Remediation Approach for the Integrated Facility Disposition Project at the Oak Ridge National Laboratory - 9069

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ABSTRACT

The Integrated Facility Disposition Project (IFDP) is a multi-billion-dollar remediation effort being conducted by the U.S. Department of Energy (DOE) Office of Environmental Management in Oak Ridge, Tennessee. The scope of the IFDP encompasses remedial actions related to activities conducted over the past 65 years at the Oak Ridge National Laboratory (ORNL) and the Y-12 National Security Complex (Y-12). Environmental media and facilities became contaminated as a result of operations, leaks, spills, and past waste disposal practices. ORNL's mission includes energy, environmental, nuclear security, computational, and materials research and development. Remediation activities will be implemented at ORNL as part of IFDP scope to meet remedial action objectives established in existing and future decision documents.

Remedial actions are necessary (1) to comply with environmental regulations to reduce human health and environmental risk and (2) to release strategic real estate needed for modernization initiatives at ORNL. The scope of remedial actions includes characterization, waste management, transportation and disposal, stream restoration, and final remediation of contaminated soils, sediments, and groundwater. Activities include removal of at or below-grade substructures such as slabs, underground utilities, underground piping, tanks, basins, pits, ducts, equipment housings, manholes, and concrete-poured structures associated with equipment housings and basement walls/floors/columns. Many interim remedial actions involving groundwater and surface water that have not been completed are included in the IFDP remedial action scope.

INTRODUCTION

The Oak Ridge National Laboratory (ORNL) site encompasses approximately 3,560 acres (over 14 million square meters) of land and is divided into two watersheds – Bethel Valley and Melton Valley. Bethel Valley is comprised of approximately 1,734 acres (7 million square meters) that primarily houses a number of active and inactive nuclear research and development laboratories, reactors, and support facilities. Melton Valley is comprised of approximately 1,826 acres (7.4 million square meters) and houses several active and inactive reactor facilities, solid waste management areas, and waste storage tanks. Many of these facilities were constructed in the 1940s and 1950s to support the World War II Manhattan Project and subsequent national nuclear technology development missions. Over the years, these missions have resulted in a diverse legacy of materials that require remediation in order to eliminate or reduce risks to workers, the public, and the environment. This paper will focus on the remediation approach for the Bethel Valley watershed at ORNL.

Bethel Valley, the site of the ORNL main plant and support facilities, is contaminated from past ORNL operations and waste management activities. Sources of contamination include buildings and other facilities, belowground infrastructure such as buried liquid low-level-waste (LLLW) and process pipelines, ducts, and waste holding tanks, and three solid waste burial grounds. LLLW containing a mixture of fission products was derived from many of the processes at ORNL. The main plant area has numerous underground LLLW holding tanks with an interconnected network of buried liquid waste transfer pipelines, four liquid waste holding ponds, and evaporator facilities used to reduce the volume of the LLLW. In addition to the main plant area ORNL includes a support facility located approximately

0.75 mile (1207 m) east of the main plant area that houses the shipping and receiving facilities as well as numerous shop facilities, the garage, and the vehicle fuel storage pumps.

The principal groundwater contaminants in Central Bethel Valley are strontium-90 (Sr-90), tritium, uranium-234(U-234), and cobalt-60 (Co-60). Although there are other radionuclides present in soils at the various known leak sites in the main plant area, Sr-90, tritium, U-234, and Co-60 are of most concern because of their potential mobility. Additionally, mercury, trichloroethene (TCE), beryllium, cadmium, chromium, and lead are present in shallow groundwater in Central Bethel Valley.

The principal groundwater contamination problem in the East Bethel Valley area is a volatile organic compound (VOC) plume that originates from the shipping and receiving area. The source area has not been identified but is most likely from either a leaking storage tank or surface spill.

Several other small point and non-point releases to surface water exist in Bethel Valley, including discharges from surface impoundments and from the plant site that enter the storm drain system. The sources of some of these releases include small localized groundwater plumes that are collected into the storm drain system and sumps that are piped to the Process Waste Treatment Complex.

REMEDIAL ACTION OBJECTIVES AND REMEDIATION LEVELS

Remediation levels have been derived for the industrial areas of Bethel Valley so that the residual cumulative risk within an exposure unit will not exceed an average excess lifetime cancer risk (ELCR) of 1×10^{-4} and a hazard index (HI) of 1. The estimated risk is based on direct contact routes of exposure including incidental ingestion, inhalation of particulates (and/or vapors), dermal contact, and external exposure. The maximum remediation level for any individual location (elevated area or hot spot) within the exposure unit is based on an exposure of 200 h/yr, one-tenth the exposure frequency of the average remediation level. The average remediation level applies across the entire exposure unit, while the maximum remediation level applies to individual areas of elevated activity.

The remedial action objectives (RAOs) for soil and sediment identified in the Record of Decision (ROD) for Interim Actions in Bethel Valley [1] include the following:

1. Protect human health for (a) controlled industrial use in ORNL's main plant area, (b) unrestricted industrial use in the remainder of the ORNL developed areas, (c) recreational use in Solid Waste Storage Area (SWSA) 3 and the Contractor's Landfill area, and (d) unrestricted use in the undeveloped areas – all to a risk level of 1×10^{-4}.
2. Achieve the sediment recreational risk-based limit of 1×10^{-4}.
3. Protect reach-level populations of aquatic organisms.
4. Control releases from contaminated soil to minimize further impacts to groundwater.

In addition to the RAOs stated in the ROD, a goal of the IFDP is to allow for future redevelopment of the ORNL central campus (main plant) area without undue restrictions as older contaminated buildings are removed. Thus portions of the central campus that have been designated for controlled industrial use may be remediated to meet unrestricted industrial land use requirements if justified based on removal of contaminated hot spots to achieve water quality objectives and be protective of site workers, as well as redevelopment potential. Cleanup to achieve the unrestricted industrial land use criteria will involve removal of contamination to a depth of 10 ft (3.048 m), rather than the 2 ft (0.6096 m) depth requirement for controlled industrial use. Remediation levels were not determined for the passive recreational area encompassing SWSA 3 and the Contractor's Landfill because these waste units will be capped or covered over with clean fill.

REMEDIATION APPROACH

Remediation for Bethel Valley and Melton Valley will follow the Environmental Protection Agency's (EPA's) suggested phased approach to decision making [2]. Phase 1 will consist of early or interim actions that can be taken to prevent exposure to contaminated groundwater, prevent further contaminant migration, control sources, and provide additional data for subsequent decision making. Many of these interim actions are already completed as required by removal actions under the Comprehensive Environmental Response, Compensation, and Liability Act process or Resource Conservation and Recovery Act closures.

Phase 2 involves source control and evaluation to determine if more action is needed or a more optimum or long-term remedy is required to attain interim goals as well as source-control decisions to protect groundwater. Remediation of remaining contaminant source areas will involve identification (through process knowledge and/or characterization activities) of source hot spots and stabilization through grouting followed by removal of inactive pipelines, tanks, and contaminated soil to meet unrestricted industrial use. Some areas that require cleanup have been identified based on the results of characterization conducted in support of the current Interim Action ROD. Other areas have not been characterized due to the presence of buildings and other infrastructure that prevented sampling of underlying soil. As old contaminated buildings are demolished and removed, underlying soil will be evaluated and characterized as appropriate to determine the removal necessary to meet end-use requirements.

Phase 3, final decisions on groundwater remediation, is the determination of whether restoration is practicable, and if so, what method(s) should be used. This decision will be made after source-control actions have been taken and their effectiveness determined through the monitoring program.

Characterization and decision-making protocols will be established using guidance from the EPA Triad approach [3] and the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) [4]. EPA's Triad approach provides guidance on use of systematic planning tools and field measurement methods for obtaining "decision quality" data. MARSSIM was developed by a multi-agency committee representing DOE, EPA, the Department of Defense, and the Nuclear Regulatory Commission and provides guidance on verification methods for cleanup of radiologically contaminated sites. These approaches provide methods that when used together, allow for effective and efficient decision making using dynamic work plans and near real-time data. To the extent possible, characterization methods will be used that provide sufficient information (data quality) to serve as verification data if no contamination greater than that specified in cleanup guidelines is detected. This will allow for closure of some areas (not requiring remediation) without mobilization of crews for a second round of verification measurements and sampling.

CHARACTERIZATION AND VERIFICATION

Characterization and remediation activities are subject to uncertainty. Subsurface conditions are difficult to define because they are hidden. Soils under buildings and other paved structures have not been characterized; as a result, uncertainty remains regarding the type and extent of contamination in the underlying soil. The interrelationships between groundwater movement, site geological heterogeneity and anisotropy, and the complex biological and geochemical nature of the subsurface make the fate and transport of contamination difficult to define.

It is anticipated that characterization will be accomplished using methods that maximize the use of direct-reading field instruments for collection of sufficient data for decision making, with sampling utilized as needed to supplement field characterization data. Data will be collected on a routine basis during remediation activities to help define the extent of needed excavation. This will allow for more-precise excavation, which should result in a lower volume of total excavated soils for disposition than that achieved with traditional methods.

Because the principal radiological contaminants of concern for Bethel Valley soil and sediment are gamma emitters, direct-reading gamma-scanning instrumentation such as sodium iodide (NaI) detectors and count rate meters will be relied on extensively for field characterization data. For radiological walkover (gamma-scanning) surveys, NaI detectors will be coupled with global positioning and data recording systems to provide rapid data analysis in support of survey unit classification and remedial action decision making. High purity germanium field systems may be used as feasible to provide more-quantitative analysis of soil radionuclide concentrations. For nonradiological contaminants of concern, field screening will be used to the extent possible and supplemented with conventional sampling and off-site analysis for characterization and verification purposes where field detection approaches are not feasible.

The characterization and verification techniques and instruments will be essentially the same, with the objective that data collected for characterization purposes will be of sufficient data quality to support verification analysis without further field mobilization (if characterization shows that no remedial actions are required). To support this concept, elements from EPA's Triad approach and concepts from the MARSSIM will be integrated into the characterization approach. In addition, the ROD specifies that "the number and grid spacing of samples to verify that the average remediation level has been met in disturbed areas will be determined using the approach by Gilbert [5], with $\beta = 0.1$ and $L = 30$ m (100 ft), or other appropriate statistical method approved by the three Federal Facility Agreement (FFA) parties."

Thus the characterization and verification methods for this project will be based on integration of guidance from EPA's Triad approach, MARSSIM, and the Gilbert statistical method for identifying areas of elevated contaminant concentrations. The general approach is to use the concepts of systematic planning and use of direct-reading field instruments to guide decision making in a near real-time basis. Characterization and verification data will be collected to the greatest extent possible using direct-reading field instrumentation, supplemented by sampling where appropriate and necessary. MARSSIM provides for quantitative verification measurements and sampling using statistical approaches that are based on measurement of an average remediation level over a survey unit. The Gilbert method also provides a statistical approach to determining that with an accepted degree of confidence, there are no remaining areas of a certain size within the survey unit that exceed remediation levels.

The MARSSIM and Gilbert methods provide different approaches for verifying that remediation is complete. Use of both methods is not required, and discussions will be held with the three FFA parties to determine if it is acceptable to use only the methods outlined in MARSSIM, since these methods are more applicable for determining if the average remediation level has been met. If the Gilbert method must be used (as currently specified in the ROD) it will be applied as required to "disturbed areas" only after remediation has been completed in those areas. The MARSSIM methods will be applied to the entire survey unit to verify that average remediation levels have been met over the survey unit. The Gilbert test will be utilized over the remediated portions of a survey unit (disturbed areas) to verify that no unacceptable areas of elevated concentrations have been left behind after remediation of the area.

MODELING AND MONITORING

There is significant risk of contaminant releases during decontamination and decommissioning (D&D) execution, as well as changes in site hydrology and flow paths due to alteration of sumps, drains, and recharge and dewatering activities. These activities could cause an increase in contaminant releases to surface water and possibly result in water quality violations. Current remedial systems of extraction and monitoring wells could become inadequate if flow paths are significantly changed. As necessary, systems risk analysis tools could be implemented to support decisions concerning D&D and technical project risks that could be encountered during environmental restoration of Bethel Valley. A systems analysis approach could be employed in which bounds of known and suspected contaminated media and potential high-risk transport pathways (karst or cut-and-fill zones, sumps, drains, pipelines, surface water bodies, and other relevant features) could be documented using geographic information system (GIS) technology, and then ranked according to risk. This information would be used to identify areas that would benefit from further site reconnaissance. The GIS database would be routinely updated with any new preconstruction reconnaissance data. Connection pathways would be determined and potential for contaminant movement quantified. Where appropriate, a comprehensive three-dimensional subsurface model of fluid flow and reactive chemical transport, focused on contaminant pathways, could be utilized to evaluate and predict the impact of D&D activities and remedial actions. Use of the model could improve the efficiency and cost-effectiveness of remediation and reduce overall technical risk and uncertainty. Information gained from the use of this systems analysis approach would also increase understanding and contribute to the development of cost-effective groundwater remediation decisions for the final Bethel Valley Groundwater ROD in the event that surveillance and maintenance (S&M) and monitored natural attenuation are not protective of human health and the environment.

A comprehensive monitoring strategy and system will be implemented to determine the optimum type and placement of sensors and monitoring points to access the condition of ground and surface water before, during, and after remediation. Interim assessments and modeling results will reveal situations appropriate for remediation technologies, including use of novel sensors and monitoring techniques such as polymer-encapsulated soil to measure and immobilize contaminants, as well as chemical and ecological manipulation techniques that can be employed to reduce overall risk levels during and after completion of remediation activities.

REMEDIAL ACTIONS

The general approach to remediation of contaminated soil and sediment in Bethel Valley will involve identification (through process knowledge and/or characterization activities) and cleanup of areas where soil or sediment exceeds cleanup criteria established to meet the RAOs specified in the Bethel Valley ROD for Interim Actions. Some areas needing cleanup have been identified based on the results of characterization conducted in support of the ROD. Other areas are not yet characterized because of the presence of buildings and other infrastructure that prevented sampling of soil underlying the area. As old contaminated buildings are demolished and removed, soil underneath these buildings will be evaluated and characterized as appropriate to determine if removal is necessary.

Remediation of Bethel Valley will be implemented through early groundwater actions and source removal. Actions will be taken to protect the health of on-site workers, prevent exposure to groundwater, prevent further contaminant migration, control sources, and provide additional data for subsequent decisions. Currently known and accessible contaminated soil hot spots will be removed. Inactive LLLW and process waste pipelines will be stabilized by grouting followed by removal to prevent further contamination of soil and groundwater. Contaminated sediment from White Oak Creek, First Creek, and Fifth Creek will be removed to protect the recreational user and aquatic organisms. Contaminated groundwater will continue to be extracted from existing sumps and extraction wells for treatment. The treatability studies for the VOC plume in East Bethel Valley will be completed and the selected response initiated.

Areas at ORNL that pose an unacceptable current or future risk to workers, the public, and the environment will be remediated. This remedial action will include removal of all at/or below-grade substructures such as slabs, underground utilities, underground piping, basins, vaults, pits/sumps, equipment housings, manholes, and other substructures associated with D&D. The areas to be remediated include contaminated soils and sediments, unneeded wells, inactive LLLW and process waste pipelines, underground tanks, building slabs, and burial grounds.

Remedial actions will follow the large-scale D&D activities to remove all excess buildings in Bethel Valley and achieve the RAO and redevelopment goals of the site. Currently, 2 ft (0.6096 m) is the depth of excavation for controlled industrial land use; however, excavation of soil up to a depth of 10 ft (3.048 m) could be required to remove contaminant source areas and prepare the site for future anticipated use. Inactive tanks, LLLW and process waste pipelines, and bedding materials will be removed. SWSAs 1 and 3 and the Bethel Valley landfills will be hydraulically isolated to prevent further groundwater contamination.

SUMMARY

The challenges presented by the remediation of Bethel Valley at ORNL are formidable. The proposed approach to remediation endeavors to use the best available technologies and technical approaches from EPA and other federal agencies and lessons learned from previous cleanup efforts. The objective is to minimize cost, maximize remedial effectiveness in protecting workers and the environment and meeting RAOs, and support redevelopment for future DOE missions.

REFERENCES

1. "Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee," DOE/OR/01-1862&D4 (May 2002).
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3. EPA Triad Resource Center, www.triadcentral.org.
4. "Multi-Agency Radiation Survey and Site Investigation Manual" Revision 1; NUREG-1572, Rev. 1; EPA 402-R-97, Rev. 1; DOE/EH-0624, Rev. 1 (August 2000).
5. R.O. GILBERT, *Statistical Methods for Environmental Pollution Monitoring*, John Wiley & Sons, Inc., New York (1987).