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COMMENTS ON THE ENVIRONMENTAL ASSESSMENT
OF THE HANFORD SITE

March 7, 1985

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INTRODUCTORY COMMENTS

High-level radioactive waste (HLW) - spent nuclear fuel from commercial and military sources - exists and must be dealt with. All of the hindsight about nuclear power development and desires for an end to the nuclear arms race are not going to result in the disappearance of this radioactive waste material; we cannot wish it away. Both common sense and considerable research indicate that storage to allow for radioactive decay is the only method we now have for dealing with HLW. Moreover, current temporary storage methods are unsafe over the long term, so that a more or less permanent storage method must be used. There must be suitable repositories created for HLW.

The present siting process for a HLW repository is being carried out, at least in theory, according to the Nuclear Waste Policy Act of 1982. Even if the Act did not exist, it would be necessary to find a geologic disposal site for HLW. The only other possible option for handling is sub-seabed disposal, which poses two immediate and grave questions: even less is known about sub-seabed geology than about that of land sites, and transportation to a sub-seabed site includes hazards and uncertainties which are orders of magnitude greater than the hazards of over-land transportation.

Although there cannot be absolute assurances of the safety of a site throughout its lifetime, careful selection and operation should assure a degree of safety compatible with all of the other environmental hazards of modern civilization (and, one hopes, with those of future civilizations). I would like to state, for the record, that I am not in the least opposed to, and would favor, a repository at Hanford or anywhere else if there is a reasonable amount of evidence that the repository can isolate the waste adequately.

The overriding criteria for safe operation of a site are the

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geology, seismicity, geochemistry and hydrology of the site; all other criteria are really secondary. Safe operation of a radioactive waste site is synonymous with isolation of the radioactive material from aquifers, surface waters, and the atmosphere, until the material has undergone radioactive decay to levels consistent with either background activity or the maximum permissible concentrations (MPC) deemed to be acceptable for human exposure. Safe operation therefore means isolation of the radioactive material from the human food chain, and from the air people breathe, for at least six hundred to one thousand years. Some by-products of nuclear fission which are present in spent fuel, need to be isolated for periods exceeding ten thousand years.

It is impossible to predict or estimate safe operation of a repository for the minimum 600 years; at best, only an educated guess can be made about the future integrity of any repository. The importance of the site selection is thus paramount.

Unfortunately, the site selection process which gave us Hanford was flawed from its inception. If the Department of Energy (DOE) had reason to believe that basalt was a good medium for a HLW repository, why didn't DOE survey all of the basalt in the Columbia Basin (which is essentially all of the basalt in the U. S.) and find a characterizable site by an ensuing process of elimination? If this sort of national survey process is appropriate for granite, as DOE seems to think it is, why was it inappropriate for basalt? DOE has given several responses to this question, none of which is satisfactory. The timetables in the Nuclear Waste Policy Act should not have obviated such a survey; those timetables are not being met in any case. The excuse that Hanford is already a Federal reservation is irrelevant to a search for the best possible geologic repository: Hanford isn't a Federal reservation because its geology is suitable for a repository!

There is considerable question about the suitability of basalt in the first place. Colonnades of basalt in which multiple fractures are easily visible line I-90 and other roads throughout the Columbia Basin. The subsurface basalt layers are formed in colonnades with vesicular tops exactly like the exposed basalt which one sees along the highway. One wonders whether basalt would have even been considered for a repository were it not that basalt underlies the Hanford reservation.

DOE's insistence on characterizing Hanford in spite of such widely held reservations about its suitability, and without even considering any other basalt site, thus raises questions about the integrity of the environmental assessment (EA), which the EA itself does not dispel. As is pointed out below, a good deal of information which should be in the EA is simply not there. In the instance of the geochemistry of the site, it appears as if

information has been suppressed or omitted deliberately. The suspicion of deliberate omissions raises serious questions about the DOE's credibility.

Recommendation 1: DOE should make a national survey (or at least a basin-wide survey) of basalt sites before proceeding further with the Hanford characterization.

Recommendation 2: DOE should include granite in the first round of repository sites, since the granite investigation really is a nationwide search.

Two questions are not raised at all in the DEA, and should be raised. The first is the question of preparation for a leak in the repository, should one occur in the first century of operation. It is inconceivable that the DOE has given no thought to what the operator should do to close off leaks and mitigate their effects, but nothing in the DEA addresses this question. The DEA also assumes throughout that the waste will be put into the repository as spent fuel, rather than as part of a glass or ceramic matrix. The original suggestions for HLW storage, which were made by the Geologic Survey in 1979, were that the waste first be glassified or made part of a ceramic matrix, and that the glass or ceramic then be stored in a repository. Such storage would provide a double barrier against leaks: the matrix itself and the repository rock.¹ This approach at least deserves discussion, and the reasons for rejecting it should be given, but nothing to this effect appears in the DEA.

In the following section-by-section discussion of the DEA, the discussion of geochemistry is by far the most detailed, since this is my particular area of expertise. Four documents are referred to frequently. These are the present draft environmental assessment, DOE/RL 0017, referred to as the DEA, the 1982 Environmental Assessment (1982 EA), the 1982 Site Characterization Report of the Basalt Waste Isolation Project, referred to as the Site Characterization Report, and the 1983 Draft Site Characterization Analysis published by the Nuclear Regulatory Commission (NRC). The last is referred to by its NUREG number: NUREG 0960.

GENERAL STRUCTURE OF THE CANDIDATE HORIZONS

DOE has considered only candidates in the immediate vicinity of the Reference Repository Location (RRL) which had already been part of the 1982 EA and Site Characterization Report.^{2,3} Screening of potential sites outside the Hanford reservation, and even outside the 200 area on the reservation, was cursory at best. For example, the use of some land outside the reservation as irrigated farmland is cited as a virtual disqualifier,⁴ although that didn't seem to stop the DOE in Texas. Are different siting criteria being applied in Washington than in Texas? DOE's bias

is most obviously displayed in the phrase "...these sites were not obviously superior [emphasis added] to those found within the Hanford site, and therefore, were given no further consideration."⁵ Do the siting guidelines state that the lack of "obvious superiority" is a disqualifying factor?

Section 2.2 of the DEA, which details the site screening process, states clearly that the site screening was completed and the RRL identified by 1980.⁶ Figures 2-23, 2-24 and 2-25 are basically reproductions from the 1982 EA. One might ask, what is wrong with using material from the 1982 EA? First, had the 1982 EA been adequate, there would have been no need for the 1984 DEA. Then, the 1982 EA and site characterization report were severely criticized by both the Nuclear Regulatory Commission (NRC)⁷ and by the U. S. Geologic Survey.⁸ In spite of these critiques, which amounted to virtual discreditations, DOE does not appear to have revised the 1982 Site Characterization Report and EA.

In most respects, this DEA is far less complete than the 1982 studies. It is also far less well organized and not nearly so readable. It would have been better for DOE to simply reissue the 1982 Site Characterization Report instead of issuing the DEA. The DEA does not respond to any of the criticisms made by the NRC, nor answer any of the questions raised by the NRC critique. The author, for one, fully expected a detailed response to the NRC critique, and is very surprised not to find it.

Investigations of basalt formations were not even extended to areas other than those considered in the 1982 EA; DOE has apparently decided that the site characterization borehole is going to be drilled where the drilling rig was put in 1982. Evidence which might change that decision, even on the Hanford Reservation itself, is not even being considered.

Figure 2-29 shows the relative depths of the proposed candidate horizons and Figure 6-9 compares the thickness of the dense zones below the flow top and below any vesicular zone. In the Umtanum flow, the latter is given as 42.5 meters; in the Cohasset flow, as 43 meters, with a standard deviation of approximately 11 m.⁹ DOE gives a figure of 24 meters for the minimum acceptable thickness of this densest zone.¹⁰

It is difficult to see from the DEA how this minimum figure was arrived at. The repository emplacement rooms are described as having a height of 3.3 meters.¹¹ Admittedly, until a borehole is drilled and site characterization is done, the thickness of the dense zones can be estimated apparently only to plus or minus 25%. This margin of uncertainty, when applied to the minimum acceptable thickness of 24 meters, narrows that down to a sure minimum of 12 meters - only about three and a half times the height of an emplacement room. This is not much of a margin for error. Cynicism raises the suspicion that DOE's minimum acceptable

thickness anticipates that the densest zones might be found to be considerably thinner than the present estimate.

DOE is also assuming that the thickness of this zone will not vary over a two-square-mile area, and that the rock shows little or no anisotropy. Neither of these assumptions is well founded.

Recommendation 3: DOE should include in the DEA the rationale for the selection of 24 meters as the minimum thickness for the densest zone, clearly and in quantitative detail.

TECTONICS AND SEISMICITY

Since I am not a geologist, the comments on tectonics and seismicity reflect only a general scientific viewpoint, and are limited to the adequacy of data collection and interpretation. Once again, examination of faulting, folding and seismicity of the Pasco Basin is cursory, and is described in less than one page. Descriptions of the tectonics and seismicity of the region - Washington, Oregon and Idaho between the Cascade ranges and the Northern Rockies - are missing entirely; maps of earthquake epicenters for all locations throughout the Pasco Basin should be included. Some such studies must certainly exist as a consequence of the construction permits issued for Washington Nuclear Plants 1, 2 and 4 and the proposed Skagit-Hanford nuclear power plant. The long interest in Hanford as a site for various "nuclear activities" has also resulted in a large number of papers in the open literature, particularly on seismicity, which are not even mentioned. These data, as well as information on, and assessments of, fault activity throughout the basin are needed for NRC licensing in any case.

The inescapable conclusions are that DOE didn't want to find a suitable basalt site anywhere except in the 200 area on the Hanford Reservation, and that DOE wanted to find a very low potential for seismic activity in that area.

Recommendation 4: DOE should publish a thorough literature survey of the tectonics and seismicity of the entire Pasco Basin and intermountain region, perform whatever additional studies are necessary, and include in the DEA a detailed comparison of the tectonics and seismicity of the proposed RRL with that of the rest of the region.

RADIOCHEMISTRY AND GEOCHEMISTRY

Except for a table giving the composition of the candidate horizons, ¹² Section 3 contains no discussion of the geochemistry whatsoever - not even what was in the 1982 Site Characterization Report. Only 13 pages - pages 6-87 through 6-100 - are devoted to a discussion of the chemistry and physical chemistry of the

to a discussion of the chemistry and physical chemistry of the interaction of the waste with the host rock, and another ten pages to the behavior of the rock under thermal stress. Throughout the narrative on geochemistry, it is never clear whether the DEA is discussing crushed basalt (the intended back-fill material) or small or large samples of intact basalt. Sample size and dimensions are not given.

The 1982 Site Characterization Report (DOE/RL 82-3) contained a much more complete discussion of geochemistry, including several tables of chemical composition of the basalt flows to be characterized. Since this document is in the bibliography of the DEA, one might assume that DOE is inferring a continuing reference to the geochemistry discussion contained therein. However, that geochemistry discussion has been criticized throughout by the NRC for containing unsupported assertions, conclusions unsupported by data, contradictory statements, and insufficient supporting evidence (13). The present DEA does not respond to any of the criticisms made by the NRC, nor correct any of the deficiencies pointed out by the NRC, as was expected.

In the summer of 1984, I had occasion to tour the Rockwell research laboratory at Hanford, and observe, at first hand, the crystallographic and chemical studies that were being done. Rockwell has spared no expense in equipping the laboratory, and the scientists working there are clearly very competent. The Rockwell facility is, in most respects, a "dream" laboratory, and is equipped well beyond the means of most university research laboratories. It is therefore difficult to understand why so little is included in the DEA, and why what is included is presented so confusingly and poorly.

There is no reference to the radiochemistry of the compounds in the HLW, nor is there any discussion in any detail of radiochemical and thermal effects on the basalt geochemistry. No mention is made of reactions of the compounds which make up the Hanford basalt. There is no discussion of reaction rates, equilibria, temperature coefficients of reaction, etc. In sum, there is no discussion of geochemical reactions at all.

Almost no references are made to the open chemical literature. Instead, in-house reports published by Rockwell and Battelle are cited as if they were from the open literature. Under other circumstances, such citations would be acceptable, but these in-house reports were presumably part of the DEA study itself, and the data and conclusions given in the reports should be reproduced in the DEA. DOE can't have both ways. A citation is appropriate only if it is to a study which has undergone peer review and is in the open literature. It is impossible to make a judgment about the cited studies because no data or analyses are given in the DEA. This precise point was raised repeatedly by the NRC in NUREG 0960.

Recommendation 5: Confine citations to material published in the peer-reviewed literature and give the tabulated experimental results and analyses of all material taken from Rockwell and Battelle reports.

This recommendation may apply to other sections of the DEA; I am most familiar with the chemical literature. Throughout this section, conclusions are drawn from little or no supporting evidence. The following important statements, from which conclusions are drawn about qualifying and disqualifying conditions, are examples of statements made without any supporting evidence, and with citations of in-house reports only. Virtually no statement in this section is supported by systematically collected and presented evidence. The section is replete with redundancies and internal contradictions, and dreadful syntax! It appears to be written as if DOE doubted anyone would ever read it. [Comments in square brackets are mine]:

page 6-87:

"Sorption studies on primary and secondary minerals of site-specific basalt [one assumes that the DEA means "basalt samples taken from the site"] show that these mineral phases have a high sorptive capacity for many key radionuclides [long-lived radionuclides?]"

"Laboratory tests...have indicated that basalt rapidly imposes a reducing environment in coexisting ground waters."

[Some citations on this page are from reports dated 1981 and earlier, which were cited, and in some cases discussed in some detail, in the 1982 Site Characterization Report, and virtually discredited by the NRC. Statements are made about measured and average values of solubility constants, but no values at all are given, anywhere in this section. Moreover, if the true retardation properties are not reflected in the solubility constants, as is stated here, how are the true retardation properties determined? If experimentation has been going on since 1978, in this truly magnificent laboratory, why was adequate laboratory testing not done by now?]

page 6-88:

"Theoretical studies...suggest that Eh values within the range of -0.4 volts plus or minus 0.1 volts at a pH of 9.2 plus or minus 0.5 at 60°C. are expected in this geochemical environment."

"...laboratory and theoretical studies suggest multivalent radionuclides will enter the host rock from the waste package in a reduced oxidation state having interacted with crushed basalt." [One assumes the DEA means "...oxidation state, having

interacted..."]

"Because redox-sensitive solution species [species sensitive to oxidation potential?] may or may not ["may" is adequate, it implies "may not"] respond to the redox-controlling reactions imposed by the basalt plus ground-water system, each radionuclide of concern must be demonstrated to be responsive to the redox conditions in the basalt-specific system. Preliminary tests...on technetium...and uranium...have confirmed that basalt can cause the reduction of these elements to less soluble solution species." [This paragraph is so badly written as to be nearly incomprehensible. Why are the tests just preliminary? What has been going on in that fancy Rockwell laboratory?]

"Regarding the available geochemical data base, a recent independent review...leads us to conclude that...the Hanford basalt has several favorable attributes and no seriously unfavorable ones." [The "independent review" referred to is an in-house review, cited only as a letter from D. E. Oleson to Alex Fremling. The "independence" of this review is open to question, since the review was done by Pacific Northwest Laboratories of Battelle, a prime contractor for the site investigation. This review is cited for supporting evidence, with no details given, throughout the DEA.]

page 6-89:

"Laboratory, field, and calculation studies have been completed on the basalt/water system, both at low temperatures (100°C)...and at higher..." [No data are given. No temperature is given specifically except 100°C. The ensuing brief discussion of Eh simply repeats the discussion on the preceding page. This discussion is even more vague than the analogous one in the 1982 Site Characterization Report was. Why are not data given for a continuous temperature range? The discussion of solubility on this page and the ensuing one is vague and general, and includes no supporting evidence at all. Assessment of the effect of temperature changes on oxidation potential in any medium is a rather standard laboratory exercise. The Rockwell laboratory is certainly set up to do this with basalt that has undergone all manner of physical stress. Were these assessments made? If they were made, why are they not reported in the DEA?]

page 6-90:

"Existing data suggest that conditions promoting precipitation and sorption of radionuclides are characteristic of the geochemical conditions in the reference repository location." [Was no laboratory simulation of these conditions made?]

[There is an ensuing discussion of the anticipated behavior of colloidal substances in the basalt setting which is so vague that

it is meaningless.]

page 6-91:

["Alteration minerals" are discussed briefly but never identified, nor is any supporting evidence given for their properties or nature.]

page 6-92:

"The following analysis is framed within that context [of an increase in the projected peak time of radionuclide release]."
[There is no analysis.]

"The geochemical and physical properties of the basalt at the Hanford site act to promote the retardation and isolation of many radionuclides that may be released into the repository hydrologic system."

page 6-95:

[The discussion of alpha radiolysis contradicts the statements made on page 6-88.]

"Potentially adverse geochemical processes that might enhance radionuclide mobility...are discussed in the Subsection 6.3.1.2.8." [But these processes were not discussed in the cited subsection.]

page 6-100:

"Laboratory testing of intact basalt core samples...has been conducted to determine the thermal properties of the rock." [The data given in the supporting table on page 6-102 (Table 6-7) seem not to be laboratory data, but seem to be taken entirely from literature sources. The data in Table 6-6, presumably reduced from Rockwell's laboratory data, are not accurately reflected in the corresponding data in Table 6-7.]

Recommendation 6: Present the reduced data which have been developed by Rockwell and Battelle, and rewrite the section on geochemistry.

The discussion of the thermal properties of basalt as compared to other rock types is, at best, indeterminate and confusing. What are the "generic rock types" whose thermal conductivities and coefficients of expansion are given in Table 6-8, and what relevance do they have to the discussion at hand? Rock is not a homogeneous chemical compound or a chemically uniform solid solution. Only the thermal properties of rock taken from a specific site, or measured in situ, are relevant.

More important, the favorable or unfavorable aspects of thermal conductivity and thermal expansion can only be discussed intelligently in comparison to the other rock types under consideration for the first repository. For example, salt does indeed have a coefficient of thermal expansion an order of magnitude greater than basalt or tuff, giving it a relatively high plasticity. This relative plasticity of salt should thus disqualify it, according to condition 6.3.1.3.4.,¹³ but it is exactly the property of salt beds and domes which put them in consideration for a repository in the first place. This apparent contradiction is explained rather simply: each rock type has a complex of characteristics which might make it suitable for a repository. These characteristics are favorable or unfavorable depending on other characteristics of the rock; e.g. the expansion of salt enhances its plasticity, but any expansion in basalt yields larger cracks. A large coefficient of thermal expansion would thus be a favorable condition in salt, but an unfavorable one in basalt.

The absence of such a clarifying explanation in the DEA leads to contradictions in this discussion. The "relatively low coefficient of thermal expansion" does not mean that "hydrothermal alteration of the basalt...is expected to seal fractures".¹⁴ If this were the case, fractures in tuff would seal much better, and fractures in salt, even better than that, as they are indeed expected to do.

Recommendation 7: A thorough discussion of plasticity, hydrothermal fracturing, and the comparative properties of different rock types is needed.

GROUNDWATER

There is no discussion at all of groundwater chemistry in the DEA. There was considerable discussion of geochemistry of groundwater in the 1982 Site Characterization Report, albeit a discussion largely discredited by NUREG 0960. However, if one only considers the discussion of groundwater flow in the DEA, it has sufficient internal contradictions to disqualify the site on the basis of uncertainty. Table 6-3 gives estimated or modeled ground water travel times, in various directions, which vary from a low of 20 years to a maximum of 81,000 years. NUREG 0960, it should be recalled, points out that DOE's data can be interpreted to give travel times ranging from 20 years to 40,000 years. Again, DOE has not responded to the criticisms in NUREG 0960. Failure to respond to this criticism directly casts suspicion on the assertion that "...ground-water travel time...to the accessible environment would be more than 10,000 years."¹⁵

DOE also claims support for the finding that the favorable condition "...the geohydrologic system can be readily characterized and modeled with reasonable certainty" is met.¹⁶ If

this is the case, why didn't DOE include such characterization in the DEA? On the contrary, the DEA throughout protests the difficulty of characterizing and modeling the ground water flows accurately. Once again, one of the chief criticisms made in NUREG 0960 is that there is no accurate hydrogeologic modeling and that the site characterization report includes no quantitative results of studies of groundwater flow.¹⁷

It is also unclear how DOE intends to proceed with hydraulic testing. The DEA states on page 6-69 that "large-scale hydraulic testing will rely on developed saturated-flow hydraulic theory" and states as support an irrelevant statement from NUREG 0960 (This statement is also incorrectly referenced: it is not on page 4 of NUREG 0960, but on page 3-5.) It is precisely the reliance on theory, and the absence of actual measurements of hydraulic parameters, as well as the absence of quantitative data, which is severely criticized by the NRC.¹⁸ The DEA does not contain information which was not in the 1982 Site Characterization Report, and therefore does not contain sufficient information on whether groundwater conditions are favorable or unfavorable.

Data on hydraulic pressures given in the 1982 Site Characterization Report do not indicate any uniformity in the direction of the hydraulic gradient, and do not indicate that water will flow down rather than toward the surface, as the DEA contends.

EVIDENCE OF CONSTRUCTIBILITY

The discussion of grouting and sealing the borehole, which appears on pages 6-105 and 6-175 through 6-187 can charitably be called optimistic. The borehole will be fifteen feet in diameter - one of the largest boreholes in the world. It is larger than any of the other examples given in Tables 6-20 and 6-21, and by a considerable margin. The discussion of possible grouting difficulties, extensive development of cracks, and spalling is both inadequate and overly forgiving throughout this section. Statements about loss of drilling fluid, size of spallation fragments and rock instability, and even measures to mitigate fractures and spalling are vague and imprecise. By contrast, discussion of the Geodril rig is quite specific.

Recommendation 8: DOE should include a discussion of specific problems encountered in drilling holes approaching this diameter, and should tabulate comparative data.

SYSTEM PERFORMANCE ASSESSMENT AND RISK ANALYSIS

On page 6-229 of the DEA, there is the following very disturbing statement: "...after permanent closure of the repository...the packing placed around the container becomes saturated with ground water..." I thought, as others did, that the extensive siting procedure was to find a site where the packing would not become saturated with ground water. The DEA gives

the reader to understand that the absorbent packing material of crushed basalt and bentonite was a preventive structure which would be needed in the event that ground water seeped into the repository, not because the ground water was certain to saturate the emplacements! Is this supposition - that the packing around the spent fuel containers will be completely saturated with ground water - not enough to disqualify the site? Shouldn't it be adequate for disqualification?

The same page contains a brief paragraph on the adsorptive properties of the packing and backfill material. Surely enough laboratory studies of this material have been done by now to present quantitative data on adsorption isotherms for various radionuclides, surface area calculations, rates of resorption, etc. No data are presented at all. Similarly, on page 6-237 reference is made to the calculation of release rates using a transport model. No calculations are given. Figure 6-15 gives the release rate requirement of 10 CFR 60, not any calculated release rate. Table 6-27 gives an inscrutable conglomerate of theoretically and experimentally derived values for solubilities and adsorption coefficients, without giving any examples of such derivations, and is thus meaningless.

Recommendation 9: DOE should present complete data on the adsorptive properties of the packing material and backfill material, including adsorption isotherms for all radionuclides projected to be present in the spent fuel.

The release rates shown in Figures 6-18, 6-19, and 6-20 are so poorly grounded, and the quantitative evidence for these rates is so sparse, that the rates could vary by at least an order of magnitude, and possibly by more. Any risk estimate based on such imprecise estimates of release rates, could not be at all accurate, nor could it inspire any confidence.

COMPARISON OF SITES

The lack of data and quantitative analyses in the EA make the site comparison appear questionable. However, even DOE's analysis consistently shows Hanford to rank below all, or almost all, of the other four sites proposed. Table 7-20 assigns the highest cost to Hanford. Tables 7-21 and 7-22 give Hanford the following rank:

Fifth of the five in geohydrology and rock characteristics.

Fourth of the five in tectonics, transportation, population density, radiological safety of offsite installations and operations.

If one takes this DEA at face value, Hanford does not emerge as one of the top three candidates, and should be eliminated from

consideration.

SUMMARY

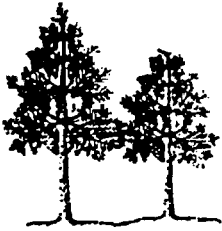
DOE suffers from a history of diminishing credibility, to the point where a superbly researched and clearly written DEA would have been scrutinized very critically and with a certain scepticism. Unfortunately, this DEA does not demonstrate good research, is poorly organized and lacks clarity. It does nothing to restore credibility to DOE, and casts the whole site selection process in question. In so doing, it brings us no closer to site selection or to any other constructive address of the high-level waste problem.

It is worth repeating, in closing, that if Hanford appeared to be a good site to isolate HLW, most citizens of Washington, including the author of this critique, would have no objection to putting the repository at Hanford and thereby moving to address the radioactive waste problem constructively. However, the closer a look one takes at Hanford, the worse it looks as a site with respect to the criteria which affect radioactive waste isolation: geology and hydrology. Site selection must be a decision based on geology, not on politics or on the present economic pressures on a community. Using the potential repository operator as the contractor for site characterization requires a superhuman degree of objectivity of that contractor which we have no right to expect.

In the light of the 1982 criticisms of DOE, most of us had high expectations of this DEA. We have been disappointed. One can't really use such a flawed document for site selection. We need a good, objective study from DOE, to get on the the task at hand. We want to see the Nuclear Waste Policy Act of 1982 implemented, but implemented scientifically and well.

FOOTNOTES

1. USGS Circular #779; Geologic Disposal of Radioactive Waste, U. S. Geologic Survey, 1979.
2. U. S. Department of Energy, Environmental Assessment for the Basalt Waste Isolation Project Exploratory Shaft Construction, 1982.
3. Hanford Operations for the USDOE, Site Characterization Report for the Basalt Waste Isolation Project, DOE/RL 82-3, 3 vols, 1982.
4. USDOE, Draft Environmental Assessment, Reference Repository Location, Hanford Site, DOE/RW-0017, 1984, p. 2-44.
5. ibid.
6. DOE/RW-0017, p. 2-41.
7. NUREG 0960
8. U.S. Geologic Survey, Technical Review of the Site Characterization Report for the Basalt Waste Isolation Project, 1982.
9. DOE/RW-0017, p. 6-163.
10. idem, p. 2-57.
11. idem, p. 5-28.
12. idem, p. 3-16.
13. idem, p. 6-100
14. NUREG 0960, Appendix B, pp. 30-40.
15. DOE/RW 0017, p. 6-62.
16. idem, p. 6-64.
17. NUREG 0960, p.3-7
18. idem, pp. 3-3 - 3-6.



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TESTIMONY BEFORE THE SUBCOMMITTEE ON
GENERAL OVERSIGHT, NORTHWEST POWER AND FOREST MANAGEMENT
April 15, 1985

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Western Washington University, Bellingham, Washington

I would like to thank the Subcommittee Chairman for holding this field hearing and thus giving me the chance to testify. My testimony is elaborated in the testimony which I submitted to the federal Department of Energy (DOE) on the Draft Environmental Assessment of the Hanford Site, and I would also like to submit that testimony for the record of this hearing.

High-level radioactive waste (HLW) - spent nuclear fuel from commercial and military sources - exists and must be dealt with. All of the hindsight about nuclear power development and desires for an end to the nuclear arms race are not going to result in the disappearance of this radioactive waste material; we cannot wish it away. Both common sense and considerable research indicate that storage to allow for radioactive decay is the only method we now have for dealing with HLW. Moreover, current temporary storage methods are unsafe over the long term, so that a more or less permanent storage method must be used. There must be suitable repositories created for HLW.

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Although there cannot be absolute assurances of the safety of a site throughout its lifetime, careful selection and operation should assure a degree of safety compatible with all of the other environmental hazards of modern civilization (and, one hopes, with those of future civilizations).

The overriding criteria for safe operation of a site are the geology, seismicity, geochemistry and hydrology of the site; all other criteria are really secondary. Safe operation of a radioactive waste site is synonymous with isolation of the radioactive material from aquifers, surface waters, and the atmosphere, until the material has undergone radioactive decay to

levels consistent with either background activity or the maximum permissible concentrations (MPC) deemed to be acceptable for human exposure. Safe operation therefore means isolation of the radioactive material from the human food chain, and from the air people breathe, for at least six hundred to one thousand years. Some by-products of nuclear fission which are present in spent fuel, need to be isolated for periods exceeding ten thousand years. It is impossible to predict or estimate safe operation of a repository for the minimum 600 years; at best, only an educated guess can be made about the future integrity of any repository. The importance of the site selection is thus paramount.

Unfortunately, the site selection process which gave us Hanford was flawed from its inception. There is considerable question about the suitability of basalt as a repository host rock. Colonnades of basalt in which multiple fractures are easily visible line I-90 and other roads throughout the Columbia Basin. The subsurface basalt layers, including the reference repository location (RRL), are formed in colonnades with vesicular tops exactly like the exposed basalt which one sees along the highway. One wonders whether basalt would have even been considered for a repository were it not that basalt underlies the Hanford reservation. The excuse that Hanford is already a Federal reservation is irrelevant to a search for the best possible geologic repository: Hanford isn't a Federal reservation because its geology is suitable for a repository!

DOE's insistence on characterizing Hanford in spite of such widely held reservations about its suitability, and without even considering any other basalt site, thus raises questions about the integrity of the environmental assessment (EA), which the EA itself does not dispel. A good deal of information which should be included in the EA is simply not there, and it appears as if information has been suppressed or omitted deliberately. Such a suspicion of deliberate omissions raises serious questions about the DOE's credibility.

In locating the first round of potential repository sites, DOE did not make either a national or even a basin-wide survey of basalt sites before proceeding with the Hanford characterization. (DOE should have included granite in the first round of repository sites, particularly since the granite investigation really is a nationwide search.) In fact, DOE considered only candidates in the immediate vicinity of the Reference Repository Location (RRL). Screening of potential sites outside the Hanford reservation, or even outside the 200 area on the reservation, was cursory at best. For example, the use of some land outside the reservation as irrigated farmland is cited as a virtual disqualifier, although that didn't seem to stop the DOE in Texas. Are different siting criteria being applied in Washington than in Texas? DOE's bias is most obviously displayed in the phrase "...these sites were not obviously superior [emphasis added] to

those found within the Hanford site, and therefore, were given no further consideration." Do the siting guidelines state that the lack of "obvious superiority" is a disqualifying factor?

Investigations of basalt formations were not even extended to areas other than those which had been considered in the 1982 Site Characterization Report of the Basalt Waste Isolation Project; DOE apparently decided that the site characterization borehole was going to be drilled where the drilling rig had been put in 1982. Evidence which might change that decision, even on the Hanford Reservation itself, was not even considered.

Turning to a critique of the geological findings themselves, one notes considerable question about the relative depths of the proposed candidate horizons, and whether the depth of any candidate horizon at the RRL is adequate for waste isolation. The deepest dense zones, where the dense zone is well below the flow top and below any vesicular zone, is 42.5 meters thick in the Umtanum flow and 43 meters thick in the Cohasset flow, with a standard deviation of approximately 11 m. DOE gives a figure of 24 meters for the minimum acceptable thickness of this densest zone.

It is difficult to understand how this minimum figure was arrived at. The repository emplacement rooms are described as having a height of 3.3 meters. Admittedly, until a borehole is drilled and site characterization is done, the thickness of the dense zones can be estimated apparently only to plus or minus 25%. This margin of uncertainty, when applied to the minimum acceptable thickness of 24 meters, narrows that down to a sure minimum of 12 meters - only about three and a half times the height of an emplacement room. This is not much of a margin for error. Cynicism raises the suspicion that DOE's minimum acceptable thickness anticipates that the densest zones might be found to be considerably thinner than the present estimate.

DOE is also assuming that the thickness of this zone will not vary over a two-square-mile area, and that the rock shows little or no anisotropy. Neither of these assumptions is well founded. DOE should have included, in the Draft Environmental Assessment, the rationale for the selection of 24 meters as the minimum thickness for the densest zone, clearly and in quantitative detail.

My comments on tectonics and seismicity reflect only a general scientific viewpoint, and are limited to the adequacy of data collection and interpretation. Once again, DOE's examination of faulting, folding and seismicity of the Pasco Basin has been cursory. Descriptions of the tectonics and seismicity of the region - Washington, Oregon and Idaho between the Cascade ranges and the Northern Rockies - have apparently never been published by DOE; maps of earthquake epicenters for all loca-

tions throughout the Pasco Basin should be included in the Draft EA. Some such studies must certainly exist as a consequence of the construction permits issued for Washington Nuclear Plants 1, 2 and 4 and the proposed Skagit-Hanford nuclear power plant. The long interest in Hanford as a site for various "nuclear activities" has also resulted in a large number of papers in the open literature, particularly on seismicity, which seem to have escaped DOE's notice. These data, as well as information on, and assessments of, fault activity throughout the basin would be needed for NRC licensing in any case, so it is surprising that DOE has not included them in the latest environmental assessment.

The inescapable conclusions from DOE's study of tectonics and seismicity, to date, are that DOE didn't want to find a suitable basalt site anywhere except in the 200 area on the Hanford Reservation, and that DOE wanted to find a very low potential for seismic activity in that area.

DOE should, by now, have published a thorough literature survey of the tectonics and seismicity of the entire Pasco Basin and intermountain region, and should make a detailed comparison of the tectonics and seismicity of the proposed RRL with that of the rest of the region.

Throughout DOE's discussions on geochemistry, it is never clear whether what is under consideration is crushed basalt (the intended backfill material) or small or large samples of intact basalt. The 1982 Site Characterization Report (DOE/RL 82-3) did contain a fairly complete discussion of geochemistry, including several tables of chemical composition of the basalt flows to be characterized. However, even this discussion contained unsupported assertions, conclusions unsupported by data, contradictory statements, and insufficient supporting evidence.

One might conclude that insufficient research into geochemistry has been done. However, in the summer of 1984, I had occasion to tour the Rockwell research laboratory at Hanford, and observe, at first hand, the crystallographic and chemical studies that were being done there. Rockwell has spared no expense in equipping the laboratory, and the scientists working there are clearly very competent. The Rockwell facility is, in most respects, a "dream" laboratory, and is equipped well beyond the means of most university research laboratories. It is therefore difficult to understand why so few results of this research are found in DOE documents.

The discussion of the thermal properties of basalt as compared to other rock types is, at best, indeterminate and confusing. What are the "generic rock types" whose thermal conductivities and coefficients of expansion are given in the Draft EA, and what relevance do they have to the discussion at hand? Rock is not a homogeneous chemical compound or a chemically

uniform solid solution. Only the thermal properties of rock taken from a specific site, or measured in situ, are relevant.

More important, the favorable or unfavorable aspects of thermal conductivity and thermal expansion can only be discussed intelligently in comparison to the other rock types under consideration for the first repository. For example, salt does indeed have a coefficient of thermal expansion an order of magnitude greater than basalt or tuff, giving it a relatively high plasticity. This relative plasticity of salt should thus disqualify it, according to the Draft EA, but it is exactly the property of salt beds and domes which put them in consideration for a repository in the first place. This apparent contradiction is explained rather simply: each rock type has a complex of characteristics which might make it suitable for a repository. These characteristics are favorable or unfavorable depending on other characteristics of the rock; e.g. the expansion of salt enhances its plasticity, but any expansion in basalt yields larger cracks. A large coefficient of thermal expansion would thus be a favorable condition in salt, but an unfavorable one in basalt. A thorough discussion of plasticity, hydrothermal fracturing, and the comparative properties of different rock types is needed.

There is no discussion at all of groundwater chemistry in the Draft EA. There was considerable discussion of geochemistry of groundwater in the 1982 Site Characterization Report, albeit a discussion largely discredited by the Nuclear Regulatory Commission. There are sufficient internal contradictions in the groundwater analysis to disqualify the site on the basis of uncertainty. Estimates of ground water travel times from various directions to the Columbia River vary from a low of 20 years to a maximum of 81,000 years. The Nuclear Regulatory Commission points out that DOE's data can be interpreted to give travel times ranging from 20 years to 40,000 years. The assertion that "...ground-water travel time...to the accessible environment would be more than 10,000 years" is thus questionable.

It is also unclear how DOE intends to proceed with hydraulic testing. The Draft EA states that "large-scale hydraulic testing will rely on developed saturated-flow hydraulic theory." It is precisely the reliance on theory, and the absence of actual measurements of hydraulic parameters, as well as the absence of quantitative data, which has been severely criticized. The Draft EA does not contain sufficient information on whether groundwater conditions are favorable or unfavorable.

Data on hydraulic pressures do not indicate any uniformity in the direction of the hydraulic gradient, and do not indicate that water will flow down rather than toward the surface.

The discussion of grouting and sealing the borehole can charitably be called optimistic. The borehole will be fifteen

feet in diameter - one of the largest boreholes in the world. It is larger than any of the other examples given in the Draft EA, and by a considerable margin. The discussion of possible grouting difficulties, extensive development of cracks, and spalling is both inadequate and overly forgiving. Statements about loss of drilling fluid, size of spallation fragments and rock instability, and even measures to mitigate fractures and spalling are vague and imprecise.

The Draft EA contains the following very disturbing statement: "...after permanent closure of the repository...the packing placed around the container becomes saturated with ground water..." I thought, as others did, that the extensive siting procedure was to find a site where the packing would not become saturated with ground water. The DEA gives the reader to understand that the absorbent packing material of crushed basalt and bentonite was a preventive structure which would be needed in the event that ground water seeped into the repository, not because the ground water was certain to saturate the emplacements! Is this supposition - that the packing around the spent fuel containers will be completely saturated with ground water - not enough to disqualify the site?

Lack of data and quantitative analyses make the site comparisons appear questionable. However, even DOE's analysis consistently shows Hanford to rank below all, or almost all, of the other four sites proposed. The highest cost is assigned to Hanford, and Hanford ranks as follows:

Fifth of the five in geohydrology and rock characteristics.

Fourth of the five in tectonics, transportation, population density, radiological safety of offsite installations and operations.

If one takes this DOE's ranking at face value, Hanford does not emerge as one of the top three candidates, and should be eliminated from consideration.

If Hanford were a good site to isolate HLW, I would have no objection to putting the repository at Hanford and thereby moving to address the radioactive waste problem constructively. However, the closer a look one takes at Hanford, the worse it looks as a site with respect to the criteria which affect radioactive waste isolation: geology and hydrology. Site selection must be a decision based on geology, not on politics or on the present economic pressures on a community. Moreover, using the potential repository operator as the contractor for site characterization requires a superhuman degree of objectivity of that contractor which we have no right to expect.

Finally, we support HR 1843. The "accessible environment" which would be threatened with contamination is, in fact, the

Columbia River. The major flaw in siting a HLW repository at Hanford is Hanford's (and the RRL's) proximity to the Columbia. Since the Columbia, downstream from Hanford, has both an Oregon bank and a Washington bank, Oregon has almost as much at stake as Washington. The claim of Oregon as an affected state is very similar to the claim of the Yakima Indian Nation, which has affected tribe status. We would therefore urge passage of HR 1843.

FIGURE 5-7:
PROJECTED HEALTH EFFECTS
OVER 10,000 YEARS*

