The Effects of Site Complexity on Model Performance – Long-term Groundwater Performance Assessment – 14292

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ABSTRACT

The Tank Closure and Waste Management Environmental Impact Statement for the DOE Hanford Site evaluated a complex set of alternative methods for closing single-shell tank farms, retrieval and treatment of high-level radioactive waste, and on-site disposal of low-level radioactive waste. A long-term groundwater performance assessment was a key component of the analysis. The Hanford site is characterized by extremely low net infiltration and a thick vadose zone of varying composition. Three-dimensional vadose zone models were developed and solved for over 400 individual source areas under a variety of different future scenarios. Contaminant flux from the vadose zone models were fed into a three-dimensional transient model of the unconfined aquifer. An iterative calibration procedure was developed to optimize the performance of the models during the operational period (1944 to 1994) and to predict outcomes over a 10,000-year period of analysis. The greatest source of complexity was the requirement to predict accurate nearfield groundwater concentrations (distance scales of several hundred meters) while at the same time predicting combined impacts from all the sources at a regional scale. In addition to the technical complexities of the site, the large number of source areas and future scenarios introduced additional issues with respect to data management and presentation. When dealing with natural systems with high degrees of complexity model, design considerations and tradeoffs require increased amounts of management attention and stakeholder communication to create confidence in the models for the purposes for which they are intended.

INTRODUCTION

The scope of the *Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland Washington* (TC & WM EIS) required the evaluation of hundreds of sources, each releasing several different contaminants that contribute to groundwater contamination at Hanford [1]. The TC & WM EIS evaluated a total of 11 Tank Closure alternatives, 3 Fast Flux Test Facility (FFTF) Decommissioning alternatives, and 3 Waste Management alternatives. Each alternative was made up of several components that had the potential to influence the groundwater water system at Hanford.

The long-term groundwater impacts analyses for the TC & WM EIS were specifically designed to satisfy the National Environmental Policy Act (NEPA) [2]. Besides meeting the objectives of the NEPA process, the TC & WM EIS team had to adhere to specific guidance for the evaluation of the long-term groundwater impacts and meet requirements of the Washington State Department of Ecology. The TC & WM EIS team also had to develop the tools necessary to address concerns raised by cooperating agencies and stakeholders about development processes and parameterization used for other Hanford groundwater simulations and satisfy project specific quality assurance requirements. The greatest source of complexity in developing the TC & WM EIS groundwater models was the requirement to predict accurate near field groundwater concentrations while also predicting combined impacts from all of the sources on a regional scale. The technical complexities of the project included understanding the uncertainties associated with potential policy decisions, emerging engineering designs, incomplete characterization of the natural environmental system yet developing groundwater model results that could be confidently used for the purposes for which they were intended.

ESTABLISHING A FRAMEWORK WITH COLLABORATORS AND STAKEHOLDERS

DOE used a process to develop a consensus for moving the TC & WM EIS groundwater analyses forward dealing with parameterization, technical assumptions, and methodology. Key parameters were discussed among the lead and cooperating agencies, and values were specified for base case and sensitivity case analyses. The process codified DOE's desire not to use overly aggressive parameters that maximize system performance, but rather to use a more representative range of parameters that would allow a reasonable evaluation of the differences among the alternatives. The key parameters were defined and tabulated in the *Technical Guidance Document for Tank Closure Environmental Impact Statement Vadose Zone and Groundwater Revised Analyses* [3]. In addition to providing guidance for parameters and technical assumptions, the *Technical Guidance Document* also provided specific guidance for evaluation of the long-term groundwater impacts. One of the major requirements outlined in the document was that the EIS groundwater analysis results had to be presented at both near and far field locations in an isopleth format, and the individual sources of contamination to the groundwater had to be simulated separately to adequately trace impacts for each contributor to the EIS alternatives.

In addition to satisfying NEPA requirements, the Washington State Department of Ecology (Ecology), a cooperating agency, needed to be able to rely on the TC & WM EIS to support analyses to meet State Environmental Policy Act and permitting considerations. Their design considerations were defined early in the project and included the requirement to present contaminant concentrations within 100 meters of important facility fence lines (e.g., tank farm barriers during post-closure period), the requirement to present contaminant isopleths (spatial distribution of groundwater concentrations at specified times) as well as concentration-versus-time plots, and the desire to standardize certain features of the regional-scale flow model.

CONCEPTUAL FRAMEWORK FOR IMPLEMENTATION

The Hanford Site in Richland, Washington consists of a large number of local-scale contaminant source areas overlying a regional-scale unconfined aquifer. The site is characterized by extremely low net infiltration and a thick vadose zone with varying lithology. An important choice made early in the development of the groundwater modeling approach for the TC & WM EIS was to simulate the exposure pathway from source to receptor as separate but interfaced segments, or components. This choice was primarily made to address the issues associated with the different scales of the observed behaviors, local and regional, at the Hanford site, and to be able to meet the programmatic objective of reporting groundwater contaminant concentrations within 100 meters of important facility fence lines. Based on characterization data, the following are important local and regional scale features which needed to be included in the complexity of the site conceptual model to reasonably predict or bound groundwater concentrations at Hanford:

- The characteristics of the waste forms
  - The initial source inventories to be released from the waste forms to the vadose zone
  - Retention of chemicals and radionuclides in the waste form
- The infiltration/recharge into the groundwater system

- The material properties of the subsurface including the highly conductive portion of the unconfined aquifer
- The velocity field of the regional-scale aquifer.

To capture the features that govern flow and transport while preserving the ability to report concentrations at the desired resolution, and staying within the computational limits of the modeling machinery, the groundwater system was conceptualized into the following segments (1) site-specific, local-scale models for release of contaminants to the vadose zone (dealing with inventory and waste form release); (2) site-specific, local-scale models for vadose zone flow and transport; (3) a regional scale groundwater flow model; and (4) local-scale applications of a regional-scale groundwater flow transport model. See Figure 1.

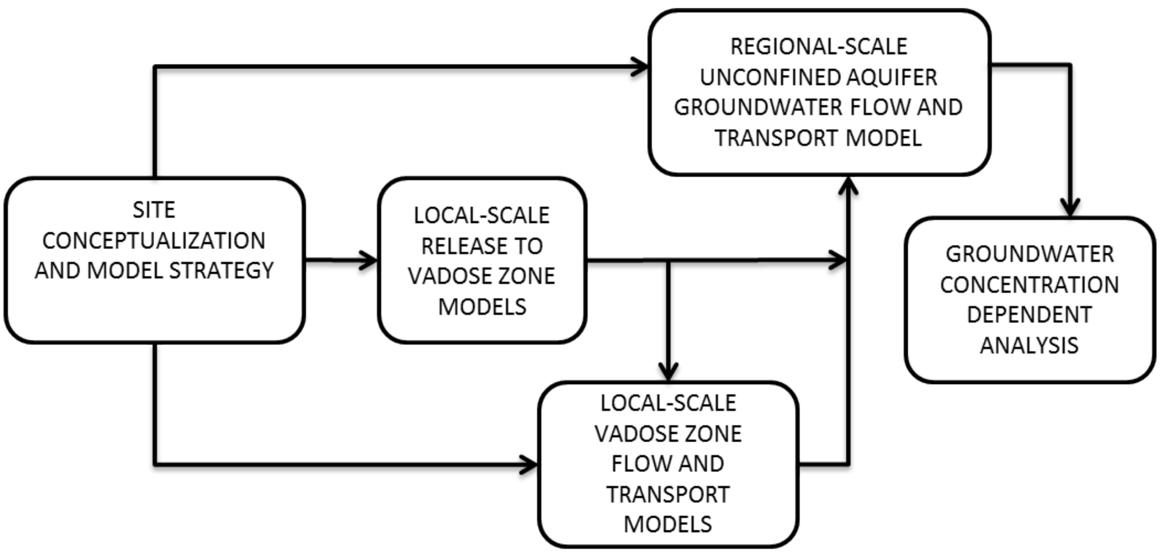

Fig. 1. TC & WM EIS Groundwater Modeling System Flowchart

UNDERSTANDING UNCERTAINTY ASSOCIATED WITH PARAMETER SELECTION

A lack of knowledge of past, present, and future conditions, as well as the variability of these conditions must be considered when estimating concentrations of hazardous constituents in groundwater and related potential human health impacts. This uncertainty derives from variability in the natural system's conditions (for example rates of precipitation and recharge over time), as well as a lack of knowledge in areas such applicability of specific models to site-specific locations and conditions and the type of climate to be experienced in the future. To address uncertainty in model structure, scenario conditions, and model parameters, two methods of analysis may be used: probabilistic techniques and deterministic sensitivity analysis. Probabilistic approaches to estimation of uncertainty in model structure involve identification of alternate conceptual models and development of probability of the alternate models applicability [4]. While the probabilistic approach to analysis of uncertainty may be the most rigorous approach available, in the context of the TC & WM EIS practical considerations of limited available knowledge and premature stage of development preclude its application in a comprehensive fashion. As an alternate to probabilistic techniques, deterministic sensitivity analysis may be applied to identify sensitive parameters and investigate the range of response of the output variable to variation over the range of input parameters.

The NEPA alternatives analyzed in the TC & WM EIS were comprised of hundreds of solid and liquid sources of releases to the vadose zone, each with different timelines, durations, waste form characteristics, areal extents, and locations on the Hanford Site. For each of the individual simulations, the EIS groundwater modeling team had to gather site characterization data, develop a conceptual model, and determine parameter values to apply to each of the model segments. NEPA regulations provide flexibility in characterizing parameter uncertainty and focus on discrimination of alternatives [2], while agency-specific guidance and other regulatory requirements direct reasonable expectation (DOE Manual 435.1-1) [5] or reasonable assurance [6], rather than exact correspondence with a criterion, as a standard for acceptability of a proposed alternative. The uncertainty associated with the related groundwater model input parameters incorporated uncertainties related to potential policy decisions, emerging engineering designs, and incomplete characterization of the natural environmental system. An associated complexity encountered during the development of the TC & WM EIS was identifying the parameters and assumptions that if changed over reasonable bounds, could influence the predicted groundwater concentrations and in turn affect a programmatic decision.

The strategy or method for determining a reasonable range of values to evaluate in an analysis depends on both the sensitivity of the model to the parameter and the uncertainty in the parameter itself. Because the degree of the characterization of parameters necessary for the TC & WM EIS groundwater simulations was variable, the following four methods for determining parameter variations were utilized to evaluate uncertainty:

- When the model was sensitive to a parameter and the uncertainty in the parameter was well-characterized, the parameter variations were selected from the statistical distribution describing the uncertainty.
- When the model was not particularly sensitive to the parameter and the uncertainty of that parameter was poorly characterized, variations utilizing rough orders of magnitudes were developed (referred to as “variation by mild exaggeration”).
- When the model was sensitive to the parameter and the uncertainty was poorly characterized, a parameter variation that spans a range with reasonably distributed values can be developed (referred to as “variation that spans a range”).
- Finally, when the model was not particularly sensitive to a parameter and the uncertainty of that parameter was well-characterized, parameter variations within the permissible range was utilized (referred to as “variation within a permissible range”).

The following are examples of analyses, from the development stage of the TC & WM EIS, which illustrate how the uncertainty of individual parameters such as inventory, background infiltration, or parameters associated with waste form performance can influence the magnitude and duration of predicted peak groundwater concentrations. Each of the following examples are for the 200-East Area Integrated Disposal Facility (IDF), as it was simulated in the TC & WM EIS under Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A (corresponding to Tank Closure Alternative 2B which included: expanded WTP vitrification, landfill closure, and Tc-99 removal in the waste treatment process). In each of the analyses the individual simulations for each of the wastes forms disposed of at IDF-East (immobilized low-activity waste glass, effluent treatment facility-generated solid secondary waste, solid secondary waste, offsite waste, fast flux test facility decommissioning secondary waste, waste management secondary waste, and onsite-generated waste) were aggregated to illustrate the predicted maximum groundwater concentration along a potential IDF-East facility fence line.

Inventory

One of the components examined under the TC & WM EIS alternatives was the receipt of offsite waste streams containing specific amounts of certain risk-driving radionuclides, e.g., I-129 and Tc-99. This offsite waste component of the analysis was of particular concern to the cooperating agencies and the public because of its potential to adversely impact the groundwater quality at Hanford. As part of DOE's January 6, 2006, Settlement Agreement with the State of Washington (as amended on June 5, 2008) regarding State of Washington v. Bodman (Civil No. 2:03-cv-05018-AAM), signed by DOE, Ecology, the Washington State Attorney General's Office, and the U.S. Department of Justice, the TC & WM EIS evaluated the transportation of LLW and MLLW from other DOE sites to Hanford for disposal. The volume of this offsite waste was established in the "Record of Decision for the Solid Waste Program, Hanford Site, Richland, WA: Storage and Treatment of Low-Level Waste and Mixed Low-Level Waste; Disposal of Low-Level Waste and Mixed Low-Level Waste, and Storage, Processing, and Certification of Transuranic Waste for Shipment to the Waste Isolation Pilot Plant" [7]. The volumes were limited to 62,000 cubic meters (81,100 cubic yards) of LLW and 20,000 cubic meters (26,200 cubic yards) of MLLW. The volume was determined to be a reasonable starting point and followed the 2006 Settlement Agreement and its associated Memorandum of Understanding between DOE and Ecology, and was reflected in the 2006 Notice of Intent [8].

There is substantial uncertainty associated with the sources, volumes, and potential long-term performance of radiological and chemical offsite waste that could potentially be disposed of at Hanford. It is important to be able to understand the initial inventory in the waste form because it is a primary factor that governs the amount of inventory available for discharge to the environment. The objective of the offsite waste analysis in the EIS was to examine the effect of varying the offsite waste inventory at IDF-East to the predicted groundwater concentrations; this example analysis has the same objective. Because it was known that the simulation was sensitive to the initial inventory input parameter and because the uncertainty was poorly characterized, the inventory was varied by values that spanned a range to understand the influence of the parameter to the predicted groundwater concentration. Figure 2 shows the comparison of the predicted concentrations versus time for the offsite waste sensitivity analysis at the IDF-East barrier, with inventories ranging from 0 to 3 curies. The only difference among the sensitivity cases is the initial offsite waste inventory; the inventories for the other components of Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A remained the same in each case. The predicted groundwater concentrations for the varying inventories of I-129 show similar dependence on time, rate of recharge, and magnitude of inventory. The increase of inventory produces a proportional increase in groundwater concentration. The shape of the time series of concentrations in is due to a combination of releases from six sources. Releases of I-129 from offsite waste occur rapidly, and the inventory of these constituents from this source is depleted within approximately 2,000 years. This release accounts for the curved early maximum portion of the graph. The latter plateau extending out for a longer period of time is due to gradual releases from other waste forms (e.g., ILAW glass).

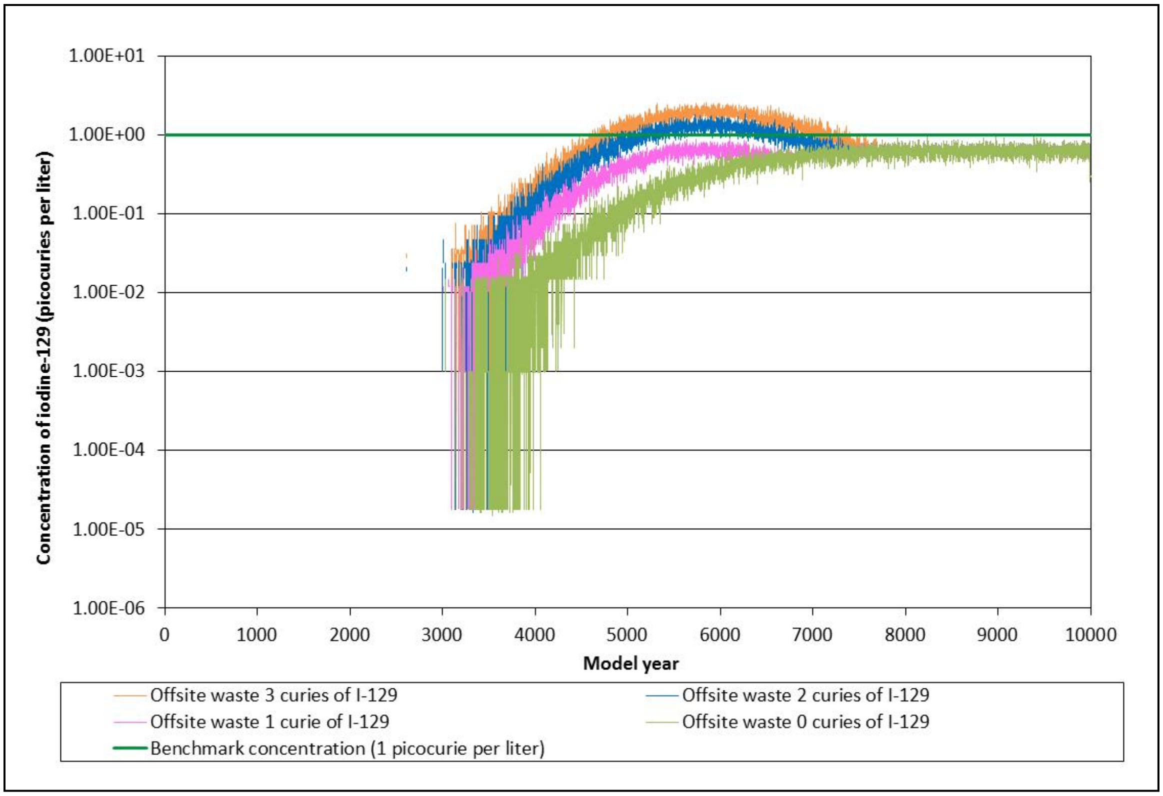

Fig. 2. Comparison of Tank Closure Alternative 2B, Groundwater I-129 Concentration at a Potential IDF-East Facility Fence Line, Offsite Waste Inventory Variants

The results indicate that there is a proportionality between initial inventory and the rate of release to the vadose zone. As the initial inventory was increased, the estimated I-129 groundwater concentrations increased. Though the magnitude of the peak was influenced by varying the initial inventory, the timing and duration of the peak groundwater concentrations were not impacted. The results of this example analysis suggest that the initial inventory is an important factor governing the groundwater concentration estimates, and therefore should be characterized to the best extent practicable before application to a groundwater fate and transport model.

Background infiltration

Increases or decreases in infiltration rates reflect changes in environmental and facility conditions, including removal or recovery of vegetation and placement and weathering of an engineered barrier. The forms of the time dependence of the infiltration rates used in the TC & WM EIS analysis (background conditions, placement of a barrier, and return to background conditions following degradation of the barrier) are provided in Table I. The infiltration rate for IDF-East is 2.85 E-11 meters per second for pre-Hanford or background conditions, 1.59E-11 meters per second for the lifetime of the barrier, and returning to 2.85E-11 meters per second after the 500 year lifetime of the barrier. The infiltration values were specified in the Technical Guidance Document for Tank Closure Environmental Impact Statement Vadose Zone and Groundwater Revised Analyses [3].

TABLE I. TC & WM EIS Infiltration Sequence for IDF-East

Sequence	Start Year of Infiltration	Infiltration Rate at the Source (meters per second)	Infiltration Rate Outside the Source (meters per second)
Background	1940	2.85E-11	1.11E-10
Operations	2050	1.59E-11	1.11E-10
Background	2550	2.85E-11	1.11E-10

The objective of this example analysis is to examine the effect of increasing the infiltration rate at IDF-East. Anticipated vadose zone effects include changes in the spatial distribution of moisture content and in the time series of the flux of water and solute at the water table. The local, transient effects on flow in the unconfined aquifer due to variation in the infiltration rate are expected to be negligible. The concentrations of solutes at the IDF-East reporting object were selected to characterize the effects of changes in the rates of infiltration. Infiltration rates in the design of this analysis cover a large arithmetic range (2.85E-11 to 1.59E-10 meters per second). This range was selected because the model is sensitive to the infiltration parameter and the uncertainty of the value is poorly characterized. Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, addresses disposal in IDF-East of the waste from Tank Closure Alternative 2B, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Waste forms for IDF-East include ILAW glass, LAW melters, tank closure secondary waste, FFTF decommissioning secondary waste, waste management secondary waste, offsite waste, and onsite non-CERCLA waste. For this combination of sources, resolution of the influence of variations in the background rates of infiltration on concentrations at an unconfined aquifer well requires consideration of the relative magnitudes of inventories from the differing sources, nuclide specific parameters, and waste-package dimensions. For example, Tc-99 inventories in onsite non-CERCLA, FFTF decommissioning, and waste management secondary wastes are small, and the release rates from ILAW glass and glass in retired melters are low. Thus, changes in the release rates and transport constituents in tank closure (WTP process and ETF-generated) secondary waste and offsite waste will determine the effects of changes in the infiltration rates. The initial inventory for the key radionuclide Tc-99 is summarized in Table II.

TABLE II. Nuclide-Specific Inventories for Waste Management Alternative 2, Disposal Group 1-A

Waste Form	Tc-99 Inventory (curies)
WTP secondary solid waste	492
ETF-generated secondary waste	86.3
Offsite waste	1460

An initial step in the analysis is a review of the rates of release to the vadose zone for the three primary radionuclides and sources. These results are presented in Figure 3 for Tc-99. These results indicate that releases from offsite waste account for a high early release, with longer-term, near-constant releases from tank closure, WTP process, and ETF-generated secondary waste. For offsite waste, the dependence of the Tc-99 release rate on infiltration profiles with background rates of 2.85E-11, 1.11E-10, and 1.59E-10 meters per second is depicted in Figure 4. Infiltration rates for the first 500 years of the period of analysis are the same for these three infiltration profiles. The peak release rates to the vadose zone at approximately year 500 increase in proportion to the background infiltration rate.

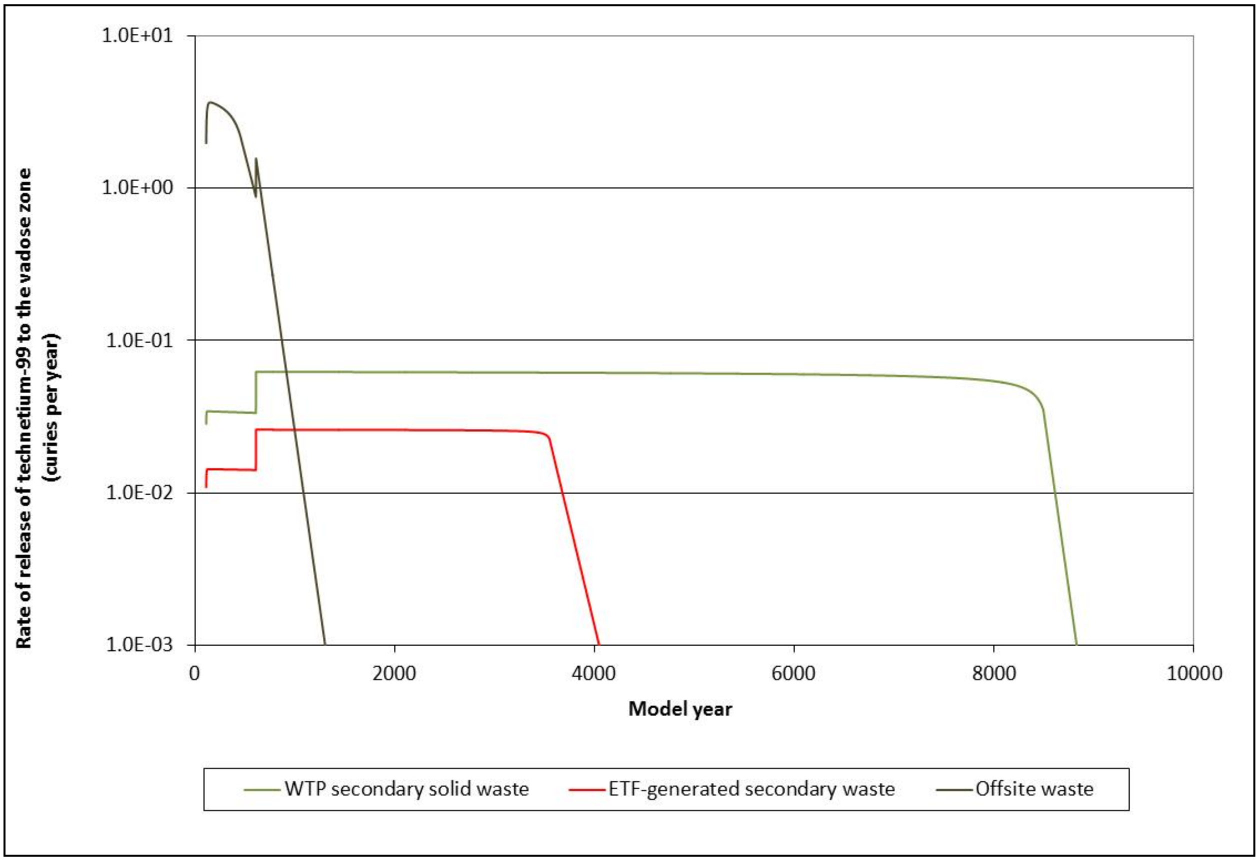

Fig. 3. Rate of Release of Tc-99 to the Vadose Zone at an Infiltration Rate of 2.85E-11 Meters per Second.

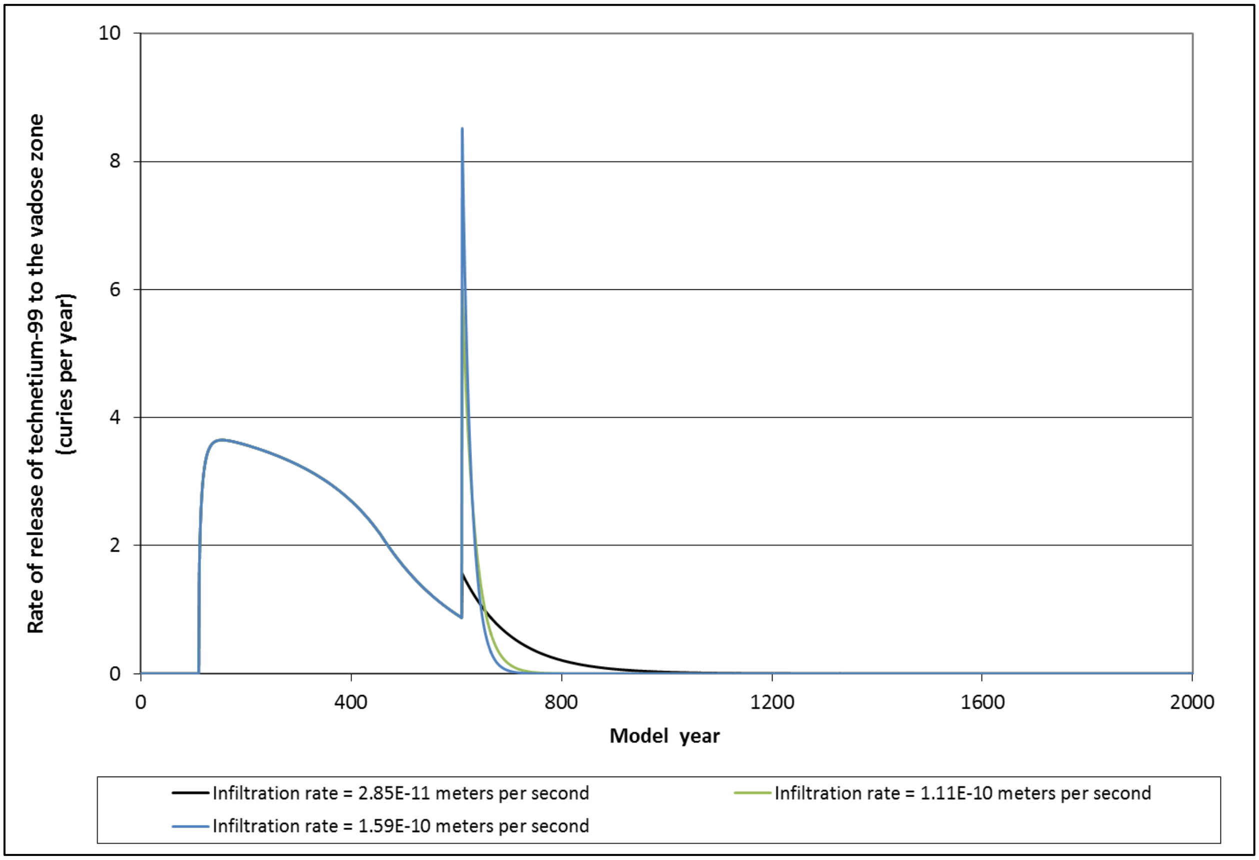

Fig. 4. Rate of Release of Tc-99 to the Vadose Zone from Offsite Waste at Infiltration Rates of 2.85E-11, 1.11E-10, and 1.59E-10 Meters per Second.

Concentrations of Tc-99 in groundwater at the IDF-East barrier are presented in Figure 5 for the six infiltration profiles described in Table III. The first dependence of an infiltration rate shown in these figures is the nonlinear dependence of travel time through the vadose zone on the rate of infiltration. The time of first arrival of Tc-99 at the water table decreases from approximately 3,000 years to approximately 1,000 years as the infiltration rate increases from 2.85E-11 to 1.59E-10 meters per second. The second dependence is the narrowing of the peak and the proportional increase in the peak level as the rate of infiltration increases. The narrowing of the peak is due to the inventory-limited nature of the release from offsite waste, as shown in the rapid decrease in the rate of release to the vadose zone in Figure 3. The final dependence is the proportional increase of the post-peak plateau level of concentration with the infiltration rate due to the releases from tank closure (WTP process and ETF-generated) secondary waste.

TABLE III. Nuclide-Specific Inventories for Waste Management Alternative 2, Disposal Group 1-A

Infiltration Rate Stages	EIS Case	3.96E-11	7.93E-11	1.11E-10	1.35E-10	1.59E-10
Pre-Hanford, background infiltration rate (meters per second)	2.85E-11	3.96E-11	7.93E-11	1.11E-10	1.35E-10	1.59E-10
Barrier (meters per second)	1.59E-11	1.59E-11	1.59E-11	1.59E-11	1.59E-11	1.59E-11
Post-barrier (meters per second)	2.85E-11	3.96E-11	7.93E-11	1.11E-10	1.35E-10	1.59E-10

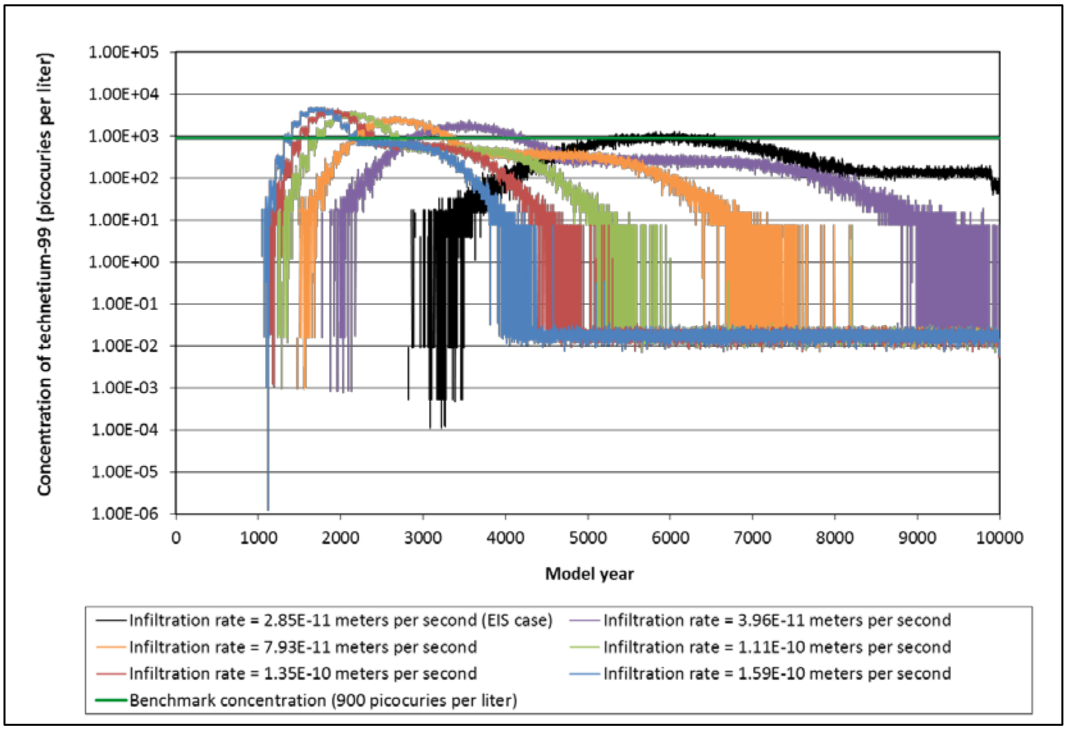

Fig. 5 . Comparison of Infiltration Variants, Waste Management Alternative 2, Tank Closure Alternative 2B, Groundwater Tc-99 Concentrations at a Potential IDF-East Facility Fence Line.

Waste Form Performance

During the development of the TC & WM EIS, numerous comments were received that expressed the concern that the disposal of secondary waste derived from treatment of tank waste would cause unacceptable adverse impacts on the groundwater. There are risks and uncertainties associated with the treatment and disposal of secondary waste produced by the WTP, as well as by the supplemental treatment technologies and, in particular, with the impacts this waste may have at an IDF. A particular interest by stakeholders and the public was the impact that mitigation would have on these potential adverse impacts. The following example analysis evaluates the potential impacts of improving the waste-form performance of grouted waste forms under Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, as analyzed in the TC & WM EIS. This analysis is intended to demonstrate that it may be beneficial for future studies to address the formulation of appropriate performance requirements for secondary- and supplemental-waste forms.

The assessment of the long-term performance of grout to be disposed of in IDF-East assumes the waste-form is saturated. The effective diffusion coefficient for I-129 used in the TC & WM EIS was 1.0E-10 square centimeters per second. [3] The distribution coefficient (Kd) value, which can be inferred from the effective diffusion coefficients for I-129 is 50 milliliters per gram and 1.1 milliliters per gram.

Documentation for Hanford indicates that the moisture content for the waste form may be below saturated conditions, ranging from 4 percent to 7 percent moisture content [9]. As the moisture content decreases, the aqueous diffusion coefficient decreases, leading to a smaller effective diffusion coefficient. *Diffusion and Leaching of Selected Radionuclides (Iodine-129, Technetium-99, and Uranium) Through Category 3 Waste Encasement Concrete and Soil Fill Material* [9] indicates that the grout effective diffusion coefficient for I-129 could range from 2.07E-14 square centimeters per second (approximately 4 percent soil moisture content) to 1.31E-12 square centimeters per second (7 percent soil moisture content). The objective of the example analysis below is to evaluate the effect of the suggested decrease in effective diffusion coefficient in I-129 on the grouted waste forms disposed of at IDF-East. The EIS sensitivity analysis for grout examined the 7 percent moisture content indicated in Mattigod et al. 2001 [9].

Waste Management Alternative 2, Disposal Group 1, Subgroup 1-A, addresses disposal in IDF-East of the waste from Tank Closure Alternative 2B, onsite non-CERCLA sources, FFTF decommissioning, waste management, and other DOE sites. Waste forms for IDF-East include ILAW glass, LAW melters, tank closure secondary waste, FFTF decommissioning secondary waste, waste management secondary waste, offsite waste, and onsite non-CERCLA waste. The grouted waste forms under this alternative are ETF-generated secondary waste and tank closure solid secondary waste. The waste packages are cylindrical, with radio of 0.25 and 0.83 meters (0.82 and 2.72 feet) for ETF-generated secondary waste and tank closure solid secondary waste, respectively. Figure 6 compares the releases of I-129 to the vadose zone for the grouted waste forms for both ETF-generated secondary waste and tank closure solid secondary waste. The releases to the vadose zone in curies per year decrease by approximately two orders of magnitude as the effective diffusivity decreases from the EIS case value to the example analysis case value. Figure 7 reports estimated groundwater concentrations at a potential IDF-East facility fence line resulting from each of the waste forms under this TC & WM EIS alternative. Groundwater concentrations predicted for the LAW melter, FFTF decommissioning secondary waste, waste management secondary waste, and onsite non-CERCLA waste are below 1.0E-08 picocuries per liter at a potential IDF-East facility fence line. As indicated in Figure 8, the example analysis case, projected concentrations of I-129 in the groundwater for the grouted waste forms (ETF-generated and tank closure solid secondary wastes) are decreased by approximately two orders of magnitude relative to the EIS case.

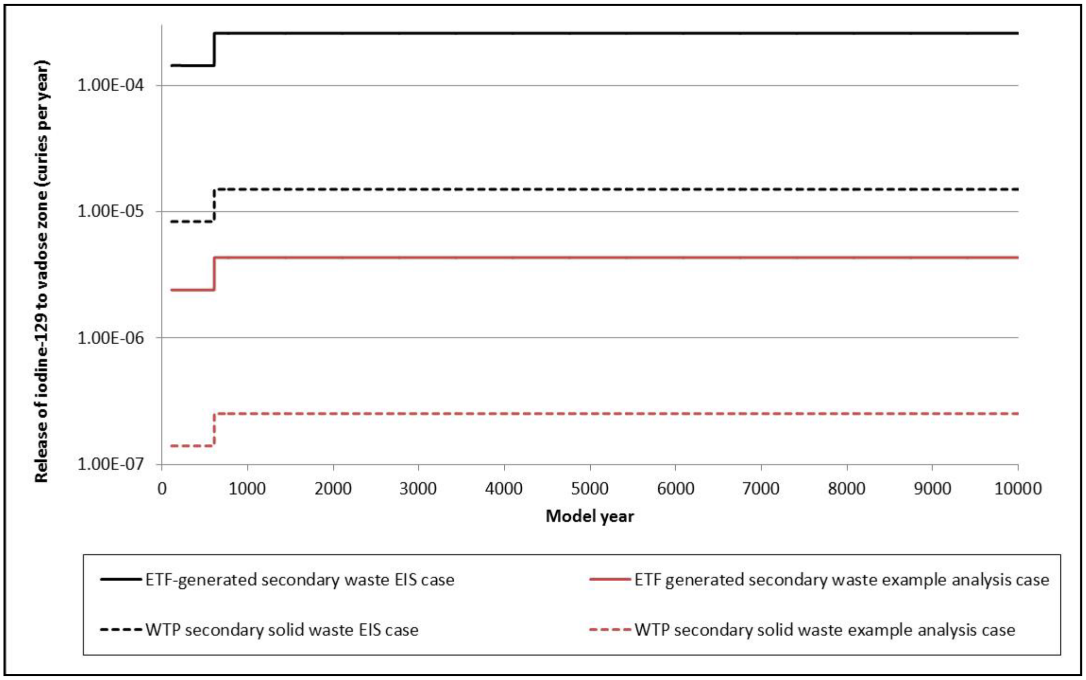

Fig. 6. Rate of I-129 Release to Vadose Zone, Grout Performance Analysis.

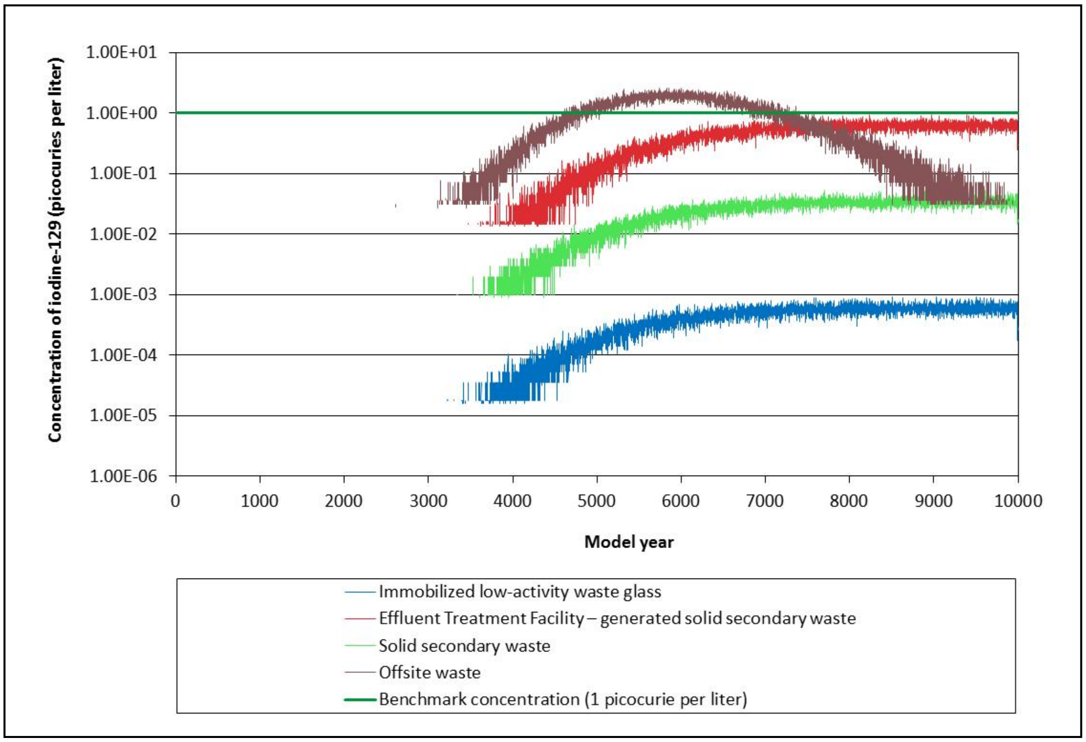

Fig. 7. Waste Management Alternative 2, Tank Closure Alternative 2B, Groundwater I-129 Concentrations at the IDF-East Barrier, EIS Case

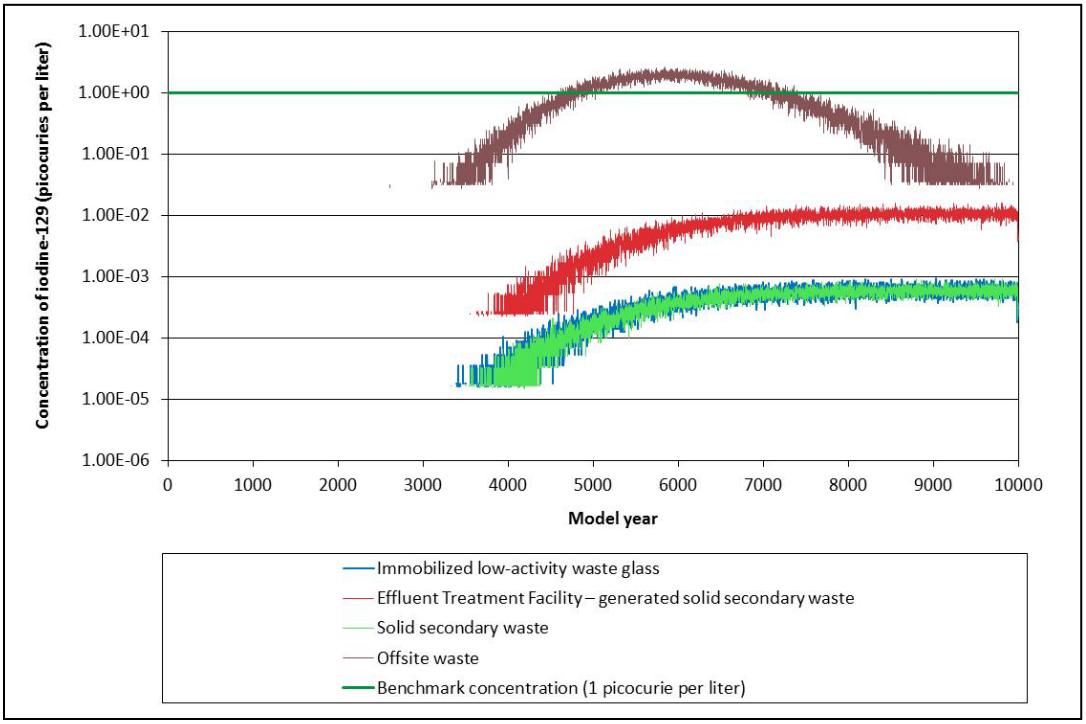

Fig. 8. Waste Management Alternative 2, Tank Closure Alternative 2B, Groundwater I-129 Concentrations at the IDF-East Barrier, Grout Example Analysis Case

CONCLUSION

As described above, the degree of the characterization of the parameters that were necessary for the TC & WM EIS groundwater simulations was variable and the uncertainties ranged from reasonably well known to poorly constrained. The strategy for evaluating the results of the example analyses was to determine if the variants had the potential to significantly affect the model outcome with the respect to the relationship of the outcome to a benchmark standard or affect the ordering (preference) of the alternatives analyzed in the TC & WM EIS. The results were evaluated in the context of how the outcomes were influenced when varying the parameter within a reasonable range of values.

In preparing the TC & WM EIS, it was found that for the IDF analysis the magnitude and direction of the groundwater flow and the total amount of key radionuclides in the underground storage system were relatively well known based on characterization data, and the analyses illustrated that these parameters had the potential to significantly influence the groundwater model results. Several other parameters were determined to have a significant influence on model outcomes however the uncertainty of the reasonable range of values were poorly constrained. The following data were found to be important, but were poorly constrained: infiltration rates, distributions of key raidonuclides among waste forms, the physical and chemical characterization of supplemental waste forms and their respective release characteristics, the packaging and placement of waste forms, and solute-soil interactions in the vadose zone. Variations in background infiltration rates at IDF were found to greatly influence the rate of release to the vadose zone and the vadose zone transport from all waste forms to be disposed of at IDF under the TC & WM EIS alternatives. The distributions of key radionuclides among waste forms as well as the physical and chemical characterization of supplemental waste forms and release characteristics were also poorly characterized but had significant influences on the magnitude of predicted peak groundwater concentrations. For example, for secondary waste, how dry the grout was and how long the grouted waste form would persist, significantly influenced the magnitude and timing of the predicted peak groundwater concentrations. It was also found that the placement of the waste forms at IDF was not important to predictions of regional-scale groundwater concentrations (at the Columbia River), however waste form placement was found to have the potential to influence predictions of near-field concentrations (at the facility fence line). Solute-soil interactions, such as the vadose zone distribution coefficient, were found to greatly influence the estimation of groundwater concentrations. As the vadose zone distribution coefficient increased, the peak estimate was lower and occurred later.

The analyses conducted for the TC & WM EIS also helped identify parameters/factors that are reasonably well understood for the Integrated Disposal Facility, but do not significantly influence the predictions of groundwater concentrations for the system as a whole. For example, it was found that release rates from the primary waste form, ILAW glass, were sufficiently low that uncertainties in the mechanisms and details of radionuclide release from the glass did not significantly influence the outcome of the system as a whole. Impacts from IDF are dominated by releases from secondary and supplemental wastes; varying the release rate from ILAW glass by two orders of magnitude around the best estimate affected the predicted near-field groundwater concentrations by less than one percent.

Based on the experience gained during the development of the TC & WM EIS, there is a potential prioritization strategy for potential future detailed IDF analyses that would be beneficial prior to the finalization and permitting of IDF. Characterization efforts for parameters that influence model outcomes but are poorly characterized, such as infiltration rates, physical and chemical waste form characteristics, waste form performance, and facility design, would help understand their potential local-scale impacts on predictions of groundwater concentrations and be a beneficial priority. Additionally, further characterization efforts for parameters that are well characterized or that do not significantly influence predicted groundwater concentrations should be limited.

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