APPLICATION OF MARSSIM CONCEPTS IN A CERCLA RI/FS FOR THE SLDA FUSRAP SITE

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ABSTRACT

The U.S. Army Corps of Engineers is investigating possible remediation activities of radioactive wastes following Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements at the Parks Shallow Land Disposal Area (SLDA), is a radiologically contaminated property that is part of the Formerly Utilized Sites Remedial Action Program (FUSRAP). The SLDA is a 44-acre site in Parks Township, Armstrong County, Pennsylvania, about 23 miles east-northeast of Pittsburgh. The site includes 10 trenches containing an estimated 23,500 to 36,000 cubic yards (yd^3) of potentially contaminated waste and soil. As part of the current Remedial Investigation/Feasibility Study (RI/FS), a Baseline Risk Assessment (BRA) was performed to evaluate risks to human health and the environment in the absence of remedial action to prevent potential exposures to the radioactive contaminants at the SLDA. The SLDA site was divided into three exposure units (EUs) to support the risk assessment process. These EUs were developed based on environmental conditions, historical uses of specific areas, representativeness of size based on receptor behavior, geographical similarity, and contamination potential. The EUs include contaminated surface and subsurface media and represent areas over which exposures to assumed receptors are averaged. In addition to the factors noted above, the EUs were developed considering the need to identify final status survey (FSS) units for future site closeout activities as identified in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM). The goal in considering FSS units while developing the EUs for the BRA is to develop consistency between the RI/FS evaluations and future site closeout activities to the maximum extent possible. The boundaries between the Class 1 and Class 2 FSS units will likely change as remedial action activities are performed at the site. However, identifying these units on a preliminary basis during preparation of the RI/FS should expedite closeout activities in the future by helping define pre-remedial design sampling requirements. By defining the FSS units early in the process, sampling activities will fill multiple data needs, supporting both remedial planning (RI/FS) and site closure (MARSSIM), specifically in areas where contamination may not be above preliminary remediation goals.

BACKGROUND

The Shallow Land Disposal Area (SLDA) is a 44-acre site in Parks Township, Armstrong County, Pennsylvania, near Leechburg and Vandergrift, about 23 miles east-northeast of Pittsburgh (Figure 1).

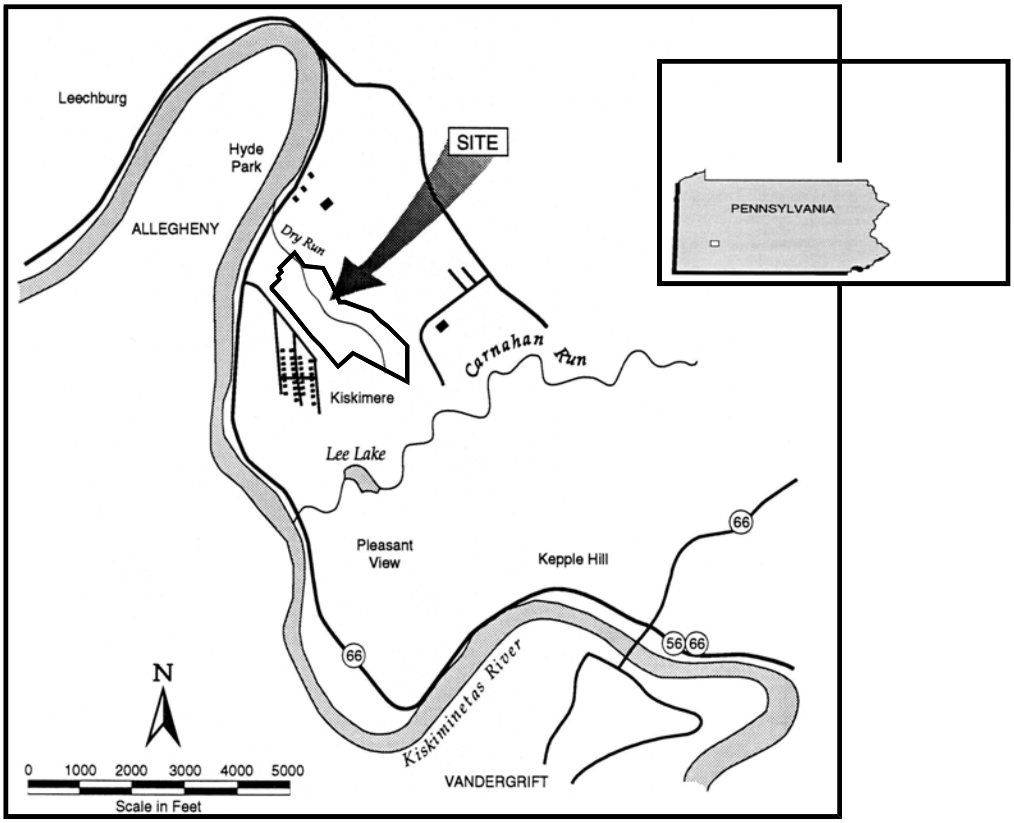

Fig. 1. SLDA site location map.

The 44-acre site includes nine trenches and a backfilled settling pond (referred to as Trench 3) containing an estimated 23,500 to 36,000 yd^3 of potentially contaminated waste and soil (Figure 2). The trenches cover an area of about 1.2 acres, or less than 3% of the site. The trenches are separated by geography into two general areas: one area containing Trenches 1 through 9 (referred to as the upper trench area) and a second area containing Trench 10 (referred to as the lower trench area).

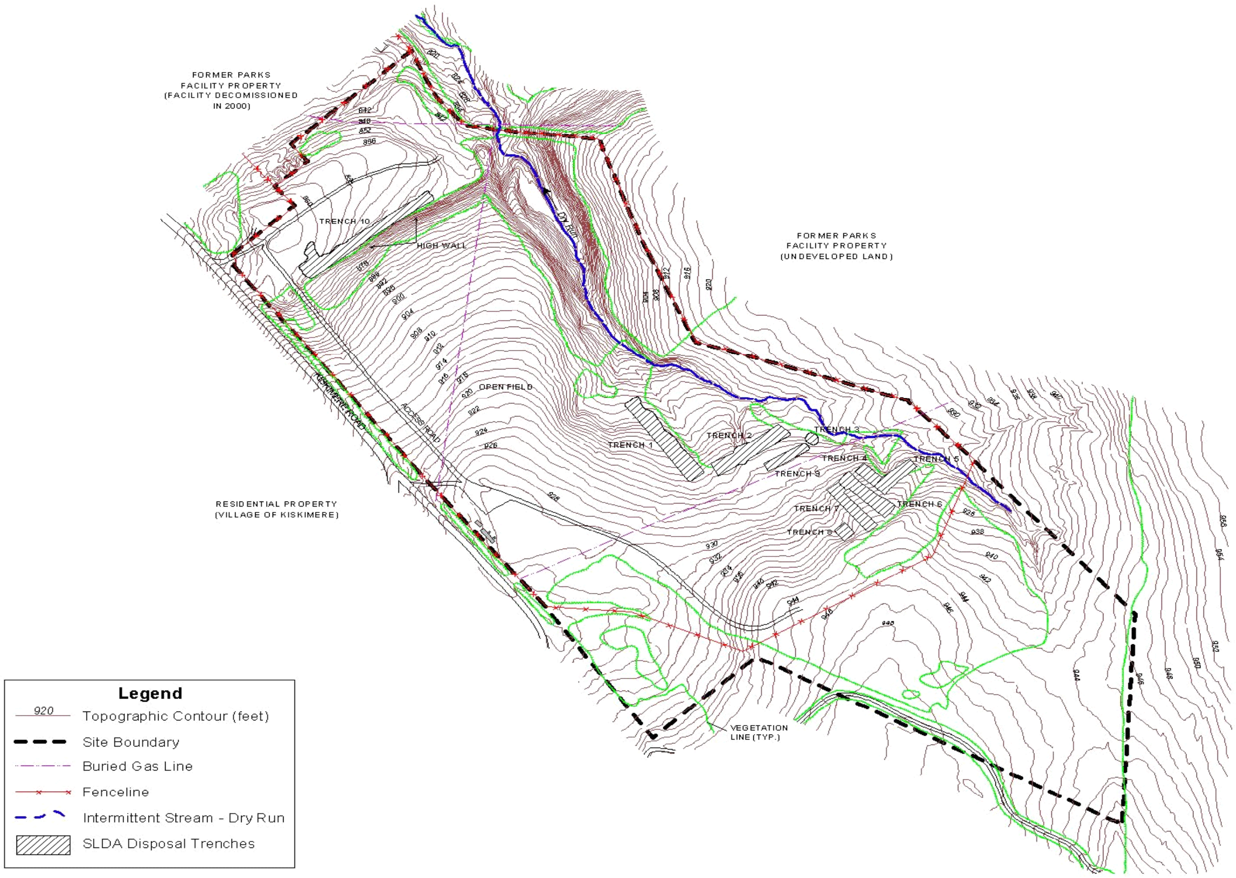

Fig. 2. SLDA site map.

The SLDA is predominantly an open field, with wooded vegetation along most of the northeastern boundary and in the southeastern and southern corners. The land slopes downward from the southeast toward the northwest, with a change in elevation of about 115 feet (ft) over a distance of 1,000 ft. A small, intermittent stream, identified as Dry Run, collects surface runoff from the site and from several groundwater seeps along the hillside. A portion of the flow in Dry Run infiltrates through the coal mine spoils in the lower trench area and into abandoned coal mines that underlie the majority of the site. The balance of Dry Run flow continues off site to the Kiskiminetas River. Land use surrounding the SLDA site is mixed, consisting of medium-sized residential communities and individual rural residences, small farms with croplands and pastures, idle farmland, forestlands, and light industrial areas.

Radioactive wastes were disposed of at the SLDA by the Nuclear Materials and Equipment Company (NUMEC) between 1961 and 1970. These waste disposal activities were done in accordance with U.S. Atomic Energy Commission (AEC) requirements set forth in 10 CFR 20.304; this regulation was rescinded in 1981. The wastes originated from the nearby Apollo nuclear fuel fabrication facility, which began operations under NUMEC in the late 1950s and fabricated enriched uranium into naval reactor fuel elements. In 1967, the Atlantic Richfield Company (ARCO) bought the stock of NUMEC. NUMEC discontinued use of the SLDA site for radioactive waste disposal in 1970, and in 1971, ARCO transferred ownership of the site to Babcock & Wilcox, which later changed its name to BWX Technologies

(BWXT). BWXT is the current licensee for the site and is responsible for compliance with the terms and conditions of U.S. Nuclear Regulatory Commission (NRC) License SNM-2001.

After performing a historical records review for the SLDA, the U.S. Department of Energy concluded that the site contained radioactive wastes from activities that supported the nation's early atomic energy program and was eligible for evaluation under the Formerly Utilized Sites Remedial Action Program (FUSRAP). This determination was provided to the U.S. Army Corps of Engineers (USACE) on May 25, 2000, consistent with responsibilities of each organization for the administration and execution of FUSRAP. Subsequent to that determination, the Senate Committee on Appropriations recommended that up to $5 million appropriated for FUSRAP in 2001 be used to determine the appropriate response action for the SLDA site under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The House of Representatives Committee of Conference concurred with this resolution, and in November 2000, the USACE included the SLDA site in FUSRAP and referred the site to the Great Lakes and Ohio Rivers Divisions for action.

In accordance with the CERCLA process, a Preliminary Assessment (PA) was performed and released in March 2002. The PA recommended no further action at the site under FUSRAP, due to the absence of an unpermitted release as defined by CERCLA. However, this recommendation was superceded by Section 8143 of the Department of Defense Appropriations Act for 2002, which directed the Secretary of the Army, acting through the Chief of Engineers, to clean up radioactive waste at the SLDA site consistent with a 2001 Memorandum of Understanding (MOU) between USACE and NRC. This MOU applies to FUSRAP sites with NRC-licensed facilities (such as the SLDA), and specifies that response actions meet the decommissioning requirements of 10 CFR 20.1402 [1].

Based on the 2002 legislation cited above and in accordance with the CERCLA process, a remedial investigation (RI) has been performed for the SLDA site to characterize the nature and extent of radiological contamination and to evaluate potential risks to human health and the environment. These results will be used to assess the need for remediation at the site based on the evaluation of alternatives in the Feasibility Study (FS). The RI report has been completed and is currently under review by oversight and regulatory agencies; it will be released to the general public in the very near future. Activities have been initiated on the FS report, and this document is expected to be completed and issued to the general public before the end of the year.

Site Contamination

Radioactive contamination at the SLDA is a result of waste-disposal activities at the site that occurred from 1961 through 1970. Waste materials were placed into a series of pits that were constructed adjacent to one another. These pits gave the appearance of linear trenches in geophysical surveys performed at the site, and they are depicted on site drawings as trenches. Trenches 1 through 9 in the upper trench area were reportedly excavated to the weathered shale bedrock, and Trench 10 (located 1,000 ft northwest of the upper trench area) was excavated in coal strip mine spoils on the northwest side of a high wall of bedrock in a generally flat area of the site (see Figure 2). The trench locations are approximate, as detailed records on the locations of these pits and waste disposal activities at the site are not available.

A wide variety of wastes were placed in the trenches in a highly heterogeneous manner. Following placement in the trenches, the waste materials were covered with about 4 ft of clean soil, as specified in AEC regulations governing these disposal activities. The average waste thickness in Trenches 1 through 9 ranges from about 8.5 to 16 ft, and the average waste thickness in Trench 10 is about 18 ft. The volume of potentially contaminated waste and soil in the trenches has been estimated to range from about 23,500 to 36,000 yd^3; much of this material may be uncontaminated soil. Most of the radioactive contamination at the site is associated with the upper trench area. Historical information indicates that the wastes disposed of in Trench 10 were generally uncontaminated or only mildly contaminated equipment and construction debris. As for the trench locations, this information on the volume and placement of wastes in the trenches is approximate due to the lack of detailed records for the site.

The primary radioactive contaminants in the disposed of wastes were uranium and thorium. The uranium-contaminated materials placed in the trenches are present in a wide range of enrichments, ranging from less than 0.2% (by weight) uranium-235 (U-235) to greater than 45% U-235. The uranium isotopes of concern at the site are those associated with natural uranium, i.e., uranium-234 (U-234), U-235, and uranium-238 (U-238). The thorium disposed of at the SLDA was principally thorium-232 (Th-232) and since more than 30 years has passed since disposal activities ceased, significant ingrowth of radium-228 (Ra-228) has occurred. The former Parks nuclear fuel fabrication facility was located adjacent to and northwest of the site (near Trench 10), and contaminated equipment from the Parks facility was reportedly stored in the area of Trench 10. Localized areas of surface soil near Trench 10 contain elevated concentrations of plutonium (i.e., plutonium-239 [Pu-239] and plutomium-241 [Pu-241]), and americium-241 (Am-241); these transuranic radionuclides were not found at depth in the recent characterization program. The investigations summarized in the RI report have concluded that these eight radionuclides are the radionuclides of concern for the site.

In 1965, Trenches 2, 4, and 5 in the upper trench area were excavated to investigate discrepancies in material accounts of disposed uranium. The materials removed from the trenches were placed on the ground and sorted. Some of the exhumed materials were placed back in the trenches and the remainder was shipped off site. Two subsequent soil remediation projects were conducted in 1986 and 1989 to remove surface soils containing elevated levels of uranium. These projects removed most of the contaminated surface soil at the site, and radiological surveys were conducted following the remedial actions to confirm the effectiveness of these actions. A gamma walkover survey was performed as part of the RI investigations in the summer of 2003, which confirmed that contaminated surface soil is present in only a few isolated areas, and the concentrations of radionuclides at these locations are lower compared to concentrations prior to the soil remediation activities.

The RI site characterization program confirmed that there is very little soil contamination outside the trench footprints. Localized areas of contaminated soil are present (generally in the vicinity of Trench 10), and there are areas of contaminated sediment in Dry Run. The concentrations of radioactive contaminants in most soil samples were generally comparable to background, although a few samples had total uranium concentrations in excess of 100 picoCuries per gram (pCi/g). The concentrations of radionuclides in the materials contained within the ten trenches are much greater than in nearby soils. Historical results indicate concentrations in excess of 1,000 pCi/g, with U-234 being the radionuclide generally having the highest concentrations; the concentrations of total uranium in leachate samples collected from within the ten trenches had concentrations up to 29,500 pCi/L. The surface water in Dry Run and the surface water and sediment in the nearby Carnahan Run do not appear to have been impacted by the radioactive wastes at SLDA; site groundwater is also largely unimpacted.

Exposure Units

A baseline risk assessment (BRA) was performed as part of the RI process consistent with U.S. Environmental Protection Agency (EPA) risk assessment guidance for sites being addressed under CERCLA. The risk assessment was limited to the radioactive contaminants at the SLDA, in accordance with the authorizing legislation for the site. The chemical toxic effects of these radioactive contaminants were considered in this BRA, specifically for uranium, which is chemically toxic to the kidney. The BRA addressed the risks to human health and the environment in the absence of future remedial actions, to help focus and guide the assessment of alternatives in the FS. The risks to human health and the environment for the various remedial action alternatives will be addressed in the FS as specified in the National Oil and Hazardous Substances Pollution Contingency Plan [2].

The SLDA site was divided into three exposure units (EUs) to support the human health risk assessment process (Figure 3). These EUs were developed based on environmental conditions, historical uses of specific areas, reasonableness of size in terms of representing receptor behavior, geographical similarity, and contamination potential. These three EUs address the upper trench area (EU 1), the lower trench area (EU 2), and an area near the fence southeast of the upper trench area (EU 3) (see Figure 3). The EUs include both contaminated surface and subsurface media and represent areas over which receptors are assumed to spend their time while at the site. In addition, a site-wide assessment was performed in which the receptors are assumed to access all areas of the site.

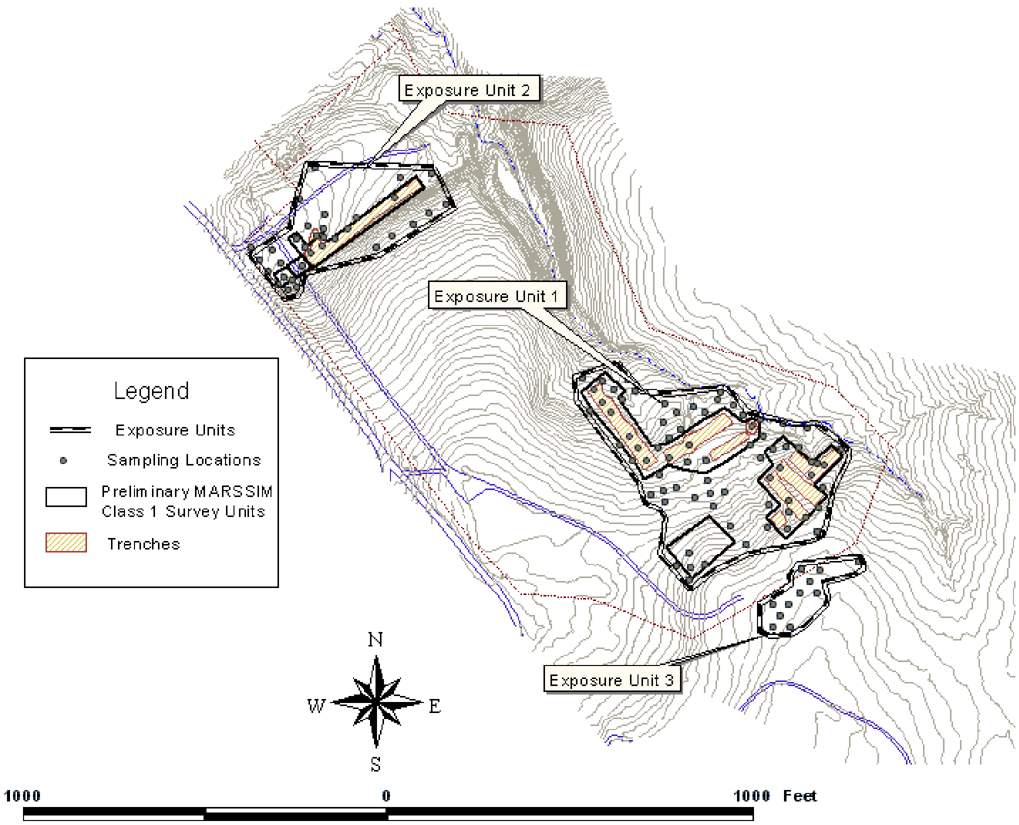

Fig. 3. Identification of the exposure units and MARSSIM Class 1 survey units.

In addition to the factors noted above, the EUs were developed considering the need to identify final status survey (FSS) units for future site closeout activities as identified in the *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* [3]. The goal in considering FSS units while developing the EUs for the BRA was to develop consistency between the RI/FS evaluations and future site closeout activities to the extent possible. Figure 3 illustrates the relationship between the EUs and preliminary MARSSIM FSS units. The boundaries of these FSS units will likely change as the FS is developed and the decision-making process evolves. However, identifying these units now should help expedite development of the FSS plan in the future.

There are three types of FSS units identified in MARSSIM. Class 1 units are areas that have a potential for radioactive contamination (based on historical uses) or known contamination (based on characterization activities) requiring remediation. The ten disposal trenches and the areas immediately surrounding them are Class 1 units. An additional Class 1 unit is identified south of the upper trench area based on the recent characterization information. Class 1 units can cover areas up to 2,000 square meters (m^2) (0.5 acres), and four Class 1 units were identified for the site as shown on Figure 3.

Class 2 units are areas that have a potential for radioactive contamination, but below levels expected to require remediation. Class 2 units at the SLDA generally consist of those areas close to the ten trenches, but outside the immediate vicinity of the trenches. Class 2 units can range from 2,000 to 10,000 m^2 (0.5 to 2.5 acres), and two such units are identified for the site, i.e., one for the upper trench area (including the area near the fence) and one near Trench 10. The Class 2 units consist of the remaining areas within the three EUs but outside the Class 1 units, which are identified on Figure 3. Note that the three EUs encompass the areas covered by the Class 1 and Class 2 FSS units.

Class 3 units are areas that are not expected to contain any (or very minimal) residual radioactive contamination, and there is no size limit for Class 3 areas. One class 3 unit is identified, which consists of the remaining areas at the site. A fourth type of area (non-impacted area) is defined in MARSSIM as those areas of a site that have no reasonable potential for residual contamination. The SLDA site is not expected to contain any non-impacted areas as defined in MARSSIM. It should be emphasized that the identification of FSS units as given in the RI report is preliminary and subject to change.

Human Health Baseline Risk Assessment

The results of the human health BRA are presented in the RI report and give the increased probability that a hypothetical receptor could develop cancer over their lifetime as a result of exposures to the radionuclides at the site. In addition to cancer risks, the BRA includes estimates of the radiation doses associated with potential exposures at the SLDA since cleanup criteria for the site need to be developed on this basis, i.e., by limiting the dose to an average member of the critical group to 25 mrem/yr as set forth in 10 CFR 20.1402. The radiation doses represent the 50-year total effective dose equivalent. Also, since uranium represents a noncarcinogenic hazard to the kidney, this was addressed in the BRA by calculation of the hazard index (HI) consistent with EPA guidance. An HI of less than one indicates that the exposures should not result in potential noncarcinogenic health effects.

Four hypothetical scenarios were developed to reflect reasonably likely patterns of human activity that might result in exposures to the contaminants at the SLDA. Two current-use scenarios (Maintenance Worker and Adolescent Trespasser) reflect possible exposures in the near term reflecting current administrative controls at the site, and two future-use scenarios (Construction Worker and Subsistence Farmer) consider greater exposures that could occur in the future should these administrative controls be removed or lost. These scenarios address a range of potential exposures and intakes and provide useful information for guiding future remedial action decisions at this site. Patterns of activity were identified for these hypothetical individuals to determine the frequency and duration of exposures, the concentrations of radioactive contaminants to which these receptors could be exposed, and appropriate intake parameters. Separate estimates were developed for each EU.

The results of the human health BRA indicate that the SLDA site presents very little risk to human health under current conditions. The SLDA is vacant and surrounded by a security fence, and the site is actively maintained and monitored, i.e., the security fence is repaired as needed, the open field is mowed several times a year, air at the site perimeter is monitored, and groundwater monitoring wells assess the potential of groundwater contamination. However, these conditions cannot be guaranteed in perpetuity, and over time the radionuclides in the trenches would be expected to gradually leach to groundwater. Subsidence is also possible at the SLDA site if any of the mine workings beneath the site collapse creating potential new migration pathways for radionuclides to move through the subsurface.

Current information indicates that there is very little radioactive contamination outside the footprint of the ten trenches, and the radioactive contamination that is present poses very little current and future risk. However, the disposed wastes contain significant concentrations of radioactive contaminants, and these materials could pose a potential risk to human health in the future. The carcinogenic risk to the Subsistence Farmer was calculated to be 3×10^{-3} using the results of the samples obtained from the trenches in the recent characterization program. This risk increases to 1×10^{-2} if the results are limited to the 13 samples that have field-screening evidence of waste. The HI exceeds one for both sample sets, and the annual radiation doses are approximately 300 and 900 mrem/yr, well in excess of the annual dose limit of 25 mrem/year identified for this site. These results confirm that the concentrations of radionuclides in the buried wastes are high enough to present a potential future risk to human health, and remedial action alternatives for these materials should be developed and evaluated.

Final Status Survey Plan

An FSS plan for the SLDA site will be issued following completion of the RI/FS process and selection of a remedy in the Record of Decision (ROD). For many CERCLA sites containing radioactive contamination, efforts on developing an FSS plan are not initiated until after the ROD has been issued and plans have been developed for implementing the selected remedy. At some sites, an FSS plan (i.e., the closeout process) is not prepared until after cleanup activities have been completed. This approach can cause some timing and administrative difficulties with regulatory and oversight agencies, including the need to perform duplicate sampling and analysis.

Efforts on developing an FSS plan for the SLDA site are being initiated in concert with preparation of the RI/FS. This is felt to be a more efficient and transparent approach, since soil cleanup criteria can then be more directly linked to the results of the human health BRA. Preliminary remediation goals (PRGs) were developed for the SLDA site as part of RI characterization activities, and these values can be considered preliminary cleanup criteria for the site; the PRGs were developed on the basis of limiting the radiation dose to 25 mrem/yr for a future Subsistence Farmer at the site. This dose limit is the same as that established in 10 CFR 20.1402, which was identified in the authorizing legislation as the appropriate standard for cleanup of the site. The PRGs were obtained using the RESRAD computer code developed by Argonne National Laboratory [4], and were based on area of 3,350 m^2, the approximate area associated with Trenches 1 through 9 in the upper trench area.

Implementation of cleanup criteria under MARSSIM involves the use of two separate parameters, i.e., numerical residual concentrations and defined areas over which these values are to be applied. Two residual concentration limits (derived concentration guideline levels, or DCGLs) are identified in MARSSIM: $DCGL_W$ (for average concentrations over a wide area) and $DCGL_{EMC}$ (for small areas of elevated activity). The PRGs developed to support site characterization efforts are considered to be preliminary $DCGL_W$ values. These values were developed on the basis of an area somewhat larger than the recommended maximum size of a Class 1 unit in MARSSIM (2,000 m^2), and may need to be modified for use as final $DCGL_W$s. In addition, it is necessary to develop $DCGL_{EMC}$s (often referred to as hot-spot criteria), which are higher than $DCGL_W$s and address exposures from smaller areas of contamination within a given unit.

An approach for the FSS plan for the SLDA has been identified, and appropriate information is being included in the RI/FS as the documentation is developed. This should help foster early discussion with regulators on application of MARSSIM principles to site cleanup activities. The intent of including MARSSIM concepts in the RI/FS is to improve consistency between the RI/FS evaluations (specifically those included in the human health BRA) and development of site-specific cleanup criteria (DCGLs). This approach should also help support selection and implementation of the most cost-effective remedy for the site consistent with the requirements of 10 CFR 20.1402.

CONCLUSIONS

MARSSIM concepts for verifying the effectiveness of site cleanup activities have been identified and are being included in the RI/FS documentation for the SLDA site as it is developed. This should allow development of the FSS plan in an expeditious manner following completion of the RI/FS process and selection of the remedy in the ROD. This approach also allows for greater consistency between the RI/FS evaluations and the development of site-specific cleanup criteria (DCGLs). PRGs have been developed to support the RI characterization program using RESRAD, and these can be considered to be preliminary $DCGL_w$s, mainly because they were developed in a manner generally consistent with identification of Class 1 survey units and serve the same general purpose.

The human health BRA was based on evaluating exposures within three EUs at the site, and a specific correlation between these EUs and FSS units was identified and included in the RI report. This should help ensure consistency between the risk assessment results and the application of DCGLs at the site, based on the definition of Class 1 and 2 units. While the boundaries of these units will likely change as the decision-making process proceeds and plans are developed for cleanup of the site, early identification of FSS units should help avoid the duplication of field sampling efforts and foster discussions with stakeholders on the appropriate application of MARSSIM concepts to site cleanup.

REFERENCES

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