Development of Cleanup Goals for the Decommissioning of the West Valley Demonstration Project - 11073

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ABSTRACT

The U.S. Department of Energy (DOE) developed radionuclide cleanup goals for surface soil, deep subsurface soil, and streambed sediment to support the phased decommissioning of the West Valley Demonstration Project. This effort took into account the complexities of the site, which include extensive subsurface soil contamination, and the need to support different potential approaches for the second and final phase of the decommissioning, including unrestricted release of the property. Derived concentration guideline levels (DCGLs) were developed for 18 radionuclides of interest for the three environmental media, followed by the establishment of more stringent cleanup goals to account for individuals exposed to residual radioactivity from different parts of the remediated site. Modeling of deep subsurface soil contamination proved to be especially complex and involved evaluation of eight different conceptual models. The RESRAD *res*idual *rad*ioactivity code, which was used for most of the modeling, was adapted for conditions for which it had not been used previously. Extensive probabilistic uncertainty analyses, combined with evaluation of the variety of conceptual models for exposure to subsurface soil contamination, added credibility to the modeling results which were included in the Phase 1 Decommissioning Plan. DOE consulted with the U.S. Nuclear Regulatory Commission (NRC) on this plan and the associated cleanup goal development, and NRC staff input helped strengthen the technical basis for the cleanup goals.

INTRODUCTION

The DOE is decommissioning the West Valley Demonstration Project using a phased decision-making approach to fulfill part of its statutory obligations under the West Valley Demonstration Project Act of 1980 [1, 2]. This project is located on the site of the only commercial spent nuclear fuel reprocessing facility to operate in the United States. At this facility, Nuclear Fuel Services, Inc. reprocessed irradiated nuclear fuel to recover uranium and plutonium from 1966 through 1972, producing approximately 2.3 million L (600,000 gal) of high-level waste that was stored in two underground tanks. This waste contained approximately 1,150,000 TBq (31 million Ci) of radioactivity – mostly Cs-137 and Sr-90 and their progeny. [2] (Unless otherwise noted, the source of the information that follows is the Phase 1 Decommissioning Plan [2].)

The site, which is licensed by the NRC, comprises approximately 13.5 square kilometers (3,345 acres). It is located in Western New York some 48 kilometers (30 miles) south of Buffalo. Known as the Western New York Nuclear Service Center, or simply the Center, it is owned by the New York State Energy Research and Development Authority.

The West Valley plant used the PUREX (plutonium-uranium extraction) process to chemically separate uranium and plutonium from fission products and unwanted actinides. The similar THOREX (thorium-uranium extraction) process was used for one fuel lot. The nuclear fuel that was reprocessed came from the N-Reactor at DOE's Hanford site and from commercial power reactors.

When Nuclear Fuel Services announced that it would abandon reprocessing in 1976, the site facilities, contained significant radioactive contamination, with dose rates in some shielded cells in the Main Plant

Process Building exceeding 20 Sv/hr (2000 rem/hr). Environmental contamination also resulted from site operations. The contaminated areas of most significance, which are described below, are known today as the north plateau groundwater plume and the cesium prong.

THE WEST VALLEY DEMONSTRATION PROJECT

In 1980, federal legislation to clean up the West Valley site was enacted in the form of the West Valley Demonstration Project Act. One provision of the Act states that "The Secretary [of Energy] shall decontaminate and decommission (A) the tanks and other facilities of the Center in which the high level waste solidified under the project was stored, (B) the facilities used in the solidification of the waste, and (C) any material and hardware used in connection with the project, in accordance with such requirements that the [Nuclear Regulatory] Commission may prescribe." [1]

Following passage of the Act, DOE began to move forward with the project. New facilities for treatment and solidification of the high-level waste were built, including a vitrification facility. The high-level waste treatment and solidification program spanned approximately 20 years. Two hundred seventy-five stainless steel canisters of vitrified high-level waste were produced, which remain temporarily stored in the Main Plant Process Building. Figure 1 shows the developed portion of the site in 2006.

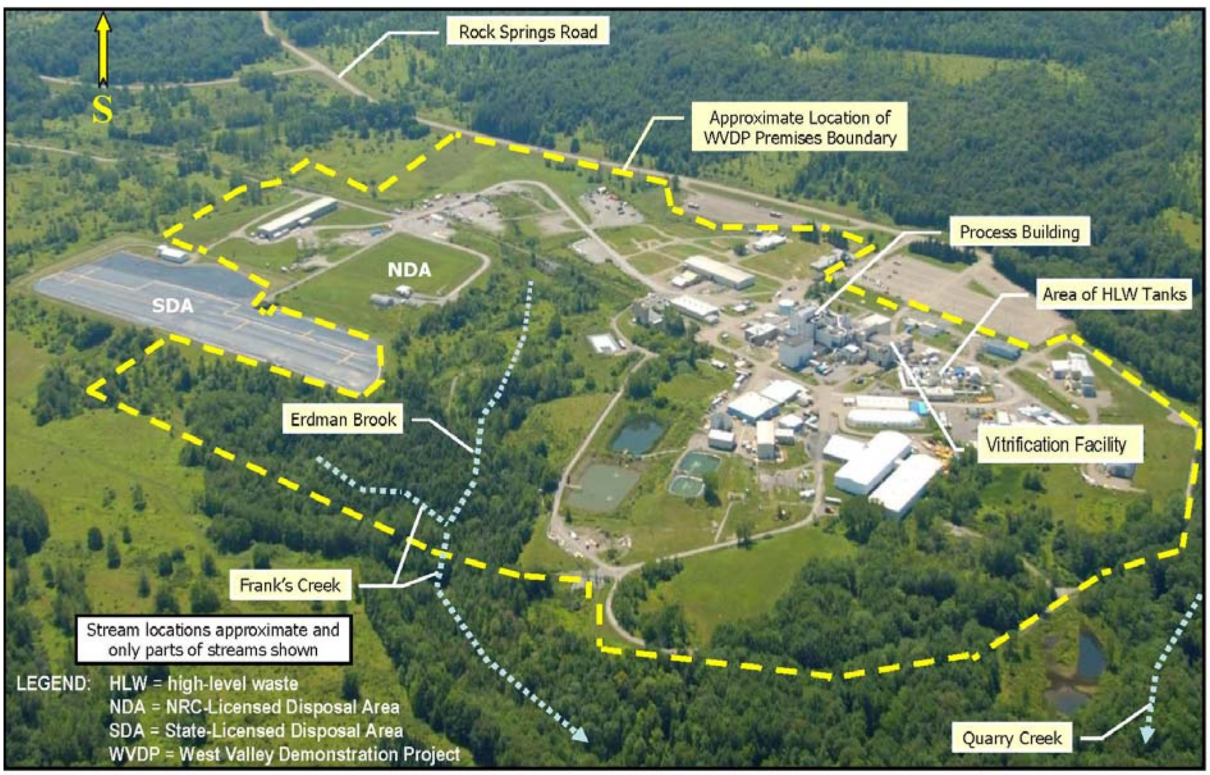

Fig 1. The West Valley Demonstration Project in 2006 [2]

The boundary of the area controlled by DOE for accomplishment of the project, which is about 0.7 square kilometer (167 acres) in size and known as the project premises, is shown in Figure 1.

SITE AND FACILITY CHARACTERISTICS

The Center is mainly a mixture of forest and wetlands, with gently rolling hills. The developed area shown in Figure 1 is divided by Erdman Brook into the north plateau, where the Main Plant Process Building (commonly referred to as the Process Building) is located, and the south plateau where the two shallow-land radioactive waste disposal facilities – the NRC-Licensed Disposal Area and the State-Licensed Disposal Area – are located. The three small streams shown in the figure are characterized by steep banks, a product of severe erosion typical of the region.

Soil near the surface on the north plateau is a mixture of gravel, sand, and clay, ranging in thickness from about 12 meters (41 feet) near the Process Building to about a meter (a few feet) on the northern, eastern, and southern edges of the north plateau. This sand and gravel layer is not present on the south plateau. Underlying this layer on the north plateau and at the surface on the south plateau is a layer of silty-clay glacial till called the Lavery till. Beneath the Lavery till lies another distinct soil layer made up of lacustrine and kame delta deposits, which are underlain by other lacustrine and kame delta deposits deposited on shale bedrock. The depth of groundwater on the north plateau ranges from just below the surface to about 4.8 meters (16 feet) below the surface.

Figure 2 shows the layout of the project premises and major sources of radioactive contamination. The site has been divided into 12 waste management areas for remediation purposes and most are shown in the figure.

Waste Management Area 1 contains the Main Plant Process Building and the Vitrification Facility. The multi-story Process Building contains the shielded cells and other areas used to mechanically disassemble reactor fuel and dissolve it in nitric acid to recover uranium and plutonium and to refine these products. Built mainly of reinforced concrete, this structure and the associated fuel pools extend up to 14 meters (45 feet) below grade. This building and the Vitrification Facility contains significant residual radioactivity as indicated in Figure 2[1].

Waste Management Area 2 contains five lagoons used for treatment of radioactive wastewater since the beginning of fuel reprocessing operations, along with in-ground concrete holding tanks and a small building containing wastewater treatment equipment. Lagoon 1 was closed in 1984 but still contains significant residual radioactivity as shown in Figure 2.

Waste Management Area 3 contains the waste tank farm, with its two 2.8 million-L (750,000-gal) underground waste tanks and two 57,000-L (15,000-gal) tanks. Waste Management Area 4 contains a closed construction and demolition debris landfill that was used for disposal of non-radioactive waste. Waste Management Area 5 contains waste storage buildings and the Remote-Handled Waste Facility. Waste Management Area 6 contains a sewage treatment plant. Waste Management Area 7 contains the NRC-Licensed Disposal Area and Waste Management Area 8, which is not controlled by DOE or part of the West Valley Demonstration Project, contains the State-Licensed Disposal Area. Both of these radioactive waste disposal facilities contain significant amounts of radioactivity as shown in Figure 2.Waste Management Area 9 contains a large shielded waste storage facility that is no longer used.

Figure 2 also shows areas impacted by significant releases of radioactivity during reprocessing operations. The so-called “cesium prong” at the top of the map is an area where surface soil became contaminated with Cs-137 as a result of Process Building ventilation system failures that occurred in 1968. The

[1] The 275 vitrified high-level waste canisters temporarily stored in one of the Process Building shielded cells together contain around 370,000 TBq (10,000,000 Ci) of activity. The canisters will be relocated to a new interim storage area early in Phase 1 of the decommissioning.

resulting contamination was found to extend off both the project premises and the Center. The north plateau groundwater plume is an area of subsurface soil and groundwater contamination resulting from radioactive acid leaking under the Process Building in 1968. Since that time mobile radionuclides such as Sr-90 have gradually migrated more than 12 meters (40 feet) under the building and about 400 meters (1300 feet) northeast. Radioactivity in this plume has contaminated subsurface soil and groundwater in much of Waste Management Area 2, the landfill in Waste Management Areas 4, and part of Waste Management Area 5.

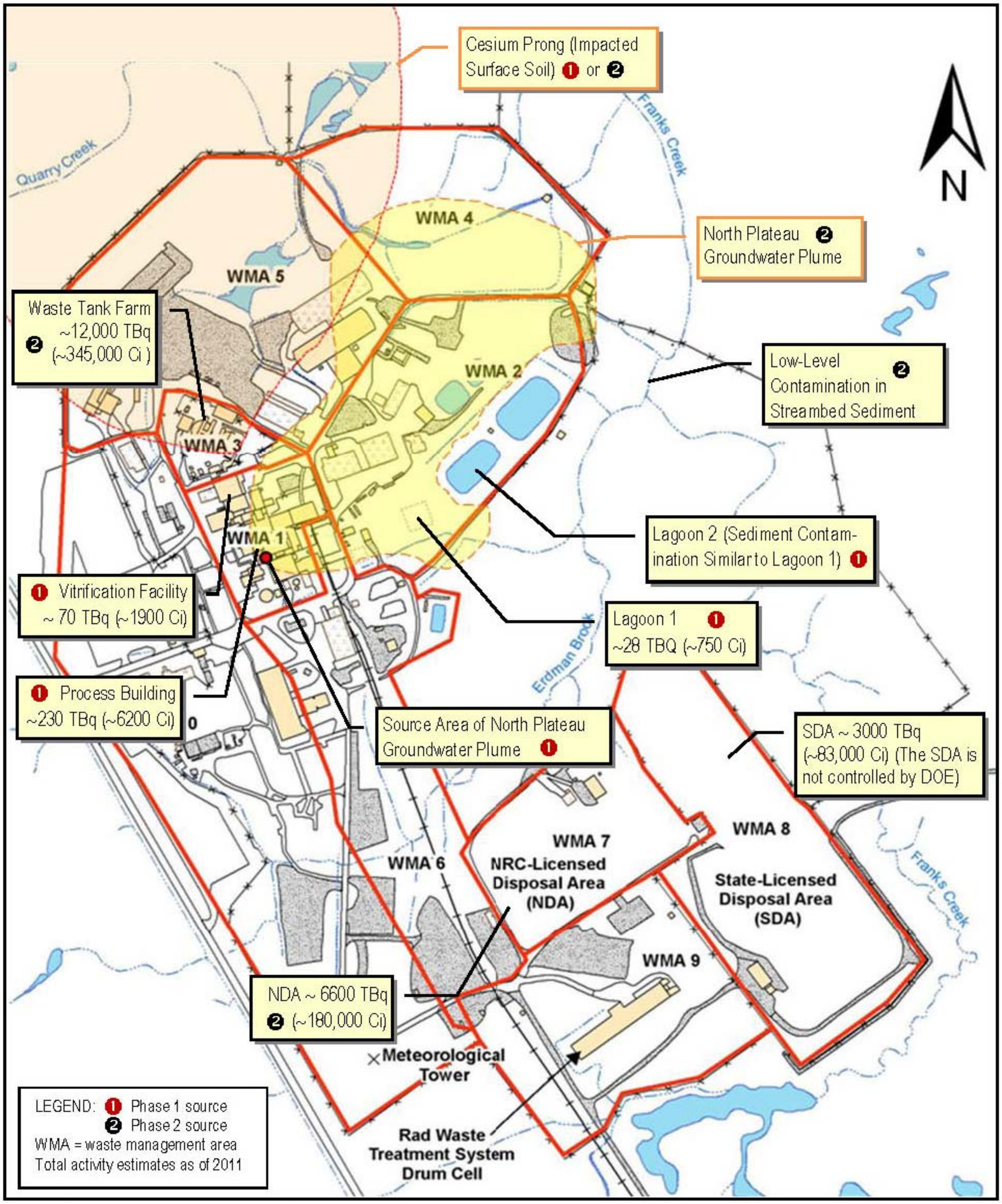

Fig 2. Important sources of contamination on the project premises.

Groundwater contamination on the project premises has been monitored for many years with a network of monitoring wells and a series of investigations have been conducted to sample subsurface soil and groundwater in the area of the plume. Low-level radioactive contamination is also known to be present in surface soil in some areas and in streambed sediment. Preparations are underway to more fully characterize soil and streambed sediment on the project premises.

THE PHASED DECISION-MAKING APPROACH

DOE issued its Record of Decision on the *Final Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center* in April 2010 [3, 4]. This Record of Decision adopted the preferred alternative, which is called the phased decision-making approach.

With this approach, the decommissioning will be accomplished in two phases. Phase 1 is scheduled to start in 2011. The approach to Phase 2 of the decommissioning is to be determined after additional studies.

The major differences between Phase 1 and Phase 2 can be seen in Figure 2. Sources labeled ❶ will be removed during Phase 1 of the decommissioning. Sources labeled ❷ will be addressed during Phase 2. Remediation of surface soil contamination, such as that associated with the cesium prong within the project premises, may be accomplished either in Phase 1 or Phase 2.

Note that a significant amount of deactivation work has been accomplished in recent years, including removing equipment from cells in the Process Building and decontaminating these cells, to establish conditions for beginning the Phase 1 decommissioning activities.

Phase 1 Decommissioning Activities

The Phase 1 Decommissioning Plan describes the work to be accomplished during the first phase of the decommissioning. The major activities in Phase 1 take place in Waste Management Areas 1 and 2.

In Waste Management Area 1, the Process Building will be completely removed, including its underground structure, as will the Vitrification Facility. The subsurface soil contamination that makes up the source area of the north plateau groundwater plume will also be removed. These activities will require an excavation approximately 11,000 square meters (2.8 acres) in area that will extend into the Lavery till more than 12 meters (40 feet) below the surface. Vertical hydraulic barriers (sheets piles and a slurry wall) will be installed around the excavation as shown in Figure 3 to control groundwater flow.

In Waste Management Area 2, all five of the wastewater treatment lagoons will be removed, along with the in-ground concrete holding tanks, concrete slabs, and the wastewater treatment building. A single excavation approximately 17,000 square meters (4.2 acres) in area will be dug to remove Lagoons 1, 2, and 3. This excavation will extend below the bottoms of the lagoons and at least 0.3 meter (one foot) into the Lavery till. Figure 4 shows the conceptual layout of the excavation, including the vertical hydraulic barrier wall designed to control groundwater flow.

In Waste Management Area 3, the decommissioning activities will be limited to removing pumps from the underground waste tanks, waste transfer piping running to the Vitrification Facility, and several small above-ground structures. There will be no Phase 1 decommissioning work in Waste Management Area 4. In Waste Management Area 5, the structures and concrete slabs and gravel pads will be removed. In Waste Management Area 6, the Sewage Treatment Plant and related facilities, two sludge ponds, and the remaining concrete floor slabs, foundations, and gravel pads will be removed. In Waste Management

Area 7, a small gravel pad will be removed. The NRC-Licensed Disposal Area itself – which is covered with a geomembrane – will not be disturbed.

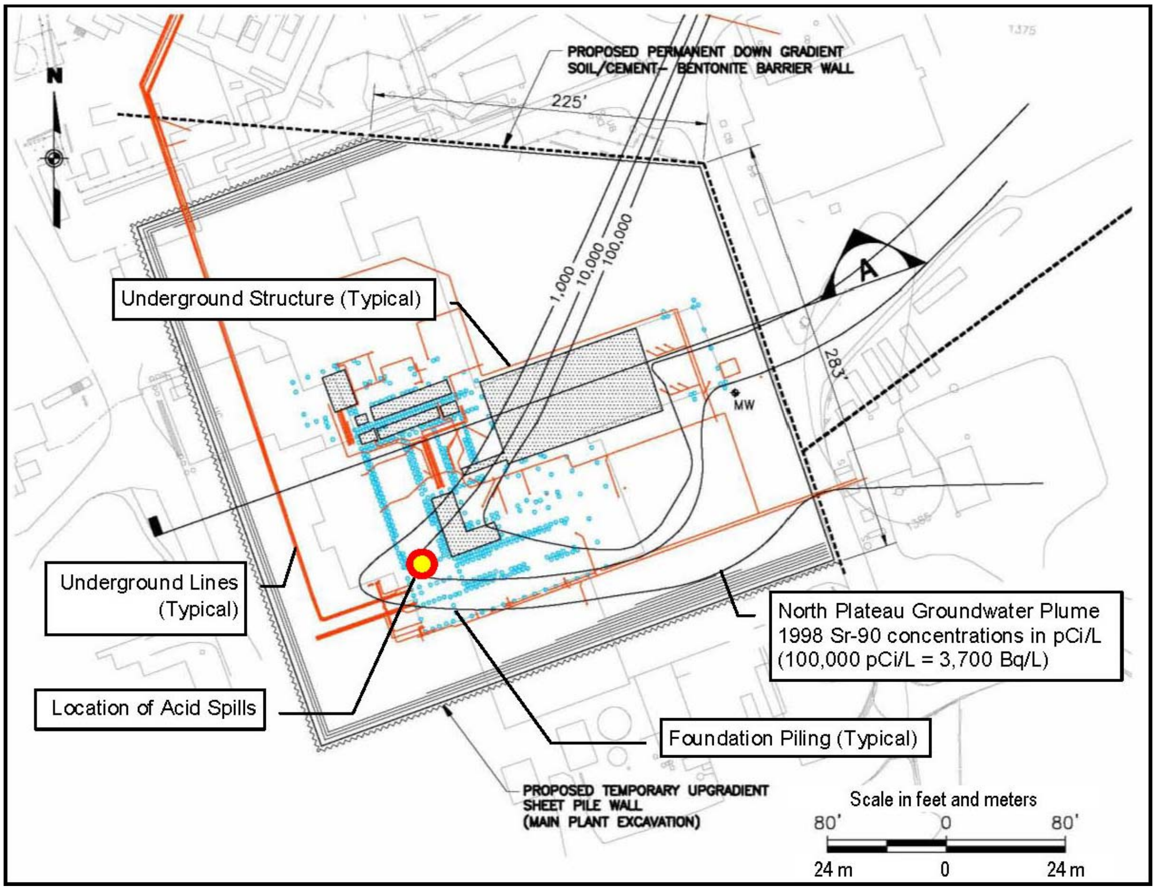

Fig 3. Conceptual layout of Waste Management Area 1 excavation.

The State-Licensed Disposal Area in Waste Management Area 8 is not within the scope of the decommissioning. In Waste Management Areas 9 and 10, the structures and gravel pads will be removed, along with the remaining concrete floor slabs and foundations. Surface soil exceeding cleanup goals may be remediated during Phase 1 in selected areas.

The Phase 1 Decommissioning Plan

The NRC, using its authority under the West Valley Demonstration Project Act, established the decommissioning criteria for the project [5]. These criteria specified that NRC's Licence Termination Rule [6], which provides for both unrestricted release and license termination under restricted conditions, would apply to the project.

Shortly after the beginning of the West Valley Demonstration Project, DOE agreed to submit a decommissioning plan to NRC for review [7]. Agreement between DOE and NRC was reached on the content of the Phase 1 Decommissioning Plan in a scoping meeting held in 2008 [8]. DOE submitted the Phase 1 Decommissioning Plan for NRC review in December 2008 and issued a revision incorporating NRC technical comments in December 2009. NRC's Technical Evaluation Report [9] on its review of the Decommissioning Plan was issued in February 2010. The NRC staff determined that the plan provides reasonable assurance that the proposed action will meet the decommissioning criteria and identified no objection to any provision of the plan [9].

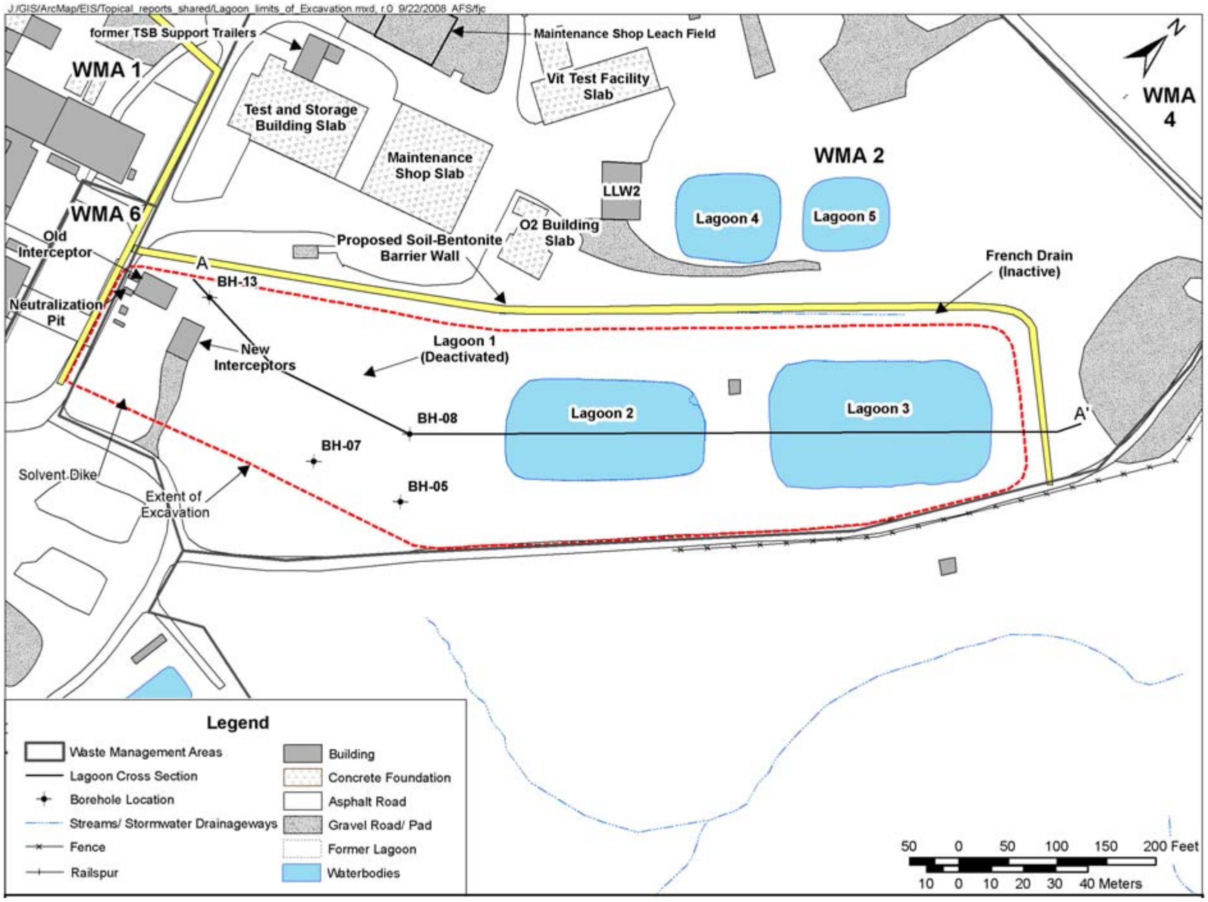

Fig 4. Conceptual layout of Waste Management Area 2 excavation.

Section 5 of the Decommissioning Plan details development of cleanup goals. Before the plan was finalized, DOE met with NRC on several occasions to discuss the planned approach to development of the cleanup goals and related requests for information and factored in input from NRC staff [10, 11, 12].

CLEANUP GOAL DEVELOPMENT

The complexities of the site and the plans for deep excavations led to the decision to develop separate cleanup goals for each of the primary media of interest: surface soil, deep subsurface soil, and streambed sediments. Conceptual models reflective of site conditions were developed to support this effort, including alternate conceptual models for the deep subsurface soil condition. The RESRAD computer code served as the primary mathematical model and was used in both its deterministic and probabilistic forms [13, 14]. First, derived concentration guidelines levels (DCGLs) that would produce 0.25 mSr/yr (25 mrem/yr) were calculated. Then lower cleanup goals were established to account for a hypothetical individual being exposed to residual radioactivity from different parts of the remediated site. Figure 5 shows the general process.

The cleanup goals will eventually be used in connection with final status surveys performed in accordance with the *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* [15] to confirm that the cleanup goals have been achieved and thereby confirm that the annual dose limit has been met.

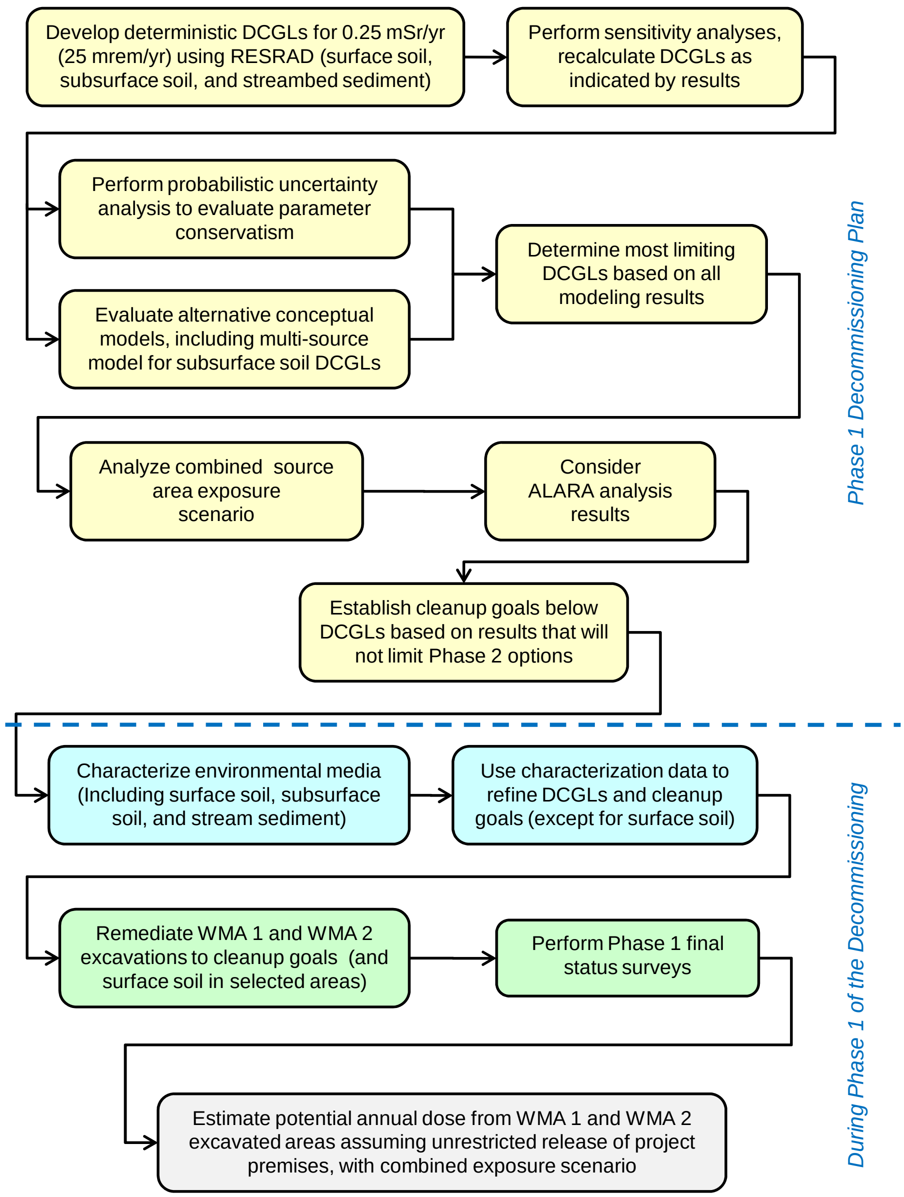

Fig. 5. General modeling process

Context for DCGL Development

A screening process was used to identify 18 radionuclides of interest. This screening process took into account factors such as half-life, quantities present initially, and the results of preliminary dose analyses. The 18 resulting radionuclides were:

Am-241	Cs-137	Pu-239	Tc-99	U-235
C-14	I-129	Pu-240	U-232	U-238
Cm-243	Np-237	Pu-241	U-233	
Cm-244	Pu-238	Sr-90	U-234	

Because subsurface soil contamination is known to be present on various areas of the project premises, it was necessary to restrict use of the surface soil cleanup goals to areas where there is no contamination below three feet in depth.

Development of subsurface soil DCGLs focused on two areas: the bottom and lower sides of the two deep excavations in Waste Management Areas 1 and 2, with the resulting cleanup goals being applicable only to those areas. As noted previously, both deep excavations will extend at least one foot into the Lavery till, which, because it is mostly clay, has much lower hydraulic conductivity than the sand and gravel layer above. Characterization data from the Lavery till suggest that contamination levels in this soil layer will be low.

Development of DCGLs for streambed sediment considered the steep banks of the streams on the project premises and the resulting cleanup goals were limited in application to only those portions of the streams with steep banks as represented in the conceptual model, which is described below.

Another factor taken into account in DCGL and cleanup goal development was the Phase 2 sources shown in Figure 2. The cleanup goals were established so that they would support any approach which DOE may select for Phase 2 of the decommissioning.

Conceptual Models

Conceptual models were developed to ensure that the dose evaluation would provide conservative estimates of the associated exposures for each media. Therefore, the RESRAD resident farmer model (which represents a broad range of significant exposure pathways) was used as the base-case conceptual model for developing surface soil DCGLs. It was assumed that the top one meter of soil was contaminated and the normal exposure pathways were used with the exceptions of aquatic food ingestion and radon inhalation. To demonstrate conservatism in the conceptual models, two alternate conceptual models were also evaluated for surface soil. One involved an offsite receptor who received exposure from radioactivity in soil eroded from the hypothetical garden used in the base-case model that washed into nearby streams. The other involved a residential gardener who resides in the area and grows a vegetable garden, but does not consume meat or milk produced on the property. The base-case surface soil model proved to be more conservative – that is, produced lower surface soil DCGLs – than the alternate models.

The base-case conceptual model for subsurface soil DCGL development was also based on the RESRAD resident farmer model. For conservatism, it was assumed that the hypothetical well for the subsistence farm consisted of a two meter diameter cistern. The bottom of this cistern was located 10 meters (33 feet) below the surface in the assumed contamination zone at the bottom of one of the deep excavations. It was assumed that during construction of the cistern, clean material was removed to a depth of nine meters along with a one-meter-thick plug of contaminated material from the bottom. In this way, the removed material is essentially a contaminated layer diluted by clean overburden material. The same exposure pathways included in surface soil DCGL development were used in the subsurface model.

To reduce uncertainty associated with the conceptual model itself, and considering the lack of a known precedent for development of deep soil DCGLs, seven alternate conceptual models were evaluated that involved dose received by the following receptors:

- An individual drilling the cistern type well,
- An individual drilling a natural gas well in the area,
- A recreational hiker in the area of the filled lagoon excavation assuming that unchecked erosion eventually cut deep gullies that extended into the excavation bottom,
- An offsite receptor exposed to contamination from the lagoon excavation bottom exposed by unchecked erosion that washed into Erdman Brook and was carried downstream,
- A residential gardener with the cistern type well scenario,
- A resident farmer in a multi-source model that considered continuing releases from the bottom of the remediated deep excavation as well as radioactivity brought to the surface, and finally,
- A residential gardener in the same multisource model.

The multi-source model was most limiting for nine radionuclides, the basic deterministic model for five radionuclides, and the probabilistic model for four. Figure 6 illustrates the multisource conceptual model.

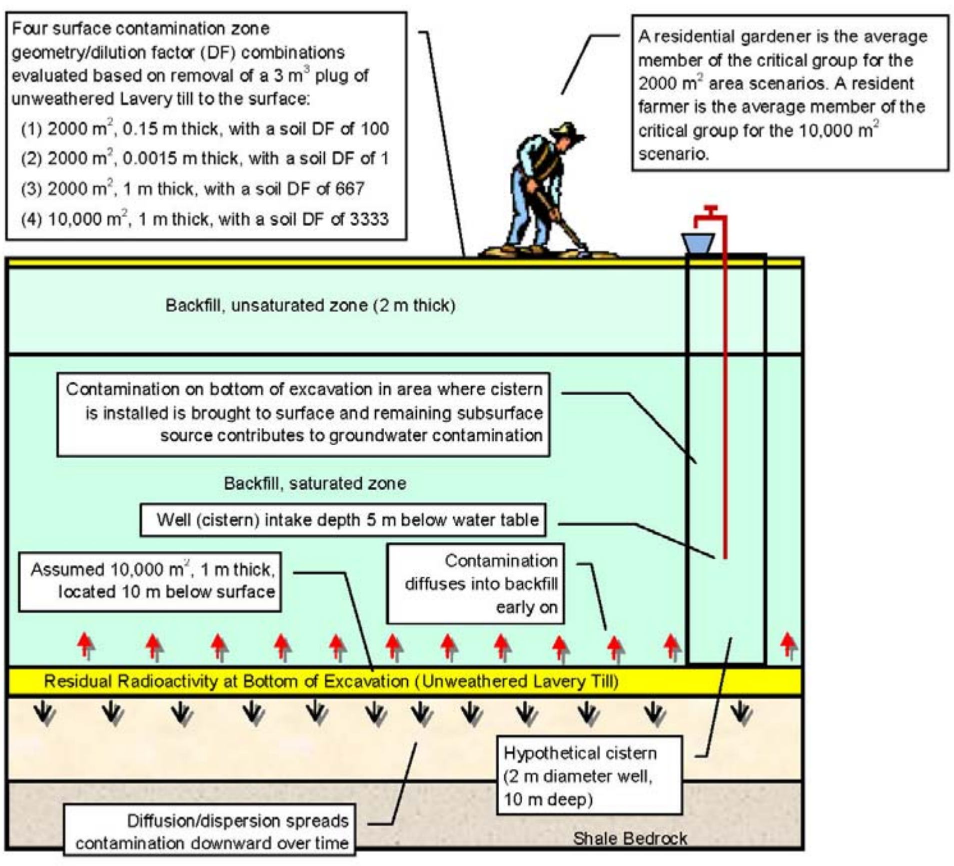

Fig 6. Multisource conceptual model for subsurface soil DCGL development [2]

The conceptual model for development of streambed sediment DCGLs involved a recreationist fishing in one of the streams and hunting, and hiking in the area. The use of a farming scenario was not considered applicable due to the steep topography associated with the stream banks. Figure 7 illustrates this conceptual model, which is applicable only to areas where the slopes are steep and preclude farming activities. The contaminated zone was assumed to be one meter thick and the exposure pathways evaluated for the recreationist included external gamma radiation from contaminated sediment, and ingestion of venison and fish contaminated by radioactivity in the stream, along with incidental ingestion of stream water and sediment.

The RESRAD model was adapted for the streambed sediment application by making certain simplifications, such as assuming there was no unsaturated zone so that the water table lies directly beneath the contaminated zone.

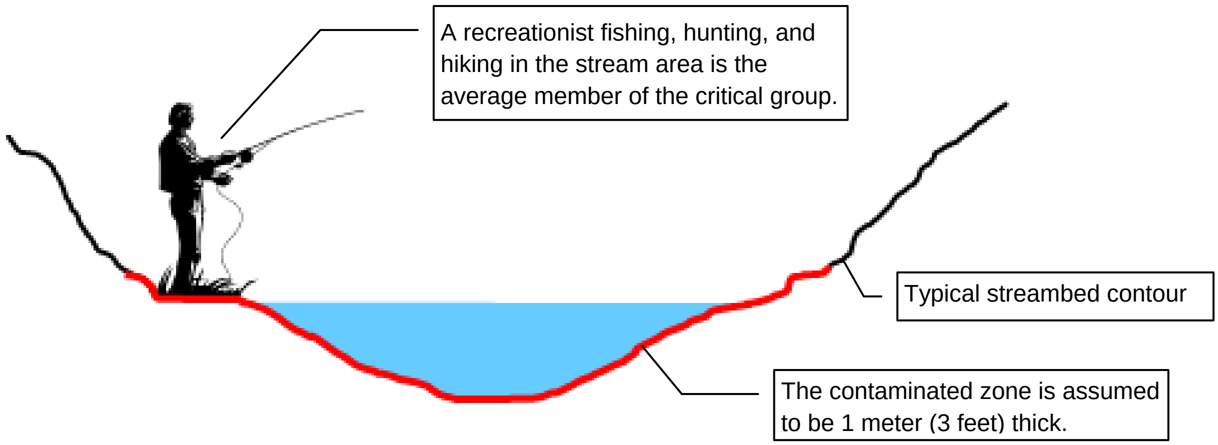

Figure 7. Conceptual model for streambed sediment DCGLs development

Mathematical Models

RESRAD version 6.4 [14] was used to calculate unit dose factors (dose-to-source ratios) for each of the 18 radionuclides of interest. These unit dose factors were scaled using Microsoft Excel to correspond to the dose limit of 0.25 mSv/yr (25 mrem/yr). The RESRAD probabilistic modules [13] were used in the uncertainty analysis discussed below.

To evaluate the complex multisource conceptual model it was necessary to model groundwater transport. The modeling was done using the three-dimensional near field Subsurface Transport Over Multiple Phases (STOMP) [16] model for the north plateau that had been used in evaluations performed in support of the Environmental Impact Statement [3]. The analyst developed a FORTRAN language computer program that was used with the STOMP results to estimate time-dependent human health effects.

Sensitivity and Uncertainty Analyses

Sensitivity analyses were performed to identify model input parameters with the most influence on dose. These analyses focused on the dose driver radionuclides. For the subsurface soil model, the most important dose driver radionuclide was Sr-90 based on characterization data from samples collected in the top portion of the Lavery till during the plume investigations. The results led to several conceptual model changes that made the results more realistic.

In addition, a comprehensive probabilistic uncertainty analysis was performed using the probabilistic modules of RESRAD Version 6.4 to confirm that key model input parameters were sufficiently conservative. This analysis evaluated the three base-case conceptual models. Selected input parameters were treated stochastically: 102 for surface soil, 67 for subsurface soil, and 63 for streambed sediment, including nuclide distribution coefficients in soil and water. The resulting DCGLs – both the peak-of-the-mean and 95th percentile values – were generally lower than the deterministic DCGLs in each media. The probabilistic results indicate that parameter distributions include significant uncertainty, particularly in the more conservative tail of the range of values, as compared with deterministic values. The uncertainty in the deterministic results warranted the use of the more stringent probabilistic DCGLs as further described below.

Resulting DCGLs

Table I shows DCGLs for representative radionuclides.

Table I. DCGLs for 0.25 mSv/yr (25 mrem/yr) for Representative Radionuclides[a] [2]

Unit	Nuclide	Surface Soil DCGLs		Subsurface Soil DCGLs		Streambed Sediment DCGLs	
		Determ.	Peak-of-the-Mean	Limiting Determ.[b]	Peak-of-the-Mean	Determ.	Peak-of-the-Mean
Bq/g	Sr-90	2.3E-01	**1.5E-01**	**1.0E+01**	1.3E+02	3.5E+02	**1.7E+02**
	Tc-99	8.9E-01	**7.8E-01**	**2.2E+01**	5.2E+02	8.1E+04	**2.4E+04**
	I-129	1.3E-02	**1.2E-02**	**2.8E-01**	2.5E+01	1.4E+02	**2.9E+01**
	Cs-137	8.9E-01	**5.6E-01**	1.6E+01	**1.1E+01**	4.8E+01	**3.7E+01**
	U-232	2.1E-01	**5.6E-02**	3.3E+00	**2.7E+00**	9.6E+00	**8.1E+00**
	Np-237	**3.5E-03**	9.6E-03	**3.7E-02**	3.4E+00	1.9E+01	**1.2E+01**
	Pu-238	1.9E+00	**1.5E+00**	4.8E+02	**5.2E+02**	7.4E+02	**4.4E+02**
pCi/g	Sr-90	6.3E+00	**4.1E+00**	**2.8E+02**	3.4E+03	9.5E+03	**4.7E+03**
	Tc-99	2.4E+01	**2.1E+01**	**5.9E+02**	1.4E+04	2.2E+06	**6.6E+05**
	I-129	3.5E-01	**3.3E-01**	**7.5E+00**	6.7E+02	3.7E+03	**7.9E+02**
	Cs-137	2.4E+01	**1.5E+01**	4.4E+02	**3.0E+02**	1.3E+03	**1.0E+03**
	U-232	5.8E+00	**1.5E+00**	8.8E+01	**7.4E+01**	2.6E+02	**2.2E+02**
	Np-237	**9.4E-02**	2.6E-01	**1.0E+00**	9.3E+01	5.2E+02	**3.3E+02**
	Pu-238	5.0E+01	**4.0E+01**	**1.3E+04**	1.4E+04	2.0E+04	**1.2E+04**

a The more limiting (lower) DCGLs are shown in bold.

b. The most limiting of all of the deterministic models, which in most cases was the multisource model.

Limited Site-Wide Dose Assessment

The DCGLs were developed independently for separate areas of interest assuming that the hypothetical exposed individual (the average member of the critical group) would be exposed only to the radioactivity source of interest. To account for this situation, and because only limited portions of the site will be remediated during Phase 1 of the decommissioning, assessments were performed that involved apportioning doses from different parts of the remediated project premises to ensure that the cleanup goals used for remediation in Phase 1 of the decommissioning will not limit Phase 2 options. These assessments involved the hypothetical individual being exposed to two different source areas and being a member of two different critical groups.

The approach used involves partitioning doses between two critical groups and two areas of interest: (1) the resident farmer who lives in an area of the project premises where surface soil or subsurface soil has been remediated to the respective DCGLs and (2) the recreationist who spends time in the areas of the streams hiking, fishing, and hunting. Consideration of potential risks related to the different areas led to assigning 90 percent of the total dose limit of 0.25 mSv/yr (25 mrem/yr) to the resident farmer activities and 10 percent to the recreationist activities.

Two separate assessments were performed with the resident farmer located in: (1) the area of the remediated WMA 1 subsurface soil excavation, and (2) the resident farmer located in an area where surface soil was assumed to have been remediated. The results were used in establishing the cleanup goals for the different media.

Cleanup Goals

Considering the results of these assessments along with the results of the ALARA (as low as reasonably achievable) analysis, DOE established cleanup goals to ensure that remediation accomplished during Phase 1 of the decommissioning will support any approach that might be used during Phase 2 of the decommissioning. Table II shows the final cleanup goals, which represent an average concentration over a survey unit. In addition, elevated measurement concentration cleanup goals were also developed to apply to small areas of higher activity.

Table II. Cleanup Goals to be Used in Remediation

Nuclide	Surface Soil		Subsurface Soil		Streambed Sediment	
	Bq/g	pCi/g	Bq/g	pCi/g	Bq/g	pCi/g
Am-241	9.6E-01	2.6E+01	1.0E+02	2.8E+03	3.7E+01	1.0E+03
C-14	5.6E-01	1.5E+01	1.7E+01	4.5E+02	6.7E+00	1.8E+02
Cm-243	1.1E+00	3.1E+01	1.9E+01	5.0E+02	1.1E+01	3.1E+02
Cm-244	2.1E+00	5.8E+01	3.7E+02	9.9E+03	1.4E+02	3.8E+03
Cs-137	5.2E-01	1.4E+01	5.2E+00	1.4E+02	3.7E+00	1.0E+02
I-129	1.1E-02	2.9E-01	1.3E-01	3.4E+00	2.9E+00	7.9E+01
Np-237	8.5E-03	2.3E-01	1.7E-02	4.5E-01	1.2E+00	3.2E+01
Pu-238	1.3E+00	3.6E+01	2.2E+02	5.9E+03	4.4E+01	1.2E+03
Pu-239	8.5E-01	2.3E+01	5.2E+01	1.4E+03	4.4E+01	1.2E+03
Pu-240	8.9E-01	2.4E+01	5.6E+01	1.5E+03	4.4E+01	1.2E+03
Pu-241	3.7E+01	1.0E+03	4.1E+03	1.1E+05	1.3E+03	3.4E+04
Sr-90	1.4E-01	3.7E+00	4.8E+00	1.3E+02	1.7E+01	4.7E+02
Tc-99	7.0E-01	1.9E+01	1.0E+01	2.7E+02	2.4E+03	6.6E+04
U-232	5.2E-02	1.4E+00	1.2E+00	3.3E+01	8.1E-01	2.2E+01
U-233	2.8E-01	7.5E+00	3.2E+00	8.6E+01	8.1E+01	2.2E+03
U-234	2.8E-01	7.6E+00	3.3E+00	9.0E+01	8.1E+01	2.2E+03
U-235	1.1E-01	3.1E+00	3.5E+00	9.5E+01	8.5E+00	2.3E+02
U-238	3.3E-01	8.9E+00	3.5E+00	9.5E+01	3.0E+01	8.2E+02

Given the complexity of the site and the two-phase decommissioning approach, certain conservatisms and limitations were applied to the cleanup goals:

- The cleanup goals for Sr-90 and Cs-137 apply to the year 2041 and later, that is, they incorporate a 30-year decay period from 2011 because unrestricted release of the project premises is unlikely to be practicable before 2041 if that Phase 2 decommissioning alternative were to be selected.
- The surface soil cleanup goals apply only to parts of the project premises without subsurface soil contamination.
- The subsurface soil cleanup goals apply only to the bottom of the deep excavations in Waste Management Areas 1 and 2 and to the sides of these excavations one meter (three feet) or more below the surface.
- The subsurface soil cleanup goals were established at 50 percent of the DCGLs calculated in the limited site-wide dose assessments, meaning they equate to approximately 0.11 mSr/yr (11 mrem/yr) for an extra measure of conservatism.
- The streambed sediment cleanup goals apply only to portions of the streams with steep banks consistent with the recreationist conceptual model.
- The streambed sediment cleanup goals will support unrestricted release of the project premises but will not necessarily support release with restrictions because the latter approach would leave some Phase 2 sources which could impact the streams.

The calculated DCGLs and the associated cleanup goals will be refined as appropriate after the data from the soil and sediment characterization program to be completed early in Phase 1 of the decommissioning becomes available.

Lessons Learned

This was the first known project where unique sets of DCGLs and cleanup goals were developed specifically for deep subsurface soil and streambed sediment. The use of these cleanup goals, which are higher than those for surface soil, is expected to reduce costs without compromising compliance with the dose standards. Among the lessons learned were:

(1) *Development of such cleanup goals can be time consuming*. It took approximately two years for this project.

(2) *Development of the subsurface soil cleanup goals was especially complex*. The situation led to use of multiple conceptual models and the decision to introduce an extra measure of conservatism in the final values.

(3) *RESRAD can be effectively adapted to conditions different from its original intent.* The use of RESRAD in developing streambed sediment DCGLs is a case in point.

(4) *The probabilistic uncertainty analysis proved particularly useful.* The resulting peak-of-the-mean DCGLs were used as the basis for the cleanup goals in most cases. The use of site specific soil/water distribution coefficients for surface and subsurface models contributed to confidence in the results. Caution must be exercised in correlating the probabilistic parameters to ensure that unrealistic parameter combinations are avoided.

(5) *Site-specific DCGLs were more conservative than generic NRC clean-up standards*. The use of site-specific scenario modeling and parameter values contributed to confidence in the conservatism of the cleanup goals.

(6) *Active involvement of the regulator is important*. The meetings with NRC staff to discuss the approaches being used and the suggestions of NRC staff helped make the results technically sound and credible.

REFERENCES

1. West Valley Demonstration Project Act, Public Law 96-368 (S. 2443) (October 1, 1980).

2. "Phase 1 Decommissioning Plan for the West Valley Demonstration Project," Revision 2, Washington Safety Management Solutions and Science Applications International Corporation, West Valley, New York (December 2009).

3. "Final Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center," DOE/EIS-0226, U.S. Department of Energy, West Valley, New York (January 2010).

4. "Record of Decision: Final Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center," U.S. Department of Energy, Washington, D.C. (April 14, 2010).

5. "Decommissioning Criteria for the West Valley Demonstration Project (M-32) at the West Valley Site; Final Policy Statement," Federal Register 67 FR 22, U.S. Nuclear Regulatory Commission, Washington, D.C. (February 1, 2002).

6. "Radiological Criteria For License Termination," Code of Federal Regulations 10 CFR 20, Subpart E, U.S. Nuclear Regulatory Commission, Washington, D.C. (March 31, 1997).

7. “West Valley Demonstration Project Memorandum of Understanding Between the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission,” (September 23, 1981).
8. “Summary of a Meeting Between NRC and DOE on the Phase 1 Decommissioning Plan, May 19, 2008.” [http://nrc.gov, ADAMS Accession Number ML081510458]
9. “Technical Evaluation Report on the U.S. Department of Energy Phase 1 Decommissioning Plan for the West Valley Demonstration Project,” U.S. Nuclear Regulatory Commission, Washington, D.C. (February 25, 2010) [http://nrc.gov, ADAMS Accession Number ML100360030]
10. “Report of October 21, 2008 Meeting with U.S. Department of Energy on Dose Modeling Approach for Phase 1 Decommissioning Plan,” U.S. Nuclear Regulatory Commission, Washington, D.C. (November 18, 2008) [http://nrc.gov, ADAMS Accession Number ML083220653]
11. “Meeting With U.S. Department of Energy West Valley Demonstration Project, West Valley, NY To discuss request for additional information on U.S. Nuclear Regulatory Commission’s Review of the U.S. Department of Energy Phase 1 Decommissioning Plan for the West Valley Demonstration Project, June 15, 2009,” U.S. Nuclear Regulatory Commission, Washington, D.C. (July 24, 2009) [http://nrc.gov, ADAMS Accession Number 092050175]
12. “Meeting with DOE to discuss two follow up items from the June 15, 2009, meeting on the request for additional information from the U.S. Nuclear Regulatory Commission (NRC) review of the U.S. Department of Energy (DOE) Phase 1 Decommissioning Plan for the West Valley Demonstration Project, September 2, 2009” U.S. Nuclear Regulatory Commission, Washington, D.C. (October 16, 2009) [http://nrc.gov, ADAMS Accession Number 092920096]
13. “Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes,” NUREG/CR-6697, ANL/EAD/TM-98, Yu, C., et al., Environmental Assessment Division, Argonne National Laboratory, Argonne, Illinois (November 2000).
14. “User’s Manual for RESRAD Version 6,” ANL/EAD-4. Yu, C., et al., Environmental Assessment Division, Argonne National Laboratory, Argonne, Illinois (July 2001).
15. “Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM),” NUREG-1575, Revision 1, U.S. Nuclear Regulatory Commission, Washington, D.C. (Also EPA 4-2-R-97-016, Revision 1, U.S. Environmental Protection Agency and DOE-EH-0624, Revision 1, U.S. Department of Energy) (August 2000)
16. STOMP, *Subsurface Transport Over Multiple Phases*, Version 2.0 Theory Guide, PNNL-12030, Richland, Washington. March, 2000.