Appendix L

System Assessment Capability: A 10,000-Year, Post-Closure Assessment

L.1 Introduction

In late 1997, the U.S. Department of Energy (DOE) established the Groundwater/Vadose Zone Integration Project with Bechtel Hanford, Inc. (BHI), the Hanford Site Environmental Restoration Contractor, as manager. The project transitioned to Fluor Hanford, the Project Hanford Management Contractor, in July 2002, and has been renamed the Groundwater Protection Program. Pacific Northwest National Laboratory (PNNL) is a partner in the project. The mission of the project is to coordinate and integrate projects that characterize, monitor, and clean up contaminants in the groundwater and vadose zone (the soil between the ground surface and the groundwater) beneath the Hanford Site. The Groundwater Protection Project also incorporates other task areas that complement these projects and several that represent accelerated actions leading to earlier site cleanup and closure.

In 1999, under the Integration Project, DOE initiated development of an assessment tool that will enable users to model the movement of contaminants from all waste sites at Hanford through the vadose zone, the groundwater, and the Columbia River and to estimate the impact of contaminants on human health, ecology and the local cultures and economy. This tool is named the System Assessment Capability (SAC).

The approach taken by the SAC is consistent with the methods, characteristics, and controls associated with a composite analysis as described by the Columbia River Comprehensive Impact Assessment (CRCIA) team (DOE-RL 1998). The CRCIA was a study initiated by DOE, the Washington State Department of Ecology, and the U.S. Environmental Protection Agency (EPA) to assess the effects of Hanford-derived materials and contaminants on the Columbia River environment, river-dependent life, and users of river resources. Part I of CRCIA was a study of present-day impacts to the Columbia River from Hanford contaminants. Part II was a suite of requirements for the development of a comprehensive impact assessment for the Columbia River. The two key elements of the SAC approach are 1) ensuring that factors that will dominate the risk are included, and 2) providing an understanding of the uncertainty of the results. Dominant factors were identified through scoping studies and the development of conceptual models for each of the analysis modules used. A stochastic modeling approach was taken to estimate uncertainty in the results. Aspects of uncertainty that could not be included in the calculation were considered in the analysis of the modeling results and discussed in the document presenting initial assessment results (Bryce et al. 2002). The analysis modules included in the SAC parallel those identified by CRCIA and were developed through work group meetings that included regulator and stakeholder participation.

Several key modules were adopted directly from the CRCIA, including the module used to calculate human health impacts (the HUMAN code) and the module used to calculate impacts to ecological species (the ECEM code).

An initial assessment was recently completed with the SAC to demonstrate its functional assessment capability. Future modifications to the tool will be driven by the requirements of specific assessments. Improvements in the results obtained from use of the SAC will be realized as input data are refined through characterization and scientific research. Bryce et al. (2002) reported the results of that assessment, which is the basis for application of the SAC to provide a site-wide perspective of waste disposal and remedial actions in this Hanford Solid Waste Environmental Impact Statement (HSW EIS). Much of the material presented in this appendix has been taken from Bryce et al. (2002).

To simplify the discussion presented in this appendix, the term "SAC" refers to the software package used for this assessment, but it should be noted that the SAC is an evolving and maturing capability.

The initial assessment in fiscal year 2002:

- Modeled the movement of contaminants from 533 locations throughout the Hanford Site representing 890 waste sites through the vadose zone, the groundwater, and the Columbia River.

- Incorporated data on 10 radioactive and chemical contaminants—carbon tetrachloride, cesium-137, chromium, iodine-129, plutonium-239/240, tritium, strontium-90, technetium-99, total uranium (chemical), and uranium (radionuclide).

- Focused on subsurface transport, the Columbia River, and risks to human and ecological health, and the economy and culture.

- Included the geographic region from Rattlesnake Mountain to the Columbia River and from Vernita Bridge to McNary Dam on the Columbia River.

- Included the cleanup actions in Hanford's cleanup plans and agreements as of October 2000.

- Consisted of a stochastic simulation for the period 1944 to 3050 using 25 realizations, thus providing insight into the median response and an initial look at uncertainty.

- Simulated a 1000-year, post-closure period. Three waste forms known to release after that time were not included—immobilized low-activity waste (ILAW), melters, and naval reactor compartments.

For the waste sites located on the Hanford Central Plateau and their associated contaminant plumes, the findings of the initial assessment parallel those of the composite analysis (Kincaid et al. 1998). The results are also consistent with concentrations in environmental media measured by the Hanford Environmental Surveillance Program (Poston et al. 2002). Both the monitoring results and the assessment reported here indicate that Hanford impacts to the Columbia River have peaked and are now declining.

For the purposes of the HSW EIS, the System Assessment Capability (SAC) is a 'best available technology' and, while it remains a tool under development, the SAC Rev. 0 tool is adequate to provide valuable information through quantification of cumulative risks and impacts associated with solid waste disposal at the Hanford Site.

L.1.1 Context of SAC Runs

The principal SAC simulation made in support of the HSW EIS is a series of 25 stochastic simulations run over the period 1944 through 12050 A.D. (that is, a 10,000-year, post-closure period), for the Hanford Site Disposition Baseline (HSDB) scenario. This simulation includes a stochastic representation of inventory, release and transport, and a deterministic representation of exposure and dose. In addition, a median-value input case, based on the median value of each input parameter represented by a distribution in the stochastic model, was simulated.

The HSDB scenario represented in the fiscal year 2002 initial assessment are based on a number of cleanup assumption including waste, debris, and contaminated soil will be removed from the 100 Areas and the remaining soil will meet residential use standards. Similarly, waste, debris, and contaminated soil will be removed from the 300 Areas, but the remaining soil will meet industrial use standards. In this scenario, retrievably stored transuranic (TRU) waste will be recovered, tested to determine waste content, repackaged, and sent offsite for disposal at the Waste Isolation Plant in New Mexico. The waste in Burial Grounds 618-10 and 618-11 will be removed, and the TRU waste will be repackaged and removed from the Hanford Site, while the low-level waste (LLW) will be disposed of in solid waste disposal facilities in the Central Plateau. Ninety-nine percent of the tank waste volume will be recovered from the tanks and a 1 percent residual volume will remain. Losses to the subsurface during waste recovery are assumed to average 30,280 L (8000 gal) per single-shell tank recovered. The recovered tank waste will be separated into low-activity and high-activity fractions. Both waste fractions are assumed to be immobilized. Low-activity waste will be disposed of onsite, while the high-activity fraction will be disposed of in the national repository. All spent fuel also will be stored in a stable configuration for shipment to and disposal in the national repository.

The initial assessment and this analysis assume that, for the duration of the analysis, the future regional and local climate will remain unchanged for the period of the analysis. Furthermore, it is assumed that major engineered structures in the region (for example, the reservoir system on the Columbia River) will remain in place. The recorded climate and environmental response (for example, Columbia River stage and discharge records) since startup of the site operations were used to simulate the period from 1944 to the present. The climate record from 1961 to 1990 was used to represent the future climate. Consequently, the Hanford Site remains a semi-arid, shrub-steppe environment in the simulations. The riparian zone, Columbia River, and river ecosystem are assumed to remain essentially unchanged for the duration of the analysis. Also, the human population will be unchanged and will be based on the current socio-economic setting. Analyses of alternate future climates (for example, global climate change or onset of an ice age and glacial flooding) and potential future events (for example, failure or removal of the reservoir system) are not addressed.

Where the initial assessment addressed the period 1944 through 3050 (that is, essentially a 1000-year, post-closure simulation), simulations for this EIS were carried out over a 10,000-year, post-closure period. Within the SAC, a single transport pathway element, the Columbia River model, is limited to the year 10,000 A.D. in its simulation algorithm, but all other transport pathways (release, vadose zone, groundwater) can execute for the full 10,000-year, post-closure period.

The stochastic simulations supporting the HSW EIS are based on the parameter distributions assembled for the initial assessment. In addition to the environmental pathway and risk/impact model parameters, the inventory and the future disposal and remedial actions assembled for the initial assessment are included. Differences between the inventory used in this extended simulation of the initial assessment and that used in the HSW EIS are described in Section L.2.2.2. Principal differences lie in the methods used to forecast solid waste disposal actions until site closure, both for onsite generators (for example, Waste Treatment Plant contributions) and for offsite generators.

The potential contaminants of greatest concern include technetium-99, iodine-129 and uranium. These contaminants appear in solid waste performance assessments (Wood et al. 1995, Wood 1996) that analyze solid waste disposals in 200 West and 200 East Areas. While the initial application of SAC to the HSW EIS did not include iodine-129, an ability to achieve simulation of iodine-129 is being established. Of necessity, simulation of iodine-129 will include an initial condition for iodine-129 representative of prior releases to the unconfined groundwater, simulation of future releases of iodine-129 per the initial assessment, and superposition of the ILAW contribution to iodine-129 risk and impact. This approach to iodine-129 simulation will include events attributed to past liquid discharges (current groundwater plumes), future solid waste releases, and long-term future releases from immobilized low-activity tank waste. The inventory estimated to exist in the unconfined aquifer, and the estimate of iodine-129 in low-activity tank waste to remain at Hanford will be used in this estimate of the iodine-129 contribution to risk/impact. As in the original 1000-yr initial assessment, simulation of technetium-99 and uranium will use the complete history and forecast of their disposal and begin in 1944 with a clean subsurface environment.

It is unlikely that the plumes from these three classes of release events will superimpose in time. The liquid discharge and unplanned release (e.g., tank leak) sites have created groundwater plumes and will likely continue to release to groundwater during the immediate future. Releases from dry solid waste disposals have some containment (e.g., boxes, drums, plastic bags) and less driving force (e.g., infiltration), and, therefore, they will likely release later than the liquid releases. Finally, the substantially stable and long-term waste forms like vitrified low-activity tank waste will not corrode and release for thousands of years. It is unlikely that peaks from each of these types of release will superimpose in space and time.

L.1.2 Relationship to EIS Calculations

The EIS calculations focus on the impacts associated with alternatives to the disposal of solid waste. The SAC represents a holistic examination of the radioactive and chemical waste legacy of the Hanford Site. For this reason, it can be used to examine the relative risk and impact associated with disposal and remedial action alternatives and the relative role of different segments of Hanford waste—for example, solid waste, past-practice liquid discharges, or tank wastes. Used in this way, the SAC provides an ability to visualize the change in impact associated with various options and wastes. This kind of cumulative impact assessment provides a larger scale site-wide context from which to view the alternatives and influence disposal decisions.

The EIS calculations provide a detailed evaluation of each specific alternative. The SAC is only able, at this time, to present the single case of an extended analysis (e.g., 10,000 yr post closure) of the HSDB. In essence, the SAC provides an estimate of the contribution made to risk and impact from technetium-99 and uranium from other Hanford waste disposal and remedial actions not explicitly considered in the HSW EIS alternatives, and to contrast that with the contribution from solid wastes.

L.2 Methods and Approach

Historically, DOE has used various tools to assess the effects of waste management and cleanup activities on the environment. Assessments have been performed to address a range of questions. Some assessments have focused on individual waste sites or waste types—for example the assessment performed to evaluate the future performance of the glass waste form proposed for isolating low-activity waste currently in tanks (Mann et al. 2001). Others have looked at contaminants from a variety of sources. The Hanford Environmental Dose Reconstruction Project estimated human health impacts from past releases to the atmosphere and river (Farris et al. 1994) during Hanford operations from 1944 to 1972. The Columbia River Comprehensive Impact Assessment (CRCIA) (DOE-RL 1998) examined ecological and human health effects that might result from the 1990 to 1996 distribution of contaminants in the environment in and near the Columbia River. The composite analysis performed in 1997 considered the impact of selected radionuclides from approximately 280 waste sites in the 200 Areas (Kincaid et al. 1998). In 2001, Bergeron et al. (2001) issued an addendum to the composite analysis that considered additional waste sites on the Central Plateau.

The collective impact of all of the waste that will remain at Hanford, however, had not yet been integrated to provide an understanding of the cumulative effects of Hanford activities on the Central Plateau as well as in the river corridor. The SAC was developed to fill this gap and has benefited from the lessons learned in previous assessments.

The initial assessment and this extension to a 10,000-year, post-closure analysis considers solid waste disposals in the Central Plateau as occurring within aggregated solid waste disposal facilities in the northern and southern portions of the 200 West and East Areas. Annual inventories for each disposal facility within a subregion of the site are aggregated to create an annual solid waste inventory for the subregion. The areal footprints of disposal facilities within a subregion are aggregated to create a total solid waste disposal facility areal footprint. Contaminants from the aggregated disposal facility are released to the unconfined aquifer at the centroid coordinates of the aggregated disposal facility. Thus, use of an aggregated representation of solid waste disposal facilities is an approximation in a number of ways. Notably, the inventory actually placed in individual trenches within each disposal facility is represented as distributed over the entire areal footprint of the disposal facility. Hence, the aggregated inventory is distributed over the aggregated areal footprint of all solid waste disposal facilities in a subregion of the site. Because