Nevada National Security Site (NNSS) Environmental Remediation Using EPA's Model Evaluation Guidance to Move to Closure -15588

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ABSTRACT

The National Nuclear Security Administration Nevada Field Office (NNSA/NFO) has adapted the Environmental Protection Agency's guidance on environmental model evaluation as a framework for evaluating corrective action investigation models. Model evaluation is an important confidence building activity, which is needed to support closure of the Nevada National Security Site (NNSS) Corrective Action Units (CAUs) associated with underground nuclear testing. Through this process, site-investigation models of groundwater flow and contaminant transport are reviewed and compared to new site-specific data to determine if the results can be used to support regulatory decisions required for closure and to achieve NNSA/NFO site management objectives. The regulatory decisions include identifying and establishing CAU regulatory boundaries; identifying institutional controls, including use-restriction boundaries; and developing a long-term closure monitoring program. A successful case study from Frenchman Flat, Nevada is used to illustrate the model evaluation process. Groundwater flow and transport from two of the 10 underground nuclear tests in Frenchman Flat had the largest potential for contaminating groundwater, and were selected for evaluation. Wells were drilled, logged, hydraulically tested, sampled, and analyzed for radionuclides and the data was evaluated with respect to previous site conceptualization and numerical model results. The approach and results of this process as applied to the PIN STRIPE test and how it helped build confidence to close the Frenchman Flat CAU is described in this case study.

INTRODUCTION

Underground testing of nuclear weapons in deep vertical shafts and tunnels was conducted from 1951 to 1992 at the NNSS which is approximately 65 miles northwest of Las Vegas, Nevada. Ten underground nuclear tests were conducted in Frenchman Flat [1]. The underground test area (UGTA) activity was initiated in order to assess the risk to the public from groundwater contamination produced as a result of nuclear testing, and is governed by a *Federal Facility Agreement and Consent Order (FFACO)* [2] between the U.S. Department of Energy, the U.S. Department of Defense, and the Nevada Division of Environmental Protection (NDEP). The FFACO has four stages: corrective action investigation plan (CAIP), corrective action investigation (CAI), corrective action decision document (CADD)/corrective action plan (CAP), and closure report (CR). Frenchman Flat has been in the CADD/CAP stage since 2011, focusing on model evaluation to ensure that existing models provide adequate guidance on the future potential for radionuclide migration in groundwater for regulatory decisions regarding monitoring and institutional controls [1]. The UGTA strategy transitions from site characterization in the CAI, to confidence building in the CADD/CAP where model evaluation occurs, and finally to closure in the CR when long-term monitoring data provides evidence of successful closure.

The US EPA [3] issued guidance on the development and application of environmental models that was adapted by UGTA in the CADD/CAP stage. The challenge facing model developers and users is determining when a model, despite its uncertainties, can be appropriately used to inform a decision.

Model evaluation is the process used to make this determination. Key relevant concepts include the following:

- Models are not crystal balls, and must be confronted with data.
- Even a “perfect” model may deviate from observed field conditions at some time.
- It is not possible to prove a model’s predictions are correct, but it is possible to prove it is incorrect with new data and analysis.
- Expert knowledge can qualitatively establish model reliability through consensus and consistency. An expert panel composed of model developers and stakeholders can determine whether there is agreement that the methods and outputs of a model are consistent with the best-available understanding of the site.

The US EPA model evaluation process adapted for UGTA is incorporated in the 5 steps in the CADD/CAP stage as shown in Figure 1. The major steps in this process include data collection to address remaining key uncertainties, evaluation of the model forecasts with the new data, review by an expert panel, and model revision as necessary.

As described by the US EPA [3] subject-matter experts reviewed the model evaluation data and analysis presented by the model developers. The reviewers were knowledgeable in the hydrogeology, geology, testing history, and radiochemistry of Frenchman Flat. Consensus was required from the panel and the developers in order to progress to the next regulatory stage; that is, both the panel and the developers had to feel that the results were sufficient to provide guidance for developing the institutional control boundary and long-term monitoring system in the closure stage. Final approval by NDEP is also required (see Figure 2).

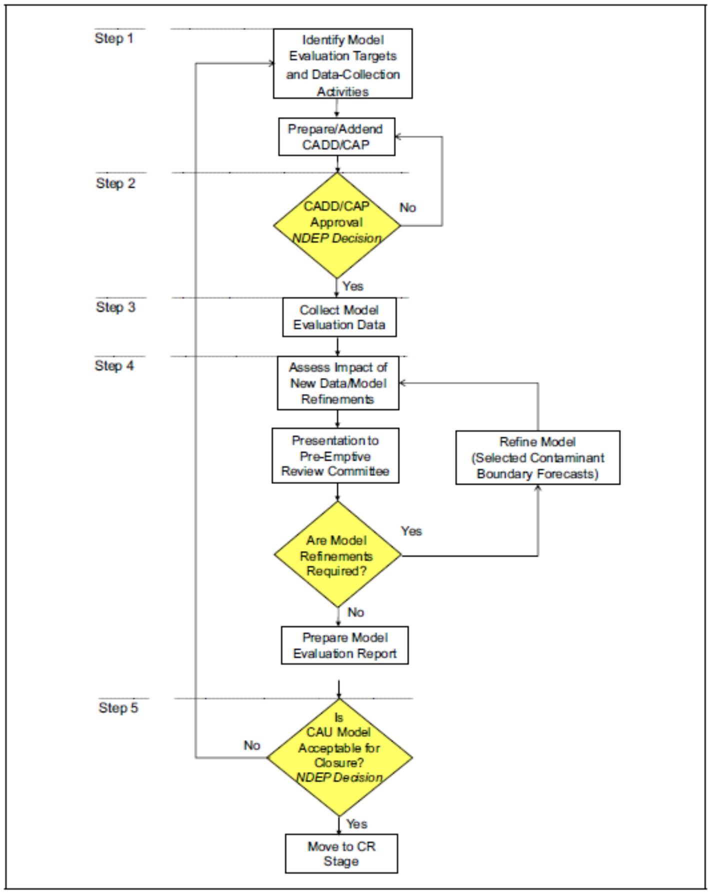

Figure 1-1
Process Flow Diagram for CADD/CAP Model Evaluation Process
Source: NNSA/NSO, 2011

Figure 1 Process Flow Diagram for CADD/CAP Model Evaluation Process

DESCRIPTION

The CAI groundwater flow and transport modeling concluded that the largest uncertainty in forecasts of radionuclide transport belonged to the tests known as MILK SHAKE and PIN STRIPE [4]. The data collection activities in the CADD/CAP focused on these two areas [1]. Two new wells were drilled as shown in Figure 2. Data collection activities included geologic and geophysical logging, water level monitoring, hydraulic testing, and sampling.

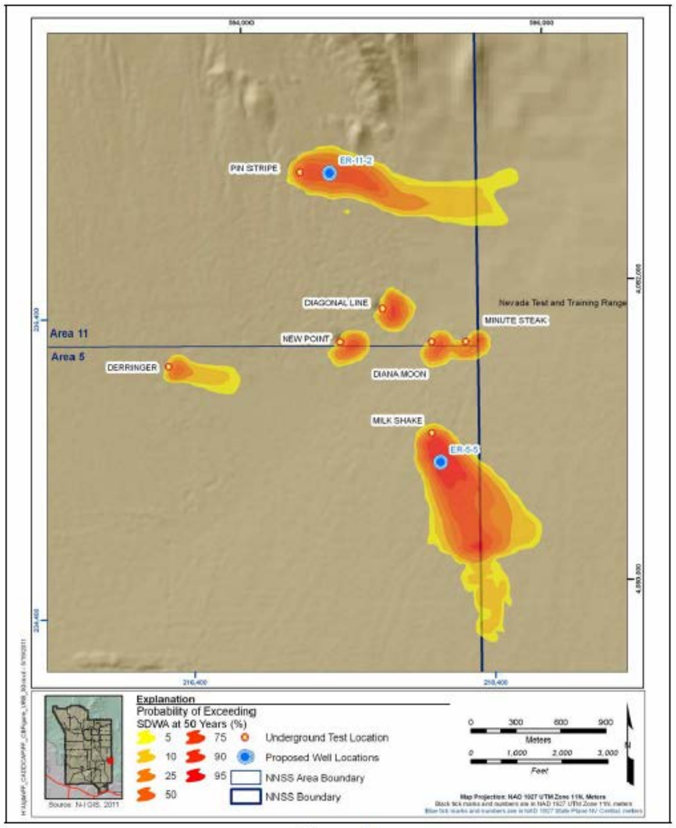

Figure 4-5
Recommended Locations for the Frenchman Flat Model Evaluation Wells

Figure 2 New Well Locations for CADD/CAP Model Evaluation

Model evaluation begins with a qualitative and/or quantitative analysis of the new data to assess their impact on the flow and contaminant transport model by the modeling team. The modeling team presents the results of the analysis to the subject matter expert committee (also called the pre-emptive review committee). The presentation also includes the modeling team's preliminary recommendation for model refinements, additional data collection, or advancement to the CR stage. A recommendation for model refinement is based on whether the new data support changes to the conceptual model, such as a different direction of contaminant transport (lateral or vertical), or significantly greater distances of contaminant transport than forecasted. The modeling team will also determine whether the new data indicate that some of the alternative contaminant-transport forecasts can be eliminated or given more credence. A recommendation for additional data collection will be made if the new data are determined to be insufficient for addressing model uncertainty; model refinement may not be recommended until additional data are collected. A recommendation to proceed to the CR stage will focus on the adequacy of the model for designing a long-term monitoring network for closure and developing effective institutional controls to restrict public access to groundwater. The recommendations made by the modeling team may be based on scientific judgment rather than quantitative measures.

The pre-emptive review committee then provides the modeling team with recommendations for the path forward. If model refinements are required, the refinements are performed; model refinements may involve re-evaluating some, but not all, of the model forecasts. After model refinement, the process returns to the beginning of Step 4. The modeling team assesses the results of the model refinements and presents their assessment to the pre-emptive review committee.

DISCUSSION

Well ER-11-2 was drilled to the east of the PIN STRIPE underground nuclear test as shown in Figure 3. The forecast potential groundwater contamination was one of the largest in Frenchman Flat, and was projected to go east through a high–transmissivity, fractured, welded-tuff aquifer.

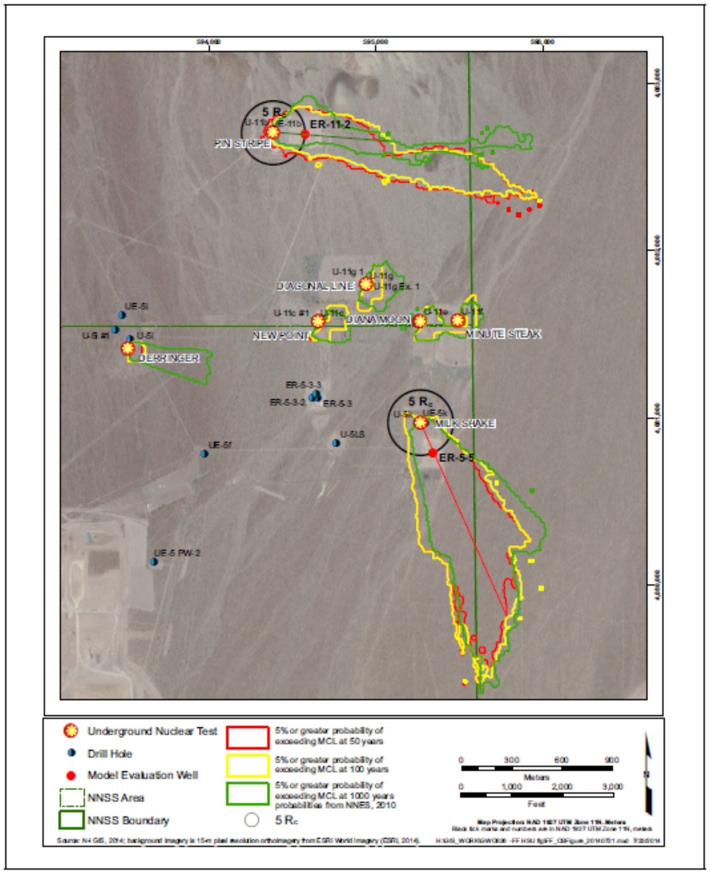

Figure 2-2
Satellite Image of Northern Frenchman Flat Showing Forecast CBs for the Northern Testing Area Underground Nuclear Tests
Note: Cavity radius is calculated using the maximum of the announced yield range in DOE/NV (2000) and Equation (1) in Pawloski (1999).

Figure 3 Satellite Image of Frenchman Flat Showing Forecast Groundwater Contamination and Evaluation Wells

This contaminant forecast was identified as uncertain during the corrective action investigation based on the plausible geologic interpretation that undocumented buried north–south-striking normal faults may be present that would offset the aquifer sufficiently to disrupt the flow path.

Well ER-11-2 demonstrated that this uncertainty was justified. As a result, the conceptual model of flow and transport from PIN STRIPE required refinement. The local geology and hydrology were reviewed to develop this conceptual model as well as its uncertainties.

The refined conceptual model near the PIN STRIPE underground nuclear test included the following elements:

- Low-permeability rocks to the east and north essentially prevents groundwater flow in those directions.

- Recharge and known areas of high hydraulic head suggest groundwater flow also cannot be strongly westward or northward.
- Flow to the east is not possible based on the hydraulic data from Well ER-11-2.
- Recharge on the mountains, southeast-trending land surface, and water-level observations suggest flow should be approximately south.
- Low recharge, small horizontal hydraulic gradients, and old groundwater ages suggest very limited inflow to the Frenchman Flat basin.
- Low (0.2 m/yr) horizontal groundwater velocities are estimated in all saturated rocks in the immediate vicinity of PIN STRIPE, reducing the source release by limiting through flow.
- The flow path best-supported by the hydraulic and geologic data is truncated about 200 m away from the source location, where the cross-sectional area for flow increases and velocity decreases to less than 1 m/yr.

Rather than extensive and costly recalculation of probabilistic contaminant boundary forecasts, the model evaluation team recommended to the panel that easily-understandable calculations could be completed that would provide the needed guidance for establishing regulatory boundaries [5]. The uncertainty observed in the direction of flow was incorporated in these calculations and the maximum velocity was used to ensure conservatism. The resultant transport forecasts are shown in Figure 4 [5].

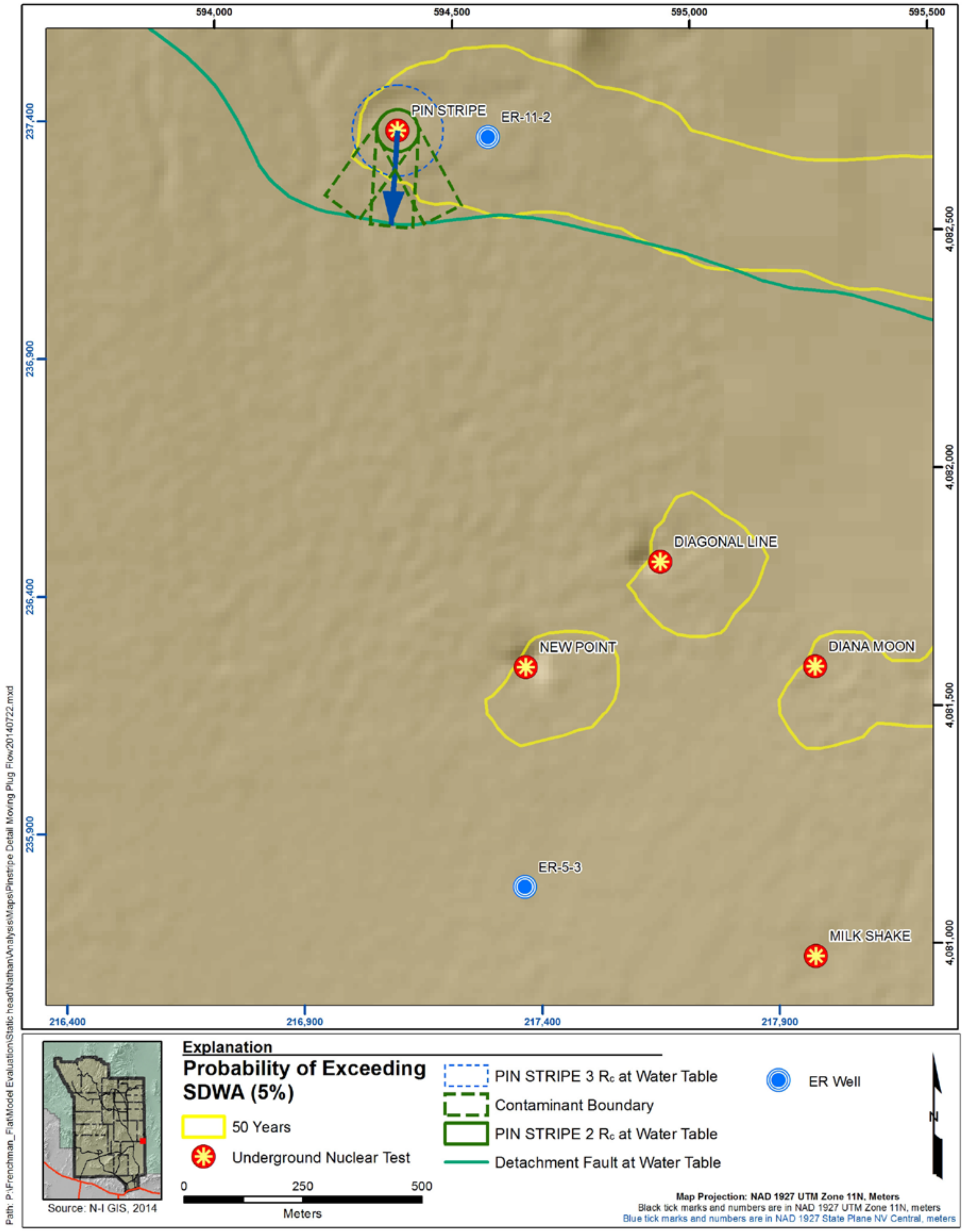

Figure 4 Updated contaminant boundary forecasts for PIN STRIPE from CADD/CAP Model Evaluation

The recommendations of the model-evaluation team were accepted by the panel of subject-matter experts and regulator (NDEP) and documented in a model evaluation report [5]. This report was specifically designed to incorporate all data and equations needed to perform the calculations and comments by the review panel and NDEP to make the process transparent for the public.

CONCLUSIONS

By adapting the EPA guidance the UGTA activity was able to successfully complete a model evaluation that included data collection based on key uncertainties, data evaluation focused on regulatory objectives, and model refinement to support regulatory decisions. By engaging the review panel throughout the process the model evaluation team was able to receive timely comments and incorporate alternative perspectives quickly. Maintaining both the panel and model-evaluation team’s focus on regulatory objectives and designing the evaluation data collection for specific targets was essential to the success of the evaluation and building confidence for further regulatory decisions.

REFERENCES

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