Unique Remote-Handled Waste Management Issues at Oak Ridge National Laboratory – 9140

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ABSTRACT

Since the Manhattan Project, Oak Ridge National Laboratory (ORNL) has been engaged in developing processes for implementation in the Department of Energy (DOE) production facilities and in producing radioisotopes for medical and industrial applications. These activities have resulted in a large variety of unique remote-handled legacy waste and contaminated hot cell facilities. The DOE has established the Integrated Facility Disposition Project (IFDP) to dispose of the ORNL legacy waste and to deactivate, decontaminate, and decommission facilities at ORNL no longer needed for the mission. The IFDP will be required to characterize, treat, package, and dispose of various remote-handled solid waste streams for which no treatment capability currently exists at ORNL. This paper describes the capabilities that will be required to manage these waste streams and the options evaluated for implementation.

INTRODUCTION

The Integrated Facility Disposition Project (IFDP) is a collaborative proposal developed by the Department of Energy (DOE), Environmental Management (EM), Office of Science (SC), Office of Nuclear Energy (NE), and National Nuclear Security Administration (NNSA) that will complete the environmental cleanup of the DOE Oak Ridge Reservation (ORR) and at the same time enable ongoing modernization efforts at Oak Ridge National Laboratory (ORNL) and the Y-12 National Security Complex (Y-12). IFDP will reduce risk to workers and the public, minimize mission risk resulting from the presence of deteriorating facilities and excess "legacy" materials, and provide valuable real estate for continued modernization.

Today's EM life-cycle baseline accounts for only about one-third of the "cleanup" scope that will exist at ORNL and Y-12 as a result of the recent mission evolution and modernization activities. The IFDP will integrate the current EM baseline scope with the new cleanup scope, resulting in more rapid and efficient performance of the work. The IFDP includes legacy materials/waste and facility characterization, deactivation and decommissioning (D&D), and demolition of ~440 excess facilities; waste and equipment disposition; remediation of underlying contaminated soil, groundwater, and surface water; and capping and closure of active and inactive landfills for the entire ORR. The scope will address waste management and mission-critical facility reconfiguration as well as surveillance of excess facilities and performance of waste management and treatment operations.

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The IFDP Mission Need Statement—Critical Decision–0 (CD-0)—was approved by DOE in July 2007, and the IFDP Alternative Selection and Cost Range—Critical Decision–1 (CD-1)— was submitted in May 2008. It is expected to be an ~$15B project with a project duration range of up to 35 years.

The EM cleanup mission at ORNL includes dispositioning of facilities and contaminated legacy materials/waste, excess, and contamination sources, as well as remediation of soil under facilities, groundwater, and surface water to support the final record of decision (ROD). The envisioned end state of IFDP at ORNL includes removal of legacy waste from the site and removal of physical barriers posed by excess facilities, thus allowing soil and groundwater cleanup leading to efficient use of the sites; finalized RODs on groundwater and surface water for the ORNL site; and a suitable IFDP waste treatment infrastructure that can be transferred to the site landlord such that EM will not be required to conduct follow-on actions.

Capabilities do not exist at ORNL to process remote-handled solid waste streams that will be generated by IFDP. Therefore, new remote-handled treatment capabilities will be necessary to support the IFDP remediation and D&D missions in a safe and cost-effective manner while maintaining compliance with all governing regulations and bodies and preserving the support of continuing operations at ORNL. The process used to determine these capability requirements began with the identification of the materials to be processed, defining the necessary processing capabilities, and identification of potential facilities that might be utilized for processing the waste. The scope of this paper is to describe the unique remote-handled solid materials that will be dispositioned under IFDP and the evaluation process used to select the preferred option for implementation in the CD-1 document.

INVENTORY OF REMOTE-HANLDED SOLID MATERIALS

The remote-handled solid waste streams requiring treatment prior to disposal will be a small subset of the IFDP waste streams, as shown in Figure 1. A significant amount of solid waste is destined for on-site disposal facilities, and the CD-1 package estimated that ~15,800 m^3 will be shipped off-site to Envirocare of Utah (presently EnergySolutions), Nevada Test Site (NTS), and Waste Isolation Pilot Plant (WIPP). It is estimated that more than 90% of this waste can be packaged at the site of generation and shipped directly to the off-site disposal facility and that less than 10% (1170 m^3) will require additional treatment prior to disposal. The latter volume is addressed in this paper.

These volumes are preliminary engineering estimates of total waste volumes and the associated potential disposal end points developed from data in the existing DOE EM baseline for previously estimated activities and engineering judgment for all other tasks. For the new activities outside the EM baseline, D&D waste estimates were based on the square footage of facilities to be decommissioned. Remedial action (RA) waste estimates were derived from the size of the contaminated soil areas. The legacy waste was inventoried in 2007. These preliminary waste generation estimates are not included in the waste forecast for any of the proposed waste disposal sites. Waste generation rates from ongoing operations were based on DOE EM waste forecast documents.

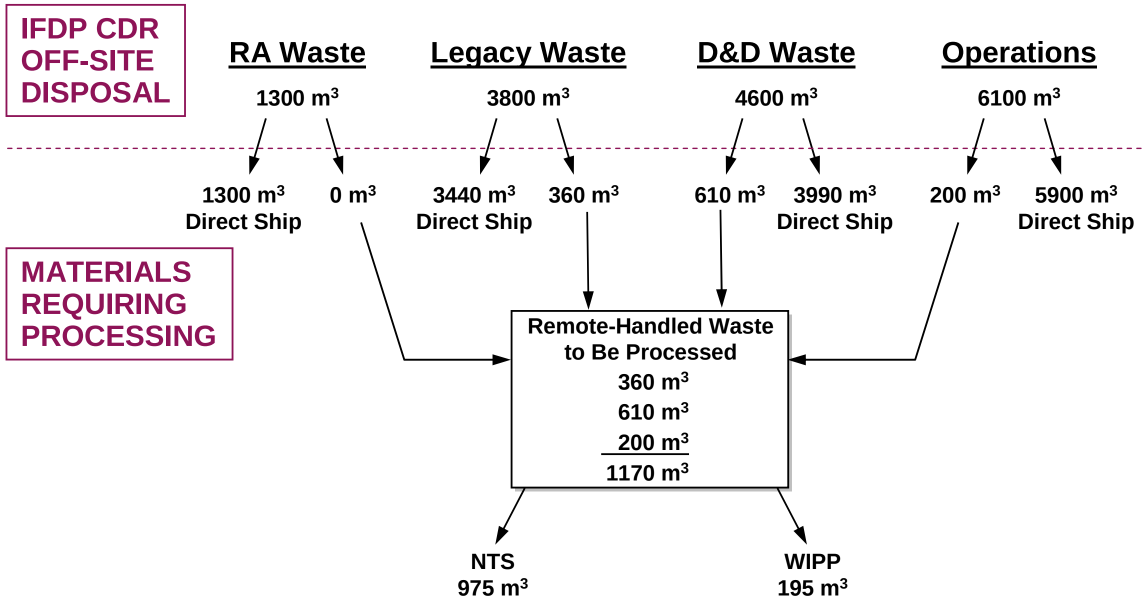

Fig. 1. Remote-handled solid waste from IFDP requiring treatment and off-site disposal.

To obtain an estimate of the materials requiring treatment prior to disposal, it was assumed that all RA waste could be shipped to the disposal site without treatment. It was also assumed that all of the remote-handled solid waste in the legacy inventory, all remote-handled waste from 20 years of ongoing operations, and 10% of the volume of the hot cells subject to D&D would require treatment.

The subset of remote-handled IFDP waste that would require treatment prior to disposal at NTS and WIPP include the following:

- TRU high-efficiency particulate air (HEPA) filters,
- Other large contaminated equipment items removed from facilities prior to D&D by IFDP,
- Legacy materials stored in hot cells,
- Activated reactor components in reactors that are to undergo D&D,
- Legacy activated reactor components currently stored on-site or in reactor pools,
- Legacy radioisotope thermoelectric generators (RTGs) containing 1 million curies Sr-90 equivalents that must be disassembled and defueled to remove certain hazardous materials prior to disposal and source material,
- Waste from D&D of IFDP facilities requiring additional treatment/processing,
- Orphan legacy waste stored in Melton Valley (MV),
- High-alpha legacy material and waste,
- Spent fuel and activated metals, and
- Waste generated from ongoing operations requiring additional treatment and processing.

TREATMENT REQUIREMENTS

The following capabilities were identified as requirements to characterize, treat, package, and dispose of various remote-handled solid waste streams expected to be generated by IFDP. The legacy waste materials described above bound the treatment and facility design requirements based on physical size, radionuclide content, dose rates, etc. These materials contain approximately 27 million curies (Sr-90 equivalents) with dose rates as high as 1 million roentgens per hour. The materials that must be handled range from less than 1 in. in all dimensions to extremely large components; the largest identified to date are 9 x 9 x 9 ft 40-ton casks (see Figure 2). Included in this list are a number of RTGs (see Figure 3) containing 10^4 to ~10^6 Ci of cesium or strontium and hazardous components (e.g., mercury and other heat-transfer and heat-sensing materials) that must be dismantled to allow recovery and segregation of the radioisotope from the hazardous materials and repackaging of the materials to meet waste acceptance criteria (WAC). A number of materials will require "down-blending" followed by solidification to meet the WIPP WAC (e.g., the Mk-42 target segments and the Cm-244 oxide containers).

Fig. 2. Casks of legacy materials.

Fig. 3. Radioisotope thermoelectric generators.

Capabilities will be required to receive shielded containers of radioactive materials; open the containers; and then examine, characterize, segregate, size reduce, and process the materials before packaging them for disposal. Capabilities will be provided in the facility to package materials for off-site transport to waste repositories. The capability is needed to load and unload a wide variety of on-site packages, including those used for on-site shipments as well as DOE/Department of Transportation (DOT) certified shipping packages. These on-site packages include, but are not limited to, the Sugarman ND S-10-13 Model 1 transfer cask, the MK-42 transfer cask, shielded B-25 boxes, and 10-ft 8-in. maximum diameter by 9-ft-high concrete storage casks. A number of the large storage casks have been backfilled with grout that must be mechanically removed in a shielded area to allow recovery of the contents for characterization and repackaging in appropriate disposal containers.

Some legacy materials will require special high-alpha processing capabilities. These high-alpha solids will be received into the facility in shielded casks, removed from containers, examined and characterized (as necessary), dissolved, and then mixed with a dry grout mix (as necessary) to form a solid waste form suitable for disposal. The packaging materials will be cleaned to the extent possible, volume reduced, and then packaged into drums for disposal. It was assumed that a subset of the materials could require an ~10 year on-site decay period to reduce the neutron dose prior to shipment to the ultimate disposal site and significantly reduce the number of shipments required.

Based on preliminary safety evaluations, facilities processing these materials will be required to have a number of safety class systems, including structural capability, ventilation, and fire protection, to prevent impact to the public. This work will require up to 5-ft-thick, high-density concrete for shielding.

EVALUATION OF ALTERNATIVES

Existing facilities on the ORR were evaluated for meeting the processing requirements described above. Combinations of construction of new facilities at ORNL and modification to existing facilities were also considered.

The option of placing solid waste materials into specially designed casks for perpetual storage was not considered since it would be in direct conflict with the objectives of the IFDP as stated in the approved mission need statement (i.e., complete the EM mission in Oak Ridge) and DOE Order 435.1. Choosing this option would result in literally thousands of cubic yards of hazardous radioactive waste being stored in waste bunkers (which would have to be constructed) or, in the worst case, in shielded containers on gravel pads. Many of these waste packages would contain Category 2 quantities of radioactive material and would, therefore, be classified as nuclear facilities. Environmental, safety, and health (ES&H) risks would be significant, and the ever-increasing safeguards and security requirements would drive up the surveillance and maintenance costs for protection of the material.

The option of transporting remote-handled solid waste materials to an off-site treatment facility (such as the Advanced Mixed Waste Facility at the Idaho National Laboratory) was not considered in this analysis because it was assumed that DOT regulations would preclude transport of a significant portion of these materials over public roads without pretreatment and repackaging in DOT-compliant shipping casks. Off-site treatment options for specific waste streams will be evaluated in more detail in the next phase of the project.

All potentially available hot cell facilities at ORNL were initially screened. Facilities were excluded from further consideration if they were not Category 2 nuclear facilities or the safety basis for the facility was not considered to be upgradeable and if the cells did not have heavy shielding (i.e. >6-in. lead) for processing high-activity IFDP materials.

Reviews of the remaining facilities identified a number of options that could potentially satisfy each required capability, including the modification and use of existing hot cell facilities and the construction of new facilities. A formal process was used to evaluate these alternatives based on weighted criteria in the areas of ES&H, project cost and schedule, extent to which the alternative could meet the IFDP requirements, and technical operability using the technical and programmatic information available in the late 2007 time frame.

The alternative analyses were performed using the Analytical Hierarchy Process (AHP), with a decision-modeling method developed at the Wharton School of Business at the University of Pennsylvania by Dr. Thomas L. Saaty [1]. This model provides a structured framework that allows comparison of both qualitative and quantitative selection criteria. The relative importance of the selection criteria was developed using a pair-wise comparison technique. This method has been implemented within many Fortune 500 companies and the federal government and is utilized in project management software tools, such as Primavera®.

The four key criteria and several subcriteria given in Figure 4 were identified for ranking alternative options:

(1) *Cost and Schedule*—Considers total project cost, operating cost, and cost risk associated with facility reconfiguration;
(2) *Operability*—Considers impact on ongoing operations, robustness of the operations to accommodate changes in WAC, and complexity of transportation and logistics support required by the option configuration;
(3) *Environmental, Safety, and Health (ES&H)*—Considers impact on ES&H of facility design, operations, siting, and likelihood of environmental release; and
(4) *Consistent with IFDP Mission Needs*—Considers access to groundwater and contaminated soils in Bethel Valley and flexibility for handling IFDP waste and accomplishing future missions successfully.

Existing facilities on the ORR were evaluated, and no single facility or combination of facilities was identified that could process the full suite of IFDP materials, including the Transuranic Waste Processing Center (TWPC), which is presently the only dedicated facility at ORNL with capabilities for processing remote-handled solid waste.

Therefore, all options evaluated using the formal evaluation process consisted of combinations of upgrading existing facilities and building new facilities. Modification to any of the existing facilities would involve performing construction work in highly contaminated areas in coordination with ongoing missions. Several technically feasible options were identified; however, all of these options were judged to be more expensive, disruptive to ongoing nuclear operations, and a higher risk than construction of a single "greenfield" facility. It was assumed that significant facility modifications will be required to meet the pending DOE-STD-1189 requirements for nuclear safety applicable to the design of major modifications at nuclear facilities. The high costs associated with these modifications, coupled with the potential operational and safety risks, and the physical constraints associated with these alternatives resulted in the construction of a new facility being selected as the preferred alternative for the CD-1 package.

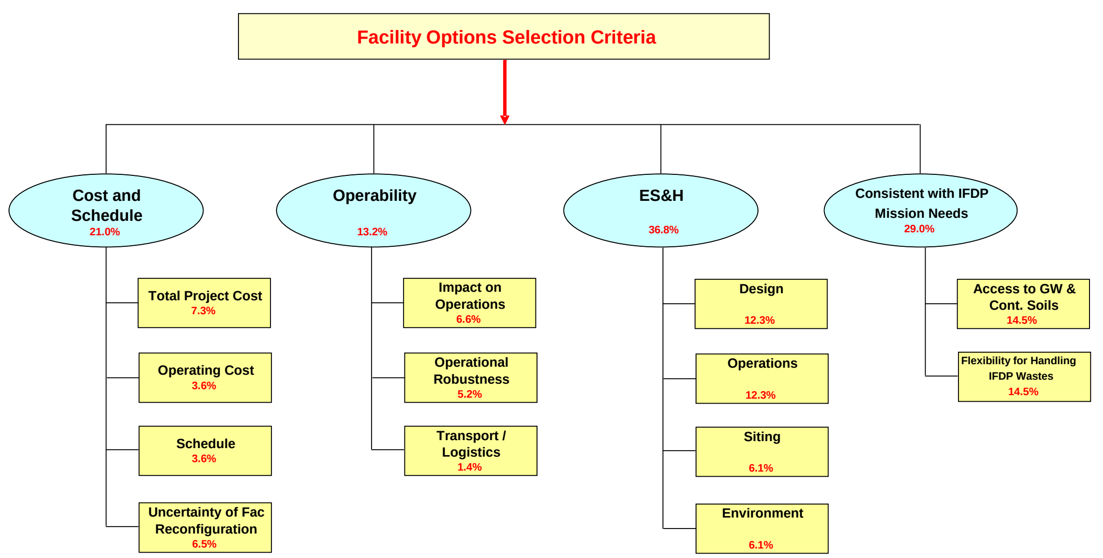

Fig. 4. Alternative analysis selection criteria.

The selected alternative, the construction of a new treatment facility for remote-handled solid waste, will be designed to meet current safety requirements to ensure the safety of workers and the public and will include all the necessary capabilities to handle the suite of IFDP wastes that have been identified. The new solids-processing facility will be designed so it can be transitioned to ORNL at the end of the IFDP and used for long-term management of waste from ongoing research missions. IFDP will thus be able to avoid the cost of D&D of the solids-processing facility needed to safely and compliantly manage the radioactive waste from the project.

SUMMARY

The IFDP CD-1 reflects the construction of a remote-handled solids-processing facility designed to meet current safety requirements to ensure the safety of workers and the public and to include all the necessary capabilities to handle the suite of IFDP wastes that have been identified. The new solids-processing facility will be designed so that it can be transitioned to ORNL at the end of the IFDP and used for long-term management of waste from ongoing research missions.

The single new facility constructed to handle all remote-handled solid waste streams from IFDP was the only one that provides the capabilities to process the full suite of IFDP materials without major modifications to existing nuclear facilities. To support the CD-2 development, an additional evaluation will be performed to determine if a less expensive alternative can be identified by using a combination of existing facilities to treat subsets of waste streams.

REFERENCES

1. T. L. SAATY, *Journal of Mathematical Psychology*, 15:234–281 (1977).