FINAL REV 0
March 25, 2005

TECHNICAL GUIDANCE DOCUMENT FOR TANK CLOSURE ENVIRONMENTAL IMPACT STATEMENT VADOSE ZONE AND GROUNDWATER REVISED ANALYSES

March 25, 2005
Revision 0

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* Nothing is this agreement precludes Ecology from commenting on the EIS or limits Ecology's regulatory authority. Information discussed in this document will be shared with Ecology through our existing Cooperating Agency Memorandum of Understanding.

TECHNICAL GUIDANCE DOCUMENT
FOR
TANK CLOSURE ENVIRONMENTAL IMPACT STATEMENT
VADOSE ZONE AND GROUNDWATER ANALYSES

1.0 Introduction

This Technical Guidance Document (TGD) provides guidance for technical assumptions, model input parameters, and methodologies for proceeding with the Tank Closure Environmental Impact Statement (TCEIS) vadose zone and groundwater analyses. This guidance results from extensive technical discussion within DOE and with the State of Washington as a cooperating agency, directed toward identifying appropriate methods for assessing the environmental impacts of the alternatives, including cumulative effects, addressed in the TCEIS. The TGD provides the rationale for key model input parameters for the TCEIS; and written guidance to Science Applications International Corporation, (SAIC), the TCEIS contractor, on how to proceed with vadose zone and groundwater risk analyses. The technical basis supporting many of the assumptions are a result of various multi-year field and science-based activities consistent with the Hanford Federal Facilities Agreement and Consent Order (also known as the Tri-Party Agreement), Tank Waste Remediation System EIS Record of Decision, and National Academy of Sciences review of the Tank Waste Remediation System Draft EIS (*The Hanford Tanks: Environmental Impacts and Policy Choices; Committee on Remediation of Buried and Tank Wastes, National Research Council,* 1996).

The Washington Department of Ecology is signing the document as a cooperating agency to support their State Environmental Policy Act requirements. Signing does not preclude Ecology from commenting on the EIS.

2.0 Purpose and Scope

The purpose of this TGD is to insure the professional and scientific integrity of discussions and analyses in the TCEIS (40 CFR 1502.24). Under NEPA procedures agencies must ensure that environmental information is available to public officials and citizens before decisions are made and before actions are taken. The information must be of high quality. Accurate scientific analysis, expert agency comments, and public scrutiny are essential to implementing NEPA. Most important, NEPA documents must concentrate on the issues that are truly significant to the action in question, rather than amassing needless detail (40 CFR 1500.1(b)). Accordingly, the TGD focuses on key parameters which have shown to be important in groundwater analysis:

- Barrier performance specifications for facility closure;
- Waste form release coefficients;

- Vadose zone and groundwater material mobility (Kds) to be used in analysis;

- Inventory quantities and inventory assumptions.

The analysis derived from these parameters will be used in preparation of impact calculations for the TCEIS. This TGD supplements guidance found in *Assessment Guidance Data Package* (DOE/ORP-2003-09), and other pertinent data packages prepared for the TCEIS. Consistent with this guidance, the TCEIS will be developed in accordance with *Council on Environmental Quality* regulations (40 CFR 1500-1508) and DOE NEPA Implementing Procedures (10 CFR 1021).

3.0 Methods

The methods will address modeling of inventory, release forms, vadose zone, and groundwater. Groundwater modeling, which estimates the migration potential and future concentrations of contaminants from sources through the aquifer, is the key to assessing the consequences of contaminant releases to the aquifer in terms of impacts to the resource affecting human health and the environment. The TCEIS vadose zone and groundwater modeling results will discuss the following:

- Adequate representation of the temporal and physical scale and intensity of the impact to the groundwater resource that can be compared to maximum contaminant levels and risk-based standards.
- Adequate precision, sensitivity, and reproducibility of results to enable decision makers and the public to differentiate impacts to the resource among the alternatives analyzed, and from major subordinate actions within the alternatives including the effect of waste form performance, barrier performance, and soil remediation.
- Adequate traceability of contaminant sources to impacts in the analysis to facilitate mitigation decisions for specific contaminant sources and actions as described in *TCEIS Vadose Zone and Groundwater Modeling Performance Specifications* (Attachment 1).

4.0 Assumptions

4.1 Inventory

The source inventory to be used in development of the TCEIS is provided in the *Inventory Data Package* (DOE/ORP-2003-02), and subsequently issued Mass Balances, which use the Best Basis Inventory as the source for tank radiological and chemical inventories.

The draft TCEIS will contain a discussion of Best Basis Inventory (BBI) changes prior to the production cycle required to produce the draft. This discussion will include an evaluation of the impact sensitivities to different inventory estimates. The use of scaling as a method to estimate impacts from different levels of inventory may be appropriate for individual sources considered in isolation, but scaling of inventory changes that start with Best Basis Inventory changes cannot be performed if this involves potential non-linear distribution of constituents through the mass balances. In addition, the TCEIS vadose zone and groundwater analyses will be based on a de-aggregation of sources.

4.2 Vadose Zone Modeling

Conceptual Models – Guidance on available source documentation that is expected to be used in developing the TCEIS conceptual model for the vadose zone is provided in Section 7.2.1 of the *Assessment Guidance Data Package*, (DOE/ORP-2003-09). Also provided are subsurface condition reports from Hanford Site Waste Management Areas for stratigraphy, recharge data for Hanford Immobilized Low Activity Waste PA, Hanford Site reports, hydraulic property catalog, scaling reports for the Hanford Site. Additional information includes *A Catalog of Vadose Zone Hydraulic Properties for the Hanford Site* (PNNL-13672), *Variability and Scaling of Hydraulic Properties for 200 Area Soils, Hanford Site* (WHC-EP-0883), *Recharge Data Package for the Integrated Disposal Facility Performance Assessment* (PNNL-14744), and *Near-Field Hydrology Data Package for the 2005 Integrated Disposal Facility(IDF)Performance Assessment* (PNNL-14700).

Representations of the vertical and horizontal variability in dimensions and physical properties of the layered sediments comprising the vadose zone should be considered and may be accomplished using a set of one-dimensional models. The number, location, and physical properties of the one-dimensional models will be based on the Hanford Site Atlas, the Waste Information Data System, the data packages developed for the IDF PA, and the Composite Analysis. For small area - large discharge sources, such as discharges to cribs and trenches, specification of the area of the one-dimensional models should consider spreading of the source due to capillary force and anisotropic character of the layered sediments.

- In modeling movement of water and transport of contaminants through the vadose zone, the Subsurface Transport Over Multiple Phases (STOMP) will be used. STOMP is capable of representing the range of transient and steady state processes occurring within the vadose zone.

4.3 Release Models

Waste sources to be evaluated for release functions in the TCEIS will include primary and secondary grouted waste, tank residual salt cake, liquid releases, and vitrified waste forms. Information on release rates from salt cake, grouted waste forms, and vitrified waste forms are available in *Risk Assessment Supporting the Decision in Initial Selection of Supplemental ILAW Technologies* (RPP-17675) and *Annual Summary of Immobilized Low Activity Waste Performance Assessment for 2003, Incorporating the Integrated Disposal Facility Concept*, (DOE/ORP-2000-19). Information on grout release is available in *An Initial Assessment of Hanford Impact Performed with the System Assessment Capability* (PNNL-14027), *Diffusion and Leaching of Selected Radionuclides (I-129, Tc-99, and U) through Category 3 Waste Encasement Cement, Concrete, and Soil Fill Material: Progress Report for 2001* (PNNL-13639), *Characterization of Grouted Low Level Waste to Support Performance Assessment* (Serne 1992). Grouted waste forms, such as secondary waste, ancillary equipment, and tank residuals will use diffusion-controlled release mechanisms reported in PNNL-13639. In selection of values of effective diffusivity consideration should be given to experimental measurements reported in PNNL-13639. Values of effective diffusivity ranged from 1 x 10^{-10} to 2.1 x 10^{-14} cm^2/s for iodine and from 8 x 10^{-9} to 4.5 x 10^{-13} cm^2/s for Tc-99. IDF PA data package *Contaminant Release from Glass/Grout: Waste Form Release Data Package for the 2005 Integrated Disposal Facility Performance Assessment* (PNNL-14805) provides the expected value for Tc-99 and iodine diffusion coefficients of 1 x 10^{-12}. The analysis shall consider degradation of grout after a period of 500 years. For purposes of analysis, values to be used for Tc-99 and iodine are listed below. If appropriate, additional sensitivity analysis will be conducted.

Diffusion Coefficients (cm^2/s) for Grouts

Contaminant	ETF Waste from the WTP going to IDF
Tc-99	5 x 10^{-9}
Iodine	1 x 10^{-10}

4.4 Infiltration Rates

Estimates of recharge rates for site-wide conditions have been developed and summarized for a range of soil type and vegetation conditions (Murphy et al. 1996, Prych 1998, Fayer 1995). Information in the 2004 IDF recharge data package (PNNL-14744) incorporates Hanford Site research and analogous site studies specific to the IDF location. Hanford site research indicates that silt-loam barriers will perform in the range of .1 to .5 mm/yr during design life and may maintain this performance after the 500 year design life. Some of the values reported for site-wide conditions *Estimated Recharge Rates at the Hanford Site*, (PNNL-10284) are higher than those recommended for the IDF location (PNNL-14744). In addition, considerable uncertainty exists in the techniques used to estimate long-term rates of infiltration. Based on these considerations, the following infiltration rates are adopted for the purposes of the TCEIS analysis.

	TCEIS Analysis Case	Sensitivity Case 1	Sensitivity Case 2
Pre-Hanford	3.5 mm/yr	3.5 mm/yr	5.0 mm/yr
Operational Era Bare Gravel Surface (Tank Farms) Bare Sandy Surface (Cribs and Trenches)	 100 mm/yr 50 mm/yr	 100 mm/yr 50 mm/yr	 100 mm/yr 50 mm/yr
Site-Wide Surface Barrier			
Design Life	0.5 mm/yr	0.5 mm/yr	1.0 mm/yr
Post Design Life	3.5 mm/yr	1.0 mm/yr	5.0 mm/yr
IDF Surface Barrier			
Design Life	0.5 mm/yr	0.5 mm/yr	0.9 mm/yr
Post Design Life	0.9 mm/yr	0.9 mm/yr	5.0 mm/yr

The three columns represent the infiltration rates for the analysis and sensitivity cases respectively and provide a reasonable range for overall barrier performance to be considered. SAIC is to analyze the analysis case, and perform sensitivity analyses as indicated above.

For tank farm related impacts, there will be various sensitivity runs – the details of these runs and on which alternatives they will be used will be defined in the up coming months. In order to support Washington Department of Ecology State Environmental Policy Act (SEPA) requirements as well as Tri-Party Agreement M-62-08 decisions, a specific sensitivity analysis will be run for the three cases above (TC-EIS Analysis Case, Sensitivity Case 1, and Sensitivity Case 2). The analysis will be done for the primary and secondary waste streams for alternatives 2B, 3A, 3B, and 3C. The results will be reported at the fence-line of IDF, the core zone, and the near shore of the river. It is estimated that the analysis will be run for a subset of five radioactive and non-radioactive constituents. Presentation of the results will be worked out between Ecology and the NEPA Document Manager.

4.5 Distribution Coefficients for Release and Transport Analysis (Retardation Values)

In selection of values of distribution coefficients, consideration will be given to material-specific conditions of Hanford sediments and geochemical conditions related to release events. Values of elemental distribution coefficients for the linear sorption isotherm model are available in PNNL-14700, *Vadose Zone Hydrogeology Data Package for the 2004 Composite Analysis(CA)*(PNNL-14702), and *Hanford Contaminant Distribution Coefficient Database and Users Guide* (PNNL-13895). Representative values that will be used in the TCEIS for undisturbed conditions of sand and silt dominated sediments are listed below in mL/g. If other values are used, a rationale will be provided in advance of the TCEIS.

Element	Vadose Zone	Grout
Hydrogen	0	0
Carbon	4.0	5
Strontium	10.0	15
Technetium	0	0.6*
Iodine	0, 0.2	30*
Cesium	80	280
Uranium	0.6	35 +
Neptunium	2.5	15
Plutonium	150	550

*Values will be consistent with effective diffusivities from cited studies.
+ Uranium will be evaluated for its toxicology impacts as well.

4.6 Alternatives Analysis Chemical Constituent Effective Kds.

Information on chemical constituents listed below is available from several sources. A rationale will be provided if different values are used.

Chemical Constituents	Effective Kd
Chromium (hexavalent)	0
Mercury	10
Nitrate	0
Lead	80
Benzene	1.0
Acetonitrile	0
Butanol	3
PCB's	170,000
2,4,6 Trichlorophenol	0.4

4.7 Groundwater Flow Field

Flow fields calculated by the Site-Wide Groundwater Model will be adapted for the TCEIS to ensure the most technically defensible representation of the unconfined aquifer. Flow fields will be transient, relaxing from an operational period with a groundwater mound beneath the central plateau to a long-term flow field consistent with boundary conditions. Two flow fields shall be evaluated. The base case will represent a condition in which the long-term flow direction is predominantly eastward. A sensitivity case will also be evaluated in which the long-term flow direction is predominantly northward.

4.8 Transport

The modeling approach for groundwater transport will be consistent with groundwater flow calculation. In particular, a fully three-dimensional representation of the aquifer geometry, flow field, and dispersivity should be used in the groundwater transport calculation. In addition, the groundwater flow calculation incorporates changes in material properties across the model domain and the transport calculation should as well. The transport model should interpolate the flow field in a method consistent with the finite-element based interpolation used in the flow calculation. In order to present results at both the near field locations (tank farm barriers and disposal fencelines) as well as far field (core zone and river), in an isopleth format, particle tracking will be used as the transport model in the EIS.

4.9 Points of Calculation (as described in the TCEIS)

The following points of calculation will be used for the alternatives as well as the cumulative impact analysis for the various constituents of concern;

- Tank Farm barriers
- IDF fence line
- River Protection Project Disposal Facility fence line
- Core zone boundary
- Near shore of Columbia River

4.10 Validation/Verification

SAIC shall:

- Identify all inputs to the model and model parameters, and describe how they impact model results. Provide the information to the Configuration Management Group (CMG).
- Identify all model switches and settings, and explain their impacts to model results. Provide the information to the CMG.
- Run internal diagnostic software checks and ensure checks are appropriate to any model modifications. Provide the results to CMG.
- Evaluate model results against available measured plumes or borehole data and present the evaluation in the EIS. Provide the results to CMG.
- Participate in status and technical review meetings to be held approximately monthly with the CMG to evaluate the status of the ongoing analysis, results, and interpretation.

5.0 Cumulative Impacts Methodology

SAIC will complete the following work;
Cumulative impacts are defined in *Council on Environmental Quality* regulations (40 CFR 1500) as follows:

"Cumulative impact is the impact on the environment which results in the incremental impact of the action when added to other past, present and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 CFR 1508.7)" The term "effects", as used throughout the CEQ and DOE NEPA regulations, includes direct, indirect, or cumulative impacts. (40 CFR 1508.8).

The cumulative impact analysis for groundwater will be:

1. Quantitative, commensurate with the significance of this issue and incorporate recognition of uncertainties.

2. Presented for each alternative as needed to enable a comparative evaluation.

3. Based on analytical methods, assumptions and input parameters that allow the comparison of each alternative.

The results between the alternatives and cumulative analysis will be additive at the following locations; Fence line analysis of tank farm barriers (A, T, U, S, B), IDF, River Protection Project Disposal Facility, core zone boundary, and near shore of the Columbia River.

6.0 References

BHI-01496 *Groundwater/Vadose Zone Integration Project Hanford Soil Inventory Model,* BC Simpson, March 13, 2001.

DOE/ORP-2000-19 *Annual Summary of Immobilized Low Activity Waste Performance Assessment for 2003, Incorporating the Integrated Disposal Facility Concept,* Mann F. M. 2003

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PNNL-13672, *A Catalog of Vadose Zone Hydraulic Properties for the Hanford Site,* Pacific Northwest National Laboratory, Richland, Washington, 2001.

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Prych, A.E., *Using Chlorine and Chlorine-36 as Soil-Water Tracers to Estimate Deep Percolation at Selected Locations on the Department of Energy Hanford Site, Washington*, water Supply Paper 2481, U.S.G.S., Tacoma, WA, 1996.

RPP-17675, *Risk Assessment Supporting the Decision in Initial Selection of Supplemental ILAW Technologies* Mann F. M. et al 2003

Serne et al, 1992, *Characterization of Grouted Low Level Waste to Support Performance Assessment,* Waste Management Volume 12, Pacific Northwest National Laboratory, Richland, Washington, 1992.

WHC-EP-0883, R. Khaleel, *Variability and Scaling of Hydraulic Properties for 200 Area Soils*, *Hanford Site*. Westinghouse Hanford Company, Richland, Washington, 1995.

ATTACHMENT 1

TCEIS
Vadose Zone and Groundwater Modeling
Performance Specification

1.0 Programmatic Objectives

A. Relate impacts directly to individual sources.

B. Ability to evaluate different actions within alternatives without re-running the groundwater model.

C. Ability to support evaluation of hybrid alternatives without re-running the groundwater model.

D. Reduce comment response time by being able to quantitatively analyze impacts of various scenarios that may arise during internal or public review.

E. Ability to analyze sensitivity of impacts to key input parameters without re-running the groundwater model.

2.0 Requirements

A. Separate results for each individual source:

1) Specific locations at tank farm level of geographic resolution

2) Specific source types (particularly for tank farm contributions)

   i. Cribs & trenches (at the tank farm level)
   ii. Past leaks (at the tank farm level)
   iii. Retrieval losses (at the tank farm level)
   iv. Residuals (at the tank farm level)
   v. Ancillary equipment (at the tank farm level)
   vi. Secondary waste forms (at the waste form level)

3) That vary appropriately according to source areas specific to each alternative

B. Results to be calculated are:

1) Flux to groundwater (Ci/Year) for each specific source component

2) Concentration within 100 meters of appropriate barrier/ fence line for each specific source component

3) Concentrations at the Core Zone Boundary and near shore of the Columbia River for each specific source component

4) Isopleth maps at selected times for each specific source component

C. Ability to sort, select, and summarize quantitative groundwater impacts by any combination of specific individual sources without re-running the groundwater model

D. Ability to perform quantitative sensitivity analysis by scaling individual source flux to aquifer (in terms of pCi/l) without re-running the groundwater model.