Integrated Disposal Facility Performance Assessment: Modeling Consistency to Support Regulatory Decision Making at Hanford - 17398

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ABSTRACT

Under DOE Order 435.1, “Radioactive Waste Management” [1], Washington River Protection Solutions, LLC and INTERA, Inc are currently preparing a performance assessment for the Hanford Integrated Disposal Facility, a near-surface low-activity waste disposal facility located on the Hanford Site in southeast Washington State. The disposal facility is expected to receive vitrified low-activity waste produced at the Hanford Waste Treatment and Immobilization Plant, as well as other secondary solid wastes generated during the treatment process. The performance assessment performs the analyses that will be relied upon to receive the Disposal Authorization Statement, establish waste acceptance criteria, modify the RCRA permit for the facility[2] and make a waste-incidental-to-reprocessing determination for the vitrified tank waste.

In January 2006 in the case State of Washington v. Bodman (Civil No. 2:03-cv-05018-AAM), DOE, the Washington State Department of Ecology (Ecology) and the State of Washington Attorney General's office reached a settlement agreement in Ecology’s claim regarding off-site waste shipments to Hanford and the adequacy of modeling in the environmental impact statement. In response to the agreement, the DOE Office of Environmental Management set a policy to establish a consistent use of commercially available and public domain software for a vadose zone and groundwater model platform to support regulatory decisions at Hanford. In October 2012, the Associate Principal Deputy Assistant Secretary for Environmental Management released a memorandum [3] to the manager of the Richland Operation Office directing how future environmental modeling activities to support regulatory decision making on the Hanford Site would be undertaken to be consistent with the 2006 settlement agreement. The preparation of the performance assessment must meet DOE Order 435.1 requirements and the additional direction provided by DOE [4]. This paper will identify the approach taken to comply with the requirements in the 2012 memorandum. The paper will describe how environmental modeling performed for the 2017 Integrated Disposal Facility Performance Assessment was planned in a phased approach and how the current modeling is tied to the analyses that supported the decisions made in the environmental impact statement [5] published in 2012. Additionally, the selection

and qualification of the software selected to perform modeling activities for the performance assessment will be described.

INTRODUCTION

In January 1943, the Hanford Site in southeast Washington State was selected as the most favorable location to build production facilities make Pu-239 and U-235 in support of nuclear weapons production. Plutonium production reached a peak between 1956 and 1963. However, production operations resulted in a considerable accumulation of nuclear waste at the site, as well as contributing to contamination of the site. In 1989 the Hanford Federal Facility Agreement and Consent Order [6] that began the regulation of the site cleanup mission was signed by DOE, the Washington State Department of Ecology, and the EPA. Today that cleanup mission includes the vitrification of low-activity waste (LAW) at the Hanford Waste Treatment and Immobilization Plant (WTP) with subsequent disposal of both the vitrified LAW and the secondary solid waste (SSW) generated during treatment at the Integrated Disposal Facility (IDF). The IDF is a near-surface trench in the 200 East area of the Hanford Site that is expected to receive the primary and secondary waste products from treating LAW at the WTP as well as other radioactive wastes generated on-site.

In order to receive a Disposal Authorization Statement to begin operations to receive LAW and SSW at the IDF, a performance assessment (PA) must be developed and approved in accordance with DOE Order 435.1. In addition to developing the PA in accordance with the requirements of DOE Order 435.1, the PA models must also be developed consistently with other environmental models developed for the site. The other models include the Final Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington [5] (hereafter referred to as TC & WM EIS) as well as the PA developed in 2001 [7] that led to the authorization to construct the IDF. While other efforts have modeled the long-term performance of the IDF to contain the disposed waste, the most recent is the TC & WM EIS. Beginning in 2014, a new performance assessment for the IDF was initiated to support a waste-incidental-to-reprocessing determination for the vitrified LAW and provide the analysis necessary to modify the RCRA permit to include the secondary wastes generated during waste treatment operations, decommissioning wastes generated during site cleanup, and secondary wastes generated during other on-site activities.

In addition to the modeling requirements specified in DOE Order 435.1, the DOE Office of Environmental Management (DOE-EM) set a policy to establish a consistent use of commercially available and public domain software for a vadose zone and groundwater model platform to support regulatory decisions at Hanford. The purpose of the 2006 policy was to produce a site-wide modeling system which is transparent and useable by both DOE and non-DOE personnel for replication and quality assurance; and to provide regulators and stakeholders with high-quality, consistent vadose zone and groundwater analyses [3]. The modeling platform (i.e., waste release, vadose zone, and groundwater models) developed for the TC & WM EIS provided a single, integrated analysis of the vadose zone and groundwater at Hanford consistent with the 2006 policy. DOE guidance [3] provided to site contractors performing environmental modeling of the vadose and groundwater zones includes the following requirements:

1. A phased process shall be followed to plan, scope and carry out vadose zone and groundwater modeling analyses at Hanford.
2. Approval of changes from the TC & WM EIS modeling approach, software, and/or input parameters to accommodate site/facility-specific needs or new information will be developed and documented under an approved quality assurance plan and approved by an executive council from the DOE Richland Operations Office (DOE-RL) and DOE Office or River Protection (DOE-ORP).
3. A modeling case needs to be included that uses the same assumptions and methods used to make decisions in the TC & WM EIS.
4. Simulation software for modeling will meet DOE and DOE-EM software quality assurance requirements.

The 2017 IDF PA is being developed to satisfy these requirements as well as other requirements to satisfy the expectations and requirements to develop waste acceptance criteria, establish vitrified tank waste as low-activity waste, and receive all necessary approvals to begin disposal operations.

DISCUSSION

Modeling the long-term performance of the IDF to limit releases of contaminants of concern (COPCs) to the vadose zone with subsequent travel to the groundwater has been evaluated for almost 20 years. One of the first modeling activities for the facility was completed in 1998 as part of a broader modeling effort for site-wide disposal facilities at Hanford [8]. Modeling evaluations subsequent to this effort include two PAs and multiple risk assessments. These latter efforts preceded the 2006 policy for maintaining a consistent modeling approach for site-wide modeling. The policy was enacted because of data quality and control issues for the Hanford Solid Waste EIS. The only completed modeling activity that specifically modeled releases from the IDF since the 2006 policy was established is the TC & WM EIS. Although completed in 2012, development of the TC & WM EIS began after the 2006 settlement agreement and much of the modeling performed for the EIS was completed many years before publication.

In accordance with the first requirement in the DOE guidance, the IDF PA team followed a phased approach to plan, scope and carry out vadose zone and groundwater modeling analyses at Hanford. The phased approach identified modeling requirements during a planning phase; developed facility-specific requirements and identified new information and the degree to which the modeling platform used in the TC & WM EIS met modeling requirements during a scoping phase; and conducted the identified scope during the analysis phase.

Planning Phase

In April 2013, a technology transfer between DOE-RL and CH2M HILL Plateau Remediation Company (CHPRC) occurred to provide the technical approaches, models, and data that were used to develop the TC & WM EIS so that CHPRC could utilize that information to optimize the groundwater modeling system to meet the particular needs of future modeling studies. The technology transfer was prepared by Science Applications International Corporation (SAIC), the TC & WM EIS contractor. The technology transfer also included the transfer of the hardware and software used in the TC & WM EIS. CHPRC exercised the models with the provided resources to demonstrate that the TC & WM EIS could be successfully reproduced and then the modeling platform was placed under configuration control. Shortly after the technology transfer had occurred, CHPRC recognized that the saturated zone transport software used in the TC & WM EIS may not have the capability to handle transient flows when pump and treat systems are active on the plateau. Recognizing this limitation and with the understanding that the computer code developed at the Pacific Northwest National Laboratory STOMP (Subsurface Transport Over Multiple Phases) was approved for site-wide use (the fourth requirement in the DOE guidance) for transport modeling, CHPRC planned to use STOMP for saturated zone transport calculations.

In August 2014 CHPRC had developed a quality assurance project plan for how the update to the IDF PA would be performed. The project plan documented the linkage between DOE's quality assurance and quality control requirements to CHPRC procedures and aligned modeling activities with modeling requirements in DOE Order 435.1 and other regulatory uses of the PA.

To align with scope to develop the waste forms that would be disposed in the IDF, the scope for developing the IDF PA was transitioned to DOE-ORP at the beginning of fiscal year 2015. Washington River Protection Solutions, LLC (WRPS) developed procedures and prepared a project execution plan that described the processes in place to develop the PA. The plans and procedures leveraged content from CHPRC. WRPS contracted with CHPRC's primary modeling contractor, INTERA, Inc., to perform the modeling and analysis for the IDF PA. WRPS's plan was to develop one PA and use it for all regulatory purposes.

Scoping Phase

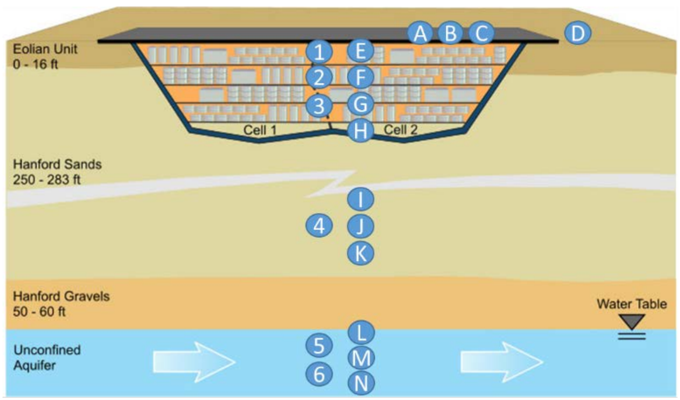
Beginning in November 2014, DOE-ORP and WRPS held a series of workshops with regulators and other stakeholders to share the modeling approach that would be used for the 2017 IDF PA. The regulators and stakeholders included technical staff and management from the DOE (local offices and headquarters), site contractors and their consultants, Washington State Department of Ecology, Oregon Department of Energy, NRC, members of affected tribal nations, and the Hanford Advisory Board. The workshops provided a forum where data developers and PA modelers could gather together with regulators and stakeholders to discuss data development activities and share the modeling approach.

The series of workshops covered the topics of exposure scenarios, natural system fate and transport models, radionuclide and chemical inventory, facility design, waste form performance characteristics and the proposed modeling approaches for source term release, natural system fate and transport, and calculating exposures. Meeting minutes were recorded so that comments on the approach could be documented. The modeling team updated the modeling approach and models to address workshop comments. In many cases new data or approaches were necessary and were developed. Sessions with subject matter experts and smaller sessions with the Washington State Department of Ecology were also held. In addition, weekly phone conversations between the data providers and modeling team were held to communicate the latest developments.

Two of the most significant comments received at the scoping sessions regarded the use of the TC & WM EIS data and models. Washington State Department of Ecology and DOE-ORP representatives commented on the long process that was necessary to reach an agreement on the data values that would be used in the TC & WM EIS. There was a concern that repeating the confidence building exercise for new data would be just as time consuming. There was also a concern that any other models, including the software used to run the models, for natural system fate and transport would be a deviation from the TC & WM EIS approach and would require additional confidence building to support their use. An approach was developed to alleviate these concerns. The approach was documented in a Summary Analysis [9] document (the second requirement in the DOE guidance) that was approved in December 2015.

To build confidence in the changes made to the TC & WM EIS modeling platform, a series of step changes that start with the TC & WM EIS and transition to updated data and models was planned. The approach was intended to address the third requirement in the DOE guidance; development of a TC & WM EIS modeling case is not necessary because the TC & WM EIS specifically modeled releases from the IDF and published the results. This process was proposed because it allows the modeling team to start with the TC & WM EIS and evaluate the individual and cumulative effects of any proposed changes to conceptual models and input parameters.

Figure 1 provides a visual representation of the key differences between the TC & WM EIS model and the proposed approach for the 2017 IDF PA. **Figure 2** shows a matrix of runs that can be used to show the significance of making these changes, beginning with the models represented in the TC & WM EIS (i.e., Case 00) and propagating recommended changes one at a time until the final IDF PA model is attained.



1: Change software for the cementitious waste form diffusive release model
2: Develop advective-diffusive release model for cementitious waste forms
3: Change software for the ILAW glass reactive transport release model
4: Change STOMP software version for 3-D vadose zone transport
5: Update saturated zone MODFLOW flow field
6: Change software and conceptual model for saturated zone transport

A: Include additional exposure scenarios – Inadvertent intruder and air pathway
B: Facility description – no changes
C: Surface cap design – no changes
D: Update long-term recharge rate
E: Update inventory from different sources
F: Update waste form performance parameters for SSW waste forms
G: Update ILAW glass dissolution rate parameters and reaction network
H: Treat all disposal cells under a single RCRA permit for MLLW
I: Update site-specific hydrostratigraphy
J: Use recommended moisture retention curves and moisture-dependent antisotropy
K: Update site-specific and recommended transport parameters (geochemical properties, hydraulic conductivities)
L: Reduce computational grid size
M: Change saturated zone hydraulic conductivity and hydraulic gradient to match Central Plateau Groundwater model
N: Change well-screen length of groundwater well and point of compliance

Figure 1. Comparison of Proposed Changes to Modeling Tools (numbers) and Key Elements (letters) Between TC & WM EIS and 2017 IDF PA

2017 IDF PA Traceability to the TC & WM EIS		Model Development Cases													
	EIS Case	Source Term Development					Vadose Zone Development				Saturated Zone Development				IDF PA Case
	Case 00	Case 01	Case 02	Case 03	Case 04	Case 05	Case 06	Case 07	Case 08	Case 09	Case 10	Case 11	Case 12	Case 13	Case 14
Source Term															
Recharge		EIS	EIS	EIS	EIS	IDF									IDF
Inventory		EIS	EIS	EIS	IDF	IDF									IDF
ILAW[1] Glass Release Model		EIS	EIS	EIS	EIS	EIS									EIS
ILAW Glass Release Model Software		IDF	IDF	IDF	IDF	IDF									IDF
ILAW Glass Release Model Parameters		EIS	IDF	IDF	IDF	IDF									IDF
SSW[2] Release Model		EIS	EIS	IDF	IDF	IDF									IDF
SSW Release Model Software		IDF	IDF	IDF	IDF	IDF									IDF
SSW Release Model Parameters		EIS	IDF	IDF	IDF	IDF									IDF
Flux to Vadose Zone/ Fractional Release Rate	***EIS***	**00 <-> 01**	**01 <-> 02**	**02 <-> 03**	**03 <-> 04**	**04 <-> 05**	EIS	EIS	EIS	EIS	EIS	EIS	EIS	EIS	***00 <-> 14***
Vadose Zone															
Transport Code		IDF	IDF	IDF	IDF	IDF	IDF	IDF	IDF	IDF	IDF	IDF	IDF	IDF	IDF
Hydrostratigraphy Model		EIS	EIS	EIS	EIS	EIS	EIS	EIS	IDF	IDF	EIS	EIS	EIS	EIS	IDF
Soil Properties		EIS	EIS	EIS	EIS	EIS	EIS	IDF	IDF	IDF	EIS	EIS	EIS	EIS	IDF
Transport Parameters (if warranted)		EIS	EIS	EIS	EIS	EIS	EIS	EIS	EIS	IDF	EIS	EIS	EIS	EIS	IDF
Flux to Groundwater	***EIS***	**00 <-> 01**	**01 <-> 02**	**02 <-> 03**	**03 <-> 04**	**04 <-> 05**	***00 <-> 06***	***06 <-> 07***	***07 <-> 08***	***08 <-> 09***	***06 <-> 10***	***06 <-> 11***	***06 <-> 12***	***06 <-> 13***	***00 <-> 14***
Saturated Zone															
Transport Code (and model)											IDF	IDF	IDF	IDF	IDF
Well Screen Length											EIS	IDF	IDF	IDF	IDF
Transport Parameters (if warranted)											EIS	EIS	IDF	IDF	IDF
Flow Field											EIS	EIS	EIS	IDF	IDF
Groundwater Concentration @ Fenceline	***EIS***										***00 <-> 10***	***10 <-> 11***	***11 <-> 12***	***12 <-> 13***	***00 <-> 14***

[1] Immobilized Low-Activity Waste

[2] Secondary Solid Waste (includes cementitious waste forms: ETF-generated SSW, WTP-generated SSW, Fast Flux Test Facility SSW, On-Site Non-CERCLA SSW)

Figure 2. Model Approach to Establish Traceability Back to the EIS

Analysis Phase

A series of step changes **(Figure 2)** to the TC & WM EIS modeling platform was proposed to compare the effect of making key updates the modeling platform.

Case 00 is the TC & WM EIS model that is under configuration control. Rather than re-run a particular TC & WM EIS case, comparisons can be made directly to published figures in the TC & WM EIS.

The effects of changing model tools or updating key model elements and input parameters can be evaluated for the source term by evaluating the releases from the facility to the vadose zone, or by coupling the TC & WM EIS vadose zone model and comparing releases to from the vadose zone to the saturated zone.

Case 01 uses updated software sets to model the source term releases. The conceptual models and input parameters to the models are unchanged from those evaluated in the TC & WM EIS. For ILAW glass, the reactive transport model uses STOMP instead of Subsurface Transport Over Reactive Multiphases (STORM), which is no longer supported. The fractional dissolution rate is compared directly to the value adopted by the TC & WM EIS. Similarly, for SSW in a cementitious waste form, the mathematical model for the diffusion-limited release used in the TC & WM EIS is implemented in GoldSim rather than the code developed by SAIC to perform the calculation. The benefits of both of these changes are that the software has been qualified under a quality assurance program that meets WRPS’s contractual obligations and no additional qualification testing of the software was needed to satisfy the fourth requirement in the DOE guidance. Additional testing of the codes used for the TC & WM EIS was required to satisfy this requirement.

Case 02 builds on Case 01 and uses updated waste form performance parameters. All other parameters that are not directly related to the waste form (e.g., recharge and inventory) are unchanged from TC & WM EIS input values. For ILAW glass the transition state theory dissolution rate parameters and reaction network for the glass types that are expected to be produced are used and the resulting fractional dissolution rates can be compared to the range of values evaluated in the TC & WM EIS. For cementitious waste forms, the key parameters that can be updated with new information in the diffusion-limited release model are the diffusion coefficients, partition coefficients, geometry, tortuosity, density, and porosity.

Case 03 is a supplement to Case 02 and uses the same waste form performance characteristics in Case 02 but the waste form is modeled in three dimensions in STOMP and allows for both advective and diffusive releases if properties support both transport mechanisms.

Case 04 updates case 02 and Case 03 with the latest inventory estimates. Inventory estimates were updated for the IDF PA in 2016.

Case 05 builds on Case 04 and uses update estimates for recharge rates.

The vadose zone confidence building cases use source term releases calculated in the TC & WM EIS and models the transport of those releases to the saturated zone. TC & WM EIS source term release files are obtained from configuration control. In a series of steps, updates or changes to key elements of the vadose zone fate and transport model are evaluated.

Case 06 evaluates any changes caused by updates made to the STOMP software between the TC & WM EIS and the latest version approved for use by WRPS.

Case 07 updates soil properties that are applied to the TC & WM EIS stratigraphy model. Changes to properties like bulk density and porosity are considered, but the most significant change is expected to be due to updates in the moisture content.

Case 08 builds on Case 07 and updates the hydrostratigraphy model based on alternative interpretations of the bore hole logs. No new bore hole information was produced so this comparison represents a comparison of different interpretations of the bore hole logs by different geologists.

Case 09 updates Case 08 with new geochemical parameters Case 09 was not exercised because there was no new data to evaluate.

The saturated zone confidence building cases use source term and vadose zone releases calculated in the TC & WM EIS. In a series of steps, updates or changes to key elements of the saturated zone fate and transport model are evaluated.

Case 10 builds on Case 06 and Case 00 by including the saturated zone representation in STOMP coupled to the TC & WM EIS flow field beneath the IDF. The TC & WM EIS flow field developed in MODFLOW is used to set initial and boundary conditions for the STOMP flow and transport simulation. Comparisons between TC & WM EIS specific discharges and hydraulic gradients are specific points in the model domain are made. In addition, transport comparisons can be made by comparing groundwater concentrations at a common point of calculation.

In Case 11, the well screen length is adjusted to values that were used in other PAs on the Hanford site. The well screen length affects the amount of uncontaminated water that is able to dilute the plume intercepted by the groundwater well. For the IDF PA, the well screen is shorter and placed at the top of the water table, where most of the contamination resides. In addition, the STOMP grid size for the saturated zone has similar dimensions to the vadose zone model (horizontal area of a 20m x 20m cell), In the TC & WM EIS model calculation point intercepted by the well was 100m x 100m. Depending on spreading at the water table, the wider capture area used in the TC & WM EIS model could also introduce dilution that is greater than observed for a smaller grid cell size.

In Case 12, the hydraulic conductivity and porosity of the saturated zone gravels are updated.

In Case 13 the MODFLOW flow field developed for the Central Plateau Groundwater model replaces the MODFLOW flow field used in the TC & WM EIS. The most significant change of this is that the flow field was calibrated to plumes away from the IDF. The central plateau flow field are calibrated to water levels and observed gradients closer to the location of the IDF. In addition, the hydraulic conductivity of the gravels used for Case 12 would be applied.

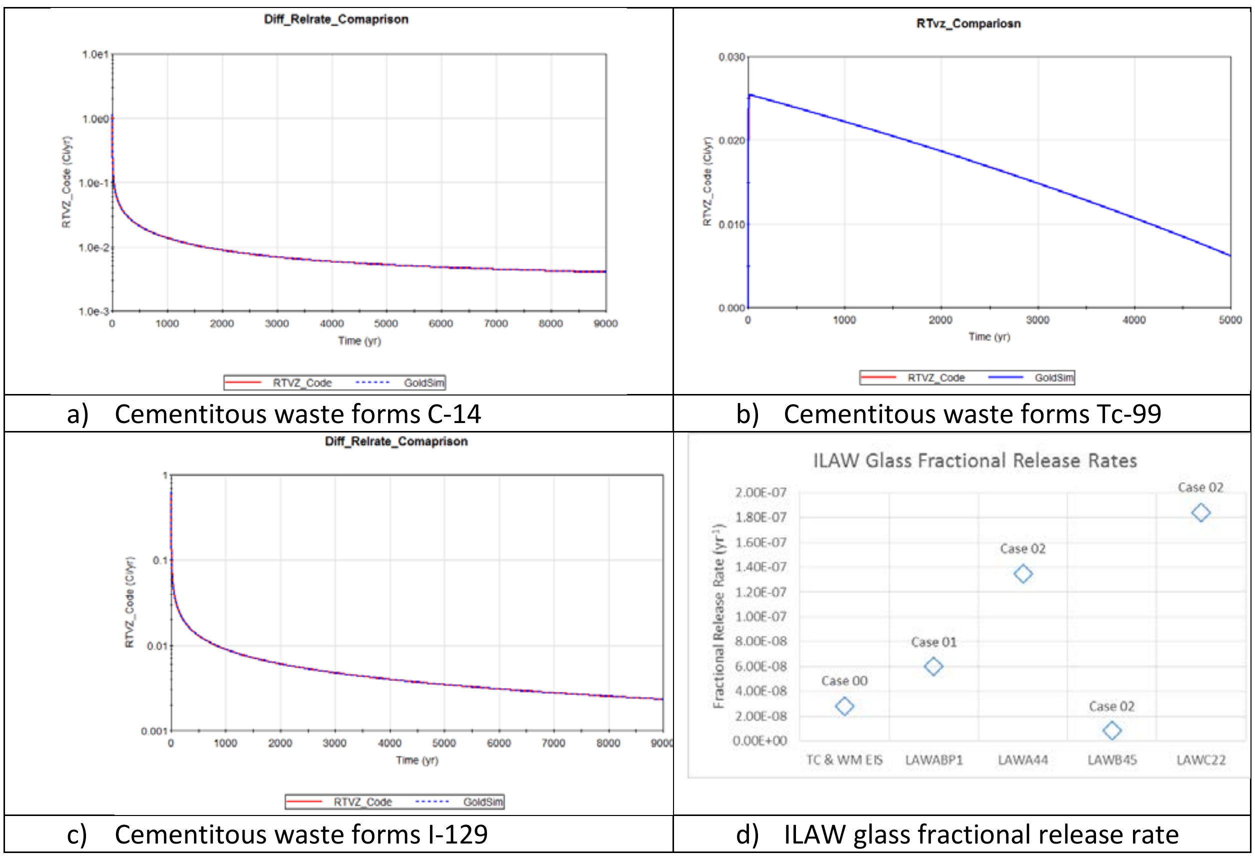
Case 14 would essentially represent a deterministic PA case using the recommended parameters and conceptual models for the 2017 IDF PA. It propagates all of the recommended changes from Case 01 to Case 13 simultaneously to evaluate the overall impact of all of the changes, including any synergistic effects when changes are coupled. This case is has yet to be run.

The cases identified above do not represent the suite of cases that will be performed for the 2017 IDF PA analysis phase. There are several cases that explore the sensitivity to changes in different parameters and conceptual models. This would be variations on Case 14 rather than the intermediate cases that help to identify the impact of the transition from the TC & WM EIS analyses to the 2017 IDF PA model. In addition, these supplemental cases will be used to develop the integrated system model that will be implemented in GoldSim to perform additional sensitivity and uncertainty analyses using the probabilistic capabilities of the GoldSim software.

RESULTS

The results of the EIS traceability cases identified in **Figure 2** are presented. Not all cases have been run and executed as planned. Several supplemental runs have been investigated to look at effects of individual parameters changes when a particular case may have included multiple parameter changes.

Case 01 evaluates the changes to the TC & WM EIS modeling tools using the same conceptual models and parameters. The desired result is that the changes to the software should not alter the release and transport of the inventory from the facility to the groundwater point of calculation. **Figure 3** shows the source term comparisons for Case 01. The comparison helps boost confidence that the change to the modeling tools for modeling waste form performance are not a direct result of the software change itself. An exact match of the fractional dissolution rate for ILAW glass could not be attained because the reactive transport model used to generate the value used in the TC & WM EIS was performed in 2003 and the input file was not available to set up an identical case.



a) Cementitous waste forms C-14

b) Cementitous waste forms Tc-99

c) Cementitous waste forms I-129

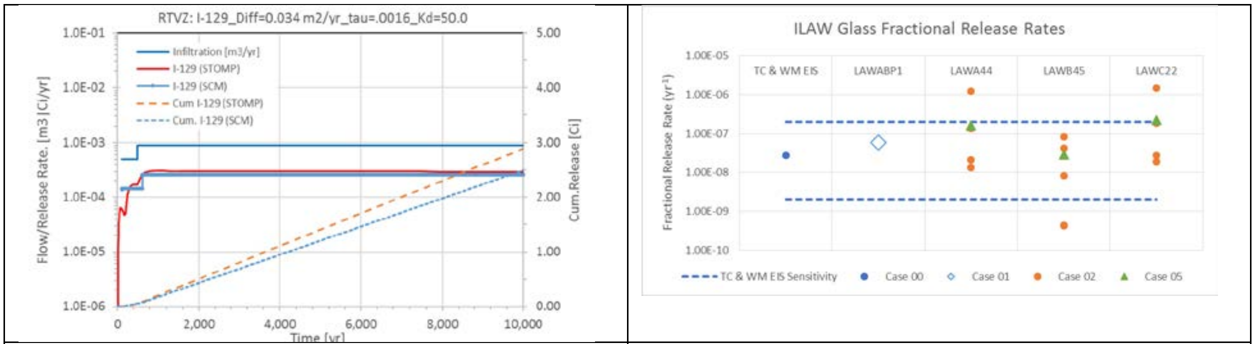
d) ILAW glass fractional release rate

Figure 3. Source Term Release Comparisons with Alternative Software
a) C-14 from cementitious waste forms, b) Tc-99 from cementitious waste forms, c) I-129 from cementitious waste forms, d) long-term congruent fractional release rates from ILAW glass waste forms

Case 02 through Case 05 evaluate the changes in release rates when waste form models are updated. **Table 1** shows the cumulative fraction released from the cementitious waste forms at 1,000 and 10,000 years. Inventory changes (Case 04) do not show up when fractional rates that have been normalized by the initial inventory are computed. The most significant change is the due to the reduction in Kd for I-129 in the waste form from 50 ml/g to 4 ml/g. This change coupled with changes that increase the performance of the waste form still result in a greater anticipated release in the 2017 IDF PA over the TC & WM EIS. **Figure 4** shows the difference when a STOMP run configured with TC & WM EIS parameters is developed and compared to the TC & WM EIS solutions for I-129 release from the cementitious waste forms (i.e. Case 03). Switching from the TC & WM EIS conceptual model to the advection-diffusion model with similar parameters increased the release rate by 20% over 10,000 years. **Figure 4** also shows the difference when the ILAW glass fractional dissolution rate is computed using updated parameter values. The results indicate that the ILAW glass performance is generally expected to be within the sensitivity range considered in the TC & WM EIS. Factional dissolution rates that exceed the range considered in the TC & WM EIS are a result of changing an input parameter over a broad range to evaluate parameter value sensitivity when uncertainty in the parameter was not specified in the source data package. The results suggest that the ILAW glass is 5-10 times less robust then modeled in the TC & WM EIS.

Table 1: Comparison of Release Rates from Cementitous Waste Forms: Model Parameter Updates, I-129.

Run	Parameter Change	I-129 Cumulative Fraction Released	
		@ 1,000 years	@ 10,000 years
Case 00	TC & WM EIS	0.0072	0.076
Case 02	Deff, porosity, density	0.0089	0.093
Case 02	Waste form Kd	0.084	0.88
Case 02	Waste form Kd, no waste form degradation	0.083	0.71
Case 02	Waste form geometry (area/volume ratio)	0.0048	0.0525
Case 04	Inventory	No change to fractional release rates	
Case 05' (still applies diffusion-limited conceptual model)	All changes above, plus increase long-term recharge	0.11	0.57

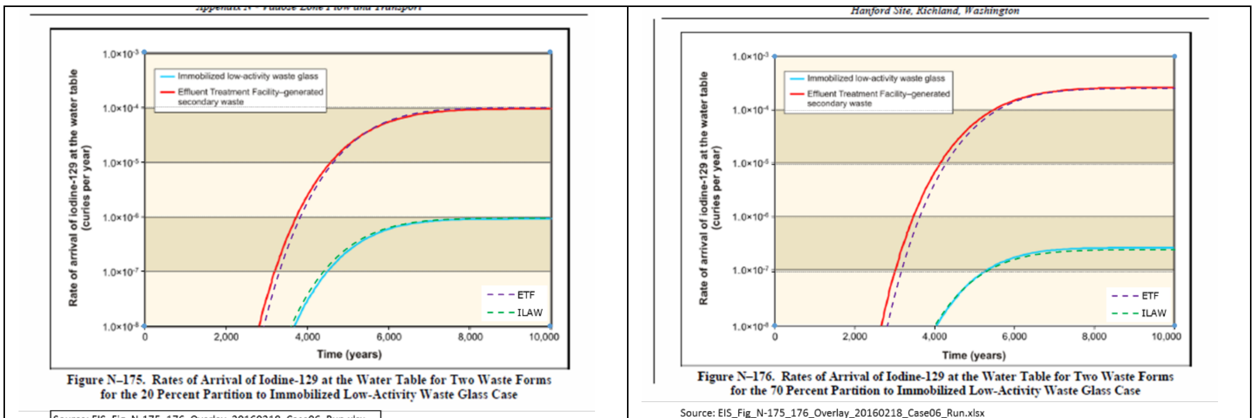


a) **Cementitious Waste Forms**

b) **ILAW Glass Waste Forms**

Figure 4. Source term release comparison for: (a) I-129 from cementitous waste forms using an advection-diffusion model in STOMP and (b) ILAW glass reactive transport modeling using STOMP

The vadose zone transport comparison cases use a version of STOMP that has been qualified for use under the contractual obligations required by CHPRC and WRPS. Case 06 compares the results when an source release from the TC & WM EIS is fed into the vadose zone model from the TC & WM EIS but implemented in an updated version of the STOMP software. **Figure 5** overlays the calculated output directly over an image of a TC & WM EIS result. The good agreement boosts the confidence that the change to the modeling tools for modeling vadose zone flow and transport is not a direct result of the software change itself.



Solid lines are TC & WM EIS results, dashed lines are results calculated using the updated versions of STOMP

Solid lines are TC & WM EIS results, dashed lines are results calculated using the updated versions of STOMP

a) I-129 transport for a TC & WM EIS inventory case;

b) I-129 transport for alternative TC & WM EIS inventory case

Figure 5. Comparison of STOMP software versions on TC & WM EIS source term releases that are transported through the vadose zone.

Case 07 and Case 08 vary properties of the vadose zone soils and transport properties. An evaluation was performed using a TC & WM EIS source term release of I-129 from cementitious waste forms. **Figure 6** shows the variations that can be anticipated when individual changes for the soil properties are varied one at a time. The changes include a factor of four reduction in the transperse and longitudinal dispersivity (**Figure 6a**), a conceptual change for a moisture dependent anisotropy (**Figure 6b**), the inclusion of a hypothetical silt layer at two different heights in the vadose zone (**Figure 6c**) and increases in the long-term recharge rates (**Figure 6d**). The application of the tensorial connectivity-tortuosity model was the recommended model and was developed and tested at a near-by site.

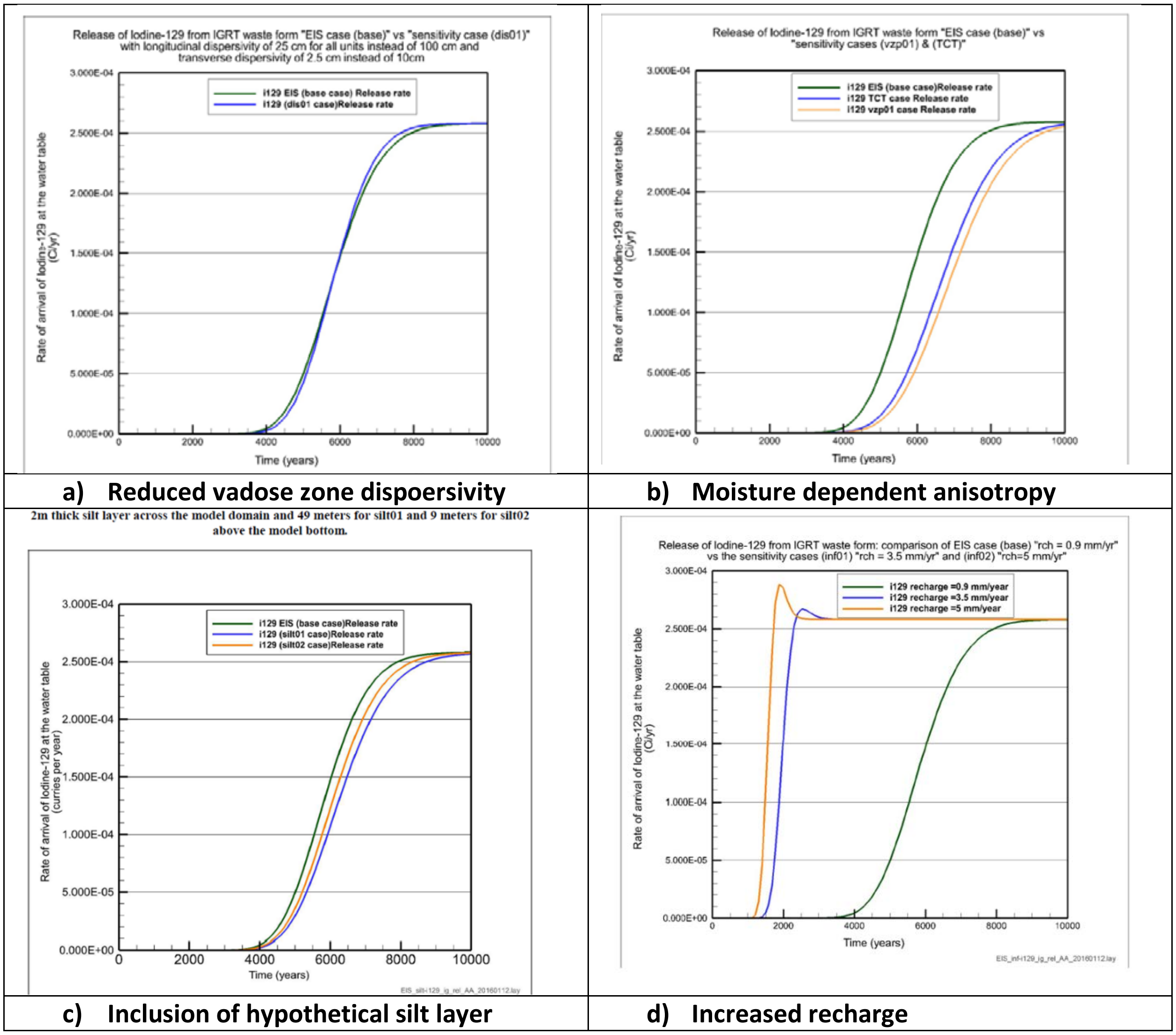


Figure 6. Comparison of TC & WM EIS releases (solid green line) from the vadose zone for different transport properties assumption's: I-129 release from cementitious source term

Case 09 is a combined run that is planned to evaluate the impact of combined changes. The run is in progress and not available at this time.

Some of the biggest differences between the TC & WM EIS and the 2017 IDF PA modeling platform involve saturated zone flow and transport. First, the saturated zone transport code used in the TC & WM EIS was a particle tracking that is replaced with STOMP. Second, the site-wide MODFLOW flow field used in the TC & WM EIS is updated using the MODFLOW flow field developed for the central plateau.

Case 10 evaluates the impact of changing saturated zone transport software from the TC & WM EIS particle tracker to STOMP. The STOMP model boundary conditions were specified to yield a result consistent with the TC & WM EIS MODFLOW flow field. The transport of I-129 from a TC & WM EIS vadose zone release history is compared in **Figure 7**. The STOMP output is overlaid on an image of a published figure from the TC & WM EIS. The agreement demonstrates that the STOMP software, when conditioned with the TC & WM EIS flow field, is able to reproduce the TC & WM EIS transport result. This STOMP saturated zone model can be coupled directly to the vadose zone model without any intermediate processing to transfer the data from one model to another.

Figure 8 uses the output of the saturated zone transport model to consider what different assumptions about the well screen length, saturated zone porosity, and grid size have on the calculated groundwater concentrations. These assumptions have a direct effect on the concentrations intercepted by the groundwater well.

Figure 9 compares the flow direction and specific discharge near the IDF when STOMP is used to compare the TC & WM EIS flow field against the Central Plateau Groundwater model. The results suggest that although the flow direction is different, the specific discharge in both cases is very similar, between 0.1 and 0.9 m/day around the IDF.

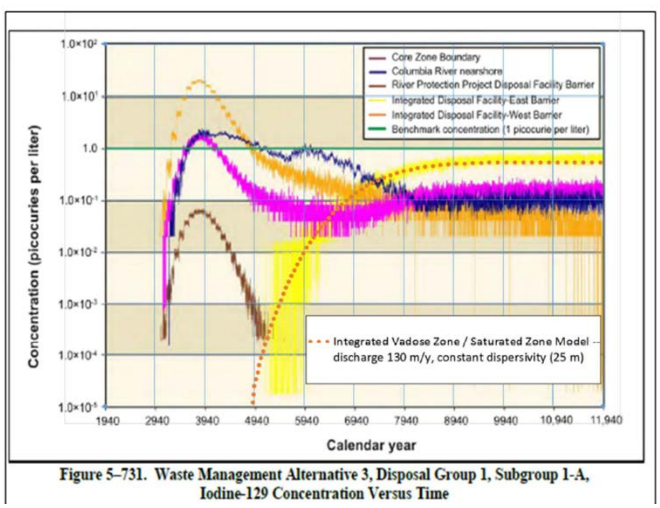


Figure 7. Comparison of Vadose Zone Releases (solid green line): I-129 Release from Cementitious Source Term

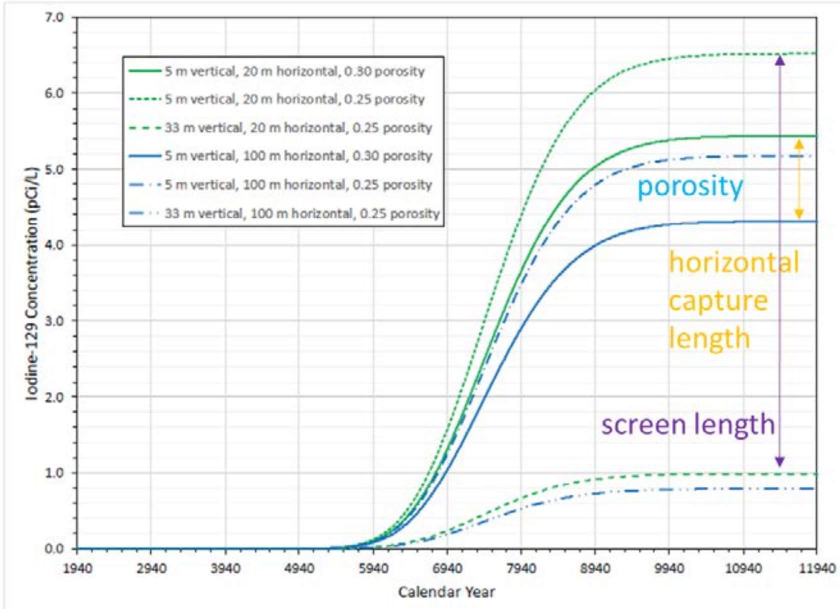


Figure 8. Comparison of Groundwater Well Concentrations: I-129 release from cementitious source term

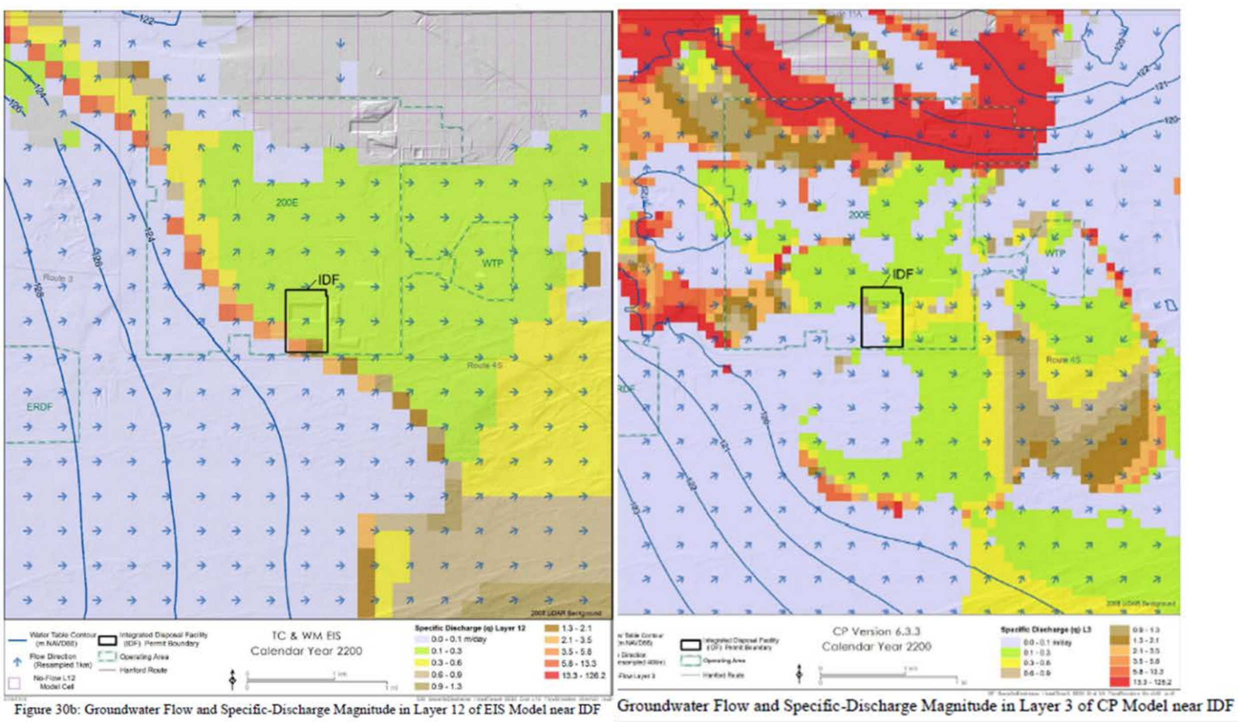


Figure 9. Comparison of Specific Discharge Between the TC & WM EIS Flow Field (left) and the Central Plateau Groundwater Model Flow Field (right)

CONCLUSIONS

The IDF PA modeling team, led by WRPS and principally composed by modelers from INTERA, Inc. have develop a systematic approach to update the TC & WM EIS modeling platform when developing the 2017 IDF PA model. The updated modeling effort attempts to honor the guidance provided by DOE to address the 2006 settlement agreement. Ultimately however, the DOE must satisfy its own regulating body with defensible conceptual models and defensible data. Matching the TC & WM EIS is not a requirement to receive authorization to operate the facility but understanding the differences is necessary to move forward with permit modifications and help the Washington State Department of Ecology meet State Environmental Policy Act obligations. Drawing upon decades of PA modeling experience, the modeling team has proposed some changes to the approach taken in the TC & WM EIS. The modeling changes have both a negative and positive impact on groundwater concentrations at the point of calculations. The net difference impact will be addressed in the PA. However, the supplemental runs provided in this report are intended to build confidence that the 2017 IDF PA is not likely to change the disposal decisions made for the IDF in the TC & WM EIS.

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