DEVELOPMENT OF THE CHARACTERIZATION APPROACH FOR A SPENT FUEL REPROCESSING FACILITY TO SUPPORT DECOMMISSIONING PLANNING

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ABSTRACT

In 1980, Congress passed the West Valley Demonstration Project (WVDP) Act, which authorized the Department of Energy (DOE) to conduct a technology demonstration project for the safe solidification of 660,000 gallons of high-level liquid waste and cleanup of associated facilities used during the solidification program. The plant operated as a spent nuclear fuel reprocessing center from 1966 to 1972 and was shut down for modifications. Following passage of the WVDP Act, the NRC amended the plant license to terminate the responsibility and authority of the operator as a co-licensee of the facility, leaving the New York State Energy Research and Development Authority (NYSERDA), the property owner, as the sole licensee. The U.S. Nuclear Regulatory Commission (NRC) suspended this license in 1981 following creation of the WVDP to allow DOE to carry out the demonstration project without NRC license authority. NRC, did however, retain certain authorities under the WVDP Act, including prescribing decommissioning criteria for facilities used by the DOE during the WVDP. In early 2002, the NRC issued a notice in the Federal Register indicating that the Commission will apply its License Termination Rule (LTR) to the facility.

To demonstrate that the WVDP will meet NRC prescribed decommissioning criteria, a Decommissioning Plan for the site is being prepared. Radiological characterization of significant WVDP-related facilities is necessary to prepare the Decommissioning Plan. This paper will discuss the characterization program that was developed and implemented to conservatively estimate the quantity of radionuclides that are present in project-related facilities. To assure the program would meet NRC=s expectations for facilities characterization, the WVDP utilized a panel of industry experts to verify the appropriateness of the program=s content. The WVDP continues to use this same panel to verify implementation of the program.

To assure the best application of limited resources, the overall characterization approach was tailored based on the level of risk associated with the expected inventory for each unit being characterized. Through the use of risk ranking and development of site-specific sensitivity levels, resource allocation was optimized. This paper will also discuss the generation of the sensitivity levels and the risk ranking of facilities to be characterized and their application to the program.

INTRODUCTION

Site History

The Western New York Nuclear Service Center (WNYNSC), owned by NYSERDA, was initially licensed by the Atomic Energy Commission (AEC) and later by the NRC under authority of the Atomic Energy Act. The plant operated as a spent nuclear fuel reprocessing center from 1966 to 1972, processing 640 metric tons of spent nuclear fuel. The plant was shut down in 1972 for modifications and control of the facilities was returned to NYSERDA in 1976.

In 1980, Congress passed the WVDP Act, which authorized DOE to conduct a technology demonstration project for the safe solidification of the 660,000 gallons of high-level liquid waste and cleanup of associated facilities used during the solidification. Following passage of the WVDP Act, the NRC amended the plant license to terminate the responsibility and authority of the former operator as a co-licensee of the facility, leaving NYSERDA as the sole licensee. The NRC suspended this license in 1981 following creation of the WVDP to allow DOE to carry out the demonstration project without NRC license authority. NRC, did however, retain certain authorities under the WVDP Act, including prescribing decommissioning criteria for facilities used by the DOE during the WVDP.

DOE is not an NRC licensee under this arrangement, and the DOE=s decontamination and decommissioning activities are conducted under the WVDP Act, not the Atomic Energy Act.

In 1996, DOE and NYSERDA issued for public comment a Draft Environmental Impact Statement (DEIS) for completing the WVDP and closure or long-term management of the facilities at the site. Upon completion of the demonstration project, the WVDP Act requires NYSERDA to reacquire and possess the facilities under license to NRC to ensure the license conforms to NRC regulations, including those regulations associated with license termination.

Following public discussion and regulatory review, DOE in 2002, divided the EIS into two separate EIS actions: (1) one addressing waste management; and (2) another addressing decommissioning, long-term monitoring, and stewardship of the site. The Record of Decision for the Decommissioning EIS is expected to be completed in calendar year 2005 under an aggressive schedule. Until the EIS process culminates with the Record of Decision, the final end state of the site will remain undefined.

On February 1, 2002, the NRC issued a notice in the Federal Register indicating that the Commission will apply its License Termination Rule to the site. Found in the Code of Federal Regulations 10 CFR 20 Subpart E, the rule provides for a range of criteria for license termination. It specifies that release for unrestricted use will be considered when a dose criterion of 25 millirem per year total effective dose equivalent (TEDE) to the average member of the critical group is not exceeded, and when residual radioactivity has been reduced as low as reasonably achievable (ALARA) (10 CFR 20.1402). The License Termination Rule specifies restricted release for a site when the individual dose is shown to be less than 25 millirem per year TEDE to the off-site receptor and 500 millirem per year for the on-site intruder using legally-enforceable institutional controls established after a public participatory process, including ALARA considerations (10 CFR 20.1404). The Commission itself must approve use of the alternate criteria, after coordination with the U.S. Environmental Protection Agency (EPA).

The NRC further defined its role at the WVDP in communications with NYSERDA in 2002. Generally, NRC indicated that they will be a cooperating agency for the decommissioning EIS and that they will be reviewing key documents such as characterization studies, engineering studies, and performance assessment modeling, with the same rigor that NRC reviews license applications under the Atomic Energy Act. The NRC noted that applicable guidance appears in the following documents:

- NUREG-1727, NMSS Decommission Standard Review Plan
- NUREG/BR-0241, NMSS Handbook for Decommissioning Fuel Cycle and Material Licensees
- NUREG-1575, Revision 1 Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)
- NUREG-1748, Environmental Review Guidance for Licensing Actions Associated with NMSS Programs
- NUREG-1757, Consolidated NMSS Decommissioning Guidance (a three-volume decommissioning manual, of which only the first volume is available in draft form)

In addition to providing NRC with a Decommissioning EIS for NEPA compliance, in May 2003, the NRC requested that the DOE also submit a Decommissioning Plan for the WVDP. The Plan will provide a detailed description of the activities that will be conducted to remove radioactivity attributable to WVDP operations to levels that permit release of the site in accordance with NRC=s regulations and termination of the license, and to demonstrate that the facility meets NRC=s requirements for release. The Decommissioning Plan is anticipated to consist of several interrelated components, including 1) current site characterization information, 2) a remediation plan, 3) site specific cost estimates for decommissioning, and 4) a final status survey plan.

PROJECT DEFINITION AND INTRODUCTION

The purpose of the Facility Characterization Project is to support the Decommissioning Plan preparation process by documenting the radiological status of the WVDP Process Building, Tank Farm, and Vitrification Facility. Pivotal to both the Decommissioning Plan and EIS is the performance assessment, which defines long-term impacts from radiological source terms on-site.

The performance assessment is a computer model that estimates the future radiological doses to off-site receptors and on-site intruders when specific closure engineering features are implemented. Since a closure alternative has not been selected for WVDP-related facilities, this project considered the in-place closure as the most bounding alternative since, under this scenario, contamination would remain in place. An evaluation of earlier inventory estimates and associated 1996 DEIS performance assessment results for in-place closure resulted in the scope of the Facility Characterization Project focusing on those key facilities and radionuclides that most significantly impact the outcome of the performance assessment
results. The key WVDP-related dose contributors to the performance assessment are the Waste Tank Farm, Vitrification Facility, and Process Building (Figure 1). The key controlling radionuclides include U-233, U-234, Np-237, Pu-239, Pu-240, and Am-241; however, the Facility Characterization Project also considered ten other radionuclides that are important to performance assessment modeling and inventory development.

CHARACTERIZATION METHODOLOGY

The standardized characterization methodology described in this paper was developed to facilitate NRC=s acceptance of this data by maximizing the completeness, accuracy, and consistency of the investigations. At the same time, this project recognized the time and resource constraints by utilizing risk ranking and investigative levels to minimize the need for extensive field efforts. The focus of the characterization methodology is to generate bounding inventory estimates and is consistent with Multi-Agency Radiation Survey & Site Investigation Manual (MARSSIM) guidance for characterization surveys and the EPA/DOE guidance for the Data Quality Objective (DQO) process. Following generation of this characterization approach, an external panel of experts was utilized to review the approach and verify its appropriateness to support NRC LTR criteria. The Characterization Management Plan (CMP) was reviewed against NRC guidance (NUREG 1727 NMSS Decommissioning Standard Review Plan). The panel consisted of experts from NRC and DOE in decommissioning and MARSSIM. The panel=s conclusion was that the characterization approach was consistent wit the NRC guidelines. This panel continues to review radioisotope inventory reports to assess implementation of the characterization approach.

Risk Ranking and Investigative Levels

Risk ranking and sensitivity levels were used to guide the Facility Characterization Project Team in the prioritization of characterization activities and determining the level of effort deployed in a unit. Risk ranking for units was done using historical information regarding level of contamination and difficulty in obtaining additional data. Investigative levels are curie values of select key radioisotopes calculated based on the

performance assessment. The select key radioisotopes were identified as U-233 and Np-237 for groundwater doses, and Pu-239/240 for erosion doses.
If a unit source term using simplified bounding assumptions resulted in key radioisotope values at or below the investigative levels, then the simplified bounding residual radionuclide inventory estimate was used since the unit=s contribution to the overall performance assessment results was minimal. The investigative levels of Pu-239 and Pu-240 were calculated as the amount of that radionuclide necessary to result in 1 percent of the total target erosion dose of 25 millirem per year. The investigative levels of U-233 and Np-237 were

Fig. 1 Key WVDP-related dose contributing areas

calculated as the amount of that radionuclide necessary to result in 1 percent of the total target groundwater dose of 500 millirem per year. Application of the investigative levels provided a quantitative means of helping the project team implement a graded approach. In order to back calculate the amount of radioactivity required, sensitivity levels had to be developed by the performance assessment modelers. Tables I and II provide the underlying curie values that were used in the performance assessment models and the resulting peak year dose rates. The investigative levels calculated for the erosion model are: Pu-239, 0.9 Ci and Pu-240, 2.3 Ci. The investigative levels for the groundwater model are: Np-237, 0.02 Ci and U-233, 0.2 Ci.

Table I Summary of dose analysis for groundwater release scenarios

Room	Long-Lived Curies Inventory (Ci)	Peak Annual Dose (mrem/yr)	Time of Peak Dose (Years After Closure Implemented)	Controlling Radionuclides
Process Mechanical Cell	6.3E+02	53	7800	U-233, Np-237
General Purpose Cell	2.1E+03	452	4700	U-233, Np-237
Chemical Process Cell	6.0E+01	7	6700	U-233, U-234, Np-237
Extraction Cell 1	2.6E+02	27	6900	U-233
Extraction Cell 2	2.1E+02	22	6400	U-233
Liquid Waste Cell	1.2E+01	4	3900	Np-237
Off Gas Cell	3.3E-01	0.2	3900	Np-237
Hot Cells 1 - 5	2.3E+01	0.9	3100	Np-237

Table II Summary of dose analysis for erosion release scenarios

Room	Long-Lived Curies Inventory (Ci)	Peak Annual Dose (mrem/yr)	Time of Peak Dose (Years After Closure Implemented)	Controlling Radionuclide
Process Mechanical Cell	6.3E+02	12.7	2040	Pu-239, Pu-240
General Purpose Cell	2.1E+03	34.6	3370	Pu-239, Pu-240
Chemical Process Cell	6.0E+01	1.2	2040	Pu-239, Pu-240
Extraction Cell 1	2.6E+02	5.5	2040	Pu-239, Pu-240
Extraction Cell 2	2.1E+02	4.2	2040	Pu-239, Pu-240
Liquid Waste Cell	1.2E+01	0.13	2440	Pu-239, Pu-240, Am-241
Off Gas Cell	3.3E-01	0.06	2040	Pu-239, Pu-240
Hot Cells 1 - 5	2.3E+01	1.2	2040	Pu-239, Pu-240
Sample Storage Cell	4.9E+01	0.6	2040	Pu-239, Pu-240

Collection/Evaluation of Existing Data And Development of Technical Approach

The first step in the characterization process is the location, collection, and assessment of available information about the various units (or areas being characterized). The three primary areas of information include: a) unit usage, b) radiological conditions, and c) unit accessibility. Since spent nuclear fuel reprocessing operations ceased in 1972, information about unit conditions have been documented in numerous sources. Available information sources include general and specific reports on the facilities and units; specific source data (e.g., surveys, on-site and off-site laboratory data); waste characterization data; videos/pictures; drawings; and personnel interviews. The quality of this information in these sources varies from document to document, unit to unit, and ranges from hypothetical estimates to quantifiable data depending on several factors, including the projected curies remaining in the unit and unit accessibility. The amount of available verifiable data on units with limited accessibility is generally low due to high dose rates, high airborne contamination areas, and inability of physical access. One example is the General Purpose Cell where fuel reprocessing wastes were packaged for disposal (Figure 2). Earlier source term estimates in support of the DEIS were based largely on this existing unit information. Since preparation of the DEIS, additional verifiable survey and isotopic distribution data has been generated for several of the units in the Process Building (Figure 3), Waste Tank Farm, and Vitrification Facility as a result of ongoing operations, flushing, and decontamination. By collecting and assessing both the historical and recently generated data, a decision can be made as to whether sufficient verifiable data exists to generate conservatively bounded curie estimates or if additional data must be collected. In most cases, verifiable data means that samples or surveys can be validated. All data, regardless of the vintage, is validated in accordance with EPA/DOE guidance as defined in the characterization approach. However, there are instances where validation is not possible but the data is still considered critical and usable for project purposes. The assessment process reviews unit usage, radiological conditions, and unit accessability information.

Based on the evaluation of existing data, a technical approach for the path forward is drafted. The draft technical approach may recommend additional data collection or proceed directly to calculating an inventory or dose-to-curie modeling using verifiable historical data.

Technical Approach Review Process

To determine if each draft technical approach and proposed path forward is technically sound and feasible, a Technical Review and Approval Panel (TRAP) was formed. The TRAP is a panel of site personnel who are considered subject-matter experts in analytical, radiological, characterization, historical process knowledge, and other pertinent areas. Upon the TRAP=s review of each draft technical approach, one of three generalized conclusions are reached by the panel for each unit.

Fig. 2 General purpose cell

Fig. 3 Process building

Conclusion A: The current curie estimate is determined to be conservatively bounded based on an evaluation of existing data.

This conclusion is reached when the panel determines that the historical and current usage of a unit is known and the existing inventory is based on verifiable data. Typically, there is only one bounding radiological distribution and radionuclides are not present above the sensitivity levels. To date, this conclusion has not been drawn and is unlikely for the remaining units.

Conclusion B: Sufficient verifiable data exists which facilitates the modeling of the unit and generation of a conservatively bounded curie estimate.

The panel will reach this conclusion if the historical and current unit usage is known, physical conditions of the unit are known, isotopic distribution in the unit includes the presence of measurable gamma emitters, and verifiable field measurement data exists. In addition, the radioisotopic distribution of the unit is known based on verifiable data or a conservative radioisotopic distribution can be developed based on verifiable process knowledge and the unit can be modeled conservatively.

Conclusion C: Additional data collection is warranted to generate a conservatively bounded radionuclide inventory.

A number of factors are considered by the panel before reaching this conclusion. Generally, these units are expected to have significant contamination with multiple radioisotopic distributions or gamma emitting signature isotopes are present, making dose-to-curie modeling more difficult. In addition, physical or radiological conditions may have changed due to ongoing operations, or the unit history not clearly defined.

Implementation of Technical Approach

Additional Data Collection

When additional data collection is required, a technical approach is prepared that includes the rationale for the data collection activities and details of the specific data collection. Data collection planning is an integrative and progressive process. The process is dictated, in part, by the purpose of the project (e.g., generate conservatively bounded curie estimates or one that yields a curie estimate that is considered high). As a result, a biased sampling program is designed to ideally collect the most conservative ratios for the radionuclides of concern which at the same time tends to minimize the number of samples and therefore also minimizes the cost and personnel exposure. The sampling program takes into consideration: data type and sources, available technologies, and unit access constraints. Data collection is conducted pursuant to written work instructions as appropriate.

Data types that can be used to generate and support conservatively bounded curie estimates exist in multiple forms and include video/pictures of cell conditions, physical conditions (e.g., component layout, vessel composition, liquid levels in vessels, pipes), field measurements (e.g., radiation dose rates, contamination levels), and sample data (e.g., samples of pipe, liquids, floor debris). Technologies deployed for field measurements include: Scaler/Ratemeter Geiger-Mueller Detector System; Single Channel Analyzer (SCA) System; RadScanJ 700; and the Multi-Channel Analyzer/In Situ Object Counting System. Visual inspections to assess unit configuration, physical conditions, and sample collection are also critical to completing a unit characterization.

For units in which additional data is needed, it is important to understand how the unit can be accessed prior to design of the sampling approach.

Data Analysis and Development of Bounded Inventory

The data analysis process is a collaborative effort between a scientist, modeler, and the TRAP. Dose-to-curie computer modeling is the main process that is used for units to translate the field information (dose rate) into a radiological inventory for the key gamma-emitting radioisotope (usually Cs-137). When multiplied by appropriate scaling factors, the radiological inventory for all the desired radioisotopes is established.

Selection of the scaling factors may be the key factor in ensuring that the results are conservatively bounded. In some areas, a choice may be made to apply analytical results from field samples to particular portions of a cell (unit), while in others, process knowledge may be the method for generating scaling factors. Results may be averaged, or the highest ratios to Cs-137 selected as the scaling factor for that calculation.

To generate scaling factors from field sample data, the physical sample analytical data is aged to a common date of September 30, 2004. If an analyte was identified as being nondetected at the method detection limit, then the method detection limit was used. Sample results for most areas are then normalized to Cs-137 or in some cases to Am-241 for those areas in which the Cs-137 concentration was significantly lower than the

Am-241 concentration. If multiple samples or different sample populations were associated with the particular investigated area, the geometric mean of the population=s scaling factors was calculated, and if multiple populations were identified, the worst-case scaling factors associated with the different sample populations were utilized. For example, for the Chemical Process Cell, data was available from numerous floor debris samples taken in the 1980s. In addition to the floor data, since the cell was involved in the treatment of high-level waste from 1966 to 1972, two other data populations were identified for the cell, namely data associated with high-level waste and data associated with spent nuclear fuel. The scaling factors from the three populations (geomean of floor samples, high-level waste, and spent nuclear fuel) were then compared and the highest scaling factors utilized. The basis for the generation of scaling factors are decided as part of the TRAP process and is determined on a unit-by-unit basis.

Utilizing the dose rate data and the physical dimensions of the area being investigated, a MicroShieldJ model is developed and a Cs-137 or Am-241 curie inventory calculated based on the recorded dose rate. To increase conservatism, for most areas, even if it was known that there were other radiation sources in the area of the entity being surveyed, the recorded dose rate was applied in its entirety to the entity. For example, in determining the dose rate of the floor in the Head End Ventilation Cell, the contribution from nearby filters was not subtracted from the recorded dose rates. However, in some areas, like the Liquid Waste Cell (Figure 4), where the source of the dose rate was unknown due to the close proximity of tank sources, it was necessary to use a shielded probe to isolate the dose rate from each tank source. The Cs-137/Am-241 curie inventories resulting from the MicroShieldJ models were then aged to a common date of September 30, 2004. When the modeled Cs-137/Am-241inventories are multiplied by appropriate scaling factors, the radiological inventory for all the desired radioisotopes is established.

Panel Approval of Developed Inventories

Upon the development of a radiological inventory, the TRAP reviews the data and the data analysis methods used to develop the inventory. If the panel approves the methods used and resultant inventory, the results of the investigative effort are documented. If the panel does not approve of the efforts, the identified issues are addressed until concurrence is received from all members of the panel. Methods of resolving issues include using different modeling geometries or performing additional surveys.

Characterization Documentation

A final report for each unit is prepared to document the implementation of this project. A project file is prepared that includes all of the source documents, field data, and report references.

The purpose of the final inventory report is to document the work completed for the individual units, document that the characterization activities completed followed the requirements of the CMP, and document that sufficient data gathering, data evaluation, and Quality Assurance/Quality Control (QA/QC) efforts were performed to ensure that the radioisotopic inventory for each unit is technically defensible and sufficient to support the performance assessment.

QUALITY ASSURANCE PROJECT REQUIREMENTS

There are three phases of data collection and assessment for the Facility Characterization Project that are subject to QA project requirements. These requirements include dose measurements, dose-to-curie modeling, and scaling factor determinations through physical sampling. A number of QA matrices are used for dose rate measurements and sample collection including precision, accuracy, completeness, representativeness, comparability, and equipment maintenance and calibration.

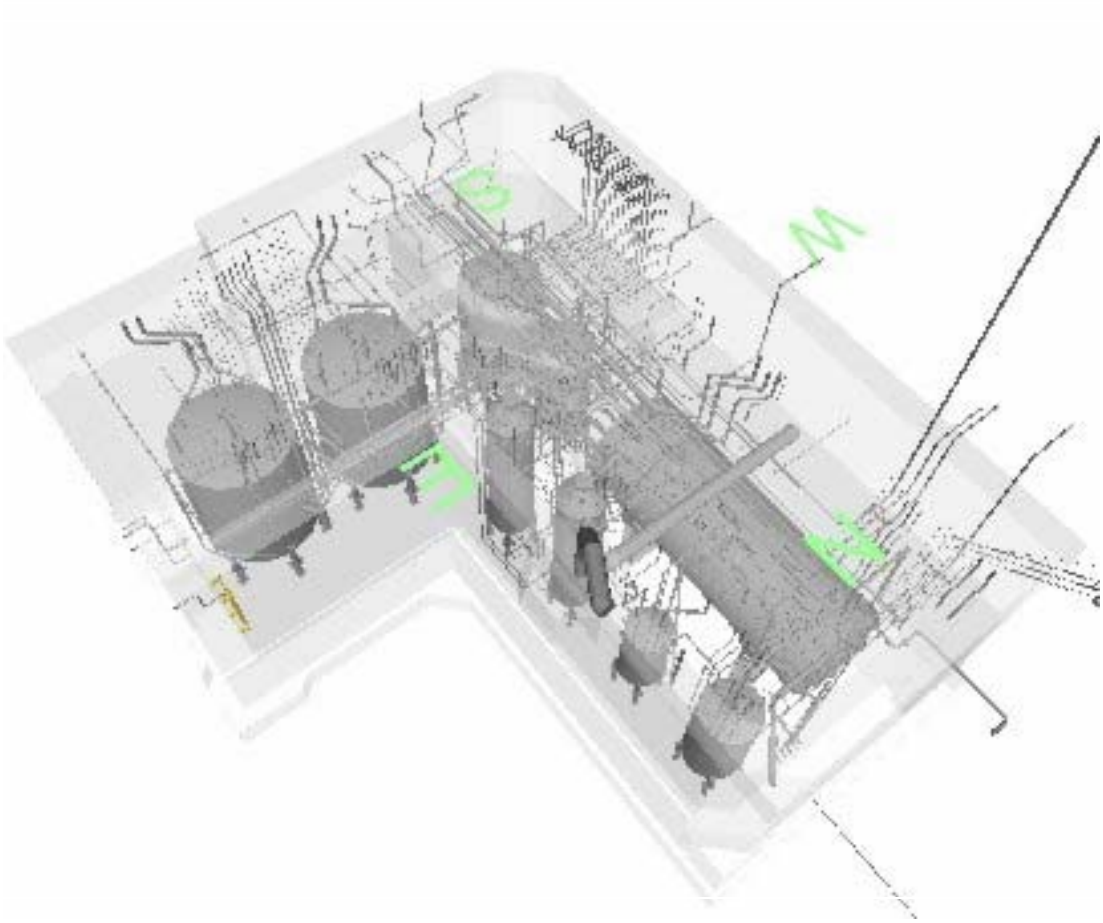

Fig. 4. Liquid Waste Cell.

Quality assurance objectives for dose-to-curie modeling include: MicroShieldJ model verification and validation; peer review of calculations; and training of personnel performing modeling.

Ongoing program and compliance assessments are conducted to verify the adequacy of the QA program. This QA program operates independently of the overall project structure. The Quality Assurance Integrated Assessment Program is responsible for coordinating assessments. The QA department, in consultation with the Project Manager or Project Lead, performs surveillances to coincide, as appropriate, with activities conducted for characterization.

DATA REDUCTION, VALIDATION, AND USABILITY

All data used in the characterization project is documented and validated per site procedures. There are instances when a critical piece of historical information is available but not able to be validated. In these instances, the TRAP is consulted based on their expert technical judgment to what extent this information can be used.

Modeling inputs include dose rate surveys and, as applicable, analytical data that are generated, reported, and validated. In addition, the model requires information regarding the configuration of the unit to be modeled. This data is generated during the information gathering process. The modeler develops a strategy for modeling the unit, in consultation with knowledgeable personnel, and inputs all of the necessary data. All

assumptions and data inputs are documented as part of the modeling data package. Spreadsheets of modeling results are maintained in the modeling data package.

All modeling results are reviewed and signed off by another individual who has been trained to perform MicroShieldJ modeling. The reviewer evaluates that the modeling assumptions are rational, data inputs are correct, and that the model outputs are reasonable for the unit being modeled.

In addition to the routine review of the modeling results, external expertise is obtained to conduct independent reviews of a unit modeling data package, including, data input, assumptions, and results. Based on the results of that review, the Project Manager or Senior Project Manager may invoke additional external reviews as necessary to ensure that the quality of the project and its products are maintained.

Model inputs and assumptions validation will be conducted in conjunction with data reduction and reporting. The TRAP serves as the final validator of the unit model results during the final review and approval process. The TRAP also serves as the final decision maker regarding the usability of the model as it is presented or whether additional work is required to make the results more usable. Additional work may include changes in the model through collection of additional field data. As part of the formal sign-off, the TRAP is the final decision maker regarding the usability of the modeling results.

Reconciliation with Project Data Quality Objectives

Decisions that determine if the Project DQOs have been satisfied are made during the data assessment process and are ultimately accepted by the TRAP.

SUMMARY AND CONCLUSIONS

The characterization project was developed to generate information as to the radiological status of significant WVDP-related facilities. This information will be assessed and incorporated into the site=s decommissioning planning process for purposes of identifying the level of contaminant removal necessary to meet the NRC prescribed decommissioning criteria. By application of risk ranking and investigative levels, the project was able to effectively manage its resources and provide a consistent, technically defensible product for the customer. Verification of the appropriateness of the upper bound inventory approach was demonstrated by an external peer review panel of industry experts who continue to monitor the implementation of the approach to completion. Using this process, new source terms are being developed for approximately 40 areas (units) at the WVDP in little more than two years.

FOOTNOTE