program. As mentioned previously in this report, any change in the groundwater flow conditions, such as cessation of extraction well activities, may trigger a need for more frequent monitoring and hydrogeologic evaluation to reestablish baseline conditions. ENVY continues to implement groundwater and environmental monitoring protocols that provide on-going radiological oversight and assessment of the onsite residual contaminated groundwater sufficient to confirm that public health and safety has not been affected.

Off-site Dose Calculation Manual

The revised ODCM includes listing of site-specific hydrologic parameters taken from the CSM report, and a simplified "stream tube" mathematical model based on Darcy's law, to calculate and evaluate current and future groundwater pathway liquid effluent releases. These estimates assess potential impacts to the public and environment in a

clear and simple manner. The revised ODCM (Revision 34 dated July 8, 2011) documents the VY groundwater release model which uses the "stream tube" concept to identify and partition the groundwater pathways in the overburden units, and estimate radionuclide fluxes to the accessible environment at each of the perimeter well locations along the Connecticut River. This calculation method establishes a specific hydraulic conductivity at each perimeter well and uses actual water table data to determine hydraulic gradients in the calculation of groundwater flux through each stream tube. The resulting groundwater flow is multiplied by the quarterly sampled tritium concentration from the applicable groundwater monitoring well (i.e., perimeter well) to estimate the tritium flux. These stream tube estimates are then totaled to determine the cumulative groundwater radioactive effluent release to the environment for each calendar quarter, as well as calculation of the dose impact to the public, as previously established in the ODCM.

The revised ODCM also identifies the groundwater potable wells to be sampled and their sampling frequency as part of the REMP. The revised ODCM indicates that the Southwest Well will be sampled quarterly for gamma isotopic and tritium analyses. Inspectors observed that the COB well, which is directly below the observed and monitored tritium contaminant plume, is not identified for sampling in the REMP portion of the ODCM. Tritium concentrations exceeding background levels but well below the EPA drinking water standard (i.e., 20,000 pCi/L) were observed in the lower portion of the COB well during an earlier source characterization campaign prior to its refurbishment. At the interface between the bedrock aquifer used for service water at VY, and the overlying "deep overburden" unit, tritium was sampled in GZ-22D with a concentration exceeding 500,000 pCi/L. Subsequently, ENVY agreed to use GZ-22D as an extraction well to minimize the groundwater effluent release. The COB well has been retrofitted as an environmental monitoring well, however, the licensee has no plans to use it as such at this time. If used as a sentinel well it could provide an early indicator of migration of radionuclides into and within the bedrock aquifer.

The revised ODCM identifies the minimum sampling frequency and radionuclide analyses. All the sentinel wells are specified with monthly sampling frequency, which is appropriate since the "stream tube" analysis uses monthly concentration data. The perimeter wells are to be sampled quarterly. Due to possible episodic changes in groundwater recharge and hydraulic gradients, some of the perimeter wells could encounter significant changes in concentrations within the quarterly period, which may not be detected. This may be especially relevant if the extraction well pumpage ceases in wells, GZ-14S and GZ-22D. Inspectors determined that monitoring perimeter wells on a monthly basis within the tritium plume, at least initially following cessation of extraction activities until the groundwater flow conditions become re-established, would ensure sufficient groundwater monitoring to capture this transient condition and the new equilibrium of monitored natural attenuation.

The analysis of "Subsurface Groundwater Pathways to the Connecticut River" section of the ODCM uses a "stream tube" approach. This approach provides for horizontal flow and transport for the "Shallow Overburden" and "Deep Overburden" hydrogeologic units. It fails to mention or consider the "Bedrock Potable Aquifer" hydrogeologic unit. There is significant uncertainty in whether there has been or could be tritium migration into or

future radionuclide transport to and within this unit. The CSM mentions the bedrock potable aquifer but relies upon the assumption that there are "constant upward gradients" from this unit to the overlying "Deep Overburden" unit. Limited monitoring data in the past supports this assumption. However, without monitoring in the COB well for hydraulic gradients there is no opportunity to confirm tritium migration to or within the bedrock potable aquifer. Therefore some uncertainty remains.

Radiological Assessment

Notwithstanding some of the remaining uncertainties in the licensee's CSM and NRC's observations referenced above, the groundwater gradient and flow direction at VY in both the overburden and bedrock aquifers is towards the Connecticut River. There is no current direct drinking water ingestion pathway to any member of the public in the current tritium plume flow path. ENVY's original calculation estimated a total tritium groundwater release for this event of approximately 2.79 Ci. The original estimate assumed a shallow plume without a vertical dispersion. Based on additional investigations that included installation of six deep overburden wells, a vertical broadening of the plume was observed prior to its entering the Connecticut River. This additional groundwater flux area contributed to a slight increase in the effluent release calculation to approximately 4.2 Ci. The perimeter monitoring wells along the Connecticut River shoreline peaked during November of 2010 and have been declining since that time. Therefore the additional tritium being released into the river during 2011 is expected to decrease from the 2010 values.

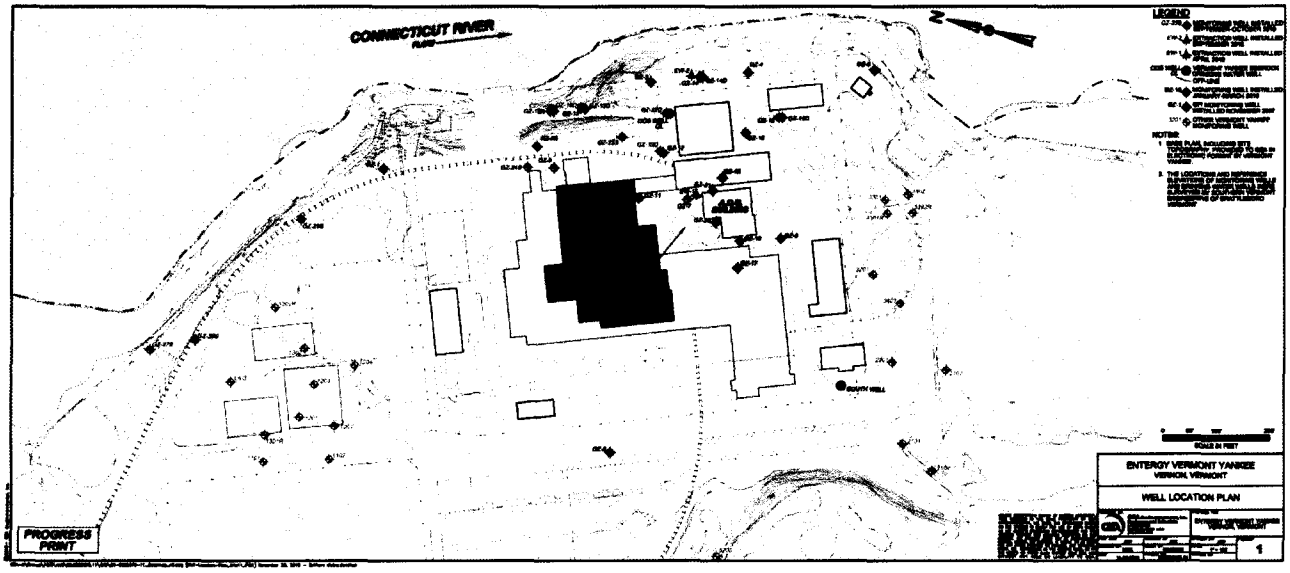
The revised ODCM specifies individual stream tube measurement calculations that include each monitoring well that borders the Connecticut River (i.e., perimeter wells). Based on this approach, the Vermont Yankee groundwater liquid effluent releases reported in the 2009 and 2010 Annual Radioactive Effluent Release Reports indicated 0.4 Ci of tritium was released in 2009 resulting in 0.00005 mrem per year to a maximally exposed member of the public (child), and 3.84 Ci of tritium was released in 2010 resulting in a maximally exposed dose of 0.00056 mrem per year to a child. The dose assessment provided a detailed ingestion pathway and age-group specific dose assessment, as specified in the ODCM. The calculations were reviewed and verified to adhere to the specifications of the ODCM, and the dose assessment methodology reflected 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." These calculations are in accordance with NRC regulatory requirements, and represent a very small fraction of NRC liquid effluent annual public exposure limit of 3 mrem per year.

4OA6 Meetings, including Exit

The inspectors presented the preliminary inspection results to Mr. M. Colomb, and other members of ENVY staff, at an exit meeting on August 30, 2011. The inspectors verified that none of the information in this report is proprietary. One Entergy drawing depicting the onsite groundwater monitoring well map is provided in Attachment A to this report.

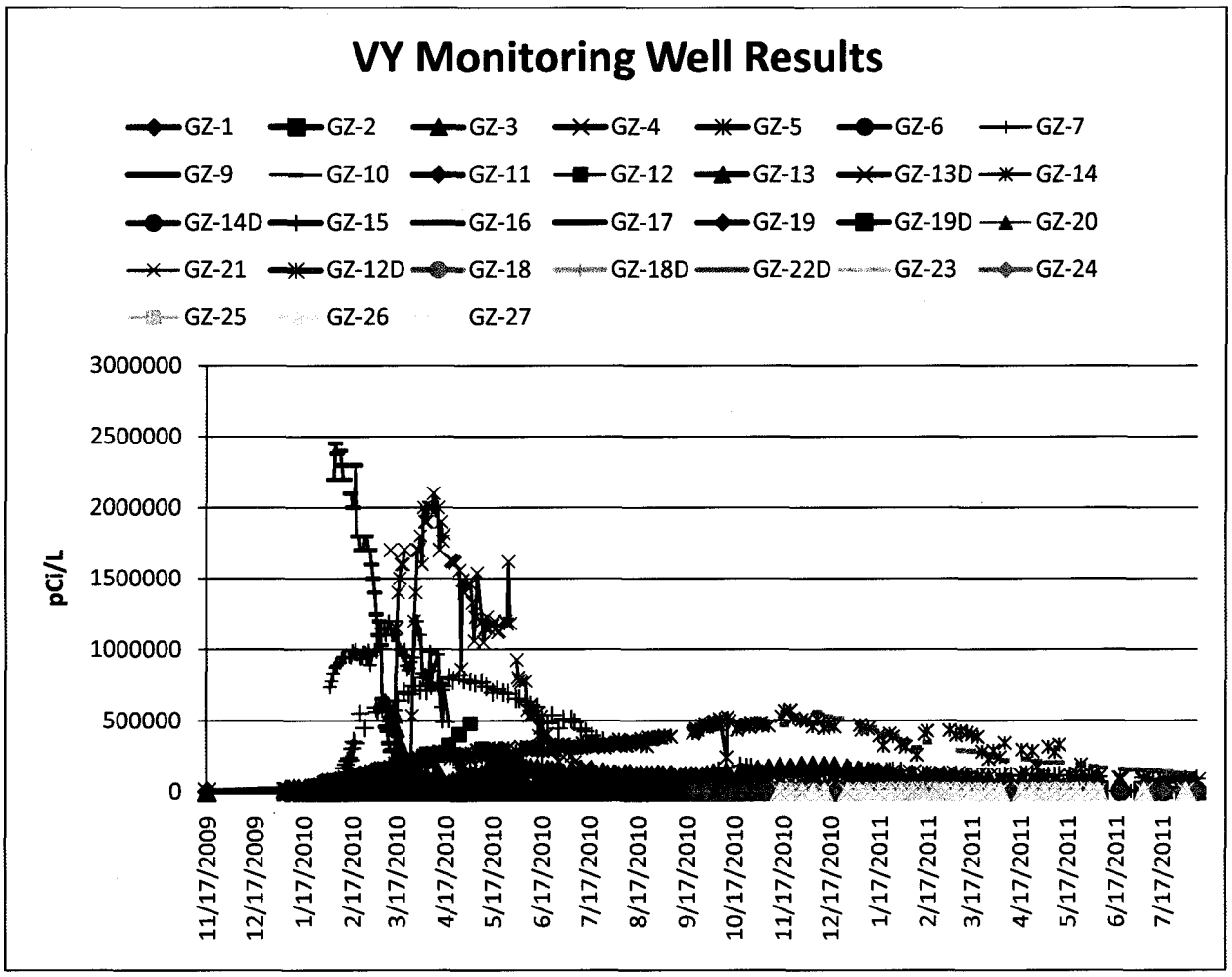
Attachment A

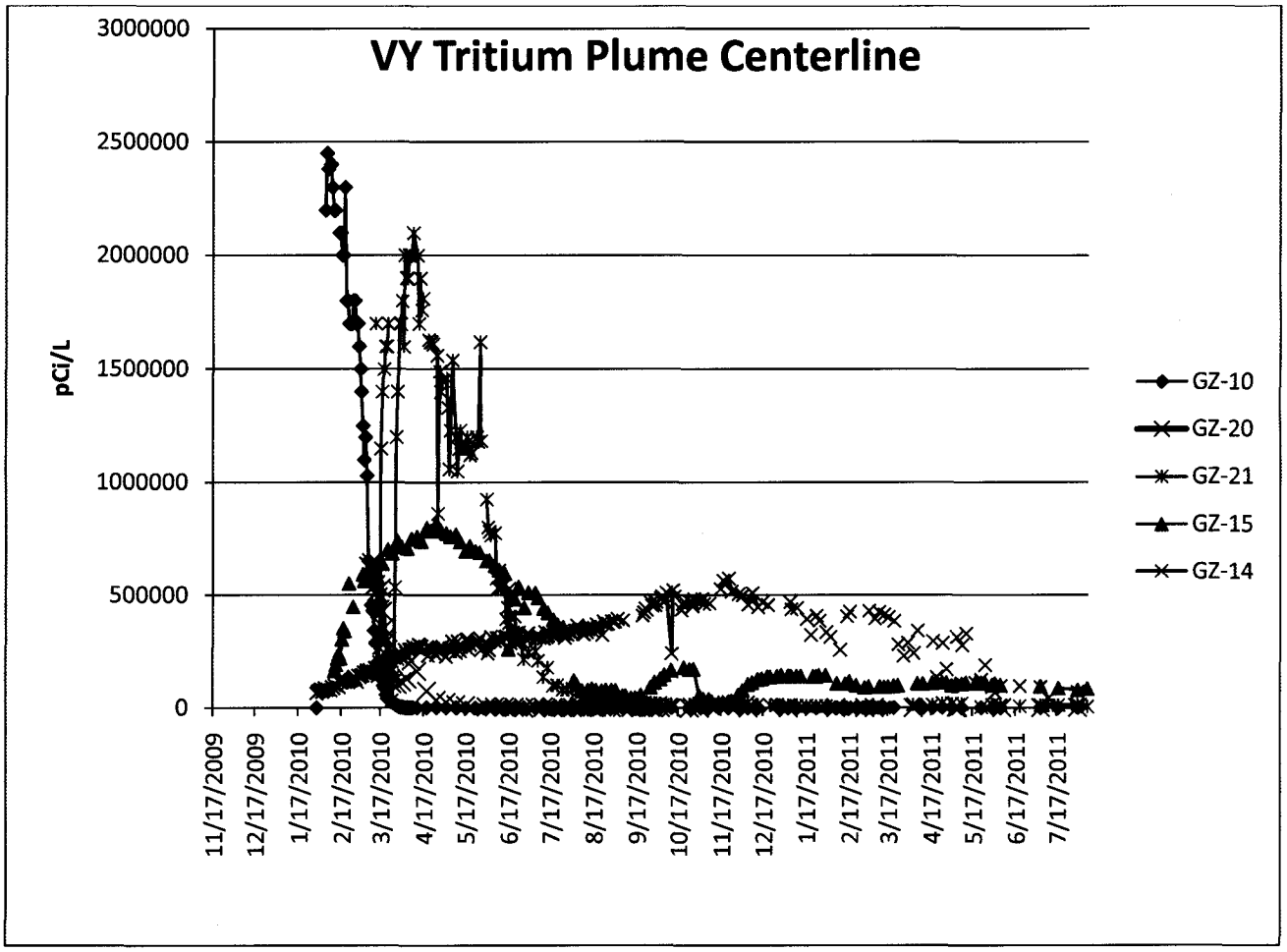
Figure 1, Vermont Yankee Groundwater Monitoring Well Map*



* Indicates a drawing obtained from ENVY for purposes of inspection review and assessment.

Vermont Yankee Groundwater Monitoring Well Tritium Data




VY Tritium Plume Centerline
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1000000
500000
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2/17/2010
3/17/2010
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5/17/2010
6/17/2010
7/17/2010
8/17/2010
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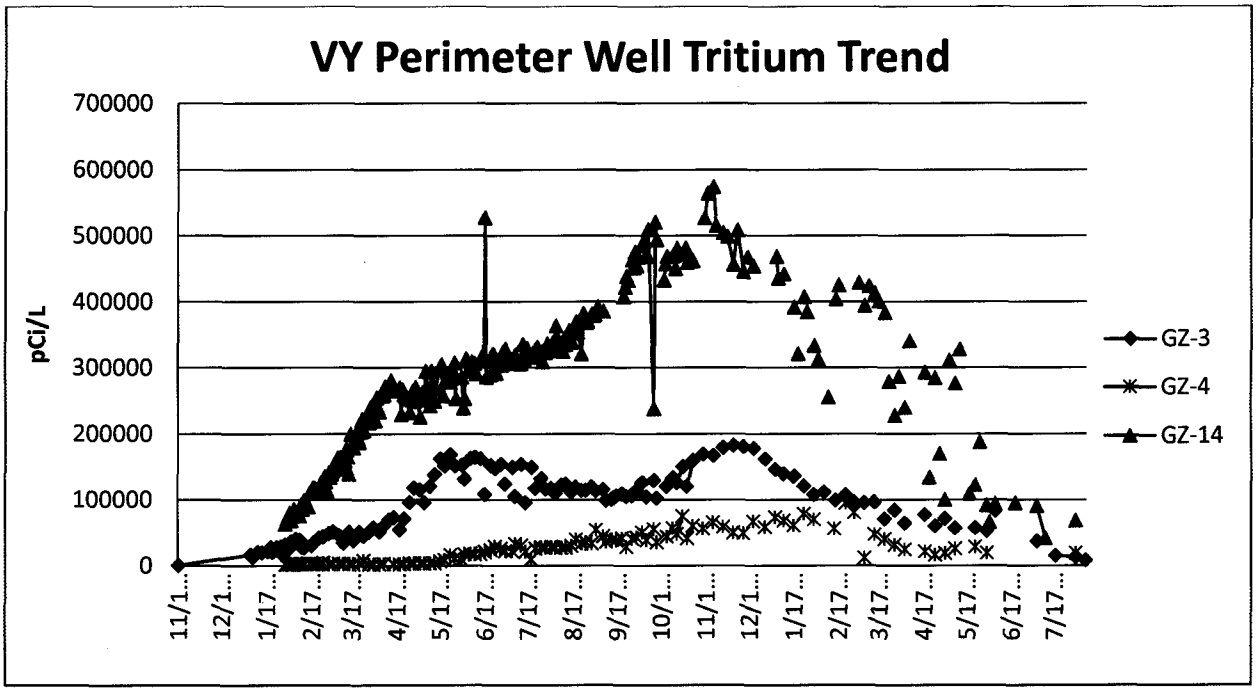
GZ-14


VY Perimeter Well Tritium Trend
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600000
500000
400000
300000
200000
100000
0
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12/1...
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2/17...
3/17...
4/17...
5/17...
6/17...
7/17...
8/17...
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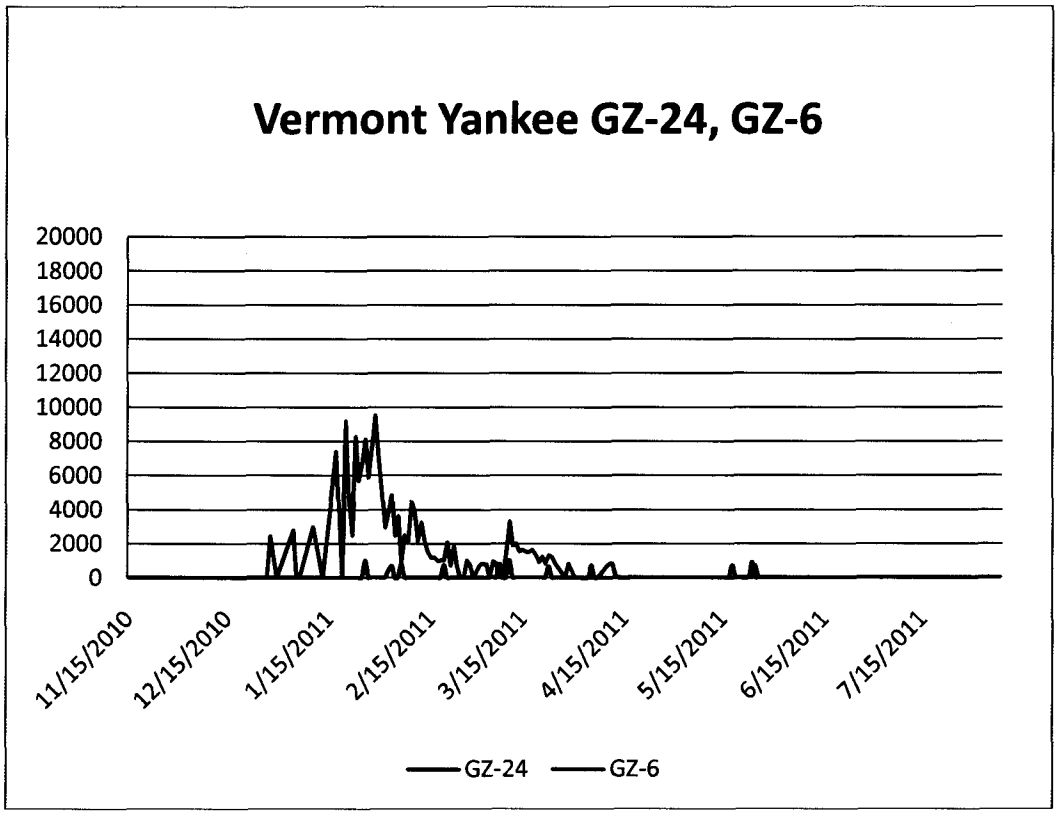
GZ-3
GZ-4
GZ-14


Vermont Yankee GZ-24, GZ-6
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12000
10000
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6000
4000
2000
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11/15/2010
12/15/2010
1/15/2011
2/15/2011
3/15/2011
4/15/2011
5/15/2011
6/15/2011
7/15/2011
GZ-24
GZ-6

ATTACHMENT B

SUPPLEMENTAL INFORMATION

KEY POINTS OF CONTACT

Licensee Personnel

S. Skibniowsky, Environmental and Effluents Chemistry Specialist
J. Hardy, Chemistry Manager
M. Shaw, Principal Hydrogeologist, GZA GeoEnvironmental, Inc.

LIST OF ITEMS OPENED, CLOSED AND DISCUSSED

Opened and Closed

None.

LIST OF DOCUMENTS REVIEWED

Procedures:

CHRP-LWD-2610-01, Rev. 1, "liquid Waste Disposal"
OP 2611, Rev. 50, "Stack Effluent Sampling and Analysis"
OP 2612, Rev. 9, "Burning of Radioactively Contaminated Used Oil"
EN-CY-111, "Groundwater Monitoring"
EN-CY-109, Rev. 2, "Sampling and Analysis of Groundwater Monitoring Wells"
EN-CY-108, Rev. 3, "Monitoring of Non-radioactive Systems"
EN-RP-113, Rev. 4, "Response to Contaminated Spills/Leaks"
OP 4605, Rev. 45, "Environmental Radiation Sampling and Analysis"
CHAD-7605-01, "Groundwater Monitoring Plan"
PP-GPP-7605, "Groundwater Protection Program"
EGAD-7605-01, "Groundwater Contamination Risk Profile"
"Hydrogeologic Investigation of Tritium in Groundwater at Vermont Yankee Nuclear Power Station" (CSM report) May 2011

Condition Reports:

CR-VTY-2009-2317
CR-VTY-2009-2889
CR-VTY-2010-4181
CR-VTY-2011-1483
CR-VTY-2011-2545

Other Documents

Vermont Yankee Groundwater Monitoring Plan, Revision 1
Final Safety Analysis Report, Section 2.4
Off-Site Dose Calculation Manual, Revision 34
Mack, T.J., Belaval, Marcel, Degnan, J.R., Roy, S.J., and Ayotte, J.D., 2011, Geophysical and flow-weighted natural-contaminant characterization of three water-supply wells in New Hampshire: U.S. Geological Survey Open-File Report 2011–1019, 20 p., at http://pubs.usgs.gov/of/2011/1019/.

LIST OF ACRONYMS

ALARA	As Low As Reasonably Achievable
AOG	Advanced Off-Gas
AREOR	Annual Radiological Environmental Operating Report
ARERR	Annual Radiological Effluent Release Report
CFR	Code of Federal Regulations
Ci	Curies
COB	Construction Office Building
CR	Condition Report
CSM	Conceptual Site Model
CST	Condensate Storage Tank
ENVY	Entergy Nuclear Vermont Yankee
EPA	Environmental Protection Agency
FSAR	Final Safety Analysis Report
GPEP	Groundwater Protection Expert Panel
GPI	Groundwater Protection Initiative
gpm	gallons per minute
HEPA	High Efficiency Particulate Air
LTGWMP	Long Term Groundwater Monitoring Program
MNA	Monitored Natural Attenuation
mrem	millirem
NEI	Nuclear Energy Institute, Inc.
NRC	Nuclear Regulatory Commission
NRR	Nuclear Reactor Regulation
ODCM	Offsite Dose Calculation Manual
PS	Public Radiation Safety
PSB	Plant Services Building
RCA	Root cause analysis
REMP	Radiological Environmental Monitoring Program
RES	Nuclear Regulatory Research
RETS	Radiological Effluents Technical Specifications
ODCM	Off-site Dose Calculation Manual
pCi/L	pico-Curies per Liter
SSC	Systems, Structures, and Components
USGS	United States Geological Survey
VY	Vermont Yankee