MEMORANDUM | June 19, 2012

TO Hanford Natural Resource Trustee Council (HNRTC)

FROM Nadia Martin and Jack Robertson, Industrial Economics, Inc. and Dale Engstrom, Oregon

SUBJECT Summary of Expert Panel: The Development of an Integrated Approach for Assessment of Injury to Resources in the Hanford Vadose Zone and Groundwater

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This memorandum provides a summary of the discussion and recommendations from the Hanford Vadose-Groundwater Expert Panel, held in Richland on Tuesday, June 5, 2012 from 8:30 am to 4 pm in room 152 of the Federal Building. The panel agenda is provided in Appendix A, the charge memorandum in Appendix B, and a list of panelists and attendees in Appendix C.

The memorandum is organized into two main sections:

- *Section 1*: the executive summary, which provides a brief description of the main discussion points and recommendations; and,
- *Section 2*: the discussion section, which provides a more detailed description of the panel discussions.

SECTION 1 EXECUTIVE SUMMARY

The discussion began with introductory remarks from Dale Engstrom (Oregon) on the panel's goal for the day. Mr. Engstrom addressed the task of making recommendations to the HNRTC for integrating the assessment of vadose zone and groundwater contamination into the groundwater estimate of damages, and in particular recommendations on injury studies that might likely affect that estimate.

MAIN DISCUSSION POINTS

- The panelists agreed that the probable radioactive contaminants of concern include uranium, technetium-99, iodine-129, and possibly plutonium and americium. There are also non-radioactive contaminants of concern, such as carbon tetrachloride, hexavalent chromium and nitrate.
- The water flux and contaminant flux to the saturated zone is one of the most important factors to characterize for purposes of integrating vadose zone contamination into the groundwater assessment (including an inventory of the degree of saturation and spatial distribution of water and an inventory of the concentrations and spatial distribution of contaminants).
- Panelists agreed that integrating the vadose contamination within a groundwater approach is a complicated task. Many argued that the best way to proceed would be to address the problem by using a simplified approach and slowly add complexity as needed for a natural resource damage assessment (NRDA). For

instance, a simple model could be used to reduce uncertainty and develop bounding calculations before adding complexity.

- A second option for integrating vadose contamination into the groundwater model is to study the complexities of the issue at one location where a lot of data is available, and then apply findings to other locations on the Hanford Site ("the Site").
- Since the task is very complex, and there will be uncertainties regardless of the chosen approach, it is best to both identify and quantify the uncertainties. Incorporating confidence intervals and Monte Carlo techniques are ways to provide a range of results and to quantify degrees of uncertainty.
- The panelists concluded that for purposes of a NRDA, there does not need to be more characterization than would normally be required for remedial purposes. It is well understood that the groundwater is contaminated and it is unlikely that all of the contamination will be cleaned up. Therefore, by using existing data on the extent of plumes, and models (to understand the system and project what will happen in the future under current remedial measures), it may be possible to predict future contamination levels and how much will reach groundwater and the Columbia River. The significant unknown in that regard is potential future increases in contaminant inflow from the vadose zone to the saturated zone. Such increases could increase the volume of injured groundwater and the time period in which it remains injured. It is important to take advantage of the existing data, such as pump-and-treat data and injection test data, to estimate the flow/flux of contaminated water through the unsaturated and saturated zones.
- Panelists discussed the importance of considering longer-term effects or events. Specifically, in a 1,000 + year time frame, what additional characterization efforts would be worthwhile to pursue.

RECOMMENDATIONS FOR STUDIES

The panel developed the following list of recommendations:

- Develop a comprehensive atmosphere to groundwater model.
- Calibrate a past model using one set of data to assess how well the models reproduce that data.
- Conduct geo-statistical analysis of sediment facies and grain size in trenches or outcrops to improve the geo-statistical characterization of these sediments in 2D.
- Agreed that a study to characterize the depth of contamination would be useful, but could be fairly expensive.

Using Existing Data

The panel discussed additional recommendations that would utilize existing data. Although there is uncertainty regarding the vadose zone and distribution of contaminants in the saturated zone, a substantial amount of relevant data has been collected at the Site and efforts should focus on utilizing those data.

- Compile data from lysimeter studies, with a stable isotope analysis with depth.
- Use data from vadose injection well tests to learn about movement of contamination in vadose zone. Also, consider doing additional vadose zone water injection tests with appropriate model analysis.
- Use cross-borehole geophysics along with data from pump-and-treat systems estimate the flux of contaminants into the system over the time period in which pump-and-treat systems were operating.
- Use cesium-137 and cobalt-60 monitoring data from tank C108 to model contaminant movement. This data has been collected over the past 30 to 35 years using subsurface gamma spectral logging to track the migration of these radionuclides from the tank source.

SECTION 2 PANEL DISCUSSION

Mr. Engstrom began the panel with a discussion of the goals and objectives for the day. The goal for the panel was to provide recommendations and advice to the HNRTC to help them develop an integrated groundwater-vadose approach to assessing injury to groundwater resources, including recommendations on injury studies that will help the HNRTC quantify injury and damages as a result of vadose contaminants. Typically in a NRDA, damages to the vadose zone are not calculated directly, but instead vadose zone contamination is treated as a source or pathway of contamination to groundwater.

Mr. Engstrom also provided a contextual overview for the panel:

- Historically at the Hanford Site, groundwater contamination has been the focus, but recently DOE has begun examining the vadose zone more closely (especially with the addition of deeper wells on the Site).
- The Groundwater Technical Working Group (GW TWG) has been working on developing an approach to integrate vadose contamination into the NRDA.
- In particular, thoughts and recommendations from this panel will help the GW TWG and the HNRTC develop a best path forward for assessing groundwater damages and how vadose zone contamination may be affecting the groundwater damage estimate.
- Panelists should try to make recommendations to HNRTC for injury studies, and how to address vadose contamination, and also address key questions such as:
    - Is there enough characterization?
    - What cost effective studies are possible that may help fill key data gaps?
    - How do infrastructure and barriers affect vadose zone contamination?

The charge provided to the panelists is attached as Appendix B. The discussion focused on 1) the important factors to consider when integrating vadose and groundwater assessment and the contaminants of concern, 2) the amount of characterization needed and how to determine when enough characterization has been obtained, 3) vadose-groundwater models and how to determine their validity for purposes of a NRDA, and 4) remedial activities.

A description of the discussion of each charge question is provided below, organized by the topic areas identified above.

1) IMPORTANT FACTORS, PATHWAYS, AND CONTAMINANTS OF CONCERN

What are the most important factors to consider when integrating the assessment of the vadose zone with groundwater contamination?

- All of the panelists agreed that *time* is a crucial factor to consider when integrating the assessment of vadose zone with groundwater contamination (i.e., the time during which the resource may be injured and over which damages are quantified).
- There was general agreement that the fate of the dissolved contaminant mass with remediation is an important factor; cleaning up the entire zone of contaminated groundwater is impossible, but viable barriers could be used to reduce the recharge rate above contaminated plumes in order to limit additional contaminants from reaching groundwater and the River. If the groundwater mass flux is determined using a cross transect, and if mass flux in the vadose zone is examined, the impact from the vadose zone influencing the groundwater could be determined.
- When the panelists revisited this question at the end of the panel discussion, they all agreed the water flux and contaminant flux to the saturated zone is the most important factor (particularly when determining impact to the River).
- How much water/contamination is in the vadose zone and how fast it is moving are important factors in understanding the impact. If contaminants are moving very quickly, they may already be out of the system, whereas if they are moving slowly, contaminants may be below standards.
- Measuring the mass flux in the vadose zone is extremely difficult. It may be possible instead to learn from the saturated zone. Transects, flux meters, and pump tests may allow the HNRTC to study the amount of mass moving into the saturated zone from the unsaturated zone. Existing pump test data may be used for this purpose, and may help reduce the range of uncertainty.

Recharge rate (into the vadose zone) is the most important long-term driver in the system. However, it is also recognized that residual excess water in the vadose zone from past waste disposal operations may be a more important shorter-term driving mechanism until that excess water has drained to field capacity levels of saturation. Focusing on the fine grained, low-permeability layers will be important because, in general, vertical flow will continue until it reaches the low-permeability layers, when the flow may become pooled or lateral flow will continue. At that point, the water may start to stair-step downwards, which can be difficult to predict. However, it should also be recognized that high porosity/high-permeability layers can be equally influential and act as capillary flow barriers in unsaturated flow, causing downward flow to be diverted laterally along the top of the high-permeability layer.

- Another important question that received considerable attention was how to address discounting, that is, how the HNRTC should determine the value of damages extending into the future. Some representatives indicated that the standard practice of discounting to present value may not be appropriate or acceptable to some of the Trustees. Some were concerned that using the present-value discounting approach essentially means that the resource has no value after the limit of the discounting period (50 to 100 years). One of the important conclusions from this discussion was that discounting damaged groundwater to present value renders the vadose zone irrelevant, if it can be determined that there would not likely be significant future increases in the amount of injured groundwater due to increased releases from the vadose zone. Even in that case, uncertainty can be built into the amount of injury and its valuation.

Discussion of studies to reduce uncertainty in the important factors for vadose-groundwater assessment:

- Mr. Engstrom explained that infiltration and water content is fairly well understood at the Site, but that information on the flux rates may be limited. Jack Robertson (IEc) agreed that there is a lack of understanding of the transient conditions from past disposal practices, and that some vadose zone areas may be saturated or nearly saturated with water moving fairly fast, but that eventually, with no additional source of water, the vadose zone will equilibrate to natural recharge rates.
- Dr. Hyndman (Michigan State) noted that a model might be the best tool to help quantify how fast vadose contamination drains after water recharge stops. Dr. Johnson (USGS) added that if drainage is occurring in a few places, it may be useful to concentrate on locations with existing data (such as on moisture conditions, disposal history) to validate the models and serve as a benchmark for other locations. However, panelists agreed that developing a reliable three-dimensional vadose zone model would be a challenging task.
- Mr. Robertson noted that injection experiments should provide some information on this topic. DOE has completed some injection experiments on Site where they pumped water into the unsaturated zone and monitored its spread in three dimensions and simulated it with three different vadose zone modeling approaches. Mike Thompson (DOE) added that retention tanks on Site could be used to determine long-term travel of contaminants rather than the waste tanks.
- For purposes of the Injury Assessment Plan, Dr. Arnold (Sandia National Lab) suggested exploring options with increasing complexity to identify the limitations and differences of each technique. This would include starting from a back of the envelope exercise, and incorporating bounding calculations, simplified

compartment calculations for mass transport (balance approach in compartments of the system), to the most complicated option, being a realistic numerical model of vadose zone contamination. Dr. Johnson suggested trying the full range of options on a location with more data, which could then be applied to other locations on Site.

In order to determine the potential for injury to groundwater resources, it is important to understand the interaction between the vadose zone contaminants and groundwater. The panel should endeavor to help the Trustees develop an approach to evaluate and prioritize potential pathways and/or length of pathways through the vadose zone that control contaminant migration, including potential uncertainties.

- Several of the discussion points addressed in the first question, above, are also applicable to this question, such as the influence of low-permeability and high-permeability unsaturated layers in controlling the pathways that downward-migrating vadose zone water takes toward the saturated zone.

When studying vadose contamination and the potential to injure groundwater resources, which are the particular contaminants we should focus on? The panel should evaluate and consider which types of contaminants are more likely to move from the vadose zone into the groundwater, how these contaminants will move through the environment, and how the Trustees will approach determining the impact of these movements on groundwater injury assessment.

- Technetium-99, uranium, iodine-129, americium and plutonium were identified as important radionuclides. Whereas, cesium-137 and strontium-90 have relatively short half-lives and may not be as important as the others.
- Risk assessment modeling for the entire site is a potential tool for evaluating the most important contaminants of concern for NRDA purposes.
- Any system with low ionic strength will have natural colloids which absorb plutonium and americium, but to what degree is uncertain. (Dr. Arnold)
- The potential presence of DNAPL (dense non-aqueous phase liquid) carbon tetrachloride was mentioned in both the vadose and saturated zones.
- Mike Thompson said DOE has looked into the possible presence of DNAPL pools in the saturated zone and are fairly certain that there are no DNAPL pools present.
- Dr. Hyndman described his experience modeling DNAPL plumes and developing a reactive barrier for a carbon tetrachloride plume. However, the microbe he worked with does not work well with highly concentrated plumes of carbon tetrachloride. DNAPL characterization and modeling is highly complex and not feasible for either the vadose or saturated zones; however, at the Hanford Site, it may be possible to model what is happening with dissolved-phase carbon tetrachloride at the leading edge of the plume.

The panel should consider the impact infrastructure and barriers may have on vadose contamination, including but not limited to the role of vertical and horizontal dikes on transportation through the vadose zone, the limiting role that barriers and caps have on contaminant retardation, and the potential for infrastructure such as buried tanks to become a future source of contamination.

- The effect of horizontal barriers is difficult to predict, but barriers become more of an issue with increasing depth.
- Capping sources in areas of significant contamination is useful. Below these areas, desiccation as a remedial measure might be appropriate. However, flow around covers and lateral flow in deep vadose zone can be an issue. The longevity of engineered covers is also a question; materials degrade over time. Others working with low level waste sites in arid environments are considering use of enhanced soil and vegetation covers to increase evapotranspiration by capturing transient rainfall events.
- Vadose models are historically good at predicting recharge under natural conditions; one use of a vadose model is to study the effects of climate variations and estimate natural recharge away from these barriers.
- The panelists were uncertain how vertical dikes might affect the movement of contamination. Dr. Mercer (Tetratech) thought vertical dikes might be less of an issue, whereas Dr. Arnold was unsure and thought they may act as a barrier sometimes, and at other times as a pathway or not affect the flow at all. Dr. Johnson speculated that the flow might move down the vertical dikes and pool at the bottom.

2) DETERMINING THE LEVEL OF CHARACTERIZATION REQUIRED FOR NRDA PURPOSES

Have the waste sites, and other vadose zone sources been sufficiently characterized to quantify the associated risks to the environment? What recommendations do they have for additional characterization if they believe it is needed? And how can we test to ascertain whether enough characterization has been done?

- The characterization needed for the purposes of a NRDA would not likely exceed the degree of characterization needed for remediation purposes (remedial investigation and feasibility studies) (Dr. Arnold). Bob Unsworth (IEc) agreed that a NRDA might not require full characterization, and that it may be enough to have a general sense of scale and an understanding of the time over which the resource will be contaminated.
- Modeling (data worth analysis) is an option for integrating all of the components to determine how to reduce uncertainty and the value of reducing particular uncertainties. (Dr. Hyndman)

- During remedial activities, monitoring of the saturated zone could provide information on the conditions in the saturated and unsaturated zones. (Dr. Johnson)

Important variables, and how to determine when there is enough characterization.

- 3D modeling is necessary in this heterogeneous system; therefore, reasonable distributions of hydraulic properties will be important. Reasonably well-constrained heterogeneity will increase the confidence in transport models. Comparing the results from a series of stochastic variations to the data will help determine if the model parameters are appropriately constrained. (Dr. Hyndman)
- Determining the sensitivity of the model can be very useful, particularly for identifying the variables with the greatest effect on the system for further study in the field. (Dr. Johnson)
- Another important variable in vadose zone contamination are the presence of low-permeability fine grain layers and high-porosity, high-permeability layers which are important in determining vertical flow through the system. (Dr. Mercer)
- Though, full characterization is not the goal, a statistical characterization of the system in general is. The question of whether there has been enough characterization can be answered subjectively by showing the data to geologists, or experimentally, by using the data in a representative model and testing it to see if it reproduces what is known about the system. (Dr. Arnold)
- Planned tracer tests can help increase confidence in flow data. A model can make predictions about the fate of a tracer injection to determine how well the model reflects the field data.

3) VALIDATING VADOSE-GROUNDWATER MODELS

What recommendations do panelists have for calibrating the vadose zone transport models? And for validating the vadose zone transport models?

Vadose models

- Vadose models should be three dimensional with a representation of heterogeneity.
- Data is imperfect, but focusing on the flow and using models with more than one dimension will help.

Validating models

- One way to validate vadose zone models is to use the model to simulate saturated zone pumping tests that are affected by recharge from the vadose zone, and then see how well the model has predicted the results.

- Develop a set of three dimensional vadose and saturated zone data for one actual sub-site. Then, present the package to three or four independent expert modeling groups (perhaps from academia, National Laboratories, USGS, or consulting firms) with a challenge to develop a model that bests simulates the data set, then compare the results.
- Think of the models as tools to help understand the system (and allow the modeler to check assumptions), not to necessarily predict the system.
- Using a Monte Carlo analysis can help address uncertainty and determine the maximum level or worst case analyses. It is important to know the uncertainty surrounding any value obtained from a model.
- Calibration-constrained analyses allow for the development of confidence intervals around each value.
- It is important to avoid confusing aleatoric (statistic) and epistemic (systematic) uncertainties.
- Information on dissipation of water-level mounds is an example of a possible way to calibrate one of the vadose models and possibly a good calibration test of the flow patterns of these models.
- Vadose zone water injection tests and/or recharge tests with lysimeters, using models to simulate the results is another potential way to refine and calibrate vadose zone models.
- Geophysics that is currently being done to detect contamination in the vadose zone is likely the best available method apart from direct sampling.
- Coupling soil moisture, fluid conductivity, and temperature data may be useful.

How do we determine if the vadose models will provide sufficient information to determine future impacts, without delving into the particulars?

- It is important to the Trustees to obtain as much remedy as possible. However, beyond that, they must identify which activities will yield the most benefit in terms of refining the injury estimate. Geographic and temporal scope become important in determining the best path forward; actions that will determine the problem is *larger* (i.e., geographic scope) than currently thought, or is going to last *longer* (i.e., temporal scope) than currently thought are most important in refining the injury estimate. For instance, if the area over which services are lost is very large, and the services lost are ubiquitous, then small refinements may not make a difference. However, if information is missing, then more refinement may add to the injury or lost services estimate. (Robert Unsworth, IEc)
- Determine if the models are reproducing plume resolution over the time for which data is available. If models are predicting current or past conditions well (including how the plumes are moving or growing over time), then the HNRTC can be fairly confident on how models will predict future conditions. (Dr. Hyndman)

- Predictive uncertainty analysis in the modeling is important component in having confidence in models (i.e., error bars). (Dr. Arnold)

Is there value in an exercise to decide the ideal sampling plan needed for NRDA purposes, and then compare location and type of data needed for NRDA to existing, available data (to determine what sampling might be left to do to fill in NRDA data gaps)?

- Mr. Thompson believed that the data set from remediation and NRDA purposes would overlap by at least 90 percent, since information on nature and extent of contamination is also required for remedial purposes. The majority of wells are installed to obtain information on the nature and extent of contamination. There was general agreement that this data should be sufficient to assess current and near-future extents of groundwater injury. However, considerable uncertainty remains regarding long-term future impacts of potential increases in contaminant releases from the vadose zone to the saturated zone.

What are the particulars of vadose models, contamination and movement modeling problems, and the interaction between vadose and groundwater models?

- The main complication present with vadose zone models compared to typical groundwater models is the introduction of air. The water itself moves with a wetting front, and modeling the wetting front can be difficult. There is low conductivity ahead of the front due to the lack of water, and the movement depends on the level of saturation. Adsorption and other complicating variables are introduced with modeling contaminant transport also. (Dr. Johnson)
- The flow process can be modeled with a variety of methods: simple models that track flow of liquid phase versus multi-phase modeling with air phase and liquid phase simulations and variations in temperature. With highly heterogeneous fractured medium, multi-phase modeling may be more appropriate. (Dr. Arnold)
- Understanding the recharge rate is also crucial for vadose models, which becomes more complicated with the addition of waste disposal in certain areas. (Dr. Mercer)
- Often the interaction between vadose and groundwater models is in one direction. There is very little feedback from the groundwater into the vadose zone, except possibly vapor and water table rises near the river or from unusual recharge or climate change events. The two models can be de-coupled. The most important factor is simulating the transport of water or the contaminant flux from the vadose zone into the groundwater, and treating the vadose zone as a source.
- Groundwater in the saturated zone primarily flows laterally, so it can be important to consider the mixing between the layers as it moves down gradient.
- The role of oxidation/reduction conditions is a potentially significant uncertainty in understanding the present and future transport of certain contaminants, such as technetium, americium, plutonium and uranium.

Technetium-99, for example, can be retarded under reducing conditions. Acids were disposed of in some of the source areas, which altered redox conditions.

- A question was raised regarding the potential impacts of long-term, low probability disruptive events, such as volcanism, earthquakes, catastrophic floods, dam failures, and climate change. Perhaps some probability analysis should be made for such events over the period of interest (1000+ years). There may be useful data on this subject from previous studies made for the former Basalt Waste Isolation Program and for citing the commercial power reactors (that were not completed) at the Site or with safety analyses that may have been done for the large dams on the Columbia River.

4) REMEDIAL ACTIVITIES

The panel should assist the Trustees to evaluate the cost effectiveness and efficiency of vadose zone remediation versus excavation and ex-situ remediation.

- There was considerable discussion about the importance of conducting cost-benefit analyses of proposed characterization studies and remedial actions. In many cases the costs may greatly exceed the benefit or the value of the lost resource or services. The value of additional vadose zone characterization is heavily dependent on the types of long-term remedial actions that might be implemented.
- There was general agreement that some source-term remedial actions are relatively robust and probably cost effective and worth doing, such as soil vapor extraction of carbon tetrachloride in the vadose zone of the 200 Area.
- Decisions regarding remedial actions should be based on cost/benefit analyses, the degree to which the remedial action will reduce the injury to the resource, and the degree to which the action will reduce risk to human health and the environment.
- It was generally agreed that taking measures to reduce recharge at source areas and areas of major vadose zone contamination could probably be an effective remedial action. Such measures might include capping or otherwise reducing permeability of the surface soil layer. Another effective measure might be enhancing evapotranspiration by enhancing surface vegetation. However, the key question is: Can recharge be curtailed by surface treatment of soil or by engineered land covers in a cost-effective manner? Also, there is uncertainty about the long-term effectiveness of such measures (hundreds of years).
- Another vadose zone remedial measure under consideration is engineered desiccation using air injection and withdrawal approaches. Such a program appears feasible for reducing the water content of the vadose

zone and thus reducing the driving mechanism for transporting contaminants to the saturated zone.

Additional discussion on remedial activities affecting vadose and groundwater contamination:

- The most effective groundwater remediation approach might be to accept as fact that it is simply not feasible to cleanup all the contaminated groundwater, or the contamination in the vadose zone. Then the long-term remedy is containment. Containment systems (i.e., reactive subsurface barrier walls and pump-and-treat systems) would be employed to capture virtually all the contaminants before discharging to the river or otherwise escaping from the Site. This would be combined with institutional controls to assure that access to the Site land and resources would be restricted in perpetuity. Such a containment and institutional controls remedy would eliminate the need to do any additional vadose zone characterization and would greatly reduce the amount of additional saturated zone characterization that might be needed.
- It may be useful to determine how far DOE remedial actions will go in separating the vadose contamination from the groundwater (i.e., through desiccation measures, etc.). If the vadose contamination is isolated from the groundwater, then integrating the assessment of vadose and groundwater may not be needed.
- Mike Thompson noted that DOE is attempting to remove, treat, and dispose of primary source terms of hexavalent chromium using pump-and-treat systems to remove chromium from the groundwater. However, DOE will have to assess the ability of the remaining chromium to re-contaminate the vadose zone. In some locations where the contamination is highly concentrated and deep, removing the source is not an option. For the uranium plume in the 300 Area, remedial actions will likely focus on using phosphate to remove the uranium; however, in the 300 Area, the river and intrusion of river water affects groundwater levels and uranium transport and causes it to be released from period re-wetting zones.

Use of clustered, non-random data that exists from remedial characterization

- There are formal methods for de-clustering data and weighting the data based on the degree of clustering. Geo-statistical methods have been designed to deal with clustered data.
- Consider adding additional randomly distributed sampling points to obtain a more statistically representative characterization of the hydrogeology and distribution of contaminants. However, a cost/benefit analysis should be done before implementing expensive additional drilling and sampling.

Natural Resource Damage Assessment - Hanford Site Integrated Vadose-Groundwater Assessment Expert Panel Agenda

June 5, 2012
Location: Room 152, Federal Building (825 Jadwin Ave, Richland)
Tel: 376-3622 (local) or 1-877-401-5229 (toll free); Conference ID 455605 (followed by pound key)

8:30-8:45 Welcome and Introduction

- Workshop Goals and Objectives
- Workshop Structure and Ground Rules
- Introductions

8:45-10:30 Discussion of charge questions

- What are the most important factors to consider when integrating the assessment of the vadose zone with groundwater contamination?
- Have the waste sites, and other vadose zone sources been sufficiently characterized to quantify the associated risks to the environment? What recommendations do they have for additional characterization if they believe it is needed? And how can we test to ascertain whether enough characterization has been done?

10:30-10:45 Break

10:45- 12:30 Continued discussion of charge questions

- In order to determine the potential for injury to groundwater resources, it is important to understand the interaction between the vadose zone contaminants and groundwater. The Panel should endeavor to help the Trustees develop an approach to evaluate and prioritize potential pathways and/or length of pathways through the vadose zone that control contaminant migration, including potential uncertainties.
- When studying vadose contamination and the potential to

injure groundwater resources, which are the particular contaminants we should focus on? The Panel should evaluate and consider which types of contaminants are more likely to move from the vadose zone into the groundwater, how these contaminants will move through the environment, and how the Trustees will approach determining the impact of these movements on groundwater injury assessment.

12:30-1:45 Lunch

1:45-3:30 Continued discussion of charge questions

- What recommendations do Panelists have for calibrating the vadose zone transport models? And for validating the vadose zone transport models?
- The Panel should assist the Trustees to evaluate the cost effectiveness and efficiency of vadose zone remediation versus excavation and ex-situ remediation.
- The Panel should consider the impact infrastructure and barriers may have on vadose contamination, including but not limited to the role of vertical and horizontal dikes on transportation through the vadose zone, the limiting role that barriers and caps have on contaminant retardation, and the potential for infrastructure such as buried tanks to become a future source of contamination.

3:30-3:45 Break

3:45-4:00 Workshop Summary and Wrap-up

HANFORD NRDA EXPERT PANEL | June 5, 2012

THE DEVELOPMENT OF AN INTEGRATED APPROACH FOR ASSESSMENT OF INJURY TO RESOURCES IN THE HANFORD VADOSE ZONE AND GROUNDWATER

This memorandum provides a general description of the purpose, need, scope, and charge for the Hanford Expert Panel on the development of an integrated approach for assessing injury to resources in the Hanford vadose zone and groundwater, as part of the Hanford Natural Resource Damage Assessment (NRDA).

INTRODUCTION

The Hanford Site, operated by the U.S. Department of Energy (DOE), is located on approximately 586 square miles of land bordering the Columbia River in southeastern Washington. Construction of nine reactors and associated uranium processing facilities began in 1943; subsets of these reactors and other production facilities were in operation from 1944 to 1987. At this time the primary mission of the Hanford site is environmental cleanup. The production processes generated billions of gallons of liquid waste and millions of tons of solid waste (DOE 2012). The DOE, Washington State Department of Ecology, and U.S. Environmental Protection Agency (EPA), signed the Hanford Facility Agreement and Consent Order (Tri-Party Agreement) in May 1989, which outlines legally enforceable milestones for Hanford cleanup over the next several decades. In November 1989, EPA placed the Hanford Site on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List (NPL).

When the release of one or more hazardous substances is suspected to have led to "injury" of natural resources, Federal law allows government officials, acting as natural resource "trustees", to enter into a Natural Resource Damage Assessment (NRDA) process. The objective of the NRDA process is to restore, replace or acquire the equivalent of injured natural resources and to compensate the public for any loss of services that occurs while natural resources are in an injured state. The Hanford Natural Resource Trustee Council (HNRTC) is a collaborative working group chartered to address injuries to natural resources resulting from contaminant releases from the Hanford Site. The Council is made up of representatives from the Department of Energy, the U.S. Fish and Wildlife Service, the National Oceanic Atmospheric Administration, the state of Oregon, the State of Washington, the Yakama Nation, the Nez Perce Tribe, and the Confederated Tribes of the Umatilla Indian Reservation.

As part of the NRDA, the HNRTC is preparing an Injury Assessment Plan (IAP). The IAP will describe injury assessment activities that will inform the HNRTC's evaluation of the extent to which natural resources and associated services in and around the Hanford

Site have been affected by the release of contaminants. To help with the development of the IAP, the Trustees are conducting a series of expert panel workshops to explore various issues related to the assessment of injury at the Hanford Site. The purpose of these workshops is to provide expert advice to the Trustees, opportunity for the exchange of ideas and information, and to inform the IAP by helping the trustees develop the best path forward and prioritize potential future injury studies (i.e., studies to characterize injury to natural resources from the release of contaminants).

Additional information on the Hanford Site can be found at www.hanford.gov, and information on the Hanford NRDA process and the HNRTC can be found at www.hanfordnrda.org. The NRDA regulations are found in Title 43 of the Code of Federal Regulations, Part 11. For reference, some key definitions of NRDA terminology are listed below, and all other key definitions can be found in 43 C.F.R. § 11.14.

Injury means a measurable adverse change, either long- or short-term, in the chemical or physical quality or the viability of a natural resource resulting either directly or indirectly from exposure to a discharge of oil or release of a hazardous substance, or exposure to a product of reactions resulting from the discharge of oil or release of a hazardous substance. As used in this part, injury encompasses the phrases "injury," "destruction," and "loss." Injury definitions applicable to specific resources are provided in §11.62 of this part.

Natural Resources or *resources* means land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States (including the resources of the fishery conservation zone established by the Magnuson Fishery Conservation and Management Act of 1976), any State or local government, any foreign government, any Indian tribe, or, if such resources are subject to a trust restriction on alienation, any member of an Indian tribe. These natural resources have been categorized into the following five groups: Surface water resources, ground water resources, air resources, geologic resources, and biological resources.

Biological resources means those natural resources referred to in section 101(16) of CERCLA as fish and wildlife and other biota. Fish and wildlife include marine and freshwater aquatic and terrestrial species; game, nongame, and commercial species; and threatened, endangered, and State sensitive species. Other biota encompass shellfish, terrestrial and aquatic plants, and other living organisms not otherwise listed in this definition.

Services means the physical and biological functions performed by the resource including the human uses of those functions. These services are the result of the physical, chemical, or biological quality of the resource.

PURPOSE AND NEED

The fate and transport of contaminants in the vadose zone of the Hanford Site is not well known. An understanding of how contaminants in the vadose zone interact and affect groundwater contamination is important for estimating groundwater injury from Hanford contaminant releases. To characterize subsurface conditions at Hanford that result in impacts to groundwater injury, the Trustees must understand the inventory of source materials, how contaminants are either resident or traveling through the vadose zone, and what quantities of contaminants complete the trip from the vadose zone to groundwater.

One difficulty recognized by the Hanford Groundwater Technical Working Group (TWG) will be attempting to assess groundwater injury without accounting for contaminant impacts that come from the vadose zone. The early attempts at preliminary injury assessment performed by the Groundwater TWG have produced uncertainties that are influenced by vadose zone contaminants.

The purpose of this expert panel is to convene an independent, impartial group of groundwater-vadose zone and NRDA experts to develop an integrated approach to injury assessment that would involve both the vadose zone and groundwater. The panelists will provide expertise and advice to help the Hanford Natural Resource Trustee Council find the best path forward for Hanford groundwater injury assessment.

PANEL MANAGEMENT

INFORMATION AND PREPARATION REQUIREMENTS

In preparation, members of the expert panel will be expected to review information on Hanford vadose zone and groundwater contamination. Panelists are also requested to specifically review pertinent sections of the following documents as needed based on prior knowledge of the subject and/or the Hanford Site:

- The *Groundwater Natural Resource Review Report* (Industrial Economics, Inc., Nov. 2011).
- Goswami, Dib. *Sitewide Groundwater and Vadose Zone Project*. Washington State Department of Ecology Nuclear Waste Program. 2011.
- PNNL-20209 *Implementation Plan for the Deep Vadose Zone-Applied Field Research Center*. Pacific Northwest National Laboratory, February 2011.
- DOE/RL-2010-89 *Long-Range Deep Vadose Zone Program Plan*. Richland Operations Office, October 2010.
- PNNL-14702 *Vadose Zone Hydrogeology Data Package for Hanford Assessments*. June 2006.
- PNNL-14834 *Sampling and Hydrogeology of the Vadose Zone Beneath the 200 Area Process Ponds.* Pacific Northwest National Laboratory, August 2004.
- CHPRC-01182-FP *Strategies for Immobilization of Deep Vadose Contaminants at the Hanford Central Plateau (11503).* Richland Operations Office, January 2011.

- PNNL-13672 *A Catalog of Vadose Zone Hydraulic Properties for the Hanford Site*. September 2001.

We anticipate that panelists will require approximately one day of pre-panel preparatory work, depending on familiarity with the Site and documents in question. Upon request of the panelists, IEc can provide access to the documents cited in reports we have developed.

Panelists should come prepared to address the following charge questions:

- What are the most important factors to consider when integrating the assessment of the vadose zone with groundwater contamination?
- In order to determine the potential for injury to groundwater resources, it is important to understand the interaction between the vadose zone contaminants and groundwater. The Panel should endeavor to help the Trustees develop an approach to evaluate and prioritize potential pathways and/or length of pathways through the vadose zone that control contaminant migration, including potential uncertainties.
- When studying vadose contamination and the potential to injure groundwater resources, which are the particular contaminants we should focus on? The Panel should evaluate and consider which types of contaminants are more likely to move from the vadose zone into the groundwater, how these contaminants will move through the environment, and how the Trustees will approach determining the impact of these movements on groundwater injury assessment.
- Have the waste sites, and other vadose zone sources been sufficiently characterized to quantify the associated risks to the environment? What recommendations do they have for additional characterization if they believe it is needed? And how can we test to ascertain whether enough characterization has been done?
- What recommendations do Panelists have for calibrating the vadose zone transport models? And for validating the vadose zone transport models?
- The Panel should assist the Trustees to evaluate the cost effectiveness and efficiency of vadose zone remediation versus excavation and ex-situ remediation.
- The Panel should consider the impact infrastructure and barriers may have on vadose contamination, including but not limited to the role of vertical and horizontal dikes on transportation through the vadose zone, the limiting role that barriers and caps have on contaminant retardation, and the potential for infrastructure such as buried tanks to become a future source of contamination.

CHARGE TO PANELISTS

Panelists are charged with advising and helping the HNRTC determine a better path forward in the development of an integrated groundwater-vadose zone approach for the Hanford natural resource injury assessment. In particular, panelists are asked to make recommendations on the most important factors to consider when evaluating potential injury from vadose zone contamination including how to evaluate the potential for vadose contamination to act as a source for future groundwater injury.

APPENDIX C PANEL ATTENDEES

The following panelists participated in the Hanford Expert Panel entitled The Development of an Integrated Approach for Assessment of Injury to Resources in the Hanford Vadose Zone and Groundwater:

- Dr. James Mercer (Tetratech)
- Dr. Bill Arnold (Sandia National Laboratory)
- Dr. Kenneth Johnson (USGS)
- Dr. David Hyndman (Michigan State)

In addition, the panel was organized by Nadia Martin (IEc) and moderated by Dale Engstrom (Oregon). The following Hanford Trustees and Technical Working Group members attended the panel:

Dana Ward (DOE)	Paul Shaffer (Oregon)
Steve Wisness (DOE)	Larry Goldstein (Ecology)
Jack Roberston (IEc)	Dib Goswami (Ecology)
Jack Bell (Nez Perce)	Beth Rochelle (Ecology)
Dan Landeen (Nez Perce)	Joe Bartoszek (USFWS)
Stan Sobczyk (Nez Perce)	Tom Bowden (Ridolfi, Inc.)
Leah Aleck (Yakama Nation)	Michael Thompson (DOE)
Wade Riggsbee (Yakama Nation)	Jean Hays (Ecology) (by phone)
Michael Calac (Yakama Nation)	Tammy Ash (USFWS) (by phone)
Alex Nazarali (CTUIR)	Callie Ridolfi (Ridolfi, Inc.) (by phone)
Ted Repasky (CTUIR)	Robert Unsworth (IEc) (by phone)
Daniel Diedrich (NOAA)	David Bernhard (Nez Perce) (by phone)