UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555-0001

July 10, 2006

NRC INFORMATION NOTICE 2006-13: GROUND-WATER CONTAMINATION DUE TO UNDETECTED LEAKAGE OF RADIOACTIVE WATER

ADDRESSEES

All holders of operating licenses for nuclear power and research and test reactors including those who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor and those authorized by Title 10 of the *Code of Federal Regulations* (10 CFR) Part 72 licenses to store spent fuel in water-filled structures.

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform addressees of the occurrence of radioactive contamination of ground water at multiple facilities due to undetected leakage from facility structures, systems, or components that contain or transport radioactive fluids. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this IN are not NRC requirements; therefore, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

Radioactive contamination of ground water has occurred at multiple facilities due to undetected leakage from facility structures, systems, or components that contain or transport radioactive fluids. Specific instances that have occurred recently include the following:

Braidwood Nuclear Power Plant

In March 2005, the licensee was notified by the Illinois Environmental Protection Agency (EPA) of tritium detected in a nearby residential well. Following that notification, the licensee began monitoring ground water between the community and the Braidwood plant. The licensee found detectable levels of tritium in a drainage ditch near the Braidwood access road, but at that time, no other offsite contaminated ground water was found. Based on the tritium identified in the drainage ditch, the licensee installed additional onsite monitoring wells to identify the source of the tritium contamination.

In November 2005, the licensee identified peak contaminated ground water levels of 58,000 picocuries per liter (pCi/L) in shallow, ground-water monitoring wells located at the edge of the owner controlled area. The licensee notified the NRC and immediately suspended all further liquid radioactive releases. The tritium was attributed to historical leakage from vacuum breakers along the circulating water system blowdown line that is routinely used for radioactive liquid releases.

Although the Braidwood piping was below ground, the vacuum breaker valve vaults communicate with the surface. Consequently, the leaks were both above and below ground. The licensee subsequently determined that onsite radioactive leakage from the blowdown system had occurred in 1996 (250,000 gallons), in 1998 (3,000,000 gallons), and in 2000 (3,000,000 gallons). Onsite tritium levels measured in a deep onsite ground-water monitoring well measured as high as 282,000 pCi/L. Offsite tritium levels measured up to 1,600 pCi/L in a residential well, below the Federal EPA drinking water standard of 20,000 pCi/L. The licensee characterized the extent and magnitude of the tritium ground-water contamination as an area that extended about 2,000 feet by 2,500 feet outside the site boundary. The licensee's radiological assessment for the hypothetical, maximally exposed individual indicates that the dose consequence would be about 0.16 millirem per year (i.e., about 5 percent of the "as low as reasonably achievable" (ALARA) criteria for nuclear plant design objectives and limiting conditions for operation).

The NRC inspection found that the licensee did not (1) adequately evaluate the radiological hazards associated with the leakage; (2) calculate dose to member(s) of the public; (3) revise its environmental monitoring program to adequately measure the impact to the environment; (4) report aspects of the leakage in its annual effluent report; and (5) record the residual contamination in files for decommissioning purposes (NRC Inspection Reports Nos. 50-456; 457/2006-02, Agency Wide Documents Access and Management System (ADAMS) Accession No. ML061360416, and 50-456; 457/2006-008, ADAMS Accession No. ML 061450522).

Byron Nuclear Power Plant

Following the identification of tritium leakage at Braidwood, the licensee initiated a sampling and analysis program along the Byron circulating water system blowdown line. Similar to the Braidwood facility, the Byron blowdown line has six vacuum breakers located in valve vaults located on plant property. Standing water in the vaults was sampled and analyzed, with five of the six vaults having detectable levels of tritium up to 80,000 pCi/L. The licensee suspended all radioactive liquid effluent releases through the blowdown line.

Residential wells were sampled and found not to have any detectable contamination. Additional monitoring wells were installed near the valve vaults and detectable levels of tritium have been found near two of the valve vaults. By April 2006, the licensee had completed repairs to the vacuum breakers and vaults, including sealing the vault floors. After repairs were completed, the licensee recommenced liquid effluent discharges through the circulating water system blowdown line (NRC Preliminary Notifications Nos. PNO-III-06-004 and PNO-III-06-004B).

Dresden Nuclear Power Station

In August 2004, the licensee identified contaminated ground water in onsite monitoring wells resulting from a leaking underground pipe connected to the condensate storage tanks. Subsequent, onsite sampling identified tritium levels consistent with those present in the condensate storage tank of about 8,000,000 pCi/L. The licensee isolated the leaking pipe and replaced the faulty section of piping.

Following the 2004 leak, the licensee sampled the private wells of nearby residents. One of the residents' wells that had shown detectable tritium for a number of years had tritium levels of approximately 1,000 pCi/L.

Additionally, three other residential wells were found to have measurable but lower levels of tritium. The licensee continues to evaluate the tritium in those wells, one of which is the normal sample point for its radiological environmental monitoring program.

In February 2006, tritium levels of 600,000 pCi/L were detected in an onsite monitoring well near a section of underground piping that had not been replaced in 2004. The leaking pipe was isolated and onsite tritium levels in the two closest onsite wells subsequently stabilized at 20,000 - 50,000 pCi/L (NRC Inspection Report Nos. 50-237; 239/2006-03, ADAMS Accession No. ML061290091).

Haddam Neck Station (Connecticut Yankee Atomic Power Plant)

The Haddam Neck Station ceased operations about 10 years ago and is being decommissioned under an approved NRC license termination plan (LTP). The licensee's monitoring programs have not identified any offsite ground-water contamination associated with plant operations.

An onsite ground-water monitoring program has been established and is being implemented in support of the decommissioning. The licensee initially identified tritium, cobalt-60, cesium-137 and strontium-90 in the onsite ground water and/or soil samples. The licensee has removed a large amount of soil and some bedrock, and backfilled the excavated areas with clean soil. While the licensee has substantially reduced residual contamination levels, recent ground-water sampling results have identified residual tritium up to 19,500 pCi/L, cesium-137 up to 12 pCi/L and strontium-90 up to 4.5 pCi/L. The licensee has completed dose assessments for the existing onsite ground-water contamination in accordance with the LTP. The dose assessments indicate a dose contribution of less than 1 millirem per year due to the ground-water contamination.

The NRC license termination requirement is that the all-pathways, total effective dose equivalent to the average member of the critical group does not exceed the 10 CFR 20.1402 unrestricted release requirement of 25 millirem per year and the residual radioactivity has been reduced to ALARA. This includes the soil exposure pathway, existing groundwater dose contributions and future groundwater dose contributions. Additionally, the licensee must comply with requirements by the State of Connecticut's Department of Environmental Protection to meet the Federal EPA Maximum Contaminant Levels. The most recent NRC onsite inspection is documented in NRC Inspection Report No. 50-213/2005-03, ADAMS Accession No. ML060390475.

Indian Point Nuclear Generating Station Units 1, 2, and 3

In September 2005, the licensee identified leakage of contaminated water from cracks in the Unit 2 spent fuel pool (SFP), and subsequently discovered tritium contaminated ground water, about 200,000 pCi/L, in a monitoring well located in the Unit 2 transformer yard. Upon discovery of this condition, the licensee initiated extensive efforts to characterize the nature and source of the ground-water contamination. Efforts included the installation of a series of instrumented monitoring wells, comprehensive hydrological and geophysical assessment of the site, engineering efforts to determine the source of contamination, and enhancements to onsite and offsite radiological environmental monitoring. Extensive efforts were also made by the licensee and NRC to keep members of the public and interested local, state, and federal

stakeholders informed of progress and developments in the site characterization, and plans to effect resolution of the ground-water contamination.

Onsite ground-water tritium concentrations have been measured as high as about 600,000 pCi/L in the immediate vicinity of the Unit 2 SFP. Strontium-90 contamination has also been identified in ground water in the vicinity of the Unit 1 decommissioned facility which has been in SAFSTOR since 1974. The current hydrological assessment indicates that ground water is likely migrating into the Hudson River. A conservative radiological assessment for the maximally exposed individual indicates that the dose consequence would be about 0.01 millirem per year (i.e., about 0.1 percent of ALARA criteria for nuclear plant design objectives and limiting conditions for operation).

NRC Inspection Report 50-247/2005-11, dated March 16, 2006 (ADAMS Accession No. ML060750842), documented the results of an NRC special inspection that was conducted to review and assess the events and circumstances in this case. While the inspection reached important safety conclusions, significant licensee performance deficiencies were not identified. However, NRC inspection activities are continuing to review the licensee efforts and progress to support a final regulatory conclusion.

BACKGROUND

NRC requirements related to the radioactive liquid effluents include:

10 CFR 20.1301(a)(1) - requires that each licensee conduct operations so that the total effective dose equivalent to individual members of the public from the licensed operation does not exceed 100 millirem (1 mSv) in a year.

10 CFR 20.1302 - requires licensees to perform appropriate surveys in unrestricted areas and controlled areas to demonstrate compliance with dose limits for individual members of the public.

10 CFR 20.1501 - requires, in part, that licensees conduct surveys that are reasonable under the circumstances to evaluate the concentrations or quantities of radioactive material and the potential radiological hazards.

10 CFR Part 50, Appendix I, Section II.A - establishes the design objectives and limiting conditions for operation to meet ALARA criteria such that the calculated annual total quantity of all radioactive material above background released to unrestricted areas will not result in an estimated annual dose or dose commitment from liquid effluents in excess of 3 millirems to the total body or 10 millirems to any organ.

10 CFR Part 50, Appendix A, Criterion 64 - requires, in part, that a means be provided for monitoring effluent discharge paths, and the plant environs for radioactivity that may be released from normal operations. To meet this regulation, licensees implement a Radiological Environmental Monitoring Program (REMP) which provides for ground-water monitoring. However, the REMP program is designed to validate the results of the licensee's normal radioactive gaseous and liquid effluent release programs for dose assessment in the Unrestricted Area. Consequently, the data from the REMP program may not provide a full understanding of the extent, types, and movement of potentially undetected radioactive contamination in onsite ground water within the Restricted Area. NRC Regulatory Issue

Summary 2002-02, "Lessons Learned Related to Recently Submitted Decommissioning Plans and License Termination Plans," dated January 16, 2002, provides additional information in this regard (ADAMS Accession No. ML013510432).

10 CFR 50.75(g)(1) - requires, in part, that each licensee keep a record of spills or other unusual occurrences involving the spread of contamination in and around the facility or site. These records must include any known information on identification of involved nuclides, quantities, forms, and concentrations. Such documentation in a decommissioning record file is important to provide a database for site characterization during decommissioning, as well as, providing support for public and worker dose assessments. NUREG-1757, "Consolidated [Office of Nuclear Material Safety and Safeguards] NMSS Decommissioning Guidance," provides guidance on decommissioning record keeping (ADAMS Accession No. ML032530410).

10 CFR 50.72 - requires a four-hour report to NRC Operations Center when any event or situation occurs, related to protection of the environment, for which a news release or notification to other government agencies has been or will be made.

Related Generic Communications

NRC Information Notice 2004-05, "Spent Fuel Pool Leakage to Onsite Ground Water," dated March 3, 2004, (ADAMS Accession No. ML040580454) discussed SFP leakage at Salem Station Unit 1 to the onsite ground water, including potential impact to the public and workers, and the structural integrity of the SFP. The NRC noted that leaks can develop in SFPs and go undetected for long periods of time absent appropriate monitoring, resulting in the contamination of onsite ground water and the potential for undetected, unevaluated releases of radioactivity to an unrestricted area.

DISCUSSION

NRC reviews to-date have identified the following important points associated with ground-water contamination events:

1. Leakage from structures, systems, or components that contain and transport radioactive fluids can contribute, over long periods of time, to extensive ground-water contamination. This leakage may not be easily detectable due to small leakage rates or because the area near the point of leakage is not subject to routine radiological monitoring. Leakage from underground piping at Braidwood released substantial quantities of contaminated water to onsite ground water. Representative sampling and analysis of onsite ground water may be the only viable method to detect this leakage and the subsequent migration of the contamination, particularly for subsurface leakage (e.g., buried pipe leakage).

2. Existing NRC regulations do not explicitly mandate routine onsite ground-water monitoring in the Restricted Area during facility operations. If the contamination is detected by environmental monitoring at or beyond the site boundary under the REMP, extensive contamination may have already occurred that could have been contained if detected sooner. Further, although licensees may be sampling onsite drinking water as

part of its REMP, this water may originate from deeper hydro-geologic units not affected by contamination of the shallow water table hydro-geologic unit.

3. The identification of onsite contamination may serve as an early indicator of degradation of onsite structures, systems, or components or the need for maintenance, particularly degradation caused by boric acid.

4. The principal screening method of detecting leakage at reactor sites is sampling and analyses for tritium contamination. However, other analysis methods can detect radioactive gamma emitters, and consideration should be given to performing analyses for typical hard-to-detect radionuclides. These nuclides can consist of both fission or activation products that may include Nickel-63, Iron-55, Strontium-90, transuranics, and others. While initial analyses may conclude the absence of gamma emitters and hard-to-detect radionuclides, long-term migration may subsequently result in the transport of contamination to downstream locations. Further, a working knowledge and understanding of onsite hydrology would aid development of monitoring strategies, sampling plans, and selection of individual sampling locations.

5. Licensees typically establish onsite ground-water monitoring and sampling programs in response to known, identified structure, system, or component leakage. Once the source of the leakage is repaired, it is important to objectively evaluate whether it is appropriate to terminate these supplemental onsite monitoring and sampling programs, as the onsite monitoring and sampling programs may be the only reliable method for detecting repeat occurrences in a timely manner, particularly for subsurface leakage. In the case of the Dresden facility, the onsite ground-water monitoring wells that had been installed for previous leakage incidents were instrumental in identifying the 2006 leakage, which enabled a more timely identification and limited the extent of the contamination.

6. SFP leak detection may require special techniques since SFPs have an evaporation rate up to several hundred gallons per day. This evaporation rate may mask small leaks in the SFP liner and make small leakage rates difficult to detect by evaluation of make-up rates within a water balance calculation. Consequently, licensees who are not closely evaluating the potential for leakage, including through-wall and/or floor leakage, may not detect such leakage. Further, the leakage may be from SFP fuel transfer tubes and may only occur during refueling outages. Because there is considerable water transfer activity during refueling outages, small leakage rates may not be readily apparent during make-up or transfer operations. Other considerations include:

   - Licensee experience with onsite and offsite ground-water contamination as a result of SFP leakage varies significantly. Some licensees have identified large areas of onsite ground-water contamination due to SFP leakage. It is important to be aware that small, long-term, undetected leaks from SFPs can result in extensive areas of contamination.
   - Due to the difficulty in detecting single small leaks or small leaks from different locations, particularly those that occur over long time periods, corrective actions may involve management of leakage (e.g., collection and treatment) rather than leak repair.

   - Some licensees have not evaluated the capability of their SFP leak detection systems to detect small leaks. Leakage trending and tracking programs can

supplement leakage detection systems and provide an indication of changes in apparent leakage rates. Any unexplained change in leakage rates, including a reduction in leakage rates, should prompt further evaluation.

- Clogging of SFP telltale drain systems could result in undetected SFP leakage. Maintenance and cleaning programs for SFP telltale drain systems ensure viable drain paths remain open. Alternate methods to look for leakage are available for facilities without SFP telltale drain systems.

7. Leakage from facility structures to the environment can itself become a source of contaminated in-leakage (back into the facility) at another location. Because stations have facilities and rooms below grade level, it is not uncommon for ground water to leak into the facilities. It is important to evaluate unexpected in-leakage to determine if it is contaminated ground water using radio-analytical and chemical analysis (e.g., boron).

8. Radioactive contamination of subsurface rock, soil, or ground-water contamination can impact decommissioning decisions. Remediation at the time of discovery in some instances could prevent significant migration to large subsurface areas that could complicate and increase the cost of decommissioning. Hydrogeology studies and the addition of onsite monitoring wells should be considered to identify ground-water flow patterns, support knowledge of the location and extent of contamination, to quantify contaminant migration, and to support decision-making for potential remediation measures. These studies can also support an estimation of future decommissioning costs.

9. NRC's inspection program identified that there is an apparent wide variation in licensee knowledge in the requirement to document the ground-water contamination issues consistent with all parts of 10 CFR 50.75(g)(1) for the decommissioning record file. Such documentation is important to provide a database for site characterization during decommissioning, as well as, providing support for public and worker dose assessments.

CONCLUSION

Although NRC regulations require licensees to make surveys, as necessary, to evaluate the potential hazard of radioactive material released in order to assess doses to members of the public and workers, the above examples indicate that undetected leakage to ground water from facility structures, systems, or components can occur; resulting in unmonitored and unassessed exposure pathways to members of the public.

GENERIC IMPLICATIONS

This information notice provides a timely means of communicating to licensee senior management information regarding ground-water contamination. To address this important issue, NRC is actively pursuing rulemaking to revise 10 CFR 20.1406, "minimization of contamination," and its supporting guidance, as well as changes to NRC inspection and enforcement guidance. These ongoing NRC efforts are part of the NRC's Integrated Decommissioning Improvements Plan (ADAMS Accession No. ML050890059) to resolve issues described in SECY-03-0069, "Results of the License Termination Rule Analysis" and its staff

requirements (ADAMS Accession Nos. ML030840302 and ML033210595). A publically available NRC memorandum dated September 23, 2005, provides the results of an initial NRC study of ground-water contamination at decommissioning sites (ADAMS Accession No. ML052630421).

CONTACT

This information notice requires no specific action or written response. If there are any questions about this notice, contact one of the persons listed below or the appropriate project manager in the Office of Nuclear Reactor Regulation (NRR) or Office of Nuclear Material Safety and Safeguards.

/RA/
Charles L. Miller, Director
Division of Industrial and Medical Nuclear Safety
Office of Nuclear Material Safety
and Safeguards

/RA/
Ho K. Nieh, Acting Director
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Technical Contacts:

Timothy Frye, NRR
301-415-9676
E-mail: tjf@nrc.gov

Marvin Mendonca, NRR
301-415-2191
E-mail: mmm@nrc.gov

John White , RI
610-337-5114
E-mail: jrw1@nrc.gov

James Shepherd, NMSS
301-415-6712
E-mail: jcs2@nrc.gov

Steve Orth, RIII
630-829-9827
E-mail: sko@nrc.gov

Thomas Nicholson, RES
301-415-6268
E-mail: tjn@nrc.gov

Ronald Nimitz, RI
610-337-5267
E-mail: rln@nrc.gov