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A Division of Southwest Research Institute™
6220 Culebra Road • San Antonio, Texas, U.S.A. 78228-5166
(210) 522-5160 • Fax (210) 522-5155

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Contract No. NRC–02–97–009
Account No. 20.01402.766

U.S. Nuclear Regulatory Commission
ATTN: Mr. James Firth
Office of Nuclear Material Safety and Safeguards
Division of Waste Management
Performance Assessment and HLW Integration Branch
Mail Stop 7C-18
Washington, DC 20555

Subject: Transmittal of Risk Insights Project Plan (AI 20.01402.766.220)

Dear Mr. Firth:

The purpose of this letter is to transmit the subject report, which fulfills the fiscal year 2002 deliverable Risk Insights Project Plan—Letter Report (AI 20.01402.766.220). The report describes the issues that will be investigated for their risk significance and documented in the risk insights report. The report indicates that six issues will be studied in more detail to determine whether more detailed modeling than that currently used in the TPA code would be useful because of the potential to affect calculations of repository performance. The issues that will be investigated and documented in the risk insights report include: (i) water flow paths in and near drifts, (ii) localized corrosion of C-22, (iii) dose from the use of an evaporative cooler, (iv) sufficiency of groundwater protection calculations, (v) effects of ventilation, and (vi) site-specific distribution coefficients. The report describes each of these issues and explains why each needs to be investigated in greater detail.

If you have any questions about the report, please feel free to contact me at (210) 522-5082 or Mr. James Weldy at (210) 522-6800.

Sincerely yours,

for Gordon W. Wittmeyer, Ph.D.
Manager, Performance Assessment

GW/cw
Enclosure

cc:

J. Linehan	W. Reamer	W. Dam	W. Patrick	O. Pensado
B. Meehan	S. Wastler	C. McKenney	CNWRA Directors	O. Povetko
D. DeMarco	T. McCartin	M. Rahimi	CNWRA Element Managers	J. Weldy
E. Whitt	B. Leslie	R. Johnson	T. Nagy (SwRI Contracts)	
J. Greeves	D. Esh		P. Maldonaldo	
J. Piccone	R. Codell		R. Benke	
T. Essig	M. Lee		S. Mayer	

Washington Office • Twinbrook Metro Plaza #210
12300 Twinbrook Parkway • Rockville, Maryland 20852-1606

RISK INSIGHTS PROJECT DESCRIPTION

Prepared for

U.S. Nuclear Regulatory Commission
Contract NRC–02–97–009

Prepared by

J. Weldy
S. Mayer
O. Pensado
O. Povetko
R. Benke

Center for Nuclear Waste Regulatory Analyses
San Antonio, Texas

November 2001

ABSTRACT

The assessment of performance of the Yucca Mountain repository requires the development of complex models to simulate repository behavior over thousands of years. The TPA Version 4.1 code (Mohanty, et al., 2000) was designed to model this behavior through a combination of detailed process models and simplified abstractions of processes. Some of these simplified models may not reflect realistic behavior of the repository because they include simplifying assumptions which generally lead to conservative results. The risk insights project is intended to evaluate several of these simplified models to better define the degree of realism built into them. Also, the risk insights project will determine how much the inclusion of more detailed models would change the results of the performance assessment. This project description outlines the issues that will be investigated in detail in the risk insights project.

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ACKNOWLEDGMENTS

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1 INTRODUCTION

As part of their preparation to review any future license application for a high-level nuclear waste repository, the U.S. Nuclear Regulatory Commission (NRC) and Center for Nuclear Waste Regulatory Analyses (CNWRA) developed the TPA Version 4.1 code (Mohanty, et al., 2000). This computer code simulates the performance of the engineered and natural barriers of the geologic repository and quantifies repository performance in terms of dose to a receptor individual. Models within the TPA Version 4.1 code vary from complex models that attempt to explicitly model physical processes that may affect repository performance to abstractions of the results of more complex models that depend on simplifying assumptions. The risk insights report is intended to document the results of detailed analyses of these processes that have been simplified within the TPA code. The goal is to determine the effect of these simplifications on the risk estimate and to determine how more realism may be incorporated into TPA simulations. Even if the results of these evaluations indicate that a more realistic treatment of the process would not significantly affect the risk estimate, the documentation of these results will bolster the justification for these simplifications in the TPA code. A better understanding of the risks associated with complex processes in the repository system will assist the review of any U.S. Department of Energy (DOE) license application by allowing staff to focus their review on DOE models that most affect the performance of the repository system.

2 TOPICS TO BE INVESTIGATED

The following sections list six topics that will be investigated in the risk insights project. The level of detail of each investigation will be determined as information is gathered on the risk significance of the more detailed model. Other topics identified in the issue resolution process or from sensitivity studies may be investigated should budget and schedule permit.

2.1 Flow Paths In and Near Drift

Currently, flow (in the absence of thermal effects) above the drift is modeled by imposing a capillary barrier in the continuum flow field, which forces lateral diversion of flow around the drift location. Three distinct but correlated F-factors determine how much water enters the waste packages in the dripping abstraction: F_{ow}—to account for possible flow focusing; F_{mult}—to account for near- and in-drift flow diversions; and F_{wet}—to account for the fraction of waste packages receiving a dripping flux. The current values of these parameters are based on estimates or simplifying assumptions and not on the results of detailed process level models. Risk may be under- or over-estimated if the amount or frequency of seepage is under- or over-estimated. As a first approximation, these effects could be studied by considering a mass balance of the film flow along the inner tunnel wall, the seepage, the water diverted around the drift, and the overall percolation flux. Each of these flow components needs to be approximated. These approximations include the theoretical maximum possible film flow rate based on film thickness, dripping (seepage) from that film based on distribution of pores and fractures and on percolation flux, and diverted flux around the drift based on an effective capillary pressure (which considers the influence of a water film inside the drift walls). This mechanistic modeling will produce more defensible values for the flow parameters (the F-factors) in the TPA code.

These suggested risk insight studies will assume an open, intact, noncollapsed drift during the regulatory period. In later studies, possible degraded states of the system may be considered. Currently, film flow along the inside walls is assumed to bypass the waste and therefore is excluded from the total water available for release of radionuclides. However, if the waste packages are already degraded and collapsed on the invert, then this flow could potentially reach the degraded waste forms and contribute to the total water available for release of radionuclides. In future versions of the TPA code, improved abstractions of flow within the drift may be developed to consider the evolution of water available for release as a function of the state of degradation of the engineered barrier.

2.2 Localized Corrosion of C-22

Current models of waste package corrosion within the TPA code consider the environmental conditions within the drift to compute corrosion potentials and critical potentials for localized corrosion. Localized corrosion is assumed to occur when the corrosion potential is above the critical potential during conditions where the chloride concentration and relative humidity are above defined thresholds. Due to the need for relatively simple models within the TPA code, some assumptions have been made such as requiring the pH of the solutions contacting the waste package to be around 9. The TPA Version 4.1 code basecase results indicate that localized corrosion of C-22 does not occur within 10,000 years or even longer time periods. However, if the assumption of constant pH is relaxed, it is possible that the corrosion potential may exceed the critical potential, and localized corrosion could begin, depending on the concentrations of other chemicals on the surface of the waste package. The waste package is an important contributor to the performance of the repository, and the occurrence of localized corrosion could lead to early doses. This study will investigate the sufficient and necessary environmental conditions for the onset of localized corrosion of Alloy 22, consistent with equations implemented in the TPA Version 4.1 code. Once these environmental conditions are identified, investigations will be performed to determine whether the establishment of localized corrosion environmental conditions in the Yucca Mountain system is possible.

If it is determined that development of environmental conditions that could result in localized corrosion of the waste package is credible, the risk significance of localized corrosion will be determined by analyzing the consequences of localized corrosion using the TPA Version 4.1 Code.

2.3 Dose from an Evaporative Cooler

The use of evaporative coolers is common in hot, arid environments like southern Nevada. The use of contaminated groundwater in an evaporative cooler constitutes a potential exposure pathway not currently considered in the TPA code. This study will investigate the typical parameters associated with the use of evaporative coolers, including the location of the cooler on the house, the length of time that coolers are used, and the fraction of dissolved minerals released to the air and available to be inhaled. If determined necessary based on risk significance, and if time and budget permit, limited experimentation may be performed to determine the fraction of dissolved minerals in the water that is released to the air.

The results of this study will be a quantification of potential dose pathways associated with evaporative coolers and a determination of whether the dose from the use of contaminated

water in evaporative coolers is significant compared to the dose from drinking and farming with the same contaminated water. If this pathway is determined to be significant, the results of this study could be used to add this pathway to the TPA code.

2.4 Sufficiency of Groundwater Protection Calculations in the TPA Code

The final 10 CFR Part 63 includes requirements for groundwater protection not previously included in the draft 10 CFR Part 63. The TPA Version 4.1 code includes the capability to calculate the necessary output to determine compliance with the groundwater protection standard, but little work has been conducted to exercise this part of the code. This study will investigate the sufficiency of the TPA code to perform the groundwater protection calculations, including whether any additional radionuclides need to be added to the TPA code to provide an appropriate calculation of the gross alpha, beta/gamma, and radium limits of the groundwater protection requirements in 10 CFR Part 63.

Additionally, this study will investigate which limit within 10 CFR Part 63 is most likely to be exceeded based on calculations with the TPA code: 15 mrem/yr total effective dose equivalent from all pathways, 4 mrem/yr to the whole body or any organ from beta/gamma emitters, 5 pCi/L of combined Ra-226 and Ra-228, or 15 pCi/L of total alpha, excluding uranium and radon. The results of this study will also identify the radionuclides that contribute most toward the dose or concentration limits in 10 CFR Part 63.

2.5 Ventilation and Its Impact on Experimental Results

The low thermal operating modes of the repository identified in the recent DOE repository designs include the option for ventilation of the repository for some time following waste emplacement (DOE, 2001). Current ventilation of the tunnel has lead to a substantial localized dryout zone, with potential to alter experimental conditions from the "natural" subsurface near-drift and in-drift conditions. Experiments conducted in these drier conditions may not represent the seepage and transport properties under natural (wetter) conditions. As a consequence, results of models calibrated to the drier state of the repository system may not be transferable to the nonventilated wetter environment at the drift.

The scope of this study will be to identify and evaluate the most significant implications of the ventilation (i.e., of the artificial dryout zone) on DOE experimental results and observations in and near the drift. Calculations will be performed to determine how models based on these experimental results may be changed by the artificial dryout and whether changes to these models would affect the estimated performance of the repository. The models for radionuclide transport and seepage estimates are most likely to be affected by ventilation, and risk insights will be gained related to these models in the TPA code.

2.6 Site-specific Distribution Coefficient Values

Current values of the distribution coefficients (K_d) of radionuclides in the biosphere are based on generic values for sandy soils as reported in Sheppard and Thibault (1990). However, distribution coefficients are strongly dependent on site-specific conditions, including the pH and carbonate concentration of the top soil pore water. This study would investigate how site-specific distribution coefficients compare to the generic values reported in Sheppard and

Thibault (1990). After determining an appropriate range for the distribution coefficients for key radionuclides in the TPA code, calculations will be performed to assess whether these more appropriate distributions for distribution coefficient values affect the results from the TPA code.

Additional batch experimentation may be conducted with soil samples to determine whether colloid formation in top soil is likely to occur for the significant radionuclides (Pu-239, Np-237, AM-241, and Tc-99) in the TPA code, which could constitute a more rapid removal rate from the top soil than would be predicted by the distribution coefficient model of radionuclides leaching out of surface soils. If evidence is found of colloid formation in surface soils, calculations will be performed to determine the risk significance of this removal process for both the nominal scenario and the volcanism scenario.

3 SUMMARY

The risk insights project will evaluate six specific elements included in, or potentially important to, the total system performance, as outlined in Sections 2.1–2.6. Each element was selected because of its high likelihood to be risk significant, because there are related agreements requiring DOE to further study the issue, and because further work is needed to provide (2.1, 2.3, and 2.6), enhance (2.2, and 2.4), or correct (2.5) the technical basis for the corresponding abstraction. The proposed work for this project will establish an improved technical basis to assess the respective risk significance.

The results of these six risk insights studies will be used to support the issue resolution process, because technical staff will develop specific expertise in areas in which DOE has agreed to perform further analyses. This expertise will allow staff to evaluate whether or not the DOE anticipated work will be sufficient to fulfill the agreements.

The risk insights studies will also be used to guide future TPA code development. In most cases (2.1, 2.2, 2.5, and 2.6), the potentially needed development of the TPA code is limited to changes in input parameters. If risk insight studies related to the dose from an evaporative cooler (2.3) show the need to include this dose pathway in the TPA code, a minor code change affecting the generation of input files and the transfer of parameters will be required. If the risk insights studies related to groundwater protection (2.4) shows a need to add more radionuclides to the TPA code, a minor change in the code will be required if these added radionuclides can be included with, or replace any of the existing 43 radionuclides currently in the code. Otherwise, the required code change would be significant.

4 REFERENCES

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