1/14

REVIEW OF THE HANFORD IMMOBILIZED LOW-ACTIVITY TANK WASTE PERFORMANCE ASSESSMENT

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CONTENTS

3/14

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QUALITY OF DATA, ANALYSES, AND CODE DEVELOPMENT

DATA: CNWRA-generated original data contained in this report meet quality assurance requirements described in the CNWRA Quality Assurance Manual. Sources for other data should be consulted for determining the level of quality for those data.

ANALYSES AND CODES: No computer code were used for analyses contained in this report.

1 BACKGROUND

Hanford Site tank radioactive wastes were produced from 1944 through 1988 as a result of reprocessing of irradiated nuclear fuel. The U.S. Department of Energy (DOE) plans to remove the waste from the tanks, separate it into high-activity and low-activity waste streams, and immobilize both types for disposal. The immobilized low-activity tank waste (ILAW) would be disposed at Hanford. The U.S. Nuclear Regulatory Commission (NRC) does not have regulatory authority over Hanford ILAW, but the DOE has requested the NRC to concur in a Hanford Site tank waste management plan that would classify the ILAW as incidental. A key component of the DOE compliance justification for classifying the ILAW as incidental is a performance assessment for the ILAW disposal facility.

This report documents a review of the 1998 DOE *Hanford Immobilized Low-Activity Tank Waste Performance Assessment* (Mann et al., 1998), which is a revision of the *Hanford Low-Level Tank Waste Interim Performance Assessment* (Mann et al., 1996). The latter report was reviewed by the Center for Nuclear Waste Regulatory Analyses (CNWRA) (Mackin et al., 1997) as part of its technical assessment of DOE compliance with NRC criteria for classification of Hanford ILAW as incidental.[1] Following the previous review, NRC concluded that the DOE was in compliance with the criteria, the third of which was addressed by the subject performance assessment (PA).[2] The NRC acknowledged that the interim PA (Mann et al., 1996) was preliminary because "...it was conducted before selection of a disposal facility site and design, specific treatment alternatives, LAW form, or a complete and verified radiological and chemical characterization of the contents of the Hanford tanks."[3] The letter stated that as knowledge of these parameters accrues, the NRC expected that topics raised by the NRC/CNWRA review of the PA[4] would be addressed by the DOE in future PA efforts.

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[1]Bernero, R.M. 1993. Letter (March) to J. Lytle, U.S. Department of Energy. Washington, DC: Nuclear Regulatory Commission.

[2]Paperiello, C.J. 1997. *Classification of Hanford Low-Activity Tank Waste Fraction.* Letter (June) to J. Kinzer, U.S. Department of Energy Washington, DC: Nuclear Regulatory Commission.

[3]Ibid

[4]Bell, M.J. 1997. *Request for Additional Information—Hanford Incidental Waste Classification.* Letter (February) to D. Wodrich, U.S. Department of Energy. Washington, DC: Nuclear Regulatory Commission.

2 COMMENTS

The objective of this study was to review the new PA report (Mann et al., 1998), note differences from the older PA report (Mann et al., 1996), and evaluate whether these differences substantially affect the NRC prior assessment of compliance with the incidental waste criteria.[5] In brief, this review has determined the 1998 report describes a PA not differing substantially from that in the 1996 report. Changes in the 1998 PA are few in number and minor in importance, both in the content of the report and in model implementation. Most changes are for clarification or support of adopted parameters and other model assumptions. The 1998 PA report (Mann et al., 1998) does not reflect a substantive response to reviews by NRC/CNWRA or the DOE External Review Board (ERB) and does not present significant new information on design or waste characteristics. Therefore, there is no new information on which the NRC could base a reassessment of waste classification compliance.

Differences in the 1998 PA report as compared with the 1996 report that are most significant with respect to how the PA is applied, tested, or both are described in this chapter. Appendix A contains a more complete list of changes noted and technical issues not discussed in the earlier NRC/CNWRA review (Mackin et al., 1997). Many of the changes listed in appendix A are noted not because they raise new concerns or provide new information, but because they only appear to do so. It is important to stress that the areas of concerns raised by the previous NRC/CNWRA review remain unresolved by the new PA report (Mann et al., 1998); these concerns are not repeated here except in the context of new information in the PA.

2.1 INTEGRATION OF PERFORMANCE ASSESSMENT WITH DESIGN

Requirements Set by PA, section 6.3 of Mann et al. (1998), is new. This section expands a small subsection on waste acceptance criteria from the 1996 DOE report (Mann et al., 1996) to include a methodology for incorporating the doses calculated from the detailed process models of the PA into a simple source/dose equation for determination of requirements for the waste form and disposal facility design. The method is vague, however, for estimating the parameters for the two components (intruder and groundwater) of the simple source/dose equation. For example, a factor accounting for vadose zone and aquifer transport for each radionuclide contained in k_i^{gw} in Eq. 6-3 of the DOE report (Mann et al., 1998) must be estimated or calculated from the results of complex flow and transport models. The methodology for estimating these composite parameters should be presented. In summary, the concept of integrating the PA into design appears to be a useful addition, but the methodology for this integration needs clarification, refinement, or both.

2.2 OTHER RADIONUCLIDE SOURCES

Several additions to the 1998 DOE PA text (Mann et al., 1998) discuss the potential for sources and conditions at other areas of the Hanford reservation to affect the dose at the receptor location for the 200 West and 200 East Areas. In particular: (i) page 4-11 notes that plumes from the 200 West and 200 East Areas themselves will overlap, (ii) page 4-14 includes a new paragraph discussing the ongoing review of the large-scale site modeling in regard to other sources and addressing inconsistencies between smaller scale models, and (iii) page 4-65 presents a new subsection on composite analysis as described in Kincaid et al.

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[5]Bernero, R.M. 1993. Letter (March 2) to J. Lytle, U.S. Department of Energy. Washington, DC: Nuclear Regulatory Commission.

6/14

(1998), a report to be submitted to DOE, that appears to address other sources. The assessment of the effects of combined sources is a useful addition to the 1998 DOE PA report (Mann et al., 1998).

2.3 NEW SENSITIVITY CASES

Chapter 3 of Mann et al. (1998) contains two new inventory-dependent sensitivity cases (section 3.5.5.2) and one new geochemical-dependent sensitivity case (section 3.5.5.9). One inventory case involved the use of longer half-lives for two radionuclides (^{79}Se and ^{126}Sn), resulting in lower doses. Another case used somewhat higher radionuclide inventory values for a number of radionuclides from the Tank Waste Remediation System (TWRS) standard inventory, resulting in increased doses of 10–15 percent. Inventory values in the 1998 PA (unchanged from the 1996 PA) are not entirely consistent with the most current estimates. The online-accessible TWINS2 database for the most current TWRS best-basis global inventory was reviewed by the CNWRA and found to include values for four radionuclides—^{14}C, ^{226}Ra, ^{228}Ra, and ^{227}Ac—that were an order of magnitude greater than those used in the 1998 PA. This suggests that future PAs should adopt the higher values and perform more appropriate inventory sensitivity analyses.

The new geochemical-dependent sensitivity case uses a K_d of 0.6 ml/g for ^{129}I instead of the base case value of 3 ml/g; the new value is now preferred over the old. The appropriate value of K_d for iodine was also noted in Mackin et al. (1997). Use of the lower value by DOE results in a large increase in groundwater concentration but a minimal increase in dose. The DOE PA investigators have not yet tested a case with a zero K_d for ^{129}I—a value commonly adopted in conservative analyses (Mackin et al., 1997).

2.4 PLANNED MATERIALS TESTING

Section 6.4, which describes further work, comprises a substantial revision of section 5.5 of the 1996 DOE PA report (Mann et al., 1996). Notably, the waste form data section 6.4.2, supplemented by new appendix G, has been enhanced in the 1998 DOE PA report with more detail on planned materials performance testing. The source term used in the 1998 PA is based on the 7-day product consistency test (PCT), and the time-dependent release rate is based on several simplified assumptions; however, the DOE has initiated a long-term testing program. Tests include the single-pass flow-through test (SPFT), the vapor hydration test (VHT), the PCT, and the pressurized unsaturated flow test (PUF). The data from the ongoing testing program should be reviewed by the DOE PA investigators before final decisions are made regarding adopted release rates.

2.5 COMMENTS BY REVIEWERS

A new appendix F discusses comments on the 1996 DOE PA report (Mann et al., 1996) provided by a variety of reviewers: an appointed ERB, the NRC, the U.S. Navy, and internal DOE reviewers. The NRC review and DOE response are documented in a series of letters.[6,7,8] These comments are discussed in this

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[6]Bell, M.J. 1997. *Request for Additional Information—Hanford Incidental Waste Classification.* Letter (February) to D. Wodrich, U.S. Department of Energy. Washington, DC: Nuclear Regulatory Commission.

[7]Paperiello, C.J. 1997. *Classification of Hanford Low-Activity Tank Waste Fraction.* Letter (June) to J. Kinzer, U.S. Department of Energy. Washington, DC: Nuclear Regulatory Commission.

[8]Wodrich, D. 1997. *Request for Additional Information—Hanford Incidental Waste Classification.* Letter (February) to M. Bell, Nuclear Regulatory Commission. U.S. Department of Energy.

report only in relation to new information in the 1998 DOE PA report. Appendix F of the 1998 PA report (Mann et al., 1998) contains a variety of critical comments. Responses in the 1998 DOE PA report were generally of two types (i) a justification is presented for a choice of parameter, scenario, and the like, and (ii) a commitment is made that a better model will result from incorporating specific information on the facility and waste characteristics that will be obtained in the future. A notable quote from the ERB is as follows:

> Consequently, the interim PA findings may be overly optimistic regarding the likelihood that the performance objectives will be met, and may not provide an adequate basis for setting priorities regarding possible additional data collection needed to enhance the reliability of the PA. Furthermore, in some cases, the content and form of the technical documentation needs to be improved to assure technical defensibility (Mann et al., 1998).

The ERB review should prove useful in NRC reviews of future versions of the PA. Appendix A of this report notes several topics raised in appendix F of the 1998 DOE PA report (Mann et al., 1998) not covered in the previous CNWRA review (Mackin et al., 1997). These topics are considered to be unresolved by the DOE PA team responses to the ERB.

8/14

3 SUMMARY AND CONCLUSIONS

The analysis presented in the revised Hanford ILAW PA report (Mann et al., 1998) does not differ substantially from that in the version (Mann et al., 1996) previously reviewed by the NRC and CNWRA. No new data on engineered and natural systems or waste form were incorporated. Most changes provided clarifications or expanded justifications, or more detailed plans for future work that would refine model parameters. Five changes were worthy of special note due to their particular importance to PA:

- An initial effort was made to formalize the integration of design with modeling
- Consideration of composite effects of multiple Hanford Site sources was addressed for the first time
- New sensitivity analyses on inventory and sorption coefficients were performed
- A plan for materials testing for source term information was presented
- An appendix was added containing reviews of Mann et al. (1996) by a DOE expert panel, NRC/CNWRA, and others.

These changes in the report—as well as those listed in appendix A—signify positive developments in the ILAW PA program, but the 1998 PA report does not constitute full implementation of these developments. The deficiencies noted in the NRC/CNWRA review (Mackin et al., 1996) remain unresolved. The new PA does not provide significant new information that would resolve the NRC uncertainties and concerns raised in the previous review of the DOE interim PA.

9/14

4 REFERENCES

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Mackin, P., B. Sagar, R. Pabalan, M. Jarzemba, S. Moulton, and P. Mayo. 1997. *Report on DOE Hanford Tank Waste Classification.* San Antonio, TX: Center for Nuclear Waste Regulatory Analyses.

Mann, F.M., R.J. Puigh, II, P.D. Rittmann, N.W. Kline, J.A. Voogd, Y. Chen, C.R. Eiholzer, C.T. Kincaid, B.P. McGrail, A.H. Lu, G.F. Williamson, N.R. Brown, and P.E. LaMont. 1998. *Hanford Immobilized Low-Activity Tank Waste Performance Assessment.* DOE/RL–97–69. Rev. 0. UC–2050. Richland, WA: U.S. Department of Energy.

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10/14

APPENDIX A

MORE DETAILED COMMENTS ON THE 1998 DEPARTMENT OF ENERGY PERFORMANCE ASSESSMENT REPORT

1. General

   Data on observed groundwater Pu at Hanford from June 1998 should be used by the U.S. Department of Energy (DOE) in constructing radionuclide transport scenarios, establishing transport parameters, or both (see example: www.hanford/gov/press/1998/98-062.html).

2. Section 2.2—Hanford Site Characteristics

   This section has been reorganized, though the substance is largely unchanged. For example, there is a new geochemistry section, but it does not add new data; rather, it provides background on the concept of the sorption coefficient.

3. Section 2.2.7.5.2—Seismic Hazard Assessment

   Figure 2-9 and table 2-1 are inconsistent: figure 2-9 contains peak ground acceleration for comparing different sites, whereas table 2-1 contains horizontal ground motion for the 200 West Area. For seismic hazards, as used in figure 2-9, the lower frequencies are the most destructive. Ground motion as used in table 2-1 does not correspond to the curves in figure 2-9, hence, the meaning of the term ground motion is unclear. The existing vaults are designed to withstand an earthquake with 0.25 g horizontal and 0.17 g vertical acceleration. Using the information in table 2-1, there is a 22 percent chance of an earthquake occurring that exceeds this criterion over a period of 500 yr. In contrast, using figure 2-9, there is 5 percent probability of exceeding this criterion over 500 yr. The references cited in section 2.2.7.5.2 of the 1998 DOE PA report may clarify this inconsistency. This section was unchanged from the 1996 DOE PA report (Mann et al., 1996).

4. Section 3.2.1—Relevant Isotopes

   The 1998 DOE Performance Assessment (PA) report (Mann et al., 1998) adds an explanation of the screening method for constructing the list of relevant isotopes. This appears to have been done in response to comments by the External Review Board (ERB) (appendix F). The screening method appears adequate, given the limited data available on waste characteristics.

5. Section 3.4.4.3—Waste Form Radionuclide Release Rate

   The release rate equation on page 3-39 of the 1998 PA report has not been changed, but the coefficient developed from this equation in table 3-11 has changed. The release rate is a function of constant corrosion rate, time-varying inventory waste surface area, and volume. One of the external reviewers noted the error in the development presented in the 1996 DOE PA report. The Center for Nuclear Regulatory Analyses (CNWRA) report (Mackin et al., 1997) suggested that this equation did not account for the change in the ratio of surface area to volume as the waste degraded. It should also be noted that this release rate equation does not depend on the amount of water percolating through the waste, hence, any sensitivity analysis of the infiltration rate will underestimate the effect of higher infiltration rates.

6. Section 3.4.5—Waste Disposal Facility

A short discussion on a new conceptual design for the disposal sites was incorporated into the 1998 DOE PA report. The new conceptual designs are described in portions of section 2.4, Disposal Facility, of Mann et al. (1998). The first paragraph in section 3.4.5 (page 3-42) was modified to include the rationale for not performing additional sensitivity analyses on the possible future design concept described in section 2.4.2 of Mann et al. (1998). Current PA analyses consider two design concepts labeled as 1 and 2. From the perspective of flow and transport, the primary difference is that the vaults are closely spaced in the concept 1 design, whereas rows of vaults are separated by fill in the concept 2 design. The facility would cover a larger area for the latter design. Mann et al. (1998) suggested that the new conceptual design would perform similar to concept 2 design. Figure 2-27 (2-61, Mann et al., 1998) is drawn to indicate closer spacing of sloped capillary barriers, and hence, an increased likelihood of water diverting around each row of vaults as compared to the concept 2 design. This design feature of slope capillary barriers near all vaults would have an effect on PA. However, the caption to figure 2-27 (Mann et al., 1998) notes that the design has been modified so that only the outermost units will be near sloped capillary barriers; therefore, this new design concept should behave similarly to the concept 2 design. The facility design continues to be in a state of flux.

7. Section 4.2.3—Base Analysis Case Simulation of Aquifer Transport and Section 4.8.3—Hanford Site Composite Analysis

Three changes to Mann et al. (1998) acknowledge the effect of other sources at Hanford on the PA for the vault facility and point to the interaction of the facility modeling with other modeling efforts at various scales at Hanford. Page 4-11 of section 4.2.3 contains a new paragraph discussing the 2 disposal sites and the superposition of plumes, with the implied effects of both sites contributing to dose at the receptor location. Page 4-14, also of section 4.2.3, contains a new paragraph discussing large-scale modeling that is currently undergoing review. The large-scale model could be used to eliminate any discrepancies between the independent smaller-scale models for specific contaminated sites at Hanford. A new subsection, 4.8.3, was added on the Hanford Site Composite Analysis. This subsection discusses the other past and potential contaminant releases that could affect dose at the receptor locations in the 200 West and 200 East Areas. Taken together, these three changes are indicative of a high-level change in the procedural approach to integrate the modeling efforts at Hanford in order to gain a better understanding of effect of the facility on the system, both near the facility and at the receptor location.

8. Section 4.11—As Low As Reasonably Achievable

This is a new section that centers on the need to integrate PA with the design process. No substantial new information is included. Rather, this section reviews the past interaction of PA with engineered barrier design and promises that interaction will continue in the future as the design of the facilities matures. This spells out a high-level procedural approach that was previously implied in Mann et al. (1996).

9. Chapter 5—Results for Inadvertent Intruder Scenario

This is a new chapter, but it is merely a minor revision of the intruder section of chapter 4 of the 1996 DOE PA report. The results are unchanged, but the creation of a separate chapter devoted to intruder analysis may indicate a greater emphasis in future PA efforts.

10. Chapter 7—Quality Assurance

This is a new chapter, largely taken from section 3.6 of the old report. It contains no substantial changes affecting PA, but reflects increased emphasis on QA matters.

11. Appendix E—Detailed Results

Figure E-9 through E-12 of section E.5 now have inexplicably excluded the '9972'curve. In Mann et al. (1996), the labeling of curves for these figures was ambiguous. In the new PA report (Mann et al., 1998), the symbol legend was clarified; however, a curve for '9972' was no longer presented. Though the clarification of symbols was an improvement, it became clear that the curve for year 9972 was not consistent with the other curves in terms of a chronological progression of the spatial data. This may simply have been due to improperly plotted data, or it may be an indication of a problem with the estimation routine that produced the data. This cannot be resolved with the information given.

12. Appendix E, section E.5.3—Key Results

Appendix E contains a new discussion and figures pertaining to waste form releases; normalized ^{99}Tc flux to the vadose zone as a function of pore velocity both with and without ion exchange. There is an increase in the flux of radionuclides due to pore velocity increases. This additional sensitivity analysis addresses one of the inadequacies of previous sensitivity analyses on infiltration rates (i.e., the increased flux through the system did not change the release rates). However, the surface barrier (plants and evapotranspiration) and the capillary barrier (sand and gravel layers), as presented in section 3.4.5 of the 1998 PA report, are still relied on in the base case for 1,000 yr to maintain infiltration at 0.5 mm/yr. After 1,000 yr, the rate reverts to their estimate of the ambient (3 mm/yr). The CNWRA report (Mackin et al., 1997) noted the uncertainty in the magnitude of the ambient rate and the lack of support for the integrity of the surface and capillary barriers for 1,000 yr.

13. Appendix F—ERB Report, section 4.2

One item on which the 1998 DOE PA report disagreed with the ERB was the potential for catastrophic flooding. As part of its response, the DOE stated that they will focus on the next 1,000 yr and use a 10,000-yr period for optimizing design in accordance with DOE guidance. Because DOE expects catastrophic flooding to be further in the future than 10,000 yr, they have not addressed it. They point out that this approach is consistent with NRC regulation of a commercial low level waste (LLW) disposal site on the Hanford plateau.

14. Appendix F—ERB Report, section 4.3

Regarding radionuclide inventory, the ERB suggests the need to consider additional inventory sensitivity cases (e.g., inhomogeneity). The CNWRA agrees with this assessment.

15. Appendix F—ERB Report, appendix B: Conservatism of K_d values (comments by L. Gelhar)

On page F-25, external reviewer Gelhar states that one can make a plausible, technically defensible interpretation of available Hanford data to adopt a K_d for U an order of magnitude lower than used in the PA. Key difficulties in setting a K_d are sampling and analyzing K_d in a heterogeneous medium. This suggests that Gelhar believes the K_d is a parameter that should be subjected to sensitivity studies. On page F-27, Gelhar raises the concern for lack of explicit treatment of the differing transport properties of decay-chain daughters. The 1998 DOE PA report commits to addressing this deficiency in future activities.

16. Appendix F—ERB Report, appendix B: Well screen length (comments by L. Gelhar)

In response to Gelhar's comment on the choice of a 4.6-m screen length leading to greater dilution of radionuclides than a more reasonable, shorter screen length, a new paragraph was added on page 4-61 defending the choice of the greater screen length. No basis was added to support this defense but it was noted that this length "... may seem large for sites in the Eastern United States, but this well screen height is lower than typically used on Hanford Site wells." The DOE should provide a stronger basis for choosing 4.6 m (e.g., a survey, reference to a document, or State database on wells).

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