ENVIRONMENTAL MONITORING PROGRAM INFORMATION

Introduction

The high-level waste (HLW) presently stored at the West Valley Demonstration Project is the by-product of the reprocessing of spent nuclear fuel conducted during the late 1960s and early 1970s by Nuclear Fuel Services, Inc. (NFS).

Since the Western New York Nuclear Service Center is no longer an active nuclear fuel reprocessing facility, the environmental monitoring program focuses on measuring radioactivity and chemicals associated with the Project's high-level waste treatment operations and the residual effects of NFS operations. The following information about the operations at the Project and about radiation and radioactivity may be useful in understanding the activities of the Project and the terms used in reporting the results of environmental testing measurements.

High-Level Waste Treatment

Most of the waste from NFS operations had been stored in one of four underground tanks (tank 8D-2). Inside the tank the waste had settled into two layers: a liquid — the supernatant — and a precipitate layer on the tank bottom — the sludge.

To solidify the high-level waste, WVDP engineers designed and developed a two-stage process of pretreatment and vitrification.

Pretreatment

The supernatant was composed mostly of sodium and potassium salts dissolved in water. Radioactive cesium in solution accounted for more than 99% of the total fission products in the supernatant. During pretreatment, sodium salts and sulfates were separated from the radioactive constituents in both the liquid portion of the high-level waste and the sludge layer in the bottom of the tank.

Pretreatment of the supernatant began in 1988. A four-part process, the integrated radwaste treatment system (IRTS), reduced the volume of the high-level waste that needed pretreatment by producing low-level waste stabilized in cement.

- The supernatant was passed through zeolite-filled ion exchange columns in the supernatant treatment system (STS) to remove more than 99.9% of the radioactive cesium.

- The resulting liquid was then concentrated by evaporation in the liquid waste treatment system (LWTS).
- This low-level radioactive concentrate was blended with cement in the cement solidification system (CSS) and placed in 269-liter (71-gal) steel drums.
- Finally, the steel drums were stored in an onsite aboveground vault, the drum cell.

Processing of the supernatant was completed in 1990. Eighty percent of the radioactivity in the liquid was removed and 10,393 drums of cemented waste were produced.

The sludge that remains is composed mostly of iron hydroxide. Strontium-90 accounts for most of the radioactivity in the sludge.

Pretreatment of the sludge began in 1991 and continued through 1992. (See **1992 Activities at the West Valley Demonstration Project** below.)

Vitrification

The second stage of the high-level waste treatment process, solidification into glass (vitrification), is scheduled to begin in 1996. The high-level waste mixture of sludge and zeolite from the ion-exchange process will be combined with glass-forming chemicals, fed to a ceramic melter, heated to approximately 2,000°F, and poured into stainless steel canisters. Approximately 300 stainless steel canisters 10 feet long by 2 feet in diameter will be filled with a uniform, high-level waste glass that will be suitable for eventual shipment to a federal repository. Vitrification is scheduled to be completed in 1999.

Radiation and Radioactivity

Radioactivity is a process in which unstable atomic nuclei spontaneously disintegrate or "decay" into atomic nuclei of another isotope or element. (See *Glossary*.) The nuclei continue to decay until only a stable, nonradioactive isotope remains. Depending on the isotope, this process can take anywhere from less than a second to hundreds of thousands of years.

Radiation is the energy released as atomic nuclei decay. By emitting energy the nucleus moves toward a less energetic, more stable state. The energy that is released takes three main forms: alpha particles, beta particles, and gamma rays.

α *Alpha Particles*

An alpha particle is a fragment of a much larger nucleus. It consists of two protons and two neutrons (similar to a helium atom nucleus) and is positively charged. Alpha particles are relatively large and heavy and do not travel very far when ejected by a decaying nucleus. Alpha radiation, therefore, is easily stopped by a thin layer of material such as paper or skin. However, if radioactive material is ingested or inhaled, the alpha particles released inside the body can damage soft internal tissues because all of their energy is absorbed by tissue cells in the immediate vicinity of the decay.

β *Beta Particles*

A beta particle is an electron that results from the breakdown of a neutron in a radioactive nucleus. Beta particles are small compared to alpha particles, travel at a higher speed (close to the speed of light), and can be stopped by a material such as wood or aluminum less than an inch thick. If beta particles are released inside the body they do much less damage than an equal number of alpha particles. Because they are smaller and faster and have less of a charge, beta particles deposit energy in fewer tissue cells and over a larger volume than alpha particles.

γ *Gamma Rays*

Gamma rays are high-energy "packets" of electromagnetic radiation called photons. They are similar to x-rays but generally have a shorter wavelength and therefore are more energetic than x-rays. If the alpha or beta particle released by the decaying nucleus does not carry off all the energy made available by the nuclear disintegration, the excess energy may be emitted as gamma rays. If the released energy is high, a very penetrating gamma ray is produced that can only be effectively reduced by shielding consisting of several inches of a heavy element, such as lead, or of water or concrete several feet thick. Although large amounts of gamma radiation are dangerous, gamma rays are also used in many lifesaving medical procedures.

Measurement of Radioactivity

The rate at which radiation is emitted from a disintegrating nucleus can be described by the number of decay events or nuclear transformations that occur in a radioactive material over a fixed period of time. This process of emitting energy, or radioactivity, is measured in curies (Ci) or becquerels (Bq). One becquerel equals one decay per second. One curie equals 37 billion nuclear disintegrations per second (3.7×10^{10} d/s). Very small amounts of radioactivity are sometimes measured in picocuries. A picocurie is one-trillionth (10^{-12}) of a curie or 2.22 disintegrations per minute.

Measurement of Dose

The amount of energy absorbed by the receiving material is measured in rads (radiation absorbed dose). A rad is 100 ergs of radiation energy absorbed per gram of material. (An erg is the amount of energy necessary to lift a mosquito about one-sixteenth of an inch.) "Dose" is a means of expressing the amount of energy absorbed, taking into account the effects of different kinds of radiation. Alpha, beta, and gamma radiation affect the body to different degrees. Each type of radiation is given a quality factor that indicates the extent of human cell damage it can cause compared with equal amounts of other ionizing radiation energy. Alpha particles cause twenty times as much damage to internal tissues as x-rays, so alpha radiation has a quality factor of 20 compared to gamma rays, x-rays, or beta particles, which have a quality factor of 1.

Ionizing Radiation

Radiation can be damaging if, in colliding with other matter, the alpha or beta particles or gamma rays knock electrons loose from the absorber atoms. This process is called ionization, and the radiation that produces it is referred to as ionizing radiation because it changes a previously electrically neutral atom, in which the positively charged protons and the negatively charged electrons balance each other, into a charged atom called an ion. An ion can be either positively or negatively charged. Various kinds of ionizing radiation produce different degrees of damage.

Potential Effects of Radiation

The biological effects of radiation can be either somatic or genetic. Somatic effects are restricted to the person exposed to radiation. For example, sufficiently high exposure to radiation can cause clouding of the lens of the eye or loss of white blood cells.

Radiation also can cause chromosomes to break or rearrange themselves or to join incorrectly with others. These changes may produce genetic effects and may show up in future generations. Radiation-produced genetic defects and mutations in offspring of an exposed parent, while not positively identified in humans, have been observed in some animal studies.

The effect of radiation depends on the amount absorbed. An instantaneous dose of 100-200 rem (1-2 Sv) might cause temporary effects such as vomiting but usually would have no long-lasting side effects. At 50 rem (0.5 Sv) a single instantaneous dose might cause a reduction in white blood cell count.

Assessing biological damage from low-level radiation is difficult because other factors can cause the same symptoms as radiation exposure. Moreover, the body apparently is able to repair damage caused by low-level radiation.

The effect most often associated with exposure to relatively high levels of radiation appears to be an increased risk of cancer. However, scientists have not been able to demonstrate with certainty that exposure to low-level radiation causes an increase in injurious biological effects, nor have they been able to determine if there is a level of radiation exposure below which there are no biological effects.

Background Radiation

Background radiation is always present and everyone is constantly exposed to low levels of such radiation from both naturally occurring and manmade sources. In the United States the average total annual exposure to this low-level background radiation is estimated to be about 360 millirem (mrem) or 3.6 millisieverts (mSv). Most of this radiation, approximately 300 mrem (3 mSv), comes from natural sources. The rest comes from medical procedures and from consumer products.

Background radiation includes cosmic rays, the decay of natural elements such as potassium, uranium, thorium, and radon, and radiation from sources such as chemical fertilizers, smoke detectors, and televisions. Actual doses vary depending on such factors as geographic location, building ventilation, and personal health and habits.

The unit of dose measurement to humans is the rem. Rems are equal to the number of rads multiplied by the quality factor of the kind of radiation. Dose can also be measured in sieverts. One sievert equals 100 rem.

Environmental Monitoring Program Overview

Human beings may be exposed to radioactivity primarily through air, water, and food. At the West Valley Demonstration Project all three pathways are monitored, but air and surface water pathways are the two major means by which radioactive material can move off-site.

The geology of the site (kinds and structures of rock and soil), the hydrology (location and flow of surface and underground water), and meteorological characteristics of the site (wind speed, patterns, and direction) are all considered in evaluating potential exposure through the major pathways.

The on-site and off-site monitoring program at the West Valley Demonstration Project includes measuring the concentration of solids containing alpha and beta radioactivity, conventionally referred to as "gross alpha" and "gross beta," in air and water effluents. Measuring the total alpha and beta radioactivity from key locations, which can be done within a matter of hours, produces a comprehensive picture of on-site and off-site levels of radioactivity from all sources. In a facility such as the West Valley Demonstration Project, frequent updating and tracking of the overall levels of radioactivity in effluents is an important tool in maintaining acceptable operations.

More detailed measurements are also made for specific radionuclides. Strontium-90 and cesium-137 are measured because they are normally present in WVDP waste streams. Radiation from other important radionuclides such as tritium or iodine-129 are not sufficiently energetic to be detected by gross measurement techniques, so these must be analyzed separately using methods with greater sensitivity. Heavy elements such as uranium, plutonium, and americium require special analysis to be measured because in comparison to background they exist at such low levels at the WVDP. The radionuclides monitored at the Project are those that might produce relatively higher doses or that are most abundant in air and water effluents. Because sources of radiation at the Project have been decaying for more than twenty years, the monitoring program does not routinely include short-lived radionuclides, i.e., isotopes with a half-life of less than two years, which would have only 1/1,000 of the original radioactivity remaining. (See *Appendix A* for a schedule of samples and radionuclides measured and *Appendix B* for related Department of Energy protection standards.)

Data Reporting

Because any two samples are never exactly the same, statistical methods are used to decide how a particular measurement compares with other measurements of similar samples. The term *confidence level* is used to describe how certain a measurement is of being a "true" value. The WVDP environmental monitoring program uses the 95% confidence level, which means that 95% of the measurements (19 out of 20) fall within the statistical "uncertainty" range.

The uncertainty range is the expected range of values that account for random nuclear decay and small measurement process variations. The uncertainty range of a measurement is indicated by the plus-or-minus (±) value following the measurement (e.g., 5.30±3.6E-09 µCi/mL, with the exponent of 10^{-9} expressed as "E-09." Expressed in decimal form, the number would be 0.0000000053±0.0000000036 µCi/mL). Within this range a measurement will be "true" 95% of the time. For example, a value recorded as 5.30±3.6E-09 µCi/mL means that 95% of the time the "true" value will be found between 1.7E-09 µCi/mL and 8.9E-09 µCi/mL.

If the uncertainty range is greater than the value itself (e.g., 5.30±6.5E-09 µCi/mL), the result is below the detection limit. The value will be listed as "less than," or " < " 6.5E-09 µCi/mL.

In general, the detection limit is the minimum amount of constituent or material of interest detected by an instrument or method that can be distinguished from background and instrument noise. Thus, the detection limit is the lowest value at which a sample result shows a statistically positive difference from a sample in which no constituent is present.

1992 Activities at the West Valley Demonstration Project

High-Level Waste Pretreatment

Sludge Pretreatment

Pretreatment of the sludge layer in the high-level waste tank 8D-2 began in 1991. Five specially designed 50-foot long pumps were installed in the tank that mixed the sludge layer with water in order to produce a uniform sludge blend and to dissolve sodium salts and sulfates. After mixing and allowing the sludge to settle, processing of the wash water through the integrated radwaste treatment system began. Processing removes radioactive constituents for later solidification into glass, and the wash water containing salts is then stabilized in cement.

In 1992 approximately 63,000 gallons of wash water were processed and 1,636 drums of cemented low-level waste were produced. The WVDP is scheduled to complete processing of the wash water from the first sludge wash in 1993. Three more sludge washes are planned. Following completion of sludge pretreatment, the ion-exchange material used in the IRTS to remove radioactivity will be blended with the washed sludge in the glass-forming feed mixture. A single reprocessing campaign of a special fuel, THOREX, was conducted from November 1968 to January 1969. The high-level waste from this campaign will be added to the feed mixture.

Vitrification

Several major milestones were reached in completing the Project's vitrification facility. Nonradioactive testing of a full-scale vitrification system was conducted from 1984 to 1989. In 1990 all vitrification equipment was removed to allow installation of shield walls for fully remote radioactive operations. The walls and shielded tunnel connecting the facility to the former reprocessing plant were completed in 1991.

More than 100 tons of vitrification equipment, including vessels that will be used to concentrate and blend the waste and key components of the melter off-gas treatment system, were installed in the facility in 1992. In addition, the steel shell for the new melter arrived at the Project ready for installation in 1993.

Low-Level Waste Processing

Aqueous Radioactive Waste

Water containing added radioactive material from site cleanup operations is collected and treated in the low-level liquid waste treatment facility (LLWTF). (Water from the sanitary system, which does not contain added radioactive material, is managed in a separate system.)

The treated process water is held, sampled, and analyzed before it is released through a State Pollutant Discharge Elimination System (SPDES)-permitted outfall. In 1992, 36.9 million liters (9.76 million gal) of water were treated in the LLWTF and released.

The discharge waters contained an estimated 37 millicuries of gross alpha plus gross beta radioactivity. Comparable releases during the previous seven years averaged about 43 millicuries per year. The 1992 release was about 14% below this average.

The 0.47 curies of tritium also released in 1992 was about half of the amount released in 1991.

Solid Radioactive Waste

Low-level waste at the WVDP, stored in aboveground facilities, consists of various materials generated through site maintenance and cleanup activities. Metal piping and tanks are cut up and packaged in a special contact size-reduction facility, and dry compressible materials such as paper and plastic are compacted to reduce waste volume. In 1992 waste volume was reduced from 1991 levels by about 717 cubic meters (25,300 ft^3).

Hazardous Wastes

Hazardous wastes were managed during 1992 by reclaiming, recycling, or by off-site disposal. More than 10,000 kilograms of these wastes were shipped for off-site disposal, and almost 950 kilograms of nonradioactive waste were subject to waste minimization. (See *Environmental Compliance Summary: Calendar Year 1992.*)

Waste Minimization Program

A waste minimization plan that includes long-range planning for waste storage and processing facilities, manpower, funding, and waste minimization at the Project was in effect during 1992.

A major goal of the plan was achieved in 1992 when the amount of hazardous, radioactive, and mixed waste generated by Project activities was reduced by 5% from anticipated levels. The WVDP's goal is to reduce waste generation by 25% over the next five years.

Pollution Prevention Awareness Program

The WVDP's pollution prevention awareness program is a significant part of the Project's overall waste minimization program. The program includes hazard communication training and new employee orientation that provides information about the WVDP's INDUSTRIAL HYGIENE AND SAFETY MANUAL, environmental pollution control procedures, and the HAZARDOUS WASTE MANAGEMENT PLAN.

Hazardous waste operations training programs and radiation worker/hazardous waste requalification programs were modified in 1992 to include information regarding pollution prevention goals and progress. To date, 626 employees have attended this training.

The WVDP's goal is to make all employees aware of the importance of pollution prevention both at work and at home.

1992 National Environmental Policy Act (NEPA) Activities

Under the National Environmental Policy Act, the Department of Energy is required to consider the overall environmental effects of its proposed actions. The President's Council on Environmental Quality established a screening system of analyses and documentation that requires each proposed action to be categorized according to the extent of its environmental effect. The levels of documentation include categorical exclusions (CXs), environmental assessments (EAs), and environmental impact statements (EISs).

Categorical exclusions evaluate and document actions that will not have an effect on the environment. Environmental assessments evaluate the extent to which the proposed action will affect the environment. If a proposed action has the potential for significant effects, an environmental impact statement is prepared that describes proposed alternatives to an action and explains the effects.

Phase I NEPA Activities

Phase I NEPA activities at the WVDP generally involve facility maintenance and minor projects that support high-level waste vitrification. Most of these projects are documented and submitted for approval as categorical exclusions.

Twenty-eight proposed activities were submitted in 1992 as having been previously approved within existing NEPA documents or as categorically excluded from further NEPA review.

In addition, an environmental assessment for a proposed expansion to the WVDP sewage treatment plant resulted in the DOE issuing a finding of no significant impact to the environment, and approval to proceed was given.

Phase II NEPA Activities

In December 1988 the DOE published a Notice of Intent to prepare an environmental impact statement for the completion of the West Valley Demonstration Project and closure of the facilities at the Western New York Nuclear Service Center. The environmental impact statement will describe the potential environmental effects associated with Project completion and various site closure alternatives. Completion and closure are Phase II activities. Phase I activities were described in a 1982 environmental impact statement.

In order to assess potential effects associated with alternative closure actions, an extensive multidisciplinary characterization of the site was necessary. Characterization activities began in 1989 and required data collection for several years. Site characterization studies include investigations in geomorphology, soils, geohydrology, surface water hydrology, geochemistry, water quality, air quality, seismology, demography, cultural resources, botany, and terrestrial and aquatic ecology. Many of these studies were completed in 1992.

In late 1992 the DOE selected an independent contractor, Science Applications International Corporation (SAIC) to prepare the environmental impact statement for closure or long-term management of the Western New York Nuclear Service Center. The draft EIS is scheduled to be issued for comment in 1994.

1992 Changes in the Environmental Monitoring Program

Minor updates to the 1992 monitoring program improved the environmental sampling network and supported current site characterization activities. The changes were limited but included addition of an air sampler to the southeast of the site near the bulk storage warehouse (Chapter 2, *Environmental Monitoring*) and replacement of aging air sampling equipment. Several measurements and new on-site locations were added to the routine monitoring program.

The most significant aspect of the 1992 groundwater monitoring program was the completion of a full eight-round sampling regimen for 107 groundwater sampling locations. All the points were sampled in 1991 and 1992, completing the full set of analyses and replicates planned for statistical evaluation of groundwater contaminants.

Appendix A summarizes the program changes and lists the sample points and parameters measured in 1992.

Resource Conservation and Recovery Act (RCRA) Reports

West Valley Nuclear Services Co., Inc. (WVNS) has developed a hazardous waste management plan that ensures proper management of all hazardous waste from the point of generation to final disposition. The plan's basic requisites include properly designating and packaging all hazardous waste generated at the facility; obtaining appropriate samples and characterizing wastes according to hazardous wastes regulations; maintaining required records and reports; stocking and maintaining spill control materials and equipment and ensuring that the appropriate employees are trained in emergency response; and determining nonradioactive hazardous waste release reporting and notification requirements and, when required, making appropriate notifications.

Toxic Chemical Inventory

Under the Superfund Amendments and Reauthorization Act (SARA) Title III requirements, also known as the Emergency Preparedness and Community Right-to-Know Act (EPCRA), hazardous chemical inventories on-site must be reported to the EPA. During the 1992 reporting period the WVDP produced quarterly updates of the inventory of hazardous chemicals stored on-site and sent them to local and state emergency management agencies. The chemicals and the approximate quantities stored and used on-site in 1992 included:

ammonium solution (300 lbs), used in the laboratories and for blueprinting

chlorine (500 lbs), used to disinfect potable water

diesel fuel (19,000 lbs), used for back-up power for generators

ferric hydroxide slurry (30,000 lbs), to be used for vitrification

fuel oil #2 (70,000 lbs), used for back-up power for boilers and other equipment

gasoline, unleaded (24,000 lbs), used for on-site vehicles

ion exchange media (39,000 lbs), used for ion exchange systems

nitric acid (2,500 lbs), used in vitrification testing and for pH control

oils - various grades (10,000 lbs), used to lubricate various equipment

Portland cement (90,000 lbs), used in the solidification of low-level radioactive waste

silicon dioxide (18,000 lbs), to be used for vitrification

sodium hydroxide (9,000 lbs), used in water treatment

sodium silicate - liquid grade 40 (11,000 lbs), used in the solidification of low-level radioactive waste

sodium tetraborate decahydrate (35,000 lbs), to be used for vitrification

sulfuric acid (30,000 lbs), used in water treatment and laboratories

zinc bromide solution (20,000 lbs), used for radiation shielding in viewing windows.

On-Site Environmental Training

The safety of personnel who are involved in hazardous waste operations falls under the Occupational Safety and Health Act (OSHA). This act is a comprehensive law governing diverse occupational hazards such as electrical safety and protection from fire as well as the handling of hazardous materials. The purpose of OSHA is to maintain a safe and healthy working environment for employees.

Training for hazardous waste operations at the West Valley Demonstration Project is job-specific and takes the mixed waste characteristics of the Project into consideration.

OSHA 29 CFR 1910.120 (Hazardous Waste Operations and Emergency Response) requires that employees at treatment, storage, and disposal facilities, which are regulated by the Resource Conservation and Recovery Act, who may be exposed to health and safety hazards during hazardous waste operations, receive twenty-four hours of initial training and eight hours of annual refresher training. This training is in addition to the sixteen-hour radiation worker training required for the majority of the operations work force.

The Project's training program identifies employees who are eligible for OSHA instruction, provides an initial twenty-four hour training program and an eight-hour refresher course, and documents the instruction.

Initially offered in 1990, the program provides detailed information on hazardous materials management procedures, focusing on lessons learned in the field. A total of 1,036 employees have participated in this program.

OSHA 29 CFR 1910.120 also requires training in proper response to on-site spills of hazardous materials or wastes. The Project has an organized Hazardous Materials Emergency Response Team that maintains proficiency through classroom instruction and drills.

An eight-hour course for supervisors covers how to determine site hazards, how to assess risk, on-the-job training, and incident command. Forty-four employees have completed this course.

In addition, each visitor or nonworker at the site must receive a site-specific briefing on safety and emergency procedures before being admitted to the site. Currently, each visitor views an information tape that explains site safety policies and emergency evacuation procedures.

Self-Assessment

Self-assessments were conducted periodically in 1992 to review the management and effectiveness of the Project's environmental monitoring program and adherence to various environmental regulatory requirements to which Project activities are subject.

Assessments relating to environmental monitoring and regulatory compliance are summarized in Chapter 5, *Quality Assurance.*