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Revision 3

Annual Summary of the Immobilized Low-Activity Waste Performance Assessment for 2003, Incorporating the Integrated Disposal Facility Concept

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Acronyms

APF	All Pathways Farmer (NASR)
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CRP	Columbia River Population
DAS	Disposal Authorization Statement
DOE	U.S. Department of Energy
DOE/HQ	DOE Headquarters
EDE	effective dose equivalent
EMSP	Environmental Management Science Program
EPA	U.S. Environmental Protection Agency
FLTF	Field Lysimeter Test Facility
FY	fiscal year
HSRAM	Hanford Site risk assessment methodology
IDF	Integrated Disposal Facility
ILAW	immobilized low-activity waste
LFRG	Low-Level Waste Disposal Facility Federal Review Group
LLW	low-level waste
MLLW	mixed low-level waste
NASR	Native American Subsistence Resident
ORP	U.S. Department of Energy, Office of River Protection
PA	performance assessment
RCRA	Resource, Conservation, Recovery Act
R&D	research and development
ROD	Record of Decision
SAC	System Assessment Capability
TFC	Tank Farm Contractor
TFVZP	Tank Farm Vadose Zone Project
USDA	U.S. Department of Agriculture
WTP	Waste Treatment and Immobilization Plant

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SUMMARY

As required by the U.S. Department of Energy (DOE) order on radioactive waste management (DOE 1999) and as implemented by the *Maintenance Plan for the Hanford Immobilized Low-Activity Tank Waste Performance Assessment* (Mann 2000), an annual summary of the adequacy of the Hanford Immobilized Low-Activity Tank Waste Performance Assessment (ILAW PA) is necessary in each year in which a full performance assessment is not issued. A draft version of the 2001 ILAW PA was sent to the DOE Headquarters (DOE/HQ) in April 2001 for review and approval. The DOE approved (DOE 2001) the draft version of the 2001 ILAW PA and issued a new version of the Hanford Site waste disposal authorization statement (DAS). Based on comments raised during the review, the draft version was revised and the 2001 ILAW PA was formally issued (Mann 2001). Recently, the DOE (DOE 2003a) has reviewed the final 2001 ILAW PA and concluded that no changes to the DAS were necessary.

A. STATUS OF ILAW PA

Considering the results of data collection and analysis, the conclusions of the draft and issued versions of the 2001 ILAW PA remain valid as they pertain to ILAW disposal.

B. NEW AND PENDING DOE DECISIONS

1. Solid Waste Environmental Impact Statement Record of Decision

However, since the issuance of the last annual summary (Mann 2002a), there are several decisions that impact the ILAW PA activity. A major decision is expected to be provided in the Record of Decision (ROD) for the *Hanford Site Solid (Hazardous and Radioactive) Waste Environmental Impact Statement* (revised draft is DOE 2003b), in which the ILAW Disposal Facility is replaced by the Integrated Disposal Facility (IDF). The IDF will be the disposal facility not only for ILAW, but also for the waste destined for Hanford's Solid Waste Burial Grounds after 2005/6. This latter waste (Hanford Site solid low-level radioactive waste including secondary waste generated during the production of ILAW as well as solid low-level radioactive waste sent by other DOE sites) is covered by the maintenance activities for the Hanford Solid Waste Burial Grounds Performance Assessment, the last annual summary being *Performance Assessment Review Report, 2001-2002, Annual Review of the 200 West and 200 East Area Performance Assessments* (Wood 2002). This IDF annual summary report and future IDF performance assessment actions, assuming that the ROD includes the IDF at the ILAW site, will cover all waste to be disposed in the IDF.

The IDF has a very similar design as that of the ILAW Disposal Facility. The IDF is located at the same site as the ILAW Disposal Facility. The *Integrated Disposal Facility Risk Assessment* (Mann 2003, also attached as Appendix A to this document) shows that the long-term performance of this facility easily meets the performance objectives set for the 2005 ILAW PA (Mann 2002b).

2. Tc Separation in WTP

Another significant decision by the DOE's Office of River Protection (ORP) was the elimination of the technetium separations process from the Waste Treatment and Immobilization Plant (WTP). Based on the analyses performed in the 2001 ILAW PA (Mann 2001) and repeated in the IDF Risk Assessment (Mann 2003 and Appendix A of this document), there will be an increase in estimated groundwater impacts (by about a factor of three), but the performance objectives are still easily met (by a factor of at least 100) when only ILAW glass produced by WTP is considered.

3. Supplemental ILAW Technologies

The final significant decision is to investigate the possible use of supplemental ILAW technologies (IMAP 2003) to immobilize some of the low-activity waste. Testing and analyses are at a preliminary stage. Documentation to support the initial selection of supplemental ILAW technologies is expected in the fall of 2003. Future testing and analyses would then be conducted. Whether all ILAW will be produced by WTP and in a combination of WTP and other processes will not be decided until 2005.

C. PROGRESS IN ILAW PA ACTIVITY SINCE 2001 ILAW PA

There has been significant progress to the disposal facility concept and design since the creation of the 2001 ILAW PA. The 2001 ILAW PA was based on a preliminary conceptual design. Since then, the *Conceptual Design Report for Immobilized Low-Activity Waste Disposal Facility, Project W-520* (Burbank 2001) was issued. Now the final design of IDF is underway. The IDF design is slightly deeper, has two cells instead of six trenches, and has a slightly different footprint.

Although not explicitly required by the Hanford Site Disposal Authorization Statement (DOE 2001), considerable data collection and analysis activities have occurred to fulfill the obligations of DOE O 435.1 to maintain a performance assessment and the *Maintenance Plan for the Hanford Immobilized Low-Activity Tank Waste Performance Assessment* (Mann 2000). An additional 29 articles and reports have been published since the 2002 ILAW PA Annual Summary was issued. The major thrust in waste form research has been the switching of emphasis from LAWABP1 (the glass composition used in the 2001 ILAW PA) to LAWA44, LAWB45, and LAWC22 (the glass compositions proposed by the Waste Treatment Contractor for the three low-activity envelopes to be made into the ILAW product), the improvements of the waste form simulation code to run on massively parallel computers, and the start of field testing glass samples. Hydrological and geochemical studies continued, with an increasing emphasis on how the glass waste forms will behave in situ. Hydraulic and chemical analyses of the fiscal year (FY) 2002 borehole samples have been completed. Significant improvements in understanding upscaling hydraulic parameters at the Hanford Site have been achieved. The IDF PA activity has maintained its ties with other work at the Hanford Site on similar problems, particularly in the area of inventory and dosimetry.

These data collection activities confirm the conclusions of the 2001 ILAW PA. The testing of the LAWA44 glasses indicates slightly better performance than that of LAWABP1. The testing of the two other compositions (LAWB45 and LAWC22) indicates long-term performance comparable to LAWABP1. Improvements in the waste form simulation code have allowed two-dimensional calculations that show lower environmental impacts than the one-dimensional calculations displayed in the 2001 ILAW PA due to moisture flow around the waste form packages in the 2-dimensional calculations that are that not geometrically allowed in the 1-dimensional model. Improvements in hydraulic and chemical data as well as new data from other Hanford Site activities do not indicate any change in the results presented in the 2001 ILAW PA.

D. PATH FORWARD

Because of the expanded mission, but noting that the location, design, and performance of the new facility as analyzed in this report have not significantly changed, this report provides the basis for the DOE Hanford Site field offices to request the DOE/HQ to allow construction of the IDF for the disposal of WTP glass, Hanford solid waste, off-site solid waste, and spent melters, assuming all other requirements or appropriate regulatory approvals or permits are obtained. An IDF PA is scheduled to be issued in July 2005. That PA would be the basis for modifying the DAS allowing the disposal of any other waste (such as supplemental ILAW) into IDF. It is expected that that 2005 IDF PA will contain sufficient information for any supplemental ILAW technology that might be selected. Dates for events that are significant to the IDF performance assessment are summarized in Table S-1.

Table S-1. Current Planning Dates for Integrated Disposal Facility (IDF)

Date	Event
Sept. 2003	ORP determines which supplemental ILAW technologies will be further investigated
Oct. 2003	Issuance of this document
Oct. 2003	Record of Decision for Hanford Solid Waste (authorizes IDF as the disposal facility for ILAW, Hanford radioactive and mixed solid waste, off-site solid waste, and ILAW melters)
Jan. 2004	Based on DAS and analyses described in this document, authorization to start construction of the IDF.
Feb. 2004	Start of Construction of IDF
July 2004	Publication of data packages for IDF Performance Assessment
Dec. 2004	Publication of data packages for supplemental ILAW technologies
Jan. 2005	ORP proposes a path forward for fraction of ILAW to be generated by WTP and the fraction to be generated by supplemental processes.
July 2005	Issuance of IDF Performance Assessment
July 2005	ORP and regulators decide on ILAW path forward
Late 2005	Any further modification of Hanford Disposal Statement
Feb. 2006	Start of Operation of IDF

I. INTRODUCTION

Reprocessing of irradiated nuclear reactor fuel for the production of special nuclear materials at the Hanford Site in southeastern Washington resulted in a large amount of mixed radioactive/hazardous waste. Presently 54 million gallons of this waste are stored in 177 large underground tanks in the central plateau area of the Hanford Site. The DOE (DOE 1997) plans to

- Retrieve most of this waste,
- Separate the retrieved waste into two streams: a low-activity waste stream (having most of the volume) and a high-level waste stream (having much smaller volume),
- Vitrify each waste stream,
- Store and eventually transport the immobilized high-level waste stream to a federal geologic repository, and
- Store and dispose of the ILAW on the central plateau of the Hanford Site.

Low-level waste associated with these and other activities have been and are being generated at the Hanford Site. Also, the Hanford Site has been selected (DOE 2000) as a disposal site for low-level wastes from other DOE sites. The soon-to-be issued ROD for Hanford Site Solid Hazardous and Radioactive Waste Environmental Impact Statement (revised draft is DOE 2003b) is likely to determine that the ILAW wastes, Hanford's WTP melters, other Hanford Site solid radioactive waste (including mixed radioactive/hazardous waste) as well as solid radioactive waste generated off-site are to be disposed of in an IDF at the Hanford Site. This ROD will not address ILAW generated external to the WTP.

Previous studies for this disposal site southwest of the PUREX facility in Hanford's 200 East Area (Mann 2001, Mann 2002a) concentrated on the disposal of just ILAW. Other work (Wood 1995, Wood 1996, and Wood 2002) looked at solid waste disposed of elsewhere on the Hanford Site. A risk assessment (Mann 2003, also Appendix A of this document) has been issued to evaluate the performance of the proposed IDF as defined in the Hanford Solid Waste Environmental Impact Statement (EIS.) The IDF is now in final design. Construction is now anticipated to begin in fiscal year 2004. The IDF is scheduled to start receiving wastes in 2006. These latter two dates are subject to receiving the necessary approvals (i.e., Atomic Energy Act and Resource, Conservation, and Recovery Act) by DOE/HQ and the State of Washington.

In accordance with the DOE order on radioactive waste management (DOE O 435.1 – DOE 1999), DOE/HQ must approve a PA and issue a DAS before construction can begin on the low-level waste disposal facility. A PA is an evaluation of long-term public health and the environmental impacts from the disposal action, resulting in a comparison of the estimated impacts with standards to determine whether the disposal action has a "reasonable expectation" of meeting those standards. The *Hanford Immobilized Low-Activity Tank Waste Performance Assessment* (Mann 1998) was conditionally approved in 1999 and a DAS was issued. The DAS requirements to issue a PA maintenance plan and have it approved by the Field Office Manager were met in 2000 (Mann 2000). As required by the DOE order on radioactive waste management (DOE O 435.1) and the *Maintenance Plan for the Hanford Immobilized Low-Activity Tank Waste Performance* Assessment, the first annual summary of the ILAW PA was issued in 2000 (Mann 2000a).

However, because of significant changes in waste form and in disposal facility design as well as new information about the proposed disposal site, a new performance assessment, *Hanford Immobilized Low-Activity Waste Performance Assessment: 2001 Version* was created. The draft was sent to DOE/HQs on April 3, 2001 for review and approval. Based on recommendations of the Low-Level Waste Disposal Facility Federal Review Group, the DOE approved the PA and issued a revised DAS (DOE 2001).

Because the next ILAW PA is scheduled to be sent to the DOE in July 2005, the DOE order on radioactive waste management requires that an annual summary be prepared. The format for this annual summary follows that required by the maintenance plan (as directed by the DOE guidance on PA maintenance plans [DOE 1999a]) with the exceptions of the inclusion of this introduction and the next section which provide program developments since the issuance of the 2002 ILAW PA Annual Summary (Mann 2002a).

II. PROGRAM DEVELOPMENTS

There have been significant management decisions that affect the ILAW Disposal Facility during the past year. There also has been significant progress to the disposal facility concept and design. None of these affect the conclusions of the 2001 ILAW PA regarding the disposal of vitrified low-activity waste.

A. MANAGEMENT DECISIONS

There are two significant management decisions that impact this activity:

1. Low-level radioactive waste, including mixed radioactive/hazardous waste, other than that generated under the Comprehensive Environmental Reporting, Liability, and Compensation Act (CERCLA), to be disposed of after 2006 will be disposed at the ILAW Site. Such waste includes not only traditional Hanford solid waste, but also solid waste generated by other DOE sites and melters from Hanford's Waste Treatment Plant. The disposal facility at the ILAW Site has been renamed the Integrated Disposal Facility. (This decision will be made in the Record of Decision for the *Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement Richland, Washington* [DOE/EIS-0286D2]).

2. The WTP will not have a Tc-99 separations step.

A third potential decision due in October 2003, whether to further study alternate ILAW waste forms, could impact future performance assessment activities. The decision to actually produce such waste forms will not be made until 2005.

The *Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement Richland, Washington* (DOE/EIS-0286D2) analyzed various disposal options for radioactive waste and mixed Resource, Conservation, and Recovery Act (RCRA) hazardous radioactive waste at the Hanford Site. The ROD is expected be issued soon and to document the decision that one integrated facility should be built at the site that has been proposed as the ILAW Disposal Facility.

The effect of that ROD would be to increase the scope of this performance assessment effort from just ILAW disposal (which is a mixed radioactive/hazardous waste) to all of the waste to be disposed of at the IDF. This update to the ILAW performance assessment will address the revised scope. The second effect of the ROD is to cause a slight change in the design of the disposal facility, mainly a little deeper with 2 differently shaped cells replacing the previous six trenches.

Earlier, the DOE Manager of the ORP decided (Schepens 2002) that a separate Tc separations process in the WTP was not justified based on cost, efficiency, and environmental impacts. This decision has the impact of increasing the amount of Tc-99 to be disposed of as ILAW WTP glass. As shown in the 2001 ILAW PA (Mann 2001), the lack of Tc separations would cut the 2001 IALW PA base case margin of at least 300 by a factor of three.

The ORP and the Tank Farm Contractor (TFC: CH2M Hill Hanford Group, Inc.) are investigating whether there are supplemental treatments of low-activity waste that could reduce costs and time durations of treating low-activity tank wastes, yet would protect the environment. With the consent of the Hanford Site regulators (the Washington State Department of Ecology [Ecology] and the U.S. Environmental Protection Agency [EPA]), three candidate treatment waste forms (bulk vitrification, cast stone [a cementitious waste form], steam reformer) are deserving of further investigation. In October 2003, the ORP Field Manager is scheduled to determine whether any of these materials should be further investigated. Part of this decision will be based on an environmental assessment presently being prepared (See Section 6.C).

B. PROGRAM PROGRESS

The 2001 ILAW PA was based upon the Project W-520 concept of six trenches on the ILAW disposal site. In September of 2002, an Alternative Generation Analysis (AGA) was performed to look at the disposal of ILAW, mixed low-level waste (MLLW) and low-level waste (LLW) on the Hanford site. This AGA evaluated at an integrated approach to site-wide disposal of LLW at Hanford. The conclusion was development of an IDF that is superior (financially and environmentally) to current and previously planned Hanford Site disposal facilities. The IDF would be built in phases as additional space is needed on the ILAW site.

Currently, the *Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement Richland, Washington* (EIS) is in progress and a ROD is expected in early FY 2004. The ROD will determine if the IDF will be located on the ILAW site or at another Hanford site. It is currently anticipated the ILAW site will be chosen.

To support an accelerated cleanup at Hanford, progress has continued on the ILAW site in FY 2003. The Part B Permit for the ILAW site was submitted in June 2003 (DOE 2003c), based upon the new IDF concept. In order to submit the permit, an 80 percent complete detailed design of the critical systems for the IDF was completed and included in the Part B Permit. The design provided for expansion of the IDF as necessary. The IDF design includes separate cells for hazardous and non-hazardous waste. The detail design is scheduled to be completed in early FY 2004 and will be released as a River Protection Project (RPP) document, with the addition of the non-critical systems and completion of identified trade studies from the critical system design.

To support the IDF concept, a risk assessment for the IDF (Mann 2003, and Appendix A of this document) was performed in FY 2003 to determine if there were increased environmental impacts due to the IDF concept. This risk assessment analyzed the impacts from the disposal of ILAW glass produced by the WTP, Hanford LLW (including mixed radioactive-hazardous wastes) not regulated by CERCLA, off-site low-level waste (including mixed radioactive-hazardous wastes), as well as the WTP melters. The performance objects were easily met.

Three fifteen meter bore holes were drilled and sampled on the IDF site in FY 2003 to support the IDF design and the Pre-Operation Monitoring Plan for the site.

During FY 2003 a new Level 1 Specification was developed and approved to include other MLLW as melters and the LLW. The project design criteria for the IDF are currently being revised to reflect changes in the Level 1 Specification. The waste acceptance criteria will be updated in FY 2005 time period to reflect the additional wastes for disposal in the IDF.

As previously identified a supplemental technology may be selected to treat a portion of the low-level tank waste for disposal in the IDF. When this occurs, the new waste form will be evaluated for disposal and updates to the appropriate documents (e.g., performance assessments, waste acceptance criteria) will be made.

The design for the IDF has been optimized for both near-term and lifecycle savings by consolidating operations from three working disposal sites into one, thus eliminating the need for redundant functions.

The schedule for the IDF would be accelerated from the vitrification plant need date of 2011 to 2006 to provide adequate space for site wastes and supplemental waste forms should one be chosen. Following completion of the design in February 2004, and the issuance of the Solid Waste ROD in early FY 2004, the IDF Project will be ready to start construction, which requires the revised DAS. The FY 2004 annual update will provide additional information for the IDF should studies of supplemental waste form continue.

Because of the expanded mission, but noting that the location, design, and performance of the new facility have not significantly changed, DOE/HQ will be requested to allow construction of the IDF for the disposal of the WTP glass, Hanford solid waste, and spent melters. An IDF PA is scheduled to be issued in July 2005. That PA would be the basis for modifying the DAS allowing the disposal of any other waste (such as supplemental ILAW) into the IDF. It is expected that the 2005 IDF PA will contain sufficient information for any supplemental ILAW technology that might be selected. These events are summarized in the Table 1 below.

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III. WASTE RECEIPTS

There have been no waste receipts, as the disposal facility has not yet been constructed. The expected inventory to be disposed of in IDF is given in Section 3.1 of Appendix A.

IV. MONITORING

A pre-operational monitoring plan (Horton 2000) has been issued and approved (Boston 2000). It calls for drilling groundwater monitoring wells and subsequent monitoring per the requirements of theRCRA. The plan also calls for monitoring of air resources and the identification of any surface contamination. Additional boreholes are planned to verify the lack of subsurface contamination from adjacent facilities. The pre-operational monitoring plan is now being implemented. The groundwater wells for the first cell have been completed.

The Hanford Site has a groundwater-monitoring program, with the results for FY 2002 just released (Hartman 2003). Previous discharges from Hanford Site operations, primarily liquid discharges to cribs associated with the PUREX plant, have impacted groundwater underneath the proposed disposal facility. Although these cribs are currently down gradient from the proposed disposal site, the plumes from these cribs hydraulically spread up gradient to underneath the proposed disposal site due to hydraulic pressures caused by the large volumes of liquids disposed in the cribs. The level of groundwater contamination for tritium is above drinking water standards (20,000 pCi/liter) in part of the proposed disposal site. However, given the short half-life of tritium and the long vadose zone travel time for ILAW contaminants, any tritium will have decayed by the time that ILAW contaminants reach groundwater. Groundwater contamination levels from other contaminants of concern (mainly ^{129}I and nitrate) were found to be below drinking water standards.

Hanford Site records indicate no significant operational activities have been performed at the proposed disposal site. Thus, no vadose zone contamination is expected. Part of the borehole task is to search for contamination in the vadose zone from near-by cribs. To date, no contamination (only naturally occurring radioactivity) has been found in the any of the six boreholes drilled, all of which have gone to at least 25 feet below the water table.

V. RESEARCH AND DEVELOPMENT

A. SUMMARY

Research and Development (R&D) of significance to the IDF PA is conducted in several programs. The IDF PA activity directly funds selected R&D as documented in the last update of its statement of work (Puigh 2002). The IDF PA activity also maintains close contact with the WTP, particularly in the areas of waste form composition and inventory. The IDF PA tightly coordinates its activity with the Tank Farm Vadose Zone Project, as both investigate vadose zone properties for Hanford's TFC. The IDF PA activity is also associated with the Hanford Groundwater / Vadose Zone Integration Project. As one of the "core projects" of the Hanford Groundwater / Vadose Zone Integration Project, the IDF PA activity maintains close contacts with the Integration Project's Science and Technology and System Assessment Capability activities as well as with EM-50 and the Office of Science's Environmental Management Science Program (EMSP]). These other programs provide additional data and information that are directly utilized in developing a more complete understanding of the mechanisms that impact the IDF disposal facility system performance.

B. DAS-DIRECTED R&D

No R&D activities were directly required by the facility's disposal authorization statement (DOE 2001). However, the cover letter for the DAS (DOE 2001) states, "However the LFRG [Low-Level Waste Disposal Facility Federal Review Group] review emphasized the importance of the glass waste form consistency in meeting your performance criteria established in the performance assessment. As a result of the need for short and long-term waste form integrity it is imperative that appropriate and sufficient glass testing, including product consistency tests, be carried out prior to disposal to confirm that the assumptions used in the performance assessment are representative of the final waste form." Waste Form testing is an important part of the IDF PA activity and is described in the next section.

C. IDF PA R&D

The IDF PA activity has sponsored many research and development activities. Only a few dealing with waste form performance and geology will be presented here. A list of papers and reports is presented in Table 2. Table 3 summarizes the IDF PA R&D activities by functions and provides the overall impacts the findings from these activities have on the performance assessment. The glass waste form work was acknowledged in an article appearing in *Nature* magazine (Nature 2003) and in the local newspaper (Tri City Herald 2003). A summary of the R&D activities can be found in Appendix B.

Table 2. Papers by/on IDF PA Activity from July 2002 to June 2003 (3 Pages)

D.H. Bacon, and B.P. McGrail. 2002a. "Waste Form Release Calculations for Performance Assessment of the Hanford Immobilized Low-Activity Waste Disposal Facility Using a Parallel, Coupled Unsaturated Flow and Reactive Transport Simulator," Materials Research Society 2002 Fall Meeting, Boston, MA, December 2002.
D.H. Bacon, M.I. Ojovan, B.P. McGrail, N.V. Ojovan, and I.V. Startsceva. 2003a. "Vitrified waste corrosion rates from field experiment and reactive transport modeling." *9th International Conference on Radioactive Waste Management and Environmental Remediation*, Oxford, England, 2003.
D.H. Bacon and B.P. McGrail. 2003b. "Lessons Learned From Reactive Transport Modeling of a Low-Activity Waste Glass Disposal System." *Computers and Geosciences*, 29:361-370.
D.H. Bacon and B.P. McGrail. 2003c "Parallel Reactive Transport Modeling of Low-Level Radioactive Waste Dissolution in a Subsurface Disposal Facility," (Poster), Seventh SIAM Conference on Mathematical and Computational Issues in the Geosciences, Austin, TX, March 17, 2003.
P. Ball, 2003 "To the Heart of Glass." *Nature* **421**:783
V.L. Freedman, K.P. Saripalli, and P. D. Meyer. 2003. "Influence of mineral precipitation and dissolution on hydrologic properties of porous media in static and dynamic systems, *Applied Geochemistry*, 18:589-606.
A.P. Gamerdinger, R.J. Serne, D.M. Wellman, and D.I. Kaplan. 2003 (awaiting publication). *Particle Scale Sorption Heterogeneity*. PNNL-14179, Pacific Northwest National Laboratory, Richland, Washington.
D.G. Horton H.T. Schaef, R.J. Serne, C.F. Brown, M.M. Valenta, T.S. Vickerman, I.V. Kutnyakov, S.R. Baum, K.N. Geiszler, and K.E. Parker. 2003a. *Geochemistry of Samples from Borehole C3177(299-E24-21)*. PNNL-14289, Pacific Northwest National Laboratory, Richland, Washington.
D.G. Horton, H.T. Schaef, R.J. Serne, M.M. Valenta, T.S. Vickerman, I.V. Kutnyakou, S.R. Baum, K.N. Geiszler, and K.E. Parker. 2003b. "Immobilized Low-Activity Waste Borehole 299-E24-21 Geochemistry." In *Hanford Groundwater Monitoring for Fiscal Year 2002*, Section 3.1.3.1, MJ Hartman, LF Morasch, and WD Webber (eds.), PNNL-14187, pp. 3.1-18–3.1-20, Pacific Northwest National Laboratory, Richland, Washington.
D.I. Kaplan, R.J. Serne, H.T. Schaef, C.W. Lindenmeier, K.E. Parker, A.T. Owen, D.E. McCready, and J.S. Young. 2003. *Hydraulic, Physical, Mineralogical and Sorptive Properties of NaOH-Treated Sediment Materials*, Pacific Northwest National Laboratory, Richland.

Table 2. Papers by/on IDF PA Activity from July 2002 to June 2003 (3 Pages)

R.Khaleel, 2002a, "Upscaling and Polmann Macroscopic Anisotropy for 2005 ILAW Performance Assessment Calculations," FY 2002 Status Report, Fluor Federal Services, Richland, WA, September, 2002.
R. Khaleel, 2002b, **"**Improvements to Hanford Site Database: Hydraulic Properties for Coarse-Textured Sediments at Low Water Contents," FY 2002 Status Report, Fluor Federal Services, Richland, WA, September, 2002.
R. Khaleel and P. R. Heller*,* 2003a. "On the Hydraulic Properties for Coarse-Textured Sediments at Intermediate Water Contents", *Water Resources Research*, **Vol. 39**, 2-1, 2003.
R. Khaleel, J. Yeh, and M. Ye, 2003b. "Geostatistical Analyses of Moisture Plume Dynamics at an Injection Experiment Site," in: *Geophysical Research Abstracts*, Volume 5, 2003, Paper presented at the American Geophysical Union and European Geological Society Joint Assembly, Nice, France, April 7-11, 2003
S.V. Mattigod, G. Fryxell, K.E. Parker, and D.I. Kaplan. 2002a. "Novel Functionalized Ceramic Getter Materials for Adsorption of Radioiodine." Presentation given at the 2002 Materials Research Society (MRS) Fall Meeting (December 2-6, 2002 in Boston). Paper submitted for publication in Materials Research Society symposium proceedings.
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Table 3. ILAW PA R&D Activities

Activity	Uncertainty or Question Being Addressed	Expected Completion [a]	Potential or actual impact of results on performance objectives and adequacy of current PA
Waste Form			
Primary Released Rate	Rate at which contaminants are released from waste form	2015 PA	Laboratory measurements indicate envelope A glass (most of the glass) is superior to that considered in 2001 PA. Performance of other envelopes is comparable to the LAWABP1 glass analyzed in 2001 PA. Processes modeled in 2001 PA have been shown to be dominant.
Secondary Phases	Rate at which key contaminants (e.g. Tc) may be trapped in secondary phases of waste form	2010 PA	Short-term experiments indicate a reduction of 50% in the impacts of 2001 PA. 2001 PA is bounding.
Field Verification	Reliability of laboratory testing in predicting field conditions	2020 PA	Glass has just been placed in field.
Supplemental ILAW waste forms	Rate at which contaminants are released from waste form	2005 PA [b]	Approved 2001 PA does not cover these waste forms
Geology	Adequacy in understanding different layers and adequacy of groundwater channel	2005 PA	Additional boreholes have confirmed information in 2001 PA
Hydrology	Adequacy in understanding moisture flow in vadose zone	2005 PA	Upscaling and lateral flow assumptions in 2001 PA seem adequate
Geochemistry	Adequacy in understanding contaminant transport	2005 PA	Mobile contaminants (which drive the impacts) remain the same. PA remains bounding.
Inventory	Inventory actually disposed in facility	Closure PA	ORP and HQ decisions can greatly affect inventory actually disposed. Limiting cases analyzed in 2001 PA.

Table 3. ILAW PA R&D Activities

Activity	Uncertainty or Question Being Addressed	Expected Completion [(a)]	Potential or actual impact of results on performance objectives and adequacy of current PA
Dosimetry	Conversion between groundwater concentrations and exposure	2010 PA	ORP, RL, EPA, and Washington State Department of Ecology discussing alternatives. 2001 PA should be limiting.

(a) Assumes no new data or information becomes available which contradicts PA.
(b) First full analysis. Depending on availability of information, more time may be required.

IDF PA = Integrated Disposal Facility Performance Assessment
ORP = Office of River Protection
RL = Richland Operations
R&D = research and development
HQ = Department of Energy Headquarters
EPA = Environmental Protection Agency

D. OTHER R&D

A variety of research and development activities are underway, and there is close cooperation among many of those activities. Important ties are with the Environmental Management Science Program (EMSP) (glass performance and other activities), the Tank Farm Vadose Zone Project (TFVZP) (vadose zone characterization, particularly under highly contaminated conditions), and the Environmental and Closure Science Project of the Groundwater Protection Project(various efforts).

1. Environmental Management Science Program

The EMSP is also supporting important research into glass performance. At higher temperatures, the breaking of silicon bridging bonds is the rate-determining step. At temperatures corresponding to soil conditions and with high sodium content glasses, a second reaction (the ion exchange of hydrogen and sodium) becomes significant (McGrail 2000). The EMSP activity in this area has provided important data and understanding of how this formerly overlooked reaction proceeds.

Based on borehole data for the proposed disposal site and the fact that the site is uncontaminated, several EMSP tasks are using the disposal site for field experiments. Moreover, at the kick-off meeting for principal investigators of FY 1999 EMSP subsurface awards, details of the proposed ILAW disposal site were described and many contacts established. Such contacts have been maintained through annual meetings and other means. In particular, the ground penetrating radar task of Rosemary Knight was coordinated with ILAW-specific work to better characterize the proposed disposal site as well as an adjoining site that will be used by the Science and Technology activity of the Hanford Groundwater / Vadose Zone Integration Project for research and development activities.

2. Tank Farm Vadose Zone Project

The TFVZP operates another large characterization project for the ORP. This activity is doing extensive vadose zone characterization of the Hanford Site tank farms. The *Field Investigation Report for Waste Management Area B-BX-BY* (Knepp 2002) describes the effort for the first set of tank farms being investigated. The leader of the ILAW PA activity and many of the scientific staff are working on both the ILAW PA and TFVZP efforts.

3. Integration Project's Environmental and Closure Science Project

The major projects at the Hanford Site that analyze environmental impacts have joined together to form the Hanford Groundwater Protection Program (better known as the Integration Project, which is taken from the project's original name, the Hanford Groundwater / Vadose Zone Integration Project). Various contractors manage these projects, one of which is the IDF PA activity. However, the projects coordinate their activities so that information generated by one activity can be used by all and activities can be modified for the common benefit of the site.

A major part of the Integration Project's effort is the Environmental and Closure Science Project (formerly the Science and Technology activity). This project supports tasks that supplement on-going Hanford Site characterization efforts ("wrap-around science"), that investigate near-surface vadose zone flow, and that gather data on ecological impacts. The most supportive work for the ILAW PA has been the wrap-around-science tasks associated with the Tank Farm Vadose Zone Project. Such tasks have provided a much better understanding of contaminant transport in high sodium environments. The investigations of near-surface vadose zone flow have provided information on various remote sensing monitors.

4. Integration Projects' System Assessment Capability

The Integration Project is developing an integrated system of computer models and databases to assess the cumulative impact of Hanford on human health, ecological, economic, and cultural systems. This system is called the System Assessment Capability (SAC). Assessments performed with the tool consider radiological and chemical wastes remaining, migrating, or being released from the Hanford Site and the effects of clean up decisions being made with respect to this waste. This tool will be used to perform the next Composite Analysis.

An initial assessment performed with the SAC examined the impacts resulting from contaminants remaining on the site after execution of the Hanford Site Disposition Baseline (Bryce 2002), the collection of disposal and remedial actions identified in the Tri-Party Agreement that are planned to occur as Hanford moves toward closure. The capability will now be used to estimate the impacts resulting from alternative cleanup approaches.

E. PLANNED ILAW PA R&D

The next performance assessment is planned to be sent to DOE/HQ in July 2005. Therefore, R&D efforts for that document are being completed. It is expected that data packages to be used in the 2005 IDF PA will be finalized by July 2004. The amount of R&D effort will be reduced in areas not directly supporting waste form performance.

As requested by the Low-Level Waste Disposal Facility Federal Review Group, glass testing will be an important part of the maintenance effort in FY 2004 and beyond. Emphasis will remain on testing the basic modeling approach to evaluate long-term waste form performance. The emphasis on glass testing will remain on those glasses expected to be disposed of in the IDF facility.

Long-term measurements (recharge rate measurements and field glass tests, both at the Field Lysimetry Test Facility) are expected to continue. Because of RCRA requirements, additional groundwater wells are expected to be drilled. Samples from these drillings will provide additional geological, hydraulic, and chemical data.

Other efforts will include waste form investigations for those supplemental technologies selected in October 2003 for further study. A data package based on the initial selected waste forms will be produced by December 2004 to support the 2005 PA. Results from longer term experiments will be reported in reports, annual PA summaries, and the follow-on PA to the 2005 PA.

Because the decision to create an integrated disposal facility is so recent, detail plans on other R&D efforts on solid waste has not been formalized. Such formalization is expected near the end of CY03.

F. R&D NEEDS

The major "core projects" of the Hanford Integration Project have prioritized science and technology needs. The major needs identified were

- Development and determination of long-term performance of surface barriers (Hanford Site Need RL-WT-017)
- Development of remote sensing of contaminants (^{99}Tc, nitrates, uranium) in the subsurface (Hanford Site Need RL-WT-102),
- Development and testing of materials that will chemically bind contaminants (Hanford Site Need RL-WT-061),
- Improved understanding of long-term recharge rates (Hanford Site Need RL-WT-044-S), and
- Improved understanding of moisture movement under arid conditions (Hanford Site Need RL-WT-035-S).

Interestingly, the first three of these are also major needs identified by a recent National Research Council panel on subsurface research needs (NRC 2000).

The ILAW PA activity also identified needs focused on the needs of the PA (Gauglitz 2002): They are

- Determination of compositional dependence of the long-term performance of glass as a waste form (Hanford Site Need RL-WT-066)
- Determination of the change in glass surface area as a function of time (Hanford Site Need RL-WT-016), and
- Standardization of a method for determining long-term waste form release rate (Hanford Site Need RL-WT-015)

VI. SUMMARY OF CHANGES

As noted in Chapter II, there have been major programmatic changes in this activity since the last ILAW PA Annual Summary:

- The removal of the Tc separations step in the Waste Treatment Plant (discussed in Section A)
- The pending decision from the Hanford Solid Waste Environmental Impact Statement Record of Decision to create one integrated disposal site at Hanford at the ILAW site (discussed in Section C)
- The potential of immobilizing low-activity waste using different processes than vitrification at the Waste Treatment Plant (discussed in Section C). The decision whether to produce such waste forms will not be made until 2005.

In contrast, the information on waste form, geology, hydrology, geochemistry, and dosimetry has confirmed the data in the 2001 ILAW PA. Radiological performance objectives established for the 2005 PA are the same as those for the 2001 ILAW PA.

A. INVENTORY

During the past year, the Manager of the Office of River Protection decided (Schepens 2003) that a separate Tc separations process in the WTP was not justified based on cost, efficiency, and environmental impacts. This decision has the impact of increasing the amount of Tc-99 to be disposed of as ILAW WTP glass. As shown in the 2001 ILAW PA (Mann 2001), the lack of Tc separations would cut the 2001 ILAW PA base case margin for groundwater protection (as measured by drinking water dose) of at least 300 by a factor of 3 to a margin of 100.

B. IDF

1. Introduction

Various operations at the DOE Hanford Site in south central Washington State have produced low-level radioactive waste (some of which are mixed with hazardous chemicals). The two DOE Field Offices at the Hanford Site are evaluating options for disposing these wastes. One major alternative being considered is to dispose of all low-level waste other than that generated during CERCLA actions in an IDF. This option is the preferred alternative in the Draft Hanford Solid Waste Environmental Impact Statement (DOE 2003b). A study (Mann 2003) was performed to determine the performance of an IDF near the PUREX plant in Hanford's 200 East Area starting in fiscal year 2006. This study is reproduced in Appendix A.

This study showed that the performance objectives defined for the 2005 ILAW PA effort (Mann 2002b), which are based on the appropriate and relevant regulations, should be met with a reasonable expectation for the disposal of waste planned for the IDF.

2. Sources of Waste

The candidate low-level waste that may be disposed of at the IDF can be classified into four (4) categories:

- **Low-level waste (LLW) -** waste that contains man-made radionuclides but which is not classified as high-level waste or transuranic waste, and not otherwise regulated under RCRA or the dangerous waste management laws of Washington. This waste could have been generated on the Hanford Site or could have been imported from offsite. Category 1 (unstabilized) waste has the lowest level of radionuclides. Category 3 (stabilized) waste has higher concentrations and/or amounts and is grouted before disposal.

- **Mixed low-level waste (MLLW)** - waste that contains man-made radionuclides but which is not classified as high-level waste or transuranic waste and which contains materials that are regulated under RCRA or the corresponding dangerous waste management laws of the State of Washington.

- **Immobilized Low-Activity Waste (ILAW)** - Hanford tank waste that has undergone separations treatment to remove most of the radionuclides and then solidified at the Hanford Waste Treatment and Immobilization Plant (WTP). Presently, the only DOE-approved solidification process is WTP vitrification.

- **Failed or Decommissioned Melters** - High-level and low-activity waste melters used to treat tank waste in the WTP.

3. Performance Objectives

The performance objectives currently being used by the IDF PA activity are those documented for the 2005 Immobilized Low-Activity Waste Performance Assessment, *Performance Objectives for the Hanford Immobilized Low-Activity Waste (ILAW) Performance Assessment* (Mann 2002b). They are based on evaluating all federal and State of Washington relevant and appropriate laws and regulations.

The most significant performance objectives are:

- The all-pathways dose objectives of 25 mrem effective dose equivalent (EDE) in a year

- The drinking water dose objectives for beta and gamma emitters of 4 mrem EDE in a year

- The incremental lifetime cancer risk due to chemicals of 10^{-5}/yr

- The inadvertent intruder all-pathways chronic dose objectives for a post-driller resident of 100 mrem EDE in a year.

The first three objectives are evaluated at a point 100 meters down gradient from the disposal trench and for times of 1,000 and 10,000 years after closure. The last objective is evaluated at the disposal facility at 500 years (consistent with earlier Hanford performance assessments [Wood 1995, Wood 1996, and Mann 2001]).

4. Approach and Major Data Sources

The IDF risk assessment used the data, methods, and knowledge of previous performance assessments that have analyzed the disposal (actual or planned) of the wastes in disposal configurations that differ from the integrated disposal facility concept. There have been two major efforts:

- **Solid Waste Burial Grounds** - In the mid-nineties, the Performance Assessment for the Disposal of Low-Level Waste in the 200 West Area Burial Ground (Wood 1995) and the Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Ground (Wood 1996) were completed and approved by the DOE. These performance assessments have been maintained with the most recent annual summary submitted in September 2002 (Wood 2002).

- **ILAW Disposal Facility (Project W-520)** - The first performance assessment was prepared and approved in 1998. The current performance assessment (Hanford Immobilized Low-Activity Waste Performance Assessment: 2001 Version (Mann 2001) was also approved. This performance assessment is also being maintained with the most recent annual summary issued in August 2002 (Mann 2002a).

Information on the IDF configuration was generated based on the on-going detailed design process. Inventory values for radionuclides and chemicals for various waste types as well as waste form release data and methods are based on the prior performance assessment efforts and their related activities. Geologic, hydrologic, and geochemistry data as well as the methods for flow and transport simulation are also based on prior ILAW performance assessment activities.

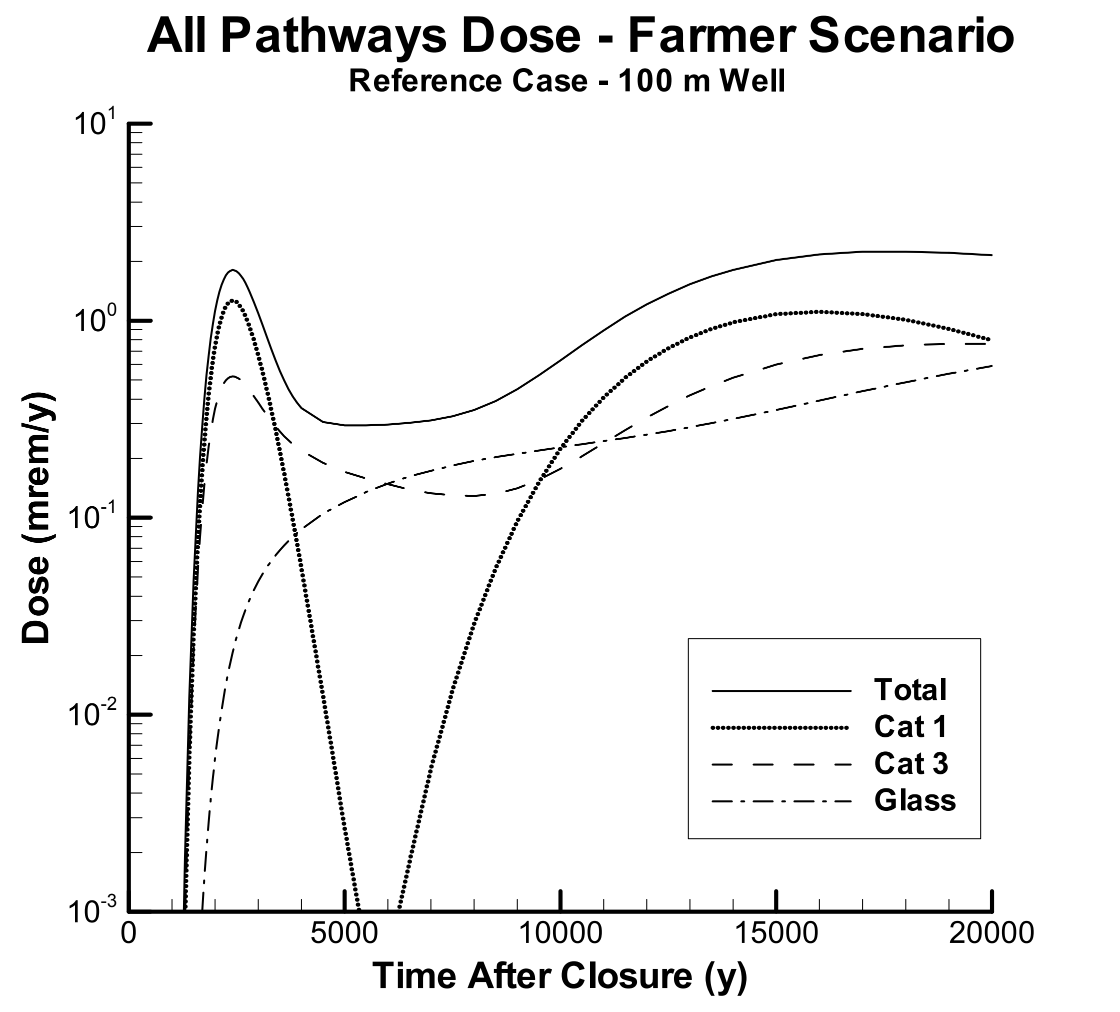
5. Summary of Results for the IDF Risk Assessment

All performance objectives associated with release and migration of radionuclides through the groundwater pathway to the point of compliance are met (ratio of performance objective to estimated impact is a factor of ~6 for drinking water doses and ~12 for all-pathways dose). The performance goals associated with release and migration of hazardous chemicals to the point of compliance are met with an even wider margin (factor of ~8 for drinking water concentrations) than met by radionuclides. The intruder dose performance objective is met with a smaller margin (factor of ~4). These values are a consequence of the much larger impacts of the disposal of Hanford solid waste at the IDF site than the impacts of the disposal of only WTP ILAW. However, the impacts are expected to be lower than if the waste is disposed of in the currently approved Hanford solid waste burial grounds This because the much higher groundwater flow underneath the IDF than in the existing operating Hanford Solid Waste Burial Grounds results in lower groundwater concentrations of radionuclides and hazardous chemicals.

a. Groundwater Impacts.

The groundwater impacts of the three main categories of waste (Category 1 solid waste, Category 3 solid waste, and ILAW glass) have different temporal distributions, as seen from Figure 1. The impacts from Category 1 wastes, which have quick releases, peak early (at ~2,400 years after facility closure for contaminants with K_d = 0 mL/g [such as ^{99}Tc and ^{129}I]) and are insignificant after a few more thousand years for those contaminants. However, slightly retarded contaminants from Category 1 wastes, such as uranium, become important at latter times, reaching a level comparable to Category 3 and ILAW wastes. The impacts from Category 3, which are encased in grout, peak a bit later than the mobile contaminants from Category 1 wastes, but in the same general time frame as mobile contaminants of Category 1 wastes. However, because of the continued release from Category 3 wastes, impacts are still significant at the longest times calculated (20,000 years after facility closure). The impacts from glass are insignificant at the times when the mobile contaminant impacts from Category 1 or 3 wastes peak, but the impacts plateau for longer times (greater than 4,000 years after facility closure).

Figure 1. Time Dependence of the Estimated Farmer Scenario All-Pathways Dose at a Well 100 m Down-gradient from the Disposal Facility. The performance objective is 25 mrem/yr.



The peak groundwater impacts are due to Category 1 waste. The impacts from Category 1, Category 3 and glass wastes are comparable at 10,000 years. Because only a relatively few Category 1 packages are expected to drive the results (i.e., those packages with high technetium/iodine content), the amount of Category 1 waste accepted is manageable (e.g., these wastes can be disposed as Category 3 waste, if necessary). Impacts from melter disposal are not significant relative to impacts from other wastes.

The contaminant groundwater impacts for ILAW-glass disposal are about five times higher than those presented in the base analysis case of the *Hanford Immobilized Low-Activity Waste Performance Assessment: 2001* Version (Mann 2001), but still below performance objectives. The key drivers are increased Tc-99 inventory due to the removal of the technetium separations process from the WTP (Schepens 2003), decreased groundwater dilution due to the placement of the disposal trenches further towards the southern end of the disposal site, and the decrease in contaminant release due to the size of the containers. Additional analyses and assumptions that could reduce the estimated impacts (such as the estimated impacts from a two-dimensional modeling of the near-field (compared to one-dimensional modeling [an improvement from the 2001 ILAW PA and the IDF analysis by about a factor of 25]) and better waste form performance) have not been included in this analysis. These improvements will be explicit in the 2005 IDF PA.

The impacts for the groundwater pathway for solid waste disposal are similar to those presented in the latest annual summary (Wood 2002). A straightforward comparison with the burial ground analysis is not plausible because several key assumptions affecting estimated impacts are different, leading to both increases and decreases in these estimates. For example, hydrogeologic properties of the unconfined aquifer at this site versus the 200 West Area site create a larger dilution effect and lower the estimated impacts. However, in both Wood 2002 and Mann 2003, performance objectives are easily satisfied.

b. Protection of General Public.

The estimated all-pathways doses are significantly lower than the performance objectives during the first 10,000 years (see Table 3). At the DOE time of compliance (1,000 years) the estimated impact is insignificant.

Table 3. Comparison of Estimated Impacts with Performance Objectives for Protecting the General Public. The DOE time of compliance is 1,000 years.

Performance Measure	Performance Objective	Estimated Peak Impact During First 1,000 years [(a)]	Estimated Peak Impact During First 10,000 years [(b)]
All-pathways [mrem in a year]	25.0		
Farmer Scenario		1.2×10^{-10}	1.8
Residential Scenario		0.73×10^{-10}	1.1
Industrial Scenario		0.22×10^{-10}	0.32
Incremental Lifetime Cancer Risk (Chemicals)*	10^{-5}	7.9×10^{-17}	5.6×10^{-7}
Hazard Index (Chemicals)*	1.0	1.8×10^{-11}	0.12

* Based on chromium, nitrate, and uranium inventory
[(a)] Peak impacts occur at the end of the 1,000 year period
[(b)] Peak impacts occur at about 2,400 years after closure

The greatest contributors to the peak all-pathways dose are mobile contaminants from the Category 1 wastes, which peak in the few thousand-year time frame (see Figure 1). Category 3 wastes show a peak at about the same time. For times exceeding 10,000 years, the contributions from the mobile contaminants from glass, contaminants from Category 3 wastes, and the slightly retarded contaminants from Category 1 wastes (uranium isotopes and ^{237}Np) are comparable.

Up to about 5,000 years, the major contributors to the farmer scenario all-path-ways estimated dose are I-129 (~90%) and Tc-99 (~10%). At 10,000 years, Np-237 contributes 44% of the all-pathways dose, Tc-99 contributes 35%, I-129 contributes 17%, and other radionuclides contribute 4%.

c. Protection of the Inadvertent Intruder.

The inadvertent intruder impacts are displayed in Table 4. The time of compliance for protecting the inadvertent intruder starts at 500 years after closure. The acute exposure performance objective is met by a factor of ~500, while the margin for continuous exposure is much lower (about a factor of 4). The maximum acute exposure dose is based on all the exhumed waste being ILAW. ^{126}Sn is the most important radionuclide. The continuous exposure performance objective is met by a factor of approximately four. The maximum homesteader dose is based on all the exhumed waste being LLW/MLLW. ^{241}Pu, ^{243}Am, and ^{239}Pu are the major contributors.

The estimated impacts for the inadvertent intruder can be mitigated through operational controls based on projected container inventories. Such operational controls will be better defined as the project matures.

Table 4. Comparison of Estimated Impacts with Performance Objectives for Protecting the Inadvertent Intruder. The time of compliance starts at 500 years.

Performance Measure	Performance Objective	Estimated Impact at 500 years
Acute exposure [mrem]	500.0	1.06
Continuous exposure [mrem in a year]	100.0	26.8

d. Protection of Groundwater Resources.

Table 5 compares the estimated impacts to the performance objectives for protecting the groundwater resources. At the DOE time of compliance (1,000 years) and the point of compliance (at a well 100 m downgradient of the disposal facility), the groundwater impacts are not significant. For the first 10,000 years the estimated impacts are approximately a factor of six less than the performance objectives for beta-photon emitters and a factor of 150 less than the performance objectives for the alpha-emitting radionuclides for the reference case. The concentration of radium is insignificant. The most important isotopes are the same as those for the all-pathways scenario.

Table 5. Comparison of Estimated Impacts with Performance Objectives for Protecting Groundwater. The DOE time of compliance is 1,000 years.

Performance Measure	Performance Objective	Estimated Impact at 1,000 years [(a)]	Estimated Peak Impact for the first 10,000 years [(b)]
βγ Emitters [mrem/year]	4.0	$4.7x10^{-11}$	0.70
Alpha-emitters [pCi/L]	15.0 [(c)]		
All radionuclides		0[(d)]	0.19
Non-uranium radionuclides		0[(d)]	0.10
Ra [pCi/L]	5.0	0.0[(d)]	0.0[(d)]

(a) Peak impacts occur at the end of the 1,000-year period.
(b) Peak impacts occur at about 2,400 years after closure
(c) The performance objective excludes uranium contribution to the concentration
(d) The estimated impact at 1,000 years after facility closure was less tan $1x10^{-20}$ pCi/L

e. Protection of Air Resources.

Table 6 compares the estimated impacts to the performance objectives for protecting air resources. The DOE time of compliance is 1,000 years and the point of compliance is just above the disposal facility. The estimated impacts are lower than the performance objectives and are based on extremely conservative assumptions.

Table 6. Comparison of Estimated Impacts with Performance Objectives for Protecting Air Resources. The DOE time of compliance is 1,000 years. The point of compliance is just above the disposal facility.

Performance Measure	Performance Objective	Estimated Impact at 1,000 years
Radon [pCi m^{-2} $second^{-1}$]	20.0	2.7
Other radionuclides (^3H and ^{14}C) [mrem in a y]	10.0	0.44

6. PERFORMANCE SENSITIVITY TO KEY PARAMETER UNCERTAINTIES

The key uncertainties of this analysis are as follows:

- Uncertainties in inventory
- Uncertainties in release rates from Category 3 and ILAW
- Uncertainties in retardation for slightly retarded contaminants from Category 1 waste
- Uncertainties in recharge
- Uncertainties in groundwater flow.

The greatest groundwater pathway impacts are from Category 1 and Category 3 solid waste disposal. The inventory for these wastes is quite uncertain since they depend on future decisions. In particular, the amount of offsite waste to be disposed at Hanford as a result of the Solid Waste EIS Record of Decision is uncertain. Better estimates of inventory values for the WTP secondary waste streams are expected as the WTP contractor finishes design and as operations begin.

For long time periods (i.e., over 5,000 years), the impacts are sensitive to the release rates from Category 3 wastes and from ILAW. The release rate from Category 3 waste was estimated based on a representative diffusion coefficient. The use of an effective diffusion model to represent the release rate of contaminants from grouted LLW and MLLW needs to be investigated further. Work is continuing on ILAW release rates and as shown by the latest ILAW annual summary, the ILAW release rates used here are conservative.

Interestingly, the slightly retarded contaminants from Category 1 waste have similar estimated impacts when compared to the mobile contaminants from Category 3 wastes and ILAW. The retardation factor for the slightly retarded contaminants is based on the lowest values thought to be likely in the Hanford environment. More realistic values for retardation would lower the estimated impacts.

Although not explicitly modeled in this document, the 2001 ILAW PA[2] showed the strong dependence of estimated impacts on the rate at which moisture infiltrates the ground surface and subsequently enters the disposal facility (i.e., the recharge rate). Again, conservative values were used in this analysis. Better estimates should lower estimated impacts.

7. SUMMARY

All of the estimated impacts easily meet the performance objectives. The estimated all-pathways dose, beta-photon drinking water dose, and concentration of alpha-emitting radionuclides in groundwater for the reference case are more than a factor of six (6) lower than the corresponding performance objective during the first 10,000 years after facility closure (2046). This margin increases by many orders of magnitude for the time of compliance of 1,000 years, as the travel time through the vadose zone is longer than 1,000 years. These estimates are based on conservative assumptions and hence should provide reasonable expectation that human health and the environment will be protected.

The most significant change from the 2001 ILAW performance assessment[2] is the inclusion of solid waste. Although the total inventories in this analysis are n ot significantly higher than analyzed in the 2001 ILAW performance assessment, the release rates of the solid waste are very much higher. Such higher release rates result in higher impacts than shown in the 2001 ILAW performance assessment. However, such impacts are consistent with impacts estimated in the most recent annual summary of the solid waste performance assessment.

C. SUPPLEMENTAL ILAW TREATMENT

The ORP and CH2M HILL Hanford Group, Inc. (CH2M HILL) are investigating whether there are supplement treatment technologies for low-activity waste that could reduce costs and time durations, yet would protect the environment. With the consent of the Hanford Site regulators (Ecology and EPA), three candidate treatment waste forms (bulk vitrification, cast stone [a cementious waste form], steam reformer) were chosen for initial testing and evaluation in FY 2003. Following this evaluation, the ORP Manager is scheduled to select one or more of these technologies for further investigated in FY 2004. Part of this selection decision will be based on a risk assessment presently being prepared.

Estimated groundwater impacts were calculated using the methodology used in the 2001 ILAW PA (Mann 2001) and the IDF risk assessment (Mann 2003). The results are shown in Table 7 for the current waste form (WTP glass) and the three supplemental waste forms under consideration. An important early finding is that for each of the thermal treatments (WTP glass, bulk vitrification, and steam reforming material) secondary waste causes larger groundwater impacts that do the products themselves. However, the uncertainties in the analyses (inventory of ^{129}I in tank waste, treatment of secondary waste, amount of ^{99}Tc in a salt form from the bulk vitrification process, the iodine effective diffusion coefficient, and the representatives of the steam reforming sample that was tested) make the exact numerical values questionable.

Table 7. Estimated Groundwater Impacts (Beta/Gamma Drinking Water Doses expressed in mrem-EDE/yr) from Disposal of Immobilized Low-Activity Waste at IDF. Each waste form is assumed to have 25% of the total inventory. The point of calculation is a well 100meters down gradient. The performance objectives is 4 mrem/yr

Material	Product Only	Secondary Waste[(a)]	Total
WTP glass	0.101	0.628	0.729
Bulk vitrification	0.000015	0.628	0.628
Cast stone	2.64	0.00074	2.64
Steam Reforming Material	0.00055	0.628	0.628

(a) Secondary waste is assumed to be disposed of as Category 3 waste, i.e., the waste is encapsulated with grout.

D. NEW WASTE FORM DATA

New waste form data that might change the results of the 2001 ILAW PA fall into two categories, the definition of reference glass compositions and other new laboratory results.

The 2001 ILAW PA used LAWABP1 as the reference glass waste form. Recently, The Waste Treatment Plant contractor identified LAWA44 as the reference glass for Envelope A, LAWAB45 for Envelope B, and LAWC22 for Envelope C. Envelope A contains most of the low-activity waste.

As noted in the 2001 ILAW PA, there has been an extensive waste form testing program. At the core of this program were 5 glasses, two of which are LAWABP1 and LAWA44. As noted in the 2002 Annual ILAW PA Annual Summary (Mann 2002a), LAWA44 performs comparable, if not slightly better than LAWABP1. The laboratory tests performed this year (see Appendix B) indicate that the performance of LAWB45 and LAWC22 are comparable to that of LAWABP1.

Other laboratory results have focused on challenges to the underlying theory used in the ILAW PA calculations. Tests have shown that alternative theories are not as adequate as those used in the 2001 ILAW PA.

E. GEOLOGY, HYDRAULIC, AND CHEMICAL RESULTS

Data from the FY 2002 IDF boreholes confirm the data used in the 2001 ILAW PA. Data from other boreholes in the Central Plateau of the Hanford Site show no reason to change geologic, hydraulic, or chemical parameters for the IDF site. Other investigations (e.g. upscaling and anisotrophy) also have shown that the parameters used in the 2001 ILAW PA are appropriate.

F. DOSIMETRY

The dosimetry data package for the 2001 ILAW PA (Rittmann 1999) was updated in order to support Hanford tank performance assessments. The new document, *Exposure Scenarios and Unit Dose Factors for the Hanford Tank Waste Performance Assessment*, Revision 3 (Rittmann 2003), includes two new post-intrusion scenarios, and 128 chemicals. The new post-intrusion scenarios correspond to a rural farmer with a cow and to a commercial farmer, the most likely scenario for future Hanford Site use if current land use in surrounding counties is a guide. Both scenarios would generate lower inadvertent intruder doses than estimated in the 2001 ILAW PA. The other changes are not significant to the conclusions to the 2001 ILAW PA. The exposures to toxic chemicals are evaluated using EPA methods for estimating the lifetime increase in cancer risk from both chemicals and radioactive materials. Other differences can be separated in three categories, general changes, intrusion scenario changes, and irrigation scenario changes. This data package is expected to be used in impact assessments not only for ILAW waste, but also for all waste disposed of in IDF, as well as impact analyses of tank farm closure.

1. General Changes:

- Three additional radionuclides (^{26}Al, ^{41}Ca, and ^{60}Fe) were included in Revision 3.
- Inhalation dose factors use solubility classes more likely to be found in environmental media rather than the worst case assumptions made in Revision 1.
- The Revision 3 food consumption rates are the U.S. Department of Agriculture (USDA) population averages published in 1999, while the Revision 1 rates are EPA numbers from 1986. The USDA averages are based on food production while the EPA averages are based on population surveys.
- In Revision 3 the grains are neither grown in the garden nor irrigated.
- Environmental transfer factors used for plants and animal changed for most elements.

2. Intrusion Scenario Changes:

The intrusion scenarios are the Well-Driller and the Suburban Gardener. The changes between Revision 3 are summarized below. Two additional post-intrusion scenarios (rural pasture and commercial farm) were presented in Revision 3 to include exposure scenarios based on land use in the vicinity of the Hanford Site.

- External dose rate factors used in the Well-Drilling scenario are for a 5-cm thick layer of soil rather than the 15-cm thick layer assumed in Revision 1.
- Scenario dose factors for the Well-Drilling scenario are based on the average soil concentration removed from the borehole rather than the average soil concentration in 15 m^3 of soil. The other exposure parameters are unchanged.
- The post-intrusion garden scenario does not include grains in the garden and has an area of 100 m^2. In Revision 1 the garden included grains and had an area of 200 m^2.
- The external exposure time for the gardener decreased from 900 h/y to 180 h/y.
- The amount of soil inhaled during the year decreased from 573 mg to 87 mg.
- The amount of soil ingested during the year decreased from 36.5 g to 18 g.

3. Irrigation Scenario Changes:

The irrigation scenarios are the All Pathways Farmer (APF), the Native American Subsistence Resident (NASR), and the Columbia River Population (CRP). Revision 1 assumes the only source of contaminated water for the APF and NASR is the groundwater. In Revision 3 a second case is evaluated in which the Columbia River is the source of contaminated water. This second case adds fish and shoreline sediment exposures to the groundwater only case. The changes to the irrigation scenarios in Revision 3 are summarized below. Four additional irrigation scenarios were presented in Revision 3 to include exposure scenarios based on the Hanford Site risk assessment methodology (HSRAM).

- The annual soil inhalation decreased from 573 mg to 539 mg for the APF. There was no change for the NASR. The CRP soil inhalation decreased from 416 mg to 405 mg.

- The annual water inhaled decreased from 0.084 L to 0.054 L for the APF. For the NASR this amount increased from 0.179 L to 45.6 L due to changes in the sweat lodge exposure. For the CRP the annual water inhaled decreased from 0.084 L to 0.039 L.

G. PERFORMANCE OBJECTIVES

The performance objectives for the 2005 IDF Performance Assessment were established (Mann 2002b). The radiological performance objectives are the same as those used in the 2001 ILAW Performance Assessment (Mann 1999a). The main changes were the establishment of integrated chemical performance objectives (incremental lifetime cancer risk and hazard index) which are used in analyses to comply with the hazardous waste laws of the State of Washington.

VII. CONCLUSIONS

As noted in this report, significant amounts of new information have been obtained since the creation of the 2001 ILAW PA. Besides new information on geology, hydrology, and geochemistry, the formulation for the ILAW packages is better defined and the release data are better supported. There is also a better understanding of potential impacts from the inadvertent drilling through the disposal facility. Groundwater impacts are expected to be a factor of three higher than in the 2001 ILAW PA because of the removal of the technetium separations process in the WTP. This increase was calculated in the 2001 ILAW PA.

Considering the results of data collection and analysis, the conclusions of the 2001 version of the ILAW PA (Mann 2001) for the WTP glass remain valid, that the disposal of ILAW glass is protective of long-term human health and the environment. These are the same conclusions that appeared in the draft version of the 2001 ILAW PA that was approved (DOE 2001).

However, with the addition of more waste types into the IDF, impacts at the IDF will be significantly higher than shown in the 2001 ILAW PA. Nevertheless, the impacts are estimated to be below performance objectives. Moreover, the additional waste streams have already been approved for disposal at Hanford (DOE 2001) and the impacts at the IDF site should be lower than at the already approved Hanford Site solid wastes disposal site because of the much greater groundwater flow at the IDF site.

Therefore, the Hanford Site is requesting DOE/HQ to allow construction of the IDF based on the analysis shown in Appendix A, assuming all other requirements or regulatory approvals or permits are obtained. Authorization to dispose of supplemental ILAW technology products and secondary waste would be supported by the 2005 IDF PA.

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