D1020 PDR-1
LPDR-wm-10 (2)
wm-11 (2)
wm-16 (2)

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Hydrogeology • Mineral Resources Waste Management • Geological Engineering • Mine Hydrology

July 23, 1987
Contract No. NRC-02-85-008
Fin No. D-1020
Communication No. 138

Mr. Jeff Pohle
Division of Waste Management
Mail Stop 623-SS
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Jeff:

A copy of the review of each of the following documents is enclosed.

1. Massmann, Joel and Freeze, R. Allan, 1987, Groundwater Contamination from Waste Management Sites: The Interaction Between Risk-Based Engineering Design and Regulatory Policy, 1. Methodology, 2. Results. Water Resources Research, vol. 23, no. 2, p. 351-67.

2. Hofer, E. and Hoffman, F.O., 1987, Selected Examples of Practical Approaches for the Assemssment of Model Reliability - Parameter Uncertainty Analysis. OECD/NEA Workshop on Uncertainty Analysis for Systems Performance Assessments, Seattle, Feb.

If you have any questions concerning these reviews, please call.

Sincerely,

Gerry Winter/sl
Gerry V. Winter

GVW:sl

enclosures

WM-RES

WM Record File
D1020
W&A

WM Project 10, 11, 16
Docket No.
PDR ✓
LPDR ✓ (B, W, S)

Distribution:
JPohle

(Return to WM, 623-SS)

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WM DOCKET CONTROL CENTER

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PDR WMRES EECWILA
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PDR w/encl LPDR w/encl D1020
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WMGT DOCUMENT REVIEW SHEET

FILE #:

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DOCUMENT: Massmann, Joel and Freeze, R. Allan, 1987, Groundwater Contamination from Waste Management Sites: The Interaction Between Risk-Based Engineering Design and Regulatory Policy, 1. Methodology, 2. Results. Water Resources Research, vol. 23, no. 2, p. 351-67 and p. 368-80.

REVIEWER: Williams & Associates, Inc., Kirk Steinhart
Stanley M. Miller

DATE REVIEW COMPLETED: July 9, 1987

ABSTRACT OF REVIEW: APPROVED BY: Roy E Williams

These two papers develop and illustrate the formal use of risk-cost-benefit analysis in planning waste disposal facilities. The objective function consists of the sum of annual discounted benefits less costs and risks viewed from the waste management facility owner/operator point of view. The purpose of the papers is to show that the information required to do such a formal analysis can be found without a great deal of difficulty. The results of varying different design parameters shows the developer the effects of various tradeoffs which can be made. From the regulatory viewpoint, policy can be formulated by doing the same manipulations while varying the costs and benefits according to proposed policy. Data are used from an existing landfill in Woodbine, New Jersey to illustrate the technique. For the example, policy should emphasize design standards over performance standards and good design over monitoring.

BRIEF SUMMARY OF DOCUMENT:

The principal thesis of these two papers is that an owner/operator of a waste management facility can and should maximize the risk-cost-benefit function,

$$\phi = \sum_{t=0}^{T} 1/(1+i)^t \, [B(t) - C(t) - R(t)]$$

where: o is the objective function (dollars),
t is time (years),
T is the planning horizon (years),
i is the discount rate (decimal fraction),
B(t) is the benefit realized in year t (dollars),
C(t) is the cost of development or operation in year t (dollars),
R(t) is the risk in year t (dollars).

Time starts at the initiation of site exploration and design. Benefits accrue from sales of services. Costs are costs of exploration and design, construction, or operation depending on the year, t. The risk in year t is the product of the probability of failure in year t and the cost incurred under such a failure (perhaps adjusted upward if one wants to take a risk averse stance). Failure is defined in this context as contaminant reaching the compliance surface. The probability of failure is modeled in year t' after the commencement of operation as the cumulative joint, probability of breach of containment and subsequent migration of contaminant to the compliance surface. The probability of breach is calculated using standard reliability theory. The probability of migration of contaminant to the compliance surface is based on a stochastic groundwater travel time model.

These concepts are quite general. However, the papers use very specific assumptions in illustrating the technique. They assume, for example, that the waste is held in a number of independent cells each with two liners in parallel that fail at an exponential rate. The groundwater travel time model is a two dimensional finite element model with hydraulic conductivity as the only stochastic coefficient. The correlation range is (perhaps) different in the two directions.

A sensitivity analysis on the various components (such as benefits, cost of operation, or parameters of the distribution of hydraulic conductivity) enables the owner/operator to see which components can be manipulated usefully to efficiently maximize the objective function.

The case study shows step-by-step how figures are gathered and used in calculating benefits, cost, and risk.

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

These two papers argue that regulatory benefit-cost-risk analysis is difficult to perform because of the problems with quantifying the social costs of impairment or loss of human life. However, by looking at the owner/operator benefit-cost-risk analysis, the regulatory agency can anticipate what regulations (design criteria, monitoring requirements, performance bonds, fines, etc.) would be most effective in insuring responsible waste management facility construction and operation while enabling the owner/operator to make a profit. This assumes that the market is rational and that the owner/operator has an objective function such as the one above in mind.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

1. The illustration used in this risk analysis is based on numerous simplistic assumptions (e.g., independent failure components, lognormal distribution of hydraulic conductivity, linear spatial correlation, plug flow, no dispersion) that hamper its credibility for providing accurate results. Its strongest points are the capability to conduct sensitivity analyses and the presentation of an overall philosophy of quantifying risks in conjunction with benefits and costs.

2. The probability of failure in terms of a groundwater contamination incident is based on two components of failure: 1) breeching of the containment structure (F_1) and 2) migration of the released contaminant(s) through the subsurface hydrogeologic environment to a defined compliance surface (F_2). Failure is defined as "...the exceedance of a maximum permissible concentration for a particular chemical species in a regulatory monitoring well located at a compliance point or on a compliance surface." The two components (i.e., events) of failure are assumed to be independent, which means that the probability of their intersection equals the product of the probabilities of the individual events:

$$P(\text{site failure}) = P(F_1 \cap F_2) = P(F_1)P(F_2)$$

(compare to eq. 4 in paper)

This assumption of independence is reasonable only if the contaminant plume travels as a "slug" whose concentration exceeds the regulatory limit. If such is not the case (e.g., leakage concentrations increase over time until a regulatory

limit is exceeded), then the probability of site failure must be expressed as a conditional probability:

$$P(\text{site failure}) = P(F_1 \cap F_2) = P(F_2/F_1)P(F_1).$$

3. The influence of a monitoring system on the estimated probability of failure (p. 360-361) is an important concept, but the conclusion that the probability of failure can be reduced by improved monitoring seems unusual. Monitoring can reduce the uncertainty in detecting a contaminant plume, but such a reduction in uncertainty should not be associated with a reduction in the probability of failure (at least, not in the context of the professional literature with which we are acquainted). Incorporating the <u>reliability</u> of the monitoring network is perhaps better achieved by a conditional probability approach whereby the probability of detection (P(d)) is a measure of the monitoring reliability. That is,

$$P(d) = P(B/A)$$

where: A = event that the contaminant plume reaches the compliance surface

B = event that the monitoring system indicates that the contaminant plume reaches the compliance surface.

Thus, the modified probability of site failure is:

$$P(\text{site failure}) = P(B/A)P(A)$$

where: $P(A) = P(F_2/F_1)P(F_1)$

4. The concepts of spatial scale and spatial averaging for hydrogeologic properties is not addressed adequately by the authors. The conversion of point-measured values to area values needed in a 2-D finite-element mesh (if such a conversion is meaningful at all) is accomplished via an overly simplistic assumption of linear spatial correlation (p. 359-360).

WMGT DOCUMENT REVIEW SHEET

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REVIEWER: Williams & Associates, Inc., Stanley M. Miller

DATE REVIEW COMPLETED: July 9, 1987

ABSTRACT OF REVIEW: APPROVED BY: Roy E Williams

This paper attempts to treat uncertainty in transfer models in a generic sense. It is not directed necessarily at the transport of radionuclides in a groundwater flow system. Some of the principles presented are pertinent to groundwater modeling and some are not pertinent.

According to the subject document the reliability of predictions produced by transfer models, or performance models, depends largely upon the uncertainties associated with making those predictions. The document divides uncertainties into two categories: Type 1 uncertainty, which is due to stochastic variability, and Type 2 uncertainty, which is due to a lack of knowledge about deterministic components of the physical system under study. The authors use the adjective stochastic to mean that the value of a variable under consideration varies in time or in space. The concept of lack of knowledge is assumed to be synonymous with lack of data. The use of probabilities and subjective probabilities in uncertainty analysis is discussed, with maximum emphasis on analyzing the uncertainties in model input parameters. The authors focus on Type 2 uncertainty (professional judgment). The major steps of a parameter uncertainty analysis are listed and an example problem using a simple algebraic model is presented. Results from the example problem, which compares several methods of parameter uncertainty analysis, indicate that numerical methods (which would include

simulation models) based upon random samples are preferred for Type 2 uncertainty analyses of complex models.

BRIEF SUMMARY OF DOCUMENT:

The reliability of predictions provided by environmental transfer (or performance) models is largely due to uncertainties in the model analysis. The document divides uncertainties into five distinct categories: 1) uncertainty due to improper definition and conceptualization of the problem or of the physical system under consideration, 2) uncertainty due to improper formulation of the mathematical model used in the conceptualization, 3) uncertainty involved in the formulation of the computational model, 4) uncertainty inherent in the estimation of input parameter values, and 5) calculation and documentation errors in the production of the model results. When possible, model predictions should be checked against independent and appropriately derived sets of data. This procedure is known as model validation. In many environmental studies model validation may be impossible or impractical. In these cases a parameter uncertainty analysis is recommended. The authors use the words uncertainty analysis in a manner that is synonymous with what hydrogeologists term sophisticated sensitivity analysis. Their sensitivity analysis is sophisticated in that sophisticated professional judgement is relied upon to introduce subjective probability density functions for parameters into the sensitivity analysis in the model. Any type of parameter uncertainty analysis should be complimented and supported by comparisons of various models and their results, as well as quality assurance in the computation and documentation procedures.

The paper explains that in any uncertainty analysis it is essential to distinguish between two fundamentally different types of uncertainty. Type 1 uncertainty is due to stochastic, or probabilistic, type variability. If the property of interest shows stochastic variability within the system to be modeled, an investigator is uncertain which value to use in the model. Type 2 uncertainty is due to a lack of knowledge about the deterministic components of the system under study. As noted above the authors use the words lack of knowledge synonymously with lack of data. Here the property of interest is determined within the system but because it is only vaguely or imprecisely known it is uncertain which value to use in the model.

The probability distribution(s) that characterizes Type 1 uncertainty is interpreted as the relative frequency distribution of values from a specified interval taken from a sample set that is considered to be representative (by professional judgment). In this context probability is based upon a frequency of

occurrence analysis. Type 2 probability is interpreted as the degree of belief (subjective probability) that a determined but vaguely or imprecisely known value is contained within a specific interval. In this case the probability is based upon a subjective interpretation (professional judgment).

A deterministic transfer model will provide a single output value. In many cases the deterministic model may be adequate. A probabilistic transfer model, on the other hand, will provide as a result a complimentary cumulative distribution function (CDF). This result is provided by expressing all assumed relevant Type 1 uncertainties in the input parameters by probability distributions. The remaining part of an uncertainty analysis then is to incorporate the Type 2 uncertainty, i.e., the subjective uncertainties. Type 2 uncertainties most often are associated with the selection of input parameter values and with certain aspects of model formulation (especially in developing conceptual models).

The major steps in assessing parameter uncertainties from a subjective viewpoint using professional judgement are portrayed as follows: Step 1, list all parameters that potentially contribute to uncertainty in the model predictions; Step 2, for each parameter listed specify the maximum conceivable range of the typical values (professional judgment); Step 3, specify the degree of belief (subjective probability) in percentages that the appropriate parameter value is not larger than specific values selected from the range established in Step 2 above; Step 4, account for correlation among model parameters by introducing suitable restrictions, by stating appropriate conditional degrees of belief, or by estimating the correlation coefficients between parameters (professional judgment); Step 5, a subjective probability density function (PDF) can now be set up for the combined range of parameter values. This procedure is subsequently referred to as a joint PDF. This joint PDF then is propagated through the model to generate a subjective probability distribution of the predicted values. Step 6, quantitative statements are derived about the effects of parameter uncertainties on the model predictions. (The parameters can be ranked with respect to their contribution to the uncertainty in the model predictions if such a ranking is so desired.) Step 7, present and interpret the results of the analysis.

Several procedures can be used to accomplish the last few steps in the parameter uncertainty analysis. These procedures include the following: 1) variance propagation, 2) moment matching, 3) distribution-free fractile estimates from a simple random sample, 4) distribution-free statistical tolerance limits from a simple random sample, 5) fractile estimates from a simple random sample (using an assumption of normal distribution), 6) statistical tolerance limits from a simple random sample (assuming a normal

or lognormal distribution), 7) distribution-free fractile estimates from a Latin hypercube sample, and 8) fractile estimates from a Latin hypercube sample (assuming normal or lognormal distribution). The simple random sample discussed in the above methods typically is obtained via computational procedures such as Monte Carlo simulation.

A simple example problem is presented whereby a deterministic model of the following form is analyzed.

$$y = abc/d$$

Distributional forms are described for the input parameters abcd; correlation is incorporated between parameters b and c. The study then progresses using a subjective probability approach and compares the above procedures (i.e., the eight procedures given above).

Results from the example problem indicate that estimates of the 95-percent fractile of the subjective probability distribution of the output y range from 200 to 2,000 while the true 95-percent fractile is about 550. Results from the example problem indicate that once subjective confidence limits have been established, results should provide one of three basic conclusions: 1) at a high subjective level of confidence the predicted value is in compliance with the limiting value (i.e., the regulatory value); 2) at a high subjective level of confidence the value to be predicted is not in compliance with the regulatory value; 3) the subjective levels of confidence for violation of and for compliance with the regulatory value have the same order of magnitude and thus additional studies are necessary to prove the knowledge base for critical parameters used in the model. Different quantitative uncertainty statements and different parameter rankings should be expected when a transfer model is applied to different physical systems, as well as when model applications are subject to different regulatory criteria.

The authors come to the following conclusions:

1) Two fundamentally different types of uncertainty always should be discriminated in an uncertainty analysis of a model prediction. Type 1 uncertainty is due to stochastic variability while Type 2 uncertainty is due to a lack of knowledge (lack of data) about deterministic components.

2) Analyses of Type 2 uncertainties (professional subjective judgment) provide quantitative statements of the influence of parameter uncertainties on the model predictions in the form of fractiles of the model predictions' subjective probability distribution. The subjective probability distribution is derived from professional judgment.

3) Numerical methods based upon random samples are preferred for Type 2 uncertainty analysis of complex transfer, or performance, models.

4) Because the transfer model in most cases cannot be provided as an algebraic expression written in terms of the uncertain parameters, the variance propagation and moment matching procedures will not be applicable in their analytical form.

5) If the transfer model requires long computational time per run the permissible sample size will be limited by CPU-time, and application of the numerical methods will be severely limited. The sample size should be considered when interpreting the results of these numerical methods.

6) When the subjective levels of confidence for compliance with or for violation of a regulatory value are of the same order of magnitude, the ranking of the uncertain parameters can provide direction for future research efforts.

The authors do not explain the ranking procedures. Instead they refer to the IAEA working document on "Procedures for Assessing the Reliability of Radionuclide Environmental Model Transfer Predictions" which we do not have.

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

Parameter uncertainty analysis is an essential part of groundwater travel-time predictions from potential high-level nuclear waste repository sites. The paper under review presents a clear, concise overview of the categories of uncertainty involved in transfer model predictions, as well as an overview of procedures used in parameter uncertainty analysis. The uncertainty analysis focuses on Type 2 uncertainties, which attempt to quantify the uncertainty in professional judgment that is required to fill data gaps or to otherwise characterize data. The development of conceptual models and the implementation of groundwater flow models should be subjected to the types of uncertainty analysis presented in this paper. Perhaps the best contribution from this paper toward the NRC Waste Management Program is in the area of quantifying subjective probabilities, i.e., the Type 2 uncertainties caused by lack of knowledge about the deterministic components in the physical system.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF REPORT:

The parameter uncertainty analysis presented in the paper under review is directed primarily toward Type 2 uncertainties which involve using professional subjective judgment to accommodate a lack of data. Three of the eight procedures described for implementing parameter uncertainty analysis depend upon assumptions of normal or lognormal distributions of the input parameters. Two of the procedures, variance propagation and moment matching, are applicable only to fairly simple transfer models that can be expressed algebraically. This leaves three procedures that have potentially wide application in reliability analysis of performance model predictions. These three procedures are: 1) distribution-free fractile estimates from a simple random sample, 2) distribution-free statistical tolerance limits from a simple random sample, and 3) distribution-free fractile estimates from a Latin hypercube sample. These three procedures are numerically intensive and the affordable sample size will be limited by the CPU time required per model run. Consequently, the sampling errors in fractile estimates of the subjective probability distribution of the model prediction are a matter of concern.

The paper provides a reasonable, but not comprehensive, overview and discussion of parameter uncertainty analysis in assessing the reliability of environmental transfer, or performance, models. In the context of groundwater modeling, one major area in the reliability assessment has been omitted in this paper. That area is the development of conceptual models of the site and the consequent development of mathematical conceptualizations. These factors determine the validity of the population that the data are supposed to represent. These areas are critical for model prediction studies, especially those that deal with groundwater transport and groundwater travel time. In addition, the discussion of model parameters has not incorporated the uncertainty associated with the validity of the testing procedures that provide the data base for populations or subpopulations of parameter values. The paper tacitly assumes point source data values. Parameter values in reality are affected by the selected scale of field testing or by interpretative or derived procedures that are used to obtain such parameter estimates. If the identification of populations of data are incorrect (conceptual model) or if data are assigned incorrectly to the wrong subpopulation and then analyzed according to the procedures presented in the paper the resulting uncertainty would not recognize the error. Similarly the selection of the wrong type of test would not be recognized as an influence on uncertainty. However, in all fairness to the authors this type of uncertainty probably cannot be quantified

except by professional judgment, which the authors do attempt to treat.

Water study could disqualify Hanford

Associated Press

WASHINGTON – Results of a groundwater study at the Hanford nuclear reservation could disqualify the south-central Washington site from the government's search for a national high-level nuclear waste repository, a Department of Energy official told lawmakers Thursday.

Ben Rusche, director of DOE's department of radioactive waste office, said findings from the study could force the department to remove Hanford from the list of three finalists without proceeding with expensive exploratory shaft drilling at Hanford.

The other two finalists are in Texas and Nevada.

The groundwater findings could be available in six months, Rusche told the Senate Energy and Natural Resources Committee.

"The first look may be able to tell us what we need to know," although it may take longer to reach a conclusion, Rusche said.

When DOE named its three repository finalists 14 months ago, it said the sites appeared suitable but that detailed, lengthy research and exploratory shaft drilling would be required before the top site could be chosen in the early 1990s.

However, DOE agreed earlier this year to conduct expanded groundwater studies at Hanford and last month said drilling there would probably be delayed until 1989 to accommodate those tests.

State Rep. Dick Nelson, D-Seattle, said state officials wanted the expanded studies because of concerns that in a few decades groundwater at the repository's proposed depths could mix with groundwater at higher elevations that reaches the Columbia River and possibly contaminate the river.

But DOE officials have said groundwater surrounding the dump flows away from the river and does not reach the environment for thousands of years.

Congress asked to take over nuke dump selection

Associated Press

SNOWBIRD, Utah — Members of the Western Governors' Association say the Department of Energy has let political considerations override safety in its search for America's first permanent storage site for highly radioactive waste.

The governors closed their annual three-day meeting here Tuesday by passing a resolution calling on Congress to take over the site selection process.

Two member states, Nevada and Washington, have been named to the Energy Department's list of finalists to receive the repository. The third site is in Texas, which does not belong to the WGA.

The governors said the department has ignored independent evaluations and the advice of its own consultants in picking the finalist states.

They also said the department has withheld information from the states and blocked federal funding aimed at helping state governments make their own assessments of the potential sites.

"I believe the Department of Energy is lying, just plain lying," said Oregon Gov. Neil Goldschmidt. "I think we've got to send these guys back to the beginning."

The underground repository would become the sole storage site for the nation's highly radioactive waste. A final site is to be selected by the mid-1990s.

The governors vented their frustrations with the DOE and approved the resolution during the final session of the conference.

They also officially turned over chairmanship of the 19-member association to Democratic Gov. Booth Gardner of Washington, who succeeded Republican Gov. Norm Bangerter of Utah.

Gardner was elected on Monday and Gov. George Deukmejian of California, a Republican, was elected vice chairman.

The governors said the DOE had failed to prove that nuclear waste can be safely stored at the sites, and had not paid enough attention to difficulties in transporting the waste.

Goldschmidt said building the repository at the Hanford, Wash., site would create the risk of radioactive material leaking into the Columbia River.

He said that of nine sites originally considered by the Energy Department, Hanford has been rated as the least acceptable in scientific evaluations, but became a finalist as a result of political considerations.

Furthermore, the governors were angry that Energy Secretary John Herrington canceled plans to build a second repository in an eastern state.

"The decision should be made on the basis of safety, not politics," said Gardner. "What I am most interested in is when they start over again, they do it on the basis of scientific data."

The resolution was opposed by Bangerter.

Utah had two possible sites on the Energy Department's original list, but both were eliminated.

Report shows some chemicals threaten water near Hanford

Associated Press

SEATTLE – Hazardous chemical wastes that have been dumped at the Hanford nuclear reservation for three decades threaten groundwater and the Columbia River, a newspaper reported Tuesday.

The non-radioactive waste is hazardous industrial and cleaning materials such as chromium, carbon tetrachloride, cyanide and chlorinated hydrocarbons, according to a new report.

The U.S. Department of Energy, in a press release on the findings issued Monday, said none of the contaminants were near drinking water systems, "and the contaminants do not constitute a health hazard to employees or the public."

But the Seattle Post-Intelligencer reported in Tuesday's editions that Hanford sources who asked not to be identified say the materials eventually will flow directly into the Columbia River, which flows through the nuclear reservation in south-central Washington, and potentially threaten public health.

Another concern is that chemicals in the groundwater make it easier for radiaoctive waste to seep into the water system as well, the newspaper said, again quoting an unnamed source.

The Energy Department has devised but not yet released a new plan to address the hazardous waste problem at Hanford. The plan, called the Hanford Environmental Management Program, was the result of a 1984 court order subjecting the agency to federal hazardous waste laws. It will be started with an initial budget of $25 million.

Since the order was issued, however, the Energy Department has been at odds with the state over full disclosure of the problem.

In February 1986 the state attorney general's office and regional U.S. Environmental Protection Agency officials issued a joint administrative order noting deficiencies and directing compliance with hazardous waste regulations at Hanford.

The new plan addressing the hazardous waste problem is an effort "to ensure compliance with the letter and spirit of all applicable state and federal laws," said Jerry White, Energy Department waste management program director.

Tribes, state officials rap Hanford dump site

Associated Press

SEATTLE – Washington state officials and representatives of several Indian tribes have told a board of scientists that the Hanford nuclear reservation would be a poor place for a permanent high-level nuclear waste repository.

Representatives from the state and the Confederation of Umatilla Tribes, the Yakima Indian Nation and the Nez Perce tribe expressed their concern about the Hanford site at a Tuesday meeting of the National Academy of Sciences' Board on Radioactive Waste Management at Seattle.

The Washington, D.C.-based board is setting up an independent oversight panel to examine the selection of Washington, Nevada and Texas as the finalist sites for the national repository.

Terry Husseman, director of the state Office of Nuclear Waste Management, and other state experts who testified before the panel suggested that instead of spending more than $1 billion on studies of the Hanford site, a much smaller amount could be spent on pursuing the "fatal flaws" at Hanford.

The state has challenged selection of Hanford, in south-central Washington, from the start.

Husseman also said he thought Congress was on its way to stopping and restructuring the nuclear waste dump program and that the board should "get involved in the process when it is straightened out."

Tom Isaacs, deputy director of repository programs for the U.S. Department of Energy, said, "We are not committed to spending all of this money if we find the site isn't suitable. We have a great deal of confidence the site is suitable."

Issues raised by state experts focused on natural resources, geology, technology and site contamination.

Bill Brewer, geologist with the state Department of Ecology, said that unlike some federal studies, his department's studies show a "high degree of probability" that there are active faults in the Hanford area. And while he is not worried about earthquake damage, he is worried about groundwater movement.

The board was told that much work needs to be done in exploring the site contamination issue, partly in light of recently released government documents showing traces of radioactive iodine 129 in groundwater outside Hanford.

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Representatives from the state and the Confederation of Umatilla Tribes, the Yakima Indian Nation and the Nez Perce tribe expressed their concern about the Hanford site at a Tuesday meeting of the National Academy of Sciences' Board on Radioactive Waste Management at Seattle.

The Washington, D.C.-based board is setting up an independent oversight panel to examine the selection of Washington, Nevada and Texas as the finalist sites for the national repository.

Terry Husseman, director of the state Office of Nuclear Waste Management, and other state experts who testified before the panel suggested that instead of spending more than $1 billion on studies of the Hanford site, a much smaller amount could be spent on pursuing the "fatal flaws" at Hanford.

The state has challenged selection of Hanford, in south-central Washington, from the start.

Husseman also said he thought Congress was on its way to stopping and restructuring the nuclear waste dump program and that the board should "get involved in the process when it is straightened out."

Tom Isaacs, deputy director of repository programs for the U.S. Department of Energy, said, "We are not committed to spending all of this money if we find the site isn't suitable. We have a great deal of confidence the site is suitable."

Issues raised by state experts focused on natural resources, geology, technology and site contamination.

Bill Brewer, geologist with the state Department of Ecology, said that unlike some federal studies, his department's studies show a "high degree of probability" that there are active faults in the Hanford area. And while he is not worried about earthquake damage, he is worried about groundwater movement.

The board was told that much work needs to be done in exploring the site contamination issue, partly in light of recently released government documents showing traces of radioactive iodine 129 in groundwater outside Hanford.