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NRC COMMENTS

ON

DOE DRAFT ENVIRONMENTAL ASSESSMENT

FOR THE

HANFORD SITE

March 20, 1985

HANFORD

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INTRODUCTION

Background

On December 20, 1984, the DOE issued draft environmental assessments (EAs) for nine potentially acceptable sites for the nation's first nuclear high-level waste repository. Issuance of final EAs will be in accordance with the Nuclear Waste Policy Act of 1982 (NWPA) which directs the U.S. Department of Energy (DOE) to issue an EA for each site that the Secretary nominates as being suitable for site characterization. Public review and comment were solicited on draft EAs for a period ending on March 20, 1985. From among the nine potentially acceptable sites, five sites are being proposed for nomination as being suitable for site characterization. Following the issuance of the final environmental assessments, DOE will formally nominate at least five sites as suitable for site characterization and recommend at least three of the nominated sites to the President for site characterization as candidates for the first repository.

Each draft environmental assessment contains: (a) a description of the decision process by which the site was selected; (b) information on the site and its surroundings; (c) an evaluation of the effects of site characterization activities; (d) an assessment of the regional and local impacts of locating a repository at the site; (e) an evaluation as to whether the site is suitable for site characterization and for development as a repository; and (f) a comparative evaluation of the site with other sites that have been considered.

The NWPA and NRC regulations governing licensing of the geologic repository provide for consultation between DOE and NRC staffs prior to formal licensing to assure that licensing information needs and requirements are identified at an early time. In accordance with the NRC/DOE Procedural Agreement on repository prelicensing interactions, NRC and DOE staffs have been conducting such consultations. According to NWPA, the environmental assessments are to provide a summary and analysis of data and information collected to date on sites which the DOE intends to nominate for site characterization. Therefore, they present an important opportunity for NRC and DOE staffs to consult on the issues that exist at each site which must be addressed for site characterization. They also afford an opportunity for the NRC staff to point out at an early stage in DOE's repository program potential licensing problems with a site if they were found to exist on the basis of available information.

NRC Staff Review

The staff conducted its review of the EAs according to the NRC Division of Waste Management's "Standard Review Plan for Draft Environmental Assessments

(Dec 12, 1984)." Because of the limited time available for review and the vast amount of data and information existing for the nine sites, the staff had prepared for the draft EA reviews well before their receipt. Preparation included: 1) broad familiarization with the overall existing data/information base for each site; 2) selected detailed reviews of data; 3) development of a clear understanding of the guidelines; and 4) development of preliminary views and issues through reviews of existing data and scoping reviews of preliminary EA drafts. This early preparation and familiarization with the existing data base has allowed the staff to determine if the conclusions and findings in the EAs are consistent with the available data.

In its review, the staff has sought to identify potential safety issues through a review of DOE's application of the siting guidelines. The staff has focused on the analyses and technical evaluations that are made on individual guidelines which constitute the factual basis upon which the site comparisons are made by DOE. The staff reviewed the available data, interpretations, assumptions and performance assessments in the EA and its references that DOE used to substantiate its evaluation of a site against the guidelines. In commenting on the EAs, the staff has recognized that the level of information which exists on each site is not equivalent to what will be necessary to make findings about the suitability of the one site that is proposed for development as a repository. The staff has reviewed the evaluations and conclusions which are called for at the EA stage by the siting guidelines. These guidelines recognize the inherent uncertainties that will face any site before detailed site characterization.

The staff's review and comment on the evaluations and conclusions on the siting guidelines effectively identified issues which are relevant to potential safety issues. In its concurrence action on the siting guidelines, the Commission found that the guidelines are consistent with the requirements of its own regulations on geologic repositories (10 CFR Part 60). Therefore, while the staff has not identified in each case how its comments relate to the specific requirements of 10 CFR Part 60, we feel that they serve to identify those issues which are relevant to potential licensing of each site based on information currently available and which will need to be resolved during site characterization.

The staff also commented on the analyses of environmental impacts of site characterization activities and repository operation with the intent of assisting DOE's preparation of the final EAs. However, the staff has not performed a detailed review with regard to the site characterization plans in Chapter 4 or the repository descriptions in Chapter 5 of the EAs. The staff only commented on those aspects of site characterization plans, such as the need for characterizing the geohydrological regime beneath Canyonlands Park, which need to be considered to evaluate the site against the siting guidelines, at this time. Site characterization plans will be reviewed upon receipt of such plans in accordance with the NWPA and in other consultations with the DOE under the interagency agreement governing repository prelicensing matters (48 FR 38701); the staff's review and positions will be documented in site characterization analyses at that time.

NRC Staff Comment-Summary

In no case did the staff conclude that a disqualifying condition was clearly present or a qualifying condition clearly absent at the sites being investigated. To a large extent the EAs recognize that uncertainties exist at each site. However, in some instances, the full range of uncertainty that exists about certain factors affecting site suitability is not recognized in the discussion supporting the EA findings. The staff noted that in a number of instances the EAs make conclusions and findings which are not supported by existing data or which existing data indicate are not conservative. In these instances, the staff points out specific data and other information which indicate that EA conclusions are not realistically conservative as required by 10 CFR Part 960 (10 CFR Part 960.3 requires that assumptions made in EA evaluations be... "realistic but conservative enough to underestimate the potential for a site to meet the qualifying condition of a guideline..."). For example, we point out information on hydrologic conditions at several sites which is not fully documented in the EAs and which could realistically support less optimistic conclusions about groundwater travel time than those presented in the EA.

In each comment, the staff has attempted to describe the significance of the comment and to recommend what DOE might do to resolve the comment. Ultimately, it may be found unnecessary to completely eliminate all of the uncertainties about site features that are identified in the comments. It is expected that through further investigation it can be shown that some of these uncertainties are compensated for by other site features which assure overall system guidelines are met. (For example, some questions about geochemical properties may be mooted or lessened in importance by development of information indicating that there are very favorable and compensating groundwater conditions.) Nevertheless, it is essential that all potential problems and uncertainties about sites be explicitly identified at this stage so that site-screening decisions are based on complete assessment of the facts and that future site characterization work is complete.

In pointing out deficiencies in DOE's evaluations of individual sites, the staff has commented on DOE's evaluations and findings with respect to the various individual factors which are important to site suitability (i.e., 10 CFR Part 960 guidelines on geohydrology, geochemistry, rock characteristics, etc.). We expect that the DOE analyses in Chapter 1 through 6 will be revised in light of our comments. The staff therefore recommends that DOE reconsider its ratings and ranking analyses of sites in Chapter 7 so that the overall comparison of sites and resulting decisions are consistent with supporting evaluations and findings on individual factors.

It is the staff's view that by recognizing uncertainties identified in our comments and reexamining its assessments in light of the other technical concerns that we raise, the environmental assessments and related decisions will be strengthened.

Presentation of EA Comments

The staff presents its comments in two parts. First, it presents major comments. The order in which these comments are presented has no special significance; the order is governed by the fact that some comments, which help the reader understand others, come first. Second, detailed comments are presented on each of the chapters of the EA. The major comments are those comments which the staff considers may potentially lead DOE to a change in EA findings with respect to specific guideline or may affect the relative ratings of sites. In some of the detailed comments, the staff identifies areas where the discussions supporting the EA findings are more certain than we believe the data supports. If such supporting discussions were considered in the comparison and ratings of sites, these detailed comments could be as significant as those labeled major comments.

Many of the staff's comments appear identical for different sites because the information presented by DOE in the EAs was often identical and therefore would result in the same comment, particularly when sites are in the same geohydrologic basin. Similar comments do, however, take into consideration differences resulting from site specific information.

MAJOR COMMENTS

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COMMENT #1

Ground-Water Travel Time

Guidelines on Geohydrology 10 CFR 960.4-2-1(b)(1) and 960.4-2-1(d).

In the draft EA, the DOE concludes that the pre-waste-emplacement ground-water travel time along any path of likely and significant radionuclide travel from the disturbed zone to the accessible environment is expected to be well in excess of 10,000 years (Sections 6.3.1.1.2, 6.3.1.1.11, 6.3.1.1.12, and 6.4.2.3.5). In support of its conclusion, the DOE has performed several preliminary deterministic and stochastic studies of ground-water travel time which have yielded a wide range of travel time estimates. The preliminary estimate which the DOE considers most representative of site conditions, as presently understood, is 81,000 years (median) with a more than 0.95 probability of exceeding 1,000 years (page 6-81).

The NRC believes there are several questionable areas with respect to DOE's finding on ground-water travel time. These areas are: 1) the applicability of previously published travel time estimates (see detailed comment 6-12); 2) the reliability and representativeness of the data base for transmissivity, hydraulic gradient and effective thickness (see detailed comments 6-15 and 6-105); 3) the treatment of these data in deterministic and stochastic models (see detailed comments 6-101, 6-12, and 6-102); 4) the treatment of the numerical model geometry (see detailed comment 6-102); and 5) the definition of the orientations and lengths of flow paths from the disturbed zone to the accessible environment (see detailed comment 6-12).

With regard to item (2) above, the NRC believes the limitations of the available data do not allow high confidence to be assigned to any travel time estimates at this time. Nevertheless, a rough evaluation by the DOE of the ability of the site to meet the ground-water travel time conditions set in the Guidelines (960.4-2-1(b)(1) and 960.4-2-1(d)) is necessary at this time.

As an aid in reviewing the DOE's preliminary conclusions (page 6-81), which are based on the existing hydrologic information base, the NRC staff has calculated alternative median travel times based on the same information. These calculations, which are consistent with DOE's conceptual model, illustrate the impact of problem area (3) noted above. They demonstrate that substantially lower estimates of median travel time can result from reasonable interpretations of the existing data (see detailed comment 6-101) and the DOE's conceptual model. Most of these estimates are less than 10,000 years, and some are less than 1,000 years, which causes the NRC to question the DOE's evidence for the finding on favorable condition 960.4-2-1(b)(1) and disqualifying condition 960.4-2-1(d). Because of 1) the simplified nature of the NRC's calculations and 2) questions about the reliability and representativeness of the underlying data base used, especially for the large-scale hydrologic properties of the site, these estimates should not be construed as accurate or reliable predictions of actual site conditions. However, the parametric analysis, and an additional analysis exploring the impact of problem area (4) noted above (see detailed comment 6-102), raise significant questions regarding the defensibility of the DOE's conclusion that the ground-water travel times can preliminarily be inferred, based on the existing data, to be well in excess of 10,000 years, or that there is a high probability that the travel times would be greater than 1,000 years.

We suggest that the DOE thoroughly reexamine the available information, considering the questions noted above with respect to the DOE's predictions of hydrologic performance. If the DOE considers that the findings presented in the draft EA should be maintained, further support of this position should be provided, specifically addressing the points noted above and in our detailed comments.

COMMENT #2

Changes that Could Affect the Geohydrologic Regime

Guidelines on Geohydrology 10 CFR 960.4-2-1(c)(1); Climatic Changes 10 CFR 960.4-2-4(c)(2); and Human Interference 10 CFR 960.4-2-8-1(c)(5).

The DOE concludes that the potentially adverse condition relating to changes in geohydrologic conditions sufficient to significantly increase the transport of radionuclides (960.4-2-1(c)(1)) is not present. In arriving at this conclusion, the DOE considers and dismisses two processes that could potentially induce changes in geohydrologic conditions. Specifically, these processes include: 1) climatic changes and 2) thermal loadings originating from decay of emplaced nuclear wastes. However, the NRC considers that these, and human-induced conditions not considered by the DOE, may significantly alter the geohydrologic regime and consequently affect repository performance.

In evaluating the effects of climatic changes on the geohydrologic system the DOE concludes that significant climatic changes are not to be expected during the next 10,000 years. Based on this conclusion, the DOE determines that the potentially adverse condition of significantly increased radionuclide transport caused by climatic changes is not present at Hanford (960.4-2-4(c)(2)). However, the NRC concludes that significant climatic variations cannot be discounted over the next 10,000 years. The potential for climate change includes both potential for significant warming, or for significant cooling (see detailed comments 6-38 and 6-39, respectively).

The DOE concludes that proglacial catastrophic flooding would be the most probable disruption scenario associated with potential climatic changes that could significantly affect the hydrologic system. Because this catastrophic flooding was associated with the late ablation phase of continental glaciation, the NRC agrees that it is not likely to recur over the next 10,000 years. However, other consequences of either significantly warmer or cooler climatic trends have not been discussed by the DOE. For example, smaller-scale climatic variations may result in future channel migrations of the Columbia River and its tributaries in response to increasing discharges and sediment loads fed by meltwaters from reactivated mountain and valley glaciers. Mountain glaciers presently exist in the northern portions of the Columbia's drainage basin. These could be reactivated and subsequently ablated in response to relatively small-scale climatic changes. If future channel displacements of the Columbia occur within the area of the Hanford Reservation they could dramatically alter regional patterns of recharge and discharge and may significantly change radionuclide transport conditions within local basalt and interbed aquifer systems (see detailed comment 6-39). Overall, in the NRC's view the potential for both cooling and warming trends, and the consequences thereof, should be more closely examined by the DOE.

With respect to heat effects caused by radionuclide decay, the DOE concludes that thermal loading is predicted to extend a distance of several hundred meters from the repository. The DOE dismisses the significance of this thermal loading because it represents a limited lateral extent relative to the 10 km lateral distance to the defined accessible environment. However, studies by the NRC staff and others (see detailed comment 6-18) suggest that post-emplacement thermal loadings may be sufficient to significantly increase hydraulic gradients, especially along vertical profiles in close proximity to the repository. Such a change in hydraulic gradients would be expected to significantly change flow paths and rates. The result could be a corresponding decrease in ground-water travel times, particularly along any existing vertical flow paths. Geochemical effects, resulting in volume reductions in fracture-filling clays, that may accompany the thermal loadings could also significantly affect the geohydrologic regime (see detailed comment 6-27).

In addition to the two mechanisms for significant changes in the geohydrologic system discussed above, which the DOE considered and dismisses, the NRC concludes that human-induced changes to the geohydrologic system may significantly affect rates of radionuclide transport to the accessible environment. These human-induced changes could be caused by onsite wastewater disposal activities and offsite ground-water and surface-water withdrawals, resulting in aquifer recharge and perturbation.

Piezometric data suggest that artificial recharge of the unconfined aquifer system, caused by four decades of wastewater disposal activities at the Hanford Site, may be causing a downwardly-progressing increase in hydraulic heads in the confined basalt and interbed aquifers. If this condition proves to be correct it would have considerable significance with regard to vertical ground-water travel paths and travel times, especially in the presence of post-emplacement thermal loadings during the period after wastewater disposal ceases (see detailed comment 6-18).

Other human-induced geohydrologic perturbations may be caused by dam construction, offsite ground-water withdrawals for irrigation and other purposes, and irrigation derived from Columbia River waters (see detailed comment 6-18). Such activities would result in greatly increased surficial recharge rates over large areas. Under the postclosure geohydrologic guideline (960.4-2-1(c)(1)) it is stated that the potentially adverse condition is not likely to exist (page 6-76). However, on page 6-143 the DOE assumes that the potentially adverse condition (960.4-2-8-1(c)(5)) regarding impacts of human activities, including ground-water withdrawals and surface impoundments, on the geohydrologic system could be present. This disparity in findings under the guidelines should be resolved by the DOE (see detailed comment 6-57).

Based on the above discussions the NRC considers that there is reasonable doubt that the potentially adverse conditions are absent. The DOE should reevaluate the potentially adverse scenarios described above and revise the EA either to further support its conclusion that the potentially adverse condition (expected changes in geohydrologic conditions sufficient to significantly increase rates of radionuclide transport) is absent or to reverse one or both of its negative findings with respect to the potentially adverse conditions [960.4-2-1(c)(1) and 960.4-2-4(c)(2)]. The DOE's finding under the postclosure geohydrologic guideline 960.4-2-1(c)(1) should be consistent with the finding under guideline 960.4-2-8-1(c)(5) regarding forseeable human activities.

COMMENT #3

Geochemical Environment

General Geochemical Guideline 10 CFR 960.4-2-2

In the draft EA Executive Summary, attention is drawn to the inferred, favorable geochemical environment at Hanford. "There is also evidence that the reference repository location has chemically reducing conditions that will promote precipitation and will maintain radionuclides in their least mobile state." (draft EA, page 15) The NRC review of the Hanford draft EA found inadequate data and analyses to support the DOE statements about the reducing nature of the basalt ground-water and the geochemical environment, and that the DOE analyses did not adequately address well-known problems of interpretation of redox information. Based on this review, the staff considers that the EA does not provide convincing support for the key conclusions in the preceding citation.

The solubility of radionuclides at Hanford is largely related to the redox conditions in the ground-water. The DOE analysis of redox conditions and reactions, as presented in the EA (pages 6-90/91/92/95/96) and cited references, do not support a conclusive evaluation that: (1) expected redox conditions are as reducing as the -0.3 volts used for EA calculations; and that (2) expected reactions will maintain redox-sensitive radionuclides in low solubility and high sorption states.

Concerning point (1), the DOE-sponsored investigations of ground-water [Early, et al. (1982 and 1984) and DOE (1982), among others] report that measured redox conditions range from about +0.35 volts to -0.2 volts, and that calculated values range as low as -0.4 volts. However, redox measurements on natural waters are difficult to interpret; therefore the DOE uses calculated redox conditions of -0.3 volts (and lower) in the draft EA, based on three arguments: a) The coexistence of titano-magnetite with ferrous secondary iron-bearing phases such as pyrite, and the lack of naturally occurring ferric iron-bearing phases such as hematite; b) limited occurrences of sulfide ions coexisting with sulfate ions, and methane coexisting with carbon dioxide; and, c) data from rock/water interaction experiments. With respect to (a) and (b), the NRC considers that neither observable mineral assemblages and/or redox couples are sufficient to indicate that site redox conditions are chemically reducing and not chemically oxidizing (see detailed comment 6-33). With respect to (c), the NRC considers that these particular experimental results are not an adequate basis for suggesting that site redox conditions are as reducing as -0.3 volts, or are not chemically oxidizing (see detailed comment 6-33).

Concerning point (2), the DOE assumes that the redox conditions will reduce virtually all redox-sensitive radionuclides to their least soluable and most sorptive state. However, it cannot be assumed that all redox sensitive elements will be in chemical equilibrium within the system (Stumm, 1966, Lindberg and Runnels, 1984, Hostettler, 1984). Therefore, even if redox conditions are established, it does not follow that redox-sensitive radionuclides will be reduced to their least mobile state. Further, experiments show that several redox-sensitive radionuclides exist in their more oxidized state under conditions of -0.3 volts and lower (Kelmers, 1984, and Meyer, et al., 1984). (See detailed comments 6-28 and 6-33).

For the Hanford site, geochemical conditions play an important role in site performance and the DOE has found favorably for all favorable and potentially adverse guidelines. Assumed reducing conditions provide either the basis or support for each favorable finding. However, existing data appear insufficient either to support an unambiguous evaluation of site conditions and reactions or to support the assumption that the conditions are chemically reactive and that radionuclides will be present in their least mobile state.

The staff suggests that the DOE reconsider the data on redox conditions and reactions and reevaluate the findings on the related conditions under geochemical guideline 960.4-2-2 (conditions and processes at the site shall permit compliance with requirement for radioactive releases). (See also detailed comments 6-1 and 6-25 through 6-33).

COMMENT #4

Tectonic Stability

Guidelines on Tectonics 10 CFR 960.4-2-7(a),(b),(c)(3),(c)(6),(d) and 960.5-2-11(a); Geohydrology (960.4-2-1(a),(b)(1) and (4)(ii); and Rock Characteristics 960.4-2-3(a).

The draft EA presents a generally favorable view of the tectonic setting and possible effects of tectonics on waste isolation. The NRC considers this view to be inadequately supported by the data and analyses in the draft EA, because a number of factors relevant to assessing tectonic stability appear to receive little consideration. For purposes of discussion, these factors are grouped into three topics: faults in and near the reference repository location; recent fault activity; and potential for future fault activity.

Evidence suggesting that faults exist in and near the reference repository location, located in the Cold Creek syncline, include the presence of tectonic breccia, seismic reflection data anomalies and aeromagnetic map lineaments (see detailed comments 2-5, 3-11, and 6-41). The presence of faults in the Cold Creek syncline would be consistent with the occurrence of major faults in the Vantage syncline area (an analog to the Cold Creek syncline, see detailed comment 3-13). Faults related to the Cle Elum Wallula (CLEW) zone (a 40 kilometer-wide deformation belt, draft EA, page 3-52) may be present near the reference repository location (detailed comment 6-41). The DOE's preliminary conclusion that the reference repository location is located away from known or suspected faults (draft EA, pages 3-79, 6-129, 6-136, 6-214) does not adequately reflect the information noted above.

Existing evidence suggests recent fault movement in the reference repository location area. Such fault movement, in the NRC's opinion, is expressed by hundreds of microearthquakes (up to magnitude 3.8) throughout the Pasco Basin including about sixty within 5 km of the reference repository location and ten with epicenters within the reference repository location boundaries (detailed comment 2-5). An extension of the 115 to 140 km-long Rattlesnake-Wallula lineament (RAW), the part of CLEW that the NRC considers capable of an earthquake magnitude $6.5M_s$, can be postulated to pass a mile from the reference repository location (see detailed comment 6-41). Recent seismic activity appears to have occurred along the trace of the RAW and its projected north-western extension (see detailed comment 6-41). The DOE's preliminary conclusion that "tectonically active faults do not appear to be present in the reference repository location" (draft EA, page 6-210) does not adequately reflect the information noted above.

An important factor in assessing future faulting activity for the Hanford site is the high horizontal stress calculated from in situ measurements at depth in and near the reference repository location (see detailed comment 3-14). The NRC considers that the high stress is resulting from the ongoing north-south compression (draft EA, page 2-18). Although the DOE considers that microearthquakes are relieving minor amounts of stress (draft EA, page 2-18), the NRC considers that the stress is not necessarily being substantially relieved by microearthquakes and may be relieved by a moderate to large earthquake (detailed comment 2-5). The DOE's preliminary conclusion that the long-term, low-average deformation rate indicates that tectonic processes such as faulting will not adversely affect waste isolation for 10,000 years after closure (draft EA, page 6-127) does not adequately reflect the information noted above.

The inadequate documentation regarding faults, fault activity, and future faulting activity in and near the reference repository location may have a significant impact on the bases of a number of DOE findings; these include: tectonics conditions: 960.4-2-7(a), (b), (c)(3), (c)(6), (d) and 960.5-2-11(a). Faults and active faulting may affect groundwater travel paths, travel times, and flow directions (see detailed comment 6-49 and geohydrology conditions 960.4-2-1(b)(1) and 4(ii)). Active faulting may also affect rock characteristics condition 960.4-2-3(a).

The NRC suggests that the DOE re-examine and document information regarding faults, faulting and future fault activity presented above and re-evaluate its position on tectonic stability as applied to the siting guidelines. The DOE should then consider re-examining the tectonics and related guideline findings and either change or better support those findings.

COMMENT #5

<u>Natural Resources</u>

<u>Guidelines on Natural Resources 10 CFR 960-2-8-1</u>

For qualifying condition 960.4-2-8-1(a), the DOE has not adequately documented available information on hydrocarbon resource potential such as: traps below or within synclines, and close proximity of anticlines to the reference repository location. The draft EA implies that any potential for natural resources in the immediate vicinity of the reference repository location is low, because the repository location is in the Cold Creek syncline and is away from anticlines that form the traps for natural gas (draft EA, page 6-142).

Exploration in the Saddle Mountains has indicated that natural gas is present below the basalts (draft EA, page 6-187). The deep (greater than 12,000 ft) Shell Oil Company well, at Saddle Mountains 26km (16 miles) north of the reference repository location (draft EA, page 6-139), is the closest commercial exploratory drilling. The exploration target is below the basalt.

The American Association of Petroleum Geologists newsletter, "Explorer", (Shirley, Nov. 1984) indicates exploration activity on the Columbia Plateau is increasing due to rapid advancements in magnetotelluric methods capable of detecting deep structure beneath the basalts. Magnetotelluric results show that the anticlines and synclines in the basalts do not reflect the structures beneath the basalts (RHO-BW-ST-19P). Hence, gas reservoirs below the basalts may be found under synclines in the basalts, as well as under anticlines. The presence of hydrocarbon traps below the Cold Creek syncline may be indicated by the presence of methane (natural gas) in groundwater samples from the Cohassett flow, in the Cold Creek syncline (draft EA, page 6-187).

The EA states, on page 6-139, that the Yakima Ridge (3 kilometers (2 miles) west of the reference repository location) is the nearest anticlinal ridge to the reference repository location. However, Yakima Ridge anticline is postulated by the DOE to exist buried (draft EA, page 3-51) within a half mile southeast of the reference repository location.

The DOE's assessment, as presented in the draft EA, does not consider possible kinds of natural gas traps other than anticlines, such as: faults (detailed comment 6-41 and 3-11) and feeder dikes which may be buried beneath the repository area (Ice Harbor dike, Pasco, U.S.G.S., 1979).

Based on the indications cited above, we consider that the DOE has incompletely documented the finding and support of the qualifying condition (Section 960.4-2-8-1(a)). Another finding that is impacted by consideration of this information is potentially adverse condition 960.4-2-8-1(c)(1).

The NRC suggests that in the final EA, the DOE document consideration of the above information on hydrocarbon potential in the geologic setting of the Hanford site, and reconsider the findings for guideline conditions 960.-4-2-8-1(a) and 960.4-2-8-1(c)(1) and consider changing or better supporting them.

COMMENT #6

Thickness of Host Rock

Guidelines on Rock Characteristics 10 CFR 960.5-2-9(b)(1),(b)(2), and (c)(1),

The draft EA states that favorable condition 960.5-2-9 (b)(1) is present. This favorable condition deals with the host rock being sufficiently thick and sufficiently laterally extensive to allow significant flexibility in selecting the depth, configuration, and location of the underground facility. Although the data presented in the draft EA indicate that the preferred candidate horizon (Cohassett Flow) thickness exceeds the 21-meter minimum thickness criterion stated on page 6-154, the discussion on pages 6-153 to 6-157 appears to be misleading because of the following reasons.

(1) Table 6-13 summarizes the statistical results of calculated thickness values of the dense interior of the Cohassett flow. Thickness values based on regional and site specific boring data are presented for the dense interior below the flow top and the dense interior below the vesicular zone (DIBVZ). None of the thickness values presented in Table 6-13 for the dense interior below the vesicular zone exceeds twice the minimum thickness criterion. Therefore, in stating that the Cohassett flow provides more than twice the minimum thickness (21 meters or 70 feet) necessary to construct the repository, the draft EA assumes that the entire dense interior is suitable for repository construction. However, Long and WCC (1984) page II-19, states that "the repository panel area would always be sited in the dense interior below the internal vesicular zone." Long and WCC (1984) also states that the vesicular zone is characterized by rock strength at least 35 to 65 percent lower than that of the underlying dense interior. Rock support requirements depend in part on the rock strength. Rock support evaluations in section 6.3.3.2.4 are based on the characteristics of the dense interior excluding the vesicular zone. It is recognized in the draft EA on page 6-157 that greater than minimal support may be required even for the openings in the DIBVZ. Therefore, it must be expected that extensive maintenance and

support may be required for openings in the vesicular zone. If calculations for support and maintenance requirements are based on properties of DIBVZ alone, it is inappropriate to take credit for the entire thickness of the dense interior.

(2) The draft EA takes credit for the ability to exercise the "option to select from three other candidate horizons (Rocky Coulee, McCoy Canyon, and Umtanum flows)." Because of this option, the draft EA states that there may be "further flexibility" in selecting a host rock horizon at depth. This does not seem to be reasonable, especially since page 6-157, paragraph 3, states that "...these flows do not appear to have sufficient minimum thickness..."

(3) An additional consideration in assessing flexibility for an underground facility location is the potential for significant thickness changes in the Cohassett flow within the reference repository location. The draft EA states (page 6-155), that the thickness data collected from boreholes in or near the RRL more closely represent the thickness of the host rock than does the regional data. Regional data for the Cohassett flow presented in Table 6-11 indicate that the thickness of the dense interior below the vesicular zone ranges from 19.8 m to 48.2 m. Therefore, the potential for lateral variation in thickness exists. It should be noted that such thickness variations were encountered in the Umtanum flow during the RRL-2 drilling. Thus, the potential for limited flexibility in the location and configuration of the repository should be recognized.

Host rock thickness is a significant element in the DOE Siting Guidelines 960.5-2-9(b)(1) and 960.5-2-9(c)(1) and may also affect the severity of rock support problems, as outlined in section 6.3.3.2.4, concerning DOE Siting Guideline 960.5-2-9(b)(2), which deals with minimal support requirements.

The final EA should provide a discussion about whether construction within the vesicular zone will be necessary. If credit is taken for the entire dense interior in evaluating DOE Siting Guidelines 960.5-2-9(b)(1) and 960.5-2-9(c)(1), modification of section 6.3.3.2.4 should be considered in the final EA so as to include a discussion on the additional support requirements for openings in the vesicular zone. If credit is not to be taken for the thickness of the vesicular zone, a reevaluation of the draft EA statement that sufficient flexibility exists in selecting the depth, configuration and location of the underground facility should be considered (see detailed comment 6-37).

COMMENT #7

Shaft Construction

Guideline on Rock Characteristics 10 CFR 960.5-2-9(c)(2)

The conclusion regarding the DOE Siting Guideline 960.5-2-9 (c)(2), page 6-172, states that the need for engineering measures beyond reasonably available technology is not expected in the construction of repository shafts and underground facilities. However, we consider that the evidence in the draft EA does not support the DOE's conclusion regarding this potentially adverse condition.

In section 6.3.3.2.6.1 (Shaft construction), page 6-172, the EA states that it is viable to use the blind-hole drilling method for shaft construction. Justification for this claim is based upon (1) geotechnical information derived from ongoing studies, (2) an extensive and ongoing (small-diameter) drilling program, and (3) experience gained from other blind hole drilling projects. The above claim is questioned for two reasons:

(1) Geotechnical information and experience gained at Hanford from the small diameter drilling program are not directly applicable to situations likely to be encountered in large diameter shaft drilling. Granted, the same geological and hydrological conditions will be encountered when drilling boreholes and shafts, however, their effect on shaft stability differ considerably. A DOE-sponsored document states that it is difficult to predict how the walls of a shaft will react based on information gathered during drilling of small diameter boreholes (see Morrison-Knudsen (1985), in detailed comment 6-65).

(2) The case histories presented in Table 6-20 on page 6-174 do not support the position on the feasibility of blind-hole drilling large diameter shafts, especially the 4.6 meter diameter operational shafts, with reasonably available technology. None of the case histories had drilling constraints closely resembling those present at Hanford. Important differences were: (a) shaft diameter; (b) shaft length; and (c) geologic conditions (see detailed comment 6-64).

The recent study by Morrison-Knudsen (1985) identifies potential geologic hazards and corresponding remedial actions associated with drilling large diameter shafts at the Hanford site. Problems in drilling full size shafts at Hanford (e.g., equipment failure, high stress condition, spalling condition, and mud loss) may be more difficult to deal with than what is presented in the draft EA.

Based on the discussion above, we suggest that DOE revise statements made in the draft EA concerning the applicability of past drilling experience to large shaft drilling under the specific conditions at Hanford and reasess the conclusion on Siting Guideline 960.5-2-9(c)(2).

COMMENT #8

Waste Package Lifetime

The draft EA Executive Summary states, "The lifetime of waste packages at the reference repository locations is estimated to exceed 6000 years" (page 16).

Probability curves for the life of a typical waste container are provided in Figure 6-16 (page 6-244). Section 6.4.2.3.3 (page 6-242, second paragraph) states that "The probability that a typical container will fail in less than 1,000 years is estimated to be close to zero. The mean and standard deviation of container lifetime are estimated to be 6,100 and 600 years, respectively." Further, a conservative approach is claimed in the draft EA's preliminary system assessment (§6.4.2.1 Scope and Objectives, page 6-227; §6.4.2.3 Subsystem Performance Assessment, page 6-232 and §7.1.2, page 7-3) The NRC considers that the degree of certainty implied in the above statements is well beyond what can be supported by the data and analysis presented in the draft EA.

Several factors which tend to limit the container life have not been adequately accounted for in the draft EA. Examples are:

1. The oxidizing environment during repository operation and after closure. (See geochemistry major comment #3 and detailed comment 6-25).

2. Localized corrosion as a waste package failure mode. (See detailed comments 6-89).

3. The effect of the packing on corrosion of the overpack material. (See detailed comment 6-94).

4. The effect which instability of packing may have on the migration of radionuclides through the packing material (§6.4.2.3.3, page 6-248). (See detailed comment 6-94).

The draft EA acknowledges (in page 6-242, last paragraph) that the corrosion analysis considers only generalized corrosion and that other container failure modes, such as pitting, hydrogen embrittlement and environment-assisted cracking, will be considered in a future analysis. It further states that "It is possible that, in localized areas, corrosion may proceed at a relatively higher rate by such means." and that "...conservatism has been built into the present analysis in a number of ways:

- o The container is assumed to fail when 7.5 centimeters (3 inches) of the wall thickness has corroded.

- o The factor of limited oxygen supply available in the waste package subsystem has not been considered.

- o The corrosion calculation did not take credit for the corrosion resistance provided by the oxide film formed in the air-steam environment."

Also, "In addition, credit was not taken for the added containment time potentially provided by the zircaloy cladding of the spent fuel" (draft EA, page 6-284).

The NRC considers that the degree of conservatism claimed by the DOE to be built into the analysis through these factors is questionable for the following reasons:

- o The container failure criterion stated above appears to correspond to axisymmetric yield for a wall thickness of 0.8 cm (i.e. 8.3 cm - 7.5 cm). However, the container will normally fail prior to this by non-axisymmetric elastic buckling (see detailed comment 6-86 for a more in depth discussion).

- o No data or analyses are provided to show that availability of dissolved oxygen limits maximum depth of corrosion. It appears at least equally plausible to assume that the amounts present dissolved oxygen and radiolytic peroxide are more than adequate for localized corrosion stress corrosion cracking and that the rates of these processes are limited by other factors.

- o No data have been presented in the draft EA, or elsewhere, to support the possible formation of a significantly protective oxide film in an air-steam environment in the repository.

The staff suggests that the draft EA might be revised to more fully express the uncertainties in estimated waste package lifetime. The DOE should then consider qualifying: 1) conclusions such as those cited in the first paragraph of this comment and 2) the descriptive material in Figure 16, page 6-244.

COMMENT #9

Comparative Evaluation of Sites Against Guidelines on Surface Flooding

In assessing the guidelines relating to surface water flooding (960.5-2-8(c) and 960.5-2-10(b)(2)) the DOE appears to be inconsistent among the nine sites. The DOE correctly concludes that at two sites (Deaf Smith and Swisher) the repository facilities are not subject to surface water flooding while at the other seven sites they are. The sites that are subject to flooding would have to be flood-protected in varying degrees through the use of engineering measures. At four of those sites (Davis Canyon, Lavender, Cypress Creek, and Vacherie) the DOE concludes that because flood protection would have to be provided the adverse condition (960.5-2-8(c)) is present and the favorable condition (960.5-2-10(b)(2)) is not. At the remaining three sites (Hanford, Yucca Mountain, and Richton) the DOE concludes that since flood protection could be provided, through engineering measures, the adverse condition is not present and the favorable condition is. The seven sites susceptible to surface flooding have not been treated equitably.

We suggest that the DOE decide whether credit for flood protection through engineering measures be considered in applying guidelines 960.5-2-8(c) and 960.5-2-10(b)(2) and then implement the decision consistently. We note that engineering measures, if properly designed and implemented, can be used to protect almost any site from almost any flood. Thus, a decision to allow credit for such flood protection may amount to eliminating the differentiation between sites with respect to these guidelines.

COMMENT # 10

Comparative Evaluation of Sites

The draft EA's describe in Chapter 7 and Appendix B the relative weights given to post-closure and pre-closure guidelines. As required by the guidelines, the DOE gave greater weight to post-closure guidelines (i.e., from 51% to 85% in applying the so-called utility estimation method). However, the staff notes that the spread of site ratings on individual guidelines (see, for example, Tables B-2 and B-3) is distinctly different between the post-closure and pre-closure analyses. The spread of ratings on pre-closure guidelines is much greater than it is for post-closure guidelines. The result of this wider spread is to have pre-closure guidelines dominate the overall ranking, notwithstanding the greater weight given to post-closure guidelines. It appears as if the ratings might be relative in nature as opposed to being an assessment of sites on an absolute scale. If ratings are indeed relative in nature, then inconsistent treatment of post-closure and pre-closure ratings may be interpreted as effectively going counter to the requirement that post-closure guidelines be assigned greater weight in site comparison.

The staff recommends that the description of the rating methods in the draft EA be expanded to explain the reason for the wider spread on pre-closure ratings and, in general, to describe more specifically the method of assigning ratings on individual factors.

Major Comments References

Caggiano, J.A., and D.W. Duncan, "Preliminary Interpretation of the Tectonic Stability of the Reference Repository Location, Cold Creek Syncline, Hanford Site," RHO-BW-ST-19P, Rockwell Hanford Operations, March 1983.

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Kelmers, A.D., "Review and Assessment of Radonuclide Sorption Information for the Basalt Waste Isolation Projects Site (1979 through May 1983)" NUREG/CR-3763, ORNL/TM-9157 Oak Ridge National Laboratory 1984.

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Long, P.E., "Repository Horizon Identification Report, Vol. 1 and 2", SD-BWI-TY-001, Woodward-Clyde Consultants for Rockwell Hanford Operations, 1984.

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RHO-BW-ST-19P, see Caggiano, 1983.

Shirley, K., "Magnetotellurics Offers New Looks: Columbia Plateau Activity Booms," American Association of Petroleum Geologists Explorer, pp. 1, 6, 7, 15, November 1984.

Stumm, W., "Redox Potential As An Environmental Parameter; Conceptual Significance And Operational Limitaions," in Advances In Water Pollution Research," Vol 1, pp. 283-308, 1966.

Swanson, D.A. and R.T. Helz, "Bedrock Geologic Map of the Vent System for the Ice Harbor Member of the Saddle Mountains Basalt, Ice Harbor Dam - Basin City Area, Southeast Washington," U.S.G.S., Open File Report 79-292, 1979.

DETAILED COMMENTS

EXECUTIVE SUMMARY COMMENTS

E-1

Section 3, The site, page 10, paragraph 4

The first sentence in this paragraph states that there are "no threatened or endangered animals and plants...known to occur at the site." The second sentence states "However, the bald eagle (an endangered species) and the peregrine falcon (a threatened species) have been sighted at the Hanford Site." The fact that both these species have been documented to be winter visitors to the A-H site (Landeen, D. S. and R. M. Mitchell, 1981) indicates that they do occur onsite.

These same two statements are also found in the following sections/pages: 3-iii; 3.4.2.5, page 3-103; 5.2.1.3.1, page 5-43; 6.2.1.6.11, page 6-37. The statement that there are no federally endangered or threatened species onsite is also made in the following sections/pages: 2.3.8.2, page 2-71; pages 5-i, 5-ii; 6.2.1.6.10, page 6-34; 6.2.1.6.11, page 6-35; 7.3.2.1.1, page 7-78.

It is suggested that the final EA clarify the apparent inconsistency perhaps by indicating that as far as is known, neither species nests onsite.

E-2

Section 5, Regional and local effects of repository development, page 14, paragraph 2

This paragraph provides an explanation of the types of transportation effects from increased commuter traffic and the hauling of supplies and radioactive waste. The second sentence states that radiological risks result from routine waste shipments; there is no mention of radiological risk from transportation accidents. It is suggested that the final EA include an assessment of both routine and transportation accidents effects and that this assessment be cited in the Executive Summary.

E-3

Section 6.2, Summary of site evaluations against the postclosure guidelines, page 15, paragraph 5

The draft EA states that "Estimates of ground-water travel time from existing data yield a median value of approximately 80,000 years. Although there are many uncertainties in travel time calculations, there is no reason to believe on the basis of current information, that the ground-water travel time is not well in excess of 10,000 years." Numerous problems do exist with respect to travel time calculations for the Hanford site. These include: 1) problems with the applicability of previously published travel time estimates; 2) problems with the transmissivity data base and manipulation of those data for model input; 3) problems with the hydraulic gradient data base and the manipulation of those data for model input; 4) problems with the effective thickness data base and the manipulation of those data for model input; 5) problems with the theoretical basis of the travel time models presented in the draft EA; 6) problems with the presentation of the results of the travel time models; and 7) problems with the definition of the orientation and length of the flow path from the disturbed zone to the accessible environment. All of these problems create reasonable doubt as to whether the travel times are "well in excess of 10,000 years," as the DOE claims. As discussed in detailed comment 6-101, reasonable alternative analyses of the existing data can be performed which suggest that ground-water travel time along paths of likely and significant travel may be substantially less than the 80,000 years claimed by the DOE.

E-4

Section 6.2, Summary of site evaluations against the postclosure guidelines, pages 15 to 16, paragraphs 4, 5 and 6

The data on Hanford Site redox condition do not support an evaluation that "... the reference repository location has chemically reducing conditions that will promote precipitation and will maintain radionuclides in their least mobile state." In fact, present redox conditions have yet to be established as either chemically reducing or chemically oxidizing (Early, et al., 1984). Further, according to Lindberg and Runnels (1984), Meyer, et al. (1984), Kelmers (1984), and others, the presence of reducing conditions alone does not mean that redox sensitive radionuclides will be present in the system as reduced species. The assumption that the reaction kinetics and the available reduction capacity of the system will be such that radionuclides will be reduced to their least mobile (low solubility, high sorption) state, would tend to underestimate radionculide releases. (See detailed comments 6-1 and 6-33.)

Executive Summary References

Early, T. O., G. K. Jacobs, and D. R. Drewes, "Geochemical Controls on Radionuclide Releases from a Nuclear Waste Repository in Basalt: Estimated Solubilities for Selected Elements," In "Geochemical Behavior of Disposal Radioactive Waste," ACS Symposium Series 146, pp. 147-165, 1984.

Kelmers, A.D., "Review and Assessment of Radionuclide Sorption Information for the Basalt Waste Isolation Project Site, (1979 through May 1983)," NUREG/CR-3763, ORNL/TM-9157, Oak Ridge National Laboratory, 1984.

Landeen, D. S. and R. M. Mitchell, "Site Ecology and Radiological Descriptions for the Basalt Waste Isolation Project Site Characterization Report," RHO-1530, p. 20, Rockwell Hanford Operations, 1981.

Lindberg, R.D., and D.D. Runnels, "Ground Water Redox Reactions: An Analysis of Equilibrium State Applied to Eh Measurements and Geochemical Modeling," Science, Vol 225, pp. 925-927, (August 31) 1984.

Meyer, R.E., W.D. Arnold, and F.I. Case, "Valence Effects on the Sorption of Nuclides on Rocks and Minerals," NUREG/CR-3389, ORNL-5978, Oak Ridge National Laboratory, 1984.

CHAPTER 1 COMMENTS

1-1

Section 1.1.1, Engineered barriers, page 1-2, paragraph 3

The draft EA states that engineered barriers "... will not be relied on to compensate for major deficiencies in the natural barriers." (Emphasis added.) In concurring in the DOE siting guidelines, the Commission was concerned that DOE may use engineered barriers to compensate for any deficiency in the geologic setting, not just "major" deficiencies. As a result, DOE revised its guidelines to state, "... engineered barriers are not relied upon to compensate for deficiencies in the geologic media" (10CFR960.3-1-5).

The staff recommends that the word "major" be deleted from the EA's discussion of deficiencies for which engineered barriers may compensate. This revision would make the discussion consistent with the Commission's understanding of how the guideline will be applied.

1-2

Section 1.2.3.1, Basalt lava in the Pasco Basin, Washington, page 1-11, paragraph 1/bullet 4

The data concerning changes in ground-water chemistry and mineral stability do not support a conclusive evaluation that "The likely geochemical reactions between the basalt rock, ground water and the materials that would be implaced . . ." are all favorable for ". . . long-term isolation."

For example, based on (inconclusive) theoretical calculations of redox conditions and in the absence of data on the reducing capacity of the basalt/water system or the kinetics of redox reactions, it is assumed that radionuclides are released in their least soluble, most sorptive state (see detailed comment 6-30). Also, observed transformation of backfill/packing/fracture-filling clays to albite suggests that bentonite is reacting to yield a typical low-grade metamorphic assemblage that includes illite (see detailed comment 6-27). This transformation assemblage to illite has less sorptive capacity than the original backfill/packing/fracture-filling clays (see detailed comment 6-32). Assumed redox conditions influence radionuclide solubility and sorption, and cannister containment (see detailed comment 6-28). Further, reported production of hydrogen and organic polymers similar to polyethylene in experiments involving Hanford site ground-water/gamma radiolysis, could affect waste package stability and radionuclide transport respectively (see detailed comment 6-1). Thus, assuming that all likely geochemical reactions are favorable to long-term isolation, biases radionuclide release and transport estimates in favor of high transport retardation and low release.

1-3

Section 1.2.4, Nominations and recommendations of site for characterization, page 1-14, paragraph 1

The draft EA states that the guidelines (10 CFR Part 960.3) require DOE to implement a seven-part decision process in selecting sites for nomination and characterization. The guidelines present a six-part, not a seven-part, decision process (10CFR960.3-2-2-1 through 960.3-2-2-3). The seventh decision point--consider the sites according to their order of preference--would be made after DOE nominates five sites and after the final EA's have been issued (see 10CFR960.3-2-3).

The staff does not object to sites being ordered in the EA according to DOE's preference. However, the EA could acknowledge that the guidelines do not require it to document how DOE orders the nominated sites.

1-4

Section 1.3.2.2, Distinct differences among the geohydrologic settings and host rocks, page 1-17, paragraph 4

It is stated that ground-water drainage within the Pasco Basin is to the Columbia River or its tributaries. This is correct in a regional sense given that the Pasco Basin is fully encompassed by the large drainage basin of the Columbia (see draft EA, page 2-19). However, the areal patterns of local recharge and discharge within the Pasco Basin are poorly understood at present. An improved understanding of these phenomena is essential to support geohydrologic modeling studies over a range of scales including the Pasco Basin and the Cold Creek syncline. The current, preliminary state of knowledge regarding recharge and discharge patterns might be presented in the final EA.

CHAPTER 2 COMMENTS

2-1

Section 2.1.1, Regional geology, page 2-5, paragraph 1

The fracture abundances may be understated due to vertical core borings in an environment of dominant vertical jointing. Fracture abundances are part of establishing a data base for assessments related to geohydrology, rock characteristics, and geochemistry. It is suggested the final EA recognize the limitations of the data on jointing fractures resulting from a lack of angle cores.

2-2

Section 2.1.1, Regional geology, page 2-5, paragraph 1

The draft EA states that dominant secondary minerals include pyrite. According to Ames (1980), Teague (1980), Long and Davidson (1981) and Benson and Teague (1979 and 1982), pyrite is a minor secondary mineral. The availability of ferrous mineral phases to interact with groundwater and the kinetics of redox reactions, are key to determining the reducing potential of the basalt/rock system, and the capacity of the system to consume oxygen after closure. In addition, some radionuclides, while not readily reduced in groundwater, can be reduced on the surface of fresh ferrous minerals (Bondietti, 1979, and Meyer, et al., 1984). An overestimate of the quantity and availability of pyrite could lead to false assumptions concerning future redox conditions, and an overestimate of retardation for those radionuclides affected by the reducing capacity of the rock and not the water (i.e., technetium and neptunium).

2-3

General comment on seismicity presented in chapters 2 and 3, Figures: 2-9, page 2-14; 2-10, page 2-16; 3-24, page 3-55; 3-25, page 3-56

Various magnitude cut-offs, depth cut-offs, and data omissions on the figures listed above lead to difficulty in understanding the seismicity of the Hanford site region. The 8km depth cut-off in Figure 2-9 is inconsistent with the 4km depth cut-off in Figures 3-24 and 3-25. The lower limit for magnitudes of shallow events of Figure 2-10 is unspecified. A well-known large microearthquake swarm near Wooded Island on the Columbia River at about 46.50°N and 119.25°W is not on Figure 2-10. The recorded seismicity is a major part of the information needed to evaluate ground motion in the geologic setting. Figure 3-25 on page 3-56 shows six microearthquake epicenters in the reference repository location but data supplied by the University of Washington shows ten microearthquakes with coordinates that plot within the reference repository location. A comprehensive figure with all earthquakes since 1969 is suggested to clarify recent seismicity.

2-4

Section 2.1.1.3, Seismicity, page 2-15, paragraph 2

This section of the draft EA states the following: "Deep seismicity generally takes place in a seemingly random pattern, associated neither with known geologic structures or areas of shallow seismicity." The implication of the above quote is that seismicity is not associated with structure. Correlations of earthquakes with tectonic processes and features (e.g., faults) may impact assessments of waste containment, regional groundwater flow, and future ground motion.

Seismicity most commonly indicates fault movement. The draft EA has statements on page 6-132, paragraph 2, page 6-136, paragraph 3 and page 6-212, paragraph 5 which appear to show agreement with the concept that seismicity is associated with fault rupture. Focal mechanism solutions can be applied to larger seismic events (independent of mapped alignments) to interpret the type of fault movement. A suggested revision to this section of the draft EA is to consider that apparent random seismicity is likely related to fault raptures even when clear map alignments do not generally appear on previously identified structures.

2-5

Section 2.1.2, Tectonics, page 2-15, paragraph 4

This section of the draft EA states that the Pasco Basin and Columbia Plateau have been deforming at low average rates of strain since the Miocene. Five bullets in this section provide the bases for this view. NRC has the following concerns about this position: 1) the importance of average deformation rates since the Miocene to tectonic assessments is questionable; and 2) information exists that suggests the deformation may be higher and has occurred episodically.

The basic premise that deformation has been at low rates when averaged over approximately 15 million years may not be significant. The importance of long-term average tectonic activity to short-term contemporary and near-future episodic activity rates has not been established. Consideration of estimated ranges of deformation rates during the Quaternary would be applicable to the siting guidelines.

The following discussion pertains to supporting bases, bullet number one, on page 2-15 of the draft EA.

Structural elevations of basalts and other units in the anticlines of Rattlesnake Hills and the Saddle Mountains have been used to support initiation of deformation in Miocene time for the Yakima Fold Belt (RHO-BW-ST-19P). The initiation of deformation may have been later than 14.5 to 10.5 million years ago, and this is recognized in document RHO-BW-ST-19P.

The deformation of Umtanum Ridge-Gable Mountain-Gable Butte structure, 2 miles north of the present repository site, appears more recent than Miocene. Deformation of Umtanum Ridge reportedly began in Saddle Mountain time (RHO-BWI-ST-4), which is more recent than that of the Rattlesnake and Saddle Mountain structures. However, other data suggests that Umtanum Ridge-Gable Mountain - Gable Butte structure did not significantly deform until even more recently than Saddle Mountain time. For example, the location of a late Pliocene channel of the ancestral Columbia River (Figure 3-20, page 3-41), seems to indicate that the Umtanum Ridge-Gable Mountain-Gable Butte structure had not developed sufficiently at that time to affect the river channel. Much of the structural growth of the Umtanum Ridge-Gable Mountain-Gable Butte structure may be late Pliocene to Recent and this is compatible with the apparent late Pliocene to early Pleistocene initiation of Manashtash Ridge to the northwest (RHO-BWI-ST-4). In addition, Umtanum Ridge-Gable Mountain-Gable Butte structure appears to be still actively growing, as expressed by surface fault offsets that are about 12,000 years old, and two recorded tilts of the Rosa Canal within the last 50 years, reportedly due to anticlinal growth of the Umtanum Ridge (Brown, 1968, page 40).

The draft EA states that average uplift rates (vertical strain rates) were approximately 40 to 80 meters per million years from 14.5 to 10.5 million years ago on anticlinal folds. Vertical uplift is only one component of the total deformation. The deformation in the Yakima fold belt includes both the vertical uplift components and the horizontal component of thrust or reverse faulting. Thrust faults are mapped along the strike of many folds in the Yakima Fold Belt (RHO-BWI-ST-4).

In the Saddle Mountains structure alone there are over 2,500 meters (in places up to 3,000 meters) of displacement on thrust faults (Reidel, 1984). For the Saddle Mountains, the horizontal component of the fault displacement may be several times the vertical displacement of basalts by the folding/faulting process.

The following discussion pertains to supporting bases, bullet number two, on page 2-18 of the draft EA.

The draft EA indicates that there is a low average strain rate in the Pasco Basin partly because few earthquakes have been felt in the area and most historical earthquakes have occurred outside the margins of the Pasco Basin. Consideration of only the felt earthquakes to support the low average strain rate in the Pasco Basin makes use of only part of the information. Hundreds of microearthquakes have been recorded in the Pasco Basin since 1969, including ten with epicenters in the boundaries of the reference repository location and about sixty within 5 km of the reference repository location which are not considered "felt." All seismic data, including both felt earthquakes and those recorded only instrumentally, should be used to estimate strain rate ranges for the Pasco Basin based on seismic data.

The following discussion pertains to the supporting basis, bullet number three, on page 2-18.

Part of the basis in the draft EA for long-term low average deformation is geodetic data. Geodetic data for only a few years (less than about 15) for a region is of uncertain value in assessing strain rates. For example, repeated leveling surveys in the area of the May 2, 1983 Coalinga, California earthquake showed that except for deformation from fluid withdrawal, most deformation from 1960 to 1983 occurred during the earthquake (Stein, 1983). If the Coalinga earthquake did not occur, geodetic data would show no significant deformation. Geodetic data and earthquake potential may not have a reliable correlation.

Another example is the 1977, San Juan, Argentina, earthquake. In the area of this earthquake, geodetic leveling data indicated a total vertical change of only 6 cm between 1938 and 1976 in the axis of the causative anticline. Between 1976 and 1978, a drastic rate change occurred, over 1.0 meters of vertical change was recognized. Most of the change is assumed to have occurred during the 1977 earthquake (Volponi, et al., 1978).

Extrapolation of present day surface deformation can yield estimated strain rates which can be orders of magnitude less than the actual strain rate, if the period of time geodetic surveying is short compared to the seismic cycle (or recurrence interval for earthquakes).

The limits of surveying equipment add uncertainty to the deformation rates. The measured rates are near the limits of detection (RHO-BW-ST-19P). The instability of surveying monuments has been a problem (RHO-BW-ST-19P). In summary, the instrumental measurements of deformation are inconclusive.

The following discussion pertains to the supporting basis, bullet number four, on page 2-18 of the draft EA.

This part of the draft EA states that instrumental earthquake data for eastern Washington indicates minor stress release as microearthquakes. In situ stress measurements indicate stress buildup to a considerable level (Kim and Haimson, 1982), and discing of basalt cores also indicates the presence of unreleased horizontal stress (NRC, 1983, Figure A-12). This existing high stress indicates microearthquakes are not relieving potentially significant major stress accumulations and it remains possible for a moderate to large earthquake to occur.

This part of the draft EA indicates earthquakes are not manifestations of stress relief along mapped or inferred faults. Focal mechanism solutions of earthquakes indicate that the north-south nearly horizontal compressions that formed the Yakima Fold Belt are still on-going (page 2-18, bullet 4). These horizontal compressional stresses may result in thrust or reverse fault movements which do not show epicenter map alignments and may not be on mapped faults. Malone, et al., 1975, studied earthquake swarms in the Yakima Fold Belt and associated these events with thrust or reverse fault planes rupturing.

Faults can be inferred by the occurrence of a seismic event. Data recorded since 1969 show hundreds of microearthquakes in the Pasco Basin. These microearthquakes are considered to be an integral part of the Quaternary record. Small fault ruptures can occur on segments of larger faults.

Microearthquake swarms occur in several locations in the Pasco Basin and provide evidence of current episodic non-uniform deformation.

It is suggested that this section of the draft EA be revised to include consideration of: a) the importance of determining average deformation rates since the Miocene; b) uncertainties about the timing of deformation in the Yakima Fold belt; c) horizontal strain rates; d) the limitations of geodetic data; and e) the microearthquakes in terms of small Quaternary fault ruptures in the subsurface, or other likely explanations for the seismicity.

2-6

Section 2.1.4, Regional ground-water hydrology, pages 2-24 through 2-26

The discussion in paragraph 2 of page 2-24 refers to Figures 2-15 and 2-16. These figures depict three-dimensional (3-D) perspective views of regional potentiometric surfaces. The perspective views lack the locations, number and distribution of data points. Accordingly, distances of inter-point extrapolation are unknown and the representativeness of the 3-D views cannot readily be determined.

It was stated in paragraph 2 on page 2-24 that surface trends and attitudes of the regional potentiometric surfaces are similar to those of regional bedrock maps. Three-D perspective views of the latter are not shown. It is possible to quantify the similarity or dissimilarity of such maps by subtracting structure contour surfaces from the potentiometric surfaces to obtain residual maps. Correlation coefficients may also be obtained.

Regional trends are important to develop an understanding of the hydrogeologic conceptual model governing large-scale ground-water flow and radionuclide transport. It would be useful to quantitatively know how closely the potentiometric surfaces are reflected by formational structural trends. The inclusion of residual maps in the draft EA, as described above, is recommended.

2-7

Section 2.2.1.1, Identification of site localities, Figure 2-21, page 2-43 and Figure 2-22, page 2-45

Figures 2-21 and 2-22 indicate that portions of the DOE's current reference repository location were previously eliminated from the candidate area during site screening. These figures show stippled areas designated on the legends as: "Areas of the Pasco Basin Eliminated during Site Screening." The reference repository location (not drawn on either Figure) encompasses areas shown on the figures as having been eliminated as a site locality during site screening.

It is suggested that the final EA be revised to reconcile the discrepancy noted above by an explanation or by redrawing the boundaries of the reference repository location.

2-8

Section 2.2.1.2, Identification and ranking of candidate sites, page 2-46, paragraph 5

The discussion in this paragraph indicates the importance of geophysical lineaments to the selection of a candidate site within the Cold Creek Syncline. However, a map depicting these lineaments is not presented in the draft EA. Given the scarcity of rock exposures in the syncline, the geophysical lineaments, as probable manifestations of geologic structures, provide data about the approximate spatial distribution of such structures.

Information about possible structures within the basalts is of significance in planning large-scale hydrologic tests. An important aspect of these tests is the evaluation of hydrologic boundary effects which may be caused by structural and/or stratigraphic discontinuities. In addition, if large-scale vertical structures exist within the syncline they may provide preferential pathways for radionuclide transport to the accessible environment.

Information about geologic structures is necessary to help guide investigations of site hydrogeology, seismology and geomechanics. Given the above, the lack of a geophysical lineament map from the draft EA is a significant omission. The only relevant map is Figure 3-23 on page 3-46, which does not show features within the Cold Creek Syncline. An example of the type of map which could be included in the final EA would be Figure 8-8 of ST-14 (Myers, 1981).

2-9

Section 2.2.3, Identification of a preferred candidate horizon, page 2-57, paragraph 4

The last sentence in this paragraph is unclear with regard to which hydrologic properties of the candidate horizons were used for comparative purposes. It is implied that porosity and dispersivity data may have been used for this purpose. To date only two field tests have been performed (Gelhar, 1982; Leonhart, et al., 1984) on-site within flow tops for the purpose of obtaining values of dispersivity and effective thickness. Of the two tests, only one appears to have been performed within the flow top of a candidate horizon, the McCoy Canyon flow (see detailed comment 3-24). Given this fact, it is unclear how other horizons could have been compared on the basis of measured values of dispersivity and effective thickness. All aspects of the decision logic used to select a preferred candidate horizon are of significance and might be clarified in the final EA.

2-10

Section 2.2.3, Identification of a preferred candidate horizon, page 2-59, paragraphs 2 and 3

The discussion of travel time and cumulative activity of iodine-129 values presented on this page is unclear. The cumulative activity values are not compatible with the travel times presented for the respective candidate horizons. Assuming equal effective thickness values and a constant source term for all four candidate horizons, one would expect the lowest total flow and the lowest cumulative iodine-129 activities to be associated with the highest travel times. This is true for the Cohassett but does not follow appropriately for the other candidate horizons. The McCoy Canyon flow would be expected to have the highest cumulative activity because it has the shortest calculated travel time. This is not the case; the Umtanum has the highest cumulative activity. This apparent inconsistency should be resolved, perhaps by presenting a more complete discussion of the values presented in this section.

2-11

Section 2.2.3.2, Application of expert judgement to the candidate horizons, page 2-63, paragraph 2

The following phrases appear in the draft EA regarding the potential for vertical confinement of radionuclides: "However, the Cohassett flow still provided vertical confinement that, based on preliminary modeling results, prevented significant contamination of the overlying, relatively high-permeability zones ....." and "Vertical confinement thus appeared adequate." These statements are important to the development of the DOE's preferred hydrogeologic conceptual model as described in paragraph 2 on page 3-93.

Although the first paragraph of this section points out that the assessment was mainly deductive, it should be emphasized that reliable estimates of vertical hydraulic conductivity have yet to be obtained for the relatively dense basalt interiors. Therefore, it was not possible to directly compare the vertical isolation potential of the candidate horizons on the basis of hydrologic test data. Given the importance of vertical isolation of radionuclides, the means by which the four candidate horizons were compared on this basis might appropriately be presented in the final EA.

2-12

Section 2.3, Summary of the evaluation of the potentially acceptable site within the geohydrologic setting, page 2-64, paragraph 1

The DOE states that before sites can be considered for nomination, the DOE must ensure that " --- no obvious disqualifying conditions exist at any of the potentially acceptable site." (Emphasis added.)

The staff considers it inappropriate for the DOE to apply only "obvious" disqualifying conditions when the DOE has committed, in the guidelines, to apply at least ten. The staff recommends that the sentence in question be revised to read, "It is prudent to ensure that at this step in the siting process none of the disqualifying conditions, identified in Appendix III of the guidelines, exist at any of the potentially acceptable sites." The same revision should also be considered for the last sentence of the same paragraph.

2-13

Section 2.3.8.2 Summary of the environmental quality disqualifier analysis, page 2-71, paragraph 1

This summary section states that "The three primary factors that indicate this disqualifying condition is not present at the reference repository location are (1)..., (2) the absence of any federally recognized threatened and endangered species at the reference repository location, and (3).... Therefore, the evidence supports a finding that the reference repository location is not disqualified on the basis of that evidence and is not likely to be disqualified (Level 2)."

As pointed out in detailed comment E-1, it is a well documented fact that the bald eagle (an endangered species) and the peregrine falcon (a threatened species) are winter visitors to the reference repository location. It is suggested that this condition be reevaluated for endangered species.

Chapter 2 References

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CHAPTER 3 COMMENTS

3-1

Section 3.2, Geologic conditions, pages 3-1 through 3-56

There is no discussion of mineral resources in this section. Also, there is no discussion of mineral resources in Chapters 4 and 5. All information on mineral resources in this draft EA is presented in detail in Section 6.3.1.8, "Human interference (natural resources)" which covers siting guideline 960.4-2-8-1. Mineral resources may have implications for the socioeconomic analysis as well as the performance of the repository system after closure. It is suggested that the appropriate information on mineral resources be placed in Chapters 3, 4 and 5 to make each of these Chapters more complete.

3-2

Section 3.2.2, Stratigraphy, page 3-10, paragraphs 2 and 3

There is no presentation in the draft EA of the results of the geophysical surveys and how they are input to stratigraphy. Geophysics is commonly used to distinguish structure or the continuity of stratigraphy. Establishing the data base on stratigraphy impacts assessments of: selecting the repository location, groundwater travel, response of units to tectonic processes, and geochemistry. The geophysical methods used for developing "stratigraphy" are simply listed on page 3-10.

It is suggested the draft EA be modified to describe, even in summary form, the results of the geophysical surveys and how they were input into selection of the reference repository location.

3-3

Section 3.2.2.1, Grande Ronde basalt, page 3-13, figure 3-8

This figure, labeled "Geologic cross section through the reference repository location" is too generalized. Less than one-half of the length of the cross section is controlled with borehole data and is uncontrolled north of DC-4 and southwest of RRL-6. Also, the cross section does not indicate known structures in the area. Cochran (1982) has described faults which lie in the area of the cross section which are not indicated in Figure 3-8. Understanding stratigraphic continuity necessitates adequate consideration of structural features and is important to assessing repository location selection.

It is suggested that better-controlled geologic cross sections which show structure be presented in the draft EA.

3-4

Section 3.2.2.1.2, McCoy Canyon flow, page 3-20, paragraph 2

There is an inconsistency within the draft EA on the minimum thickness of the McCoy Canyon flow. This paragraph of the draft EA indicates that the McCoy Canyon flow is a minimum of 112 feet thick but the executive summary (page 7, paragraph 3) indicates this flow is at least 130 feet thick.

The McCoy Canyon flow is one of four flows identified as candidate host horizons for the repository. The continuity and thickness of these four flows affects assessments of relative suitability for the repository. It is suggested that the inconsistency detailed above be reconciled.

3-5

Section 3.2.2.1.3, Cohassett flow, page 3-24, paragraph 2

If as stated in the draft EA, "the colonnade-entablature tiers are not readily correlated from borehole to borehole in the reference repository location," then the flow may have significant unassessed heterogeneities.

Lateral heterogeneities in the area of the reference repository location may impact design of the repository and groundwater flow. It is suggested this section of the EA be modified to more completely assess the uncertainties of the internal stratigraphy in the Cohassett flow by specifying the boreholes and logs showing lack of correlation and evaluating the differences among them.

3-6

Section 3.2.2.1.3, Cohassett flow, page 3-24, paragraph 2

A description is presented on this page of the Cohassett flow and the continuous vesicular zone which occurs in this flow. There is little documentation in the draft EA about where the repository would be placed with respect to the vesicular zone. This question is important to the draft EA with respect to computed ground-water travel times. The importance of this question is lessened in the draft EA since in its most recent analyses (Clifton et al. (1984)), the DOE does not take credit for travel time through the dense interior of the Cohassett flow. This could be a significant question if the DOE decides to take travel time credit through the dense interior of the Cohassett.

3-7

Section 3.2.2.2, Wanapum basalt, page 3-28, paragraph 3

In this section the Wanapum Basalt is described as thickest in the central area of Cold Creek syncline and thinning over Rattlesnake mountain and the Umtanum Ridge-Gable Mountain structures. This does not agree with other data. Isopach maps for this basalt are in Reidel and others (1980). These maps indicate the thickest sections may lie below Rattlesnake Mountain, the southeast Rattlesnake Hills adjacent to Rattlesnake Mountain, the southeastern extension of the Yakima Ridge structure and in the Snively Basin area.

As tectonic and structural interpretations, such as of age, amount and timing of folding and related faulting, are partly based on descriptions of basalt thicknesses, seismic hazard evaluations may be affected. It is suggested that other available data be considered in the final EA, including thickness changes where thrust faulting associated with Yakima fold structures has occurred.

3-8

Section 3.2.3.2, Umtanum Ridge, Gable Mountain structure, page 3-48, paragraph 4 continued from page 3-47

This section indicates that Umtanum fault, which is part of a south dipping imbricate thrust fault system of about three faults, dies out about 11 kilometers (7 miles) east of Priest Rapids Dam. This is based on "judgment" which assumes that the structural relief from folding results in thrust fault displacement (i.e., thrusting is assumed to be secondary to folding). This assumption does not consider information which could significantly affect assessments of the tectonic processes near the reference repository location.

Washington Public Power Supply System states the following in volume 25 of the WNP-2, FSAR, 1981: "West of the Columbia River, the Umtanum Ridge and Hanson Creek faults farther north have the spacing and geometry of an imbricate south dipping thrust zone of primary origin." The Umtanum faulting involves imbricate thrust fault processes. Imbricate thrust faults typically are associated with splays (Boyer and Elliott, 1982). It is possible that the Umtanum faults or associated splays, which although buried, continue east to the vicinity of the reference repository location.

The lateral extent of a thrust sheet may be controlled by stratigraphy and not folding. On the basis of stratigraphy, individual thrust sheets are often correlated long distances (Boyer and Elliott, 1982).

The Hanford Site area is still undergoing N-S compression (p. 2-18). In addition, high horizontal in situ stress conditions are evidenced in the area by hydrofracture test results (RHO-BW-ST-28P) and discing in borehole cores (RHO-BWI-ST-14). Because of the ongoing N-S deformation and because thrust faults result from high horizontal compressional failure of rock, it is reasonable to conclude that the Hanford site is in an active fold belt where thrust faulting can be expected to continue.

It is also reasonable (see paragraph 2 above) in the absence of any specific information to the contrary, to assume that the Umtanum thrust faults or splays continue east to the reference repository location area. These projected south dipping faults could go above, through, or under the reference repository location and pose a potential earthquake hazard or may affect hydrological modeling.

It is suggested this section of the draft EA be revised to consider the information above to include an assessment of the seismic hazard to the reference repository location from projected thrust faults of Umtanum Ridge.

3-9

Section 3.2.3.2, Umtanum Ridge - Gable Mountain structure, page 3-49, paragraph 1

This part of the draft EA does not adequately consider alternative interpretations of data for what may be a significant Quaternary fault in terms of ground motion impacts on the reference repository location. This paragraph indicates a long-term average displacement rate on an undesignated Gable Mountain fault of about 6×10^{-4} centimeters per year. The actual maximum possible rate for any year would be larger and more significant. The fault rupture could have been a few events.

Analysis of the episodic nature of faulting is appropriate. This cannot be achieved by reliance on an average for tectonic processes. Due to the fact that the undesignated fault apparently continues its trace at depth and is a few kilometers from the repository, a significant earthquake relative to the reference repository location could be associated with this fault. It is suggested the draft EA name the undesignated fault referenced above based on common terminology (NUREG-0309) and the magnitude of earthquakes which could be generated be addressed.

3-10

Section 3.2.3.3, Cold Creek syncline, page 3-49, paragraph 3 and page 3-50, paragraph 3, continued from page 3-49

This section of the draft EA indicates that the Cold Creek syncline is in an area of an intact volumes of basalt, excluding intraflow structures. This is not consistent with the narrative portion of Myers (1981) report (RHO-BWI-ST-14) which qualifies the interpretation of basalt volumes by using the term "relatively intact." The NRC has documented evidence suggesting structural discontinuities in the Cold Creek syncline and reference repository location (detailed comment 3-11). Structural features is part of the data base for assessments on geohydrology and potential ground motion.

It is suggested this section of the EA be revised to qualify, explain and document the statement that the Cold Creek syncline is in an area of intact volumes of basalt.

3-11

Section 3.2.3.3, Cold Creek syncline, page 3-50, paragraph 1

This section of the draft EA states the following: "Overall, the central and eastern portions of the Cold Creek Syncline, which includes the reference repository location, appear to be free of potentially adverse structures." This statement does not agree with other published information. Structural features are important to evaluations of groundwater flow and faulting.

As indicated in detailed comment 2-5, microearthquakes are likely small movements along subsurface faults. Since 1969 many (well over a hundred) microearthquakes have occurred in the central and eastern portions of the Cold Creek syncline, including ten with epicenters in the boundries of the reference repository location. It is not certain that the estimated, short, fault-rupture lengths during microearthquakes (Caggiano, 1982) are occurring on short length faults. The microearthquakes may be on major structures which have not yet been defined because monitoring has been done only since 1969.

The aeromagnetic interpretive map (RHO-BWI-ST-14) shows about five possible faults that are in the reference repository location boundaries and several others (about five) in the immediate vicinity of the reference repository location. The top of basalt contour map (RHO-BWI-ST-14) shows several (about seven) small possible fold structures that are in the reference repository location boundaries. It has been interpreted in RHO-BWI-ST-14 that the uppermost flows of the Saddle Mountains Basalt (i.e., the top of basalt) reflect some expression of the Grande Ronde Basalt flows (i.e., the repository candidate host rocks) and some small folds can be expected in the Cohassett flow.

Seismic-reflection surveys in the Cold Creek syncline located five anomalies, interpreted by Seismograph Service Corporation to be bedrock faulting (RHO-BWI-ST-14). Several interpretations other than faulting have been hypothesized by Rockwell Hanford Operations and should be considered valid possibilities (RHO-BWI-ST-14). Nevertheless, all Seismograph Service Corporation seismic anomalies were avoided in delineating potential repository sites (RHO-BWI-ST-14).

Recent seismic reflection reprocessing and interpretation by Emerald Exploration Consultants, Inc. identify possible faults within the boundaries of the reference repository location (SD-BWI-TI-177). One small anticlinal fold and one small synclinal fold were also interpreted within the boundaries of the reference repository location. Each of these folds is associated with a potential fault. This raises the possibility that the previous (RHO-BWI-ST-14) approximately seven small interpreted fold structures that are in the boundaries of the reference repository location may be associated with faults. Document SD-BWI-TI-177 entitled "Reprocessing and Interpretation Seismic Reflection Data Handford Site, Pasco Basin, South Central Washington" is not included in the draft EA references even though it was released on May 15, 1984. As with the faults and folds in document RHO-BWI-ST-14, the faults and folds in document SD-BWI-TI-177 have other possible interpretations that are also valid hypotheses. However, the Emerald Exploration anomalies have not been avoided in delineating the reference repository location.

A major difficulty in conclusively identifying structures in the basalts of the Cold Creek Syncline is that the rock exposures are covered by sediments. However, document SD-BWI-ER-005 details an analog study area, the Vantage syncline. There, rock exposures are accessible. Observations in the Vantage synclinal area show direct evidence of faulting and folding. Although, the Vantage analog area is not without considerable uncertainty regarding applicability to the Cold Creek syncline, it seems likely that many of the folds and faults interpreted in and near the reference repository location exist.

Further evidence of potential faulting in and near the reference repository location includes the presence of "tectonic breccia" in all deep boreholes in the Cold Creek syncline, including the reference repository location (RHO-BWI-ST-14). Also, it is possible that the buried part of the eastern segment of the Yakima Ridge is faulted (detailed comment 6-41).

It is suggested that: the EA be revised to remove the sentence (see paragraph 1 above) stating that the reference repository location and the central and eastern Cold Creek syncline appear free of potentially adverse structures; data from report SD-BWI-TI-177 on seismic reflection anomalies in the reference repository location be referenced in the EA; the data on anomalies and their relationship to structure in document RHO-BWI-ST-14 from each type of investigation be documented or referenced in discussions of potentially adverse structures; and information from the Vantage analog area (SD-BWI-ER-005) should also be included.

3-12

Section 3.2.3.3, Cold Creek syncline, page 3-50, continuing paragraph 1

This section of the draft EA states the following: "The structure of the top of basalt and the structure at deeper horizons within this area [Cold Creek Syncline] are interpreted as being nearly flat lying with very gentle dips toward the trough of the Cold Creek Syncline ...". Published information exists which indicates that the top of basalt is not nearly flat.

Report RHO-BWI-ST-14 shows about seven small possible fold structures that are in the reference repository location boundaries. This report also interprets that the top of basalt reflects some expression of the structure of the repository host rock. Report RHO-BWI-TI-177 has interpreted a small anticlinal and a synclinal fold in the top of basalt in the reference repository location.

Small folds in the basalt surfaces may have associated fractures or faults (detailed comment 2-5) and could affect groundwater flow and construction. It is suggested this section of the EA be revised to recognize interpreted local folds on the basalt surface and at repository depths.

3-13

Section 3.2.3.8, Structural analysis, page 3-52, paragraph 2

This section of the draft EA states the following: "Structural analysis of Yakima folds in the Pasco Basin area shows that little deformation, other than tectonic jointing, has taken place in the anticlinal crests, and that little or no deformation occurred in the syncline trough (Price, 1981)." The report by E. H. Price did not include synclines in the study areas. Further, the draft EA does not consider other information relevant to deformation in syclines.

A recent, DOE-sponsored study of the Vantage area has been undertaken to determine the nature, and extent of tectonic breccias related to faulting and folding in a synclinal area. This area, unlike the buried Cold Creek syncline, has basalt exposures visible at the ground surface. Evidence from this area suggests (is conclusive for the Vantage syncline) that synclines in the Yakima Fold Belt may have considerable deformation which could influence groundwater flow.

The Vantage study shows that tectonic breccias and fractures located to date are associated with major folds and faults mapped in the area (SD-BWI-ER-005). Tectonic breccias have been found in all deep boreholes in the Cold Creek syncline, including the reference repository location. The term tectonic breccia doesn't define the tectonic process which formed the breccia. Sheared rock zones, such as breccia, shows rock displacement and can be considered indicative of faulting whether or not associated with folding . The tectonic breccia shows deformation occurred in many places in the synclinal trough.

The Wooded Island and Coyote Rapids microearthquake swarms are in synclinal structures (see detailed comment 6-44). This shows current structural deformation occurring in synclinal troughs.

It is suggested this section of the draft EA be revised to include the evaluation of Vantage synclinal deformation, tectonic breccias, and microearthquake swarms.

3-14

Section 3.2.3.8, Structural analysis, page 3-53, paragraph 1

For structural analysis, this section of the draft EA refers to in situ hydraulic stress measurement as defining the axes of principal and least compression. However, additional structural analysis could have been made using the existing in situ stress data.

This section lacks data specifying the ranges of the in situ stress measurements and there is no information in this section to show that relative to many other deep mines in the world the horizontal in situ stresses at the Hanford site are unusually high (Hoek & Brown 1980, EA pages 6-175 and 6-200, and RHO-BW-ST-28P).

By assessing the orientation and amount of stresses which may act to cause deformations, indications can be derived of the likelihood and types of structural features and orientations that may develop or be reactivated. For a more detailed discussion of deformation, see detailed comment 2-5.

It is suggested that this section of the draft EA be revised to present data on in situ stress and consider more fully the applications of in situ stress orientations and magnitudes to structural analysis of the Hanford area.

3-15

Section 3.2.4, Seismicity of the reference repository location, page 3-54, paragraph 3, 4, and 5

This section of the draft EA describes three areas of swarm activity within 10 kilometers of the reference repository location. Two discrepancies appear to exist. First, the four events that occurred in November 1969, described in Paragraph 3 as a swarm, were not located only at the southern boundary of the reference repository location. Instead, they were located along a north-northwest, south-southeast trending zone that extends across about two-thirds of the central portion of the reference repository location to an epicenter about one mile south of the reference repository location. Second, a cluster of earthquakes located astride the northern boundary of the reference repository location that occurred between March 6, 1971 and August 17, 1971 are not discussed as a swarm. The epicenters of these six events are located within an area of about one square mile in extent and they have focal depths ranging from 6.5 to 8.0 kilometers. The largest event was a magnitude 1.1.

Microearthquake swarms in the immediate vicinity of the underground facility could have adverse impacts. For example, the larger events in a swarm could initiate rock bursts which could lead to collapse of openings and difficulties in waste emplacement or retrieval operations. Additionally, joints might open and joint fillings could be disturbed which could increase groundwater flow.

It is suggested that all areas of microearthquake swarm activity within 10 km of the reference repository location be described in this section of the final EA.

3-16

Section 3.3.1.3.5, Flash flood potential within the reference repository location, page 3-67 paragraph 2

Results of flood studies in the Cold Creek watershed (Skaggs and Walters, 1981) indicate that a potential for flooding of portions of the repository site exists. As proposed in the conceptual designs, it appears that several of the repository surface facilities will be placed in the Cold Creek floodplain.

Based on an examination of the Skaggs and Walters report, it appears that the magnitude of flooding on Cold Creek may be underestimated. The Probable Maximum Flood (PMF) was estimated in the report to have a magnitude of 55,000 cubic feet per second (cfs) at the site where the drainage area is about 86 square miles. Review of historic flood data for arid regions of Washington and Oregon with similar climates and weather patterns indicates that a flood of this magnitude has occurred on a stream with a drainage area of about 13 square miles, located less than 150 miles from the site.

Recognizing that the Cold Creek basin could have different flood-producing characteristics than the stream which produced the historic maximum discharge, it is nevertheless important that the PMF represent the upper limit of flood potential for a particular stream. It appears that this upper limit has not been well-defined for Cold Creek.

Based on preliminary observations, it appears that the most probable cause of underestimating the PMF is overestimating the time of concentration, resulting in lower flood peaks. The presence of steep (>2%) channel gradients upstream of the site indicates that Cold Creek channel velocities will likely be high and that the time of concentration (tc) may be considerably less than the tc estimated in the report. PMF peak flows should be re-examined, in light of the potential for reduced times of concentration.

In addition, maximum water levels will be increased as a result of increased PMF discharge and will also be increased by site location in the flood plain. The amount of increase in water level due to flood plain constriction has not been discussed in the draft EA. Based on examination of the topography and cross-sections in the site area, it is likely that surface facilities may have to be placed on several feet of fill to elevate important accesses and structures above maximum expected flood levels. Constriction of flow area in the flood plain may increase the water levels associated with major floods. This increased level and its impact should be discussed.

Additionally, the flood analyses and the information provided on the proposed site conceptual design indicate that repository facilities may be exposed to a potential flood threat from Cold Creek. Recognizing that definite locations and site grades have not been established for surface facilities, it appears that the requirements of Executive Order (E.O.) 11988, "Floodplain Management," have not been addressed. This E.O. requires, among other considerations, that alternatives to siting in a floodplain (along with the hazards and impacts associated with those alternatives) be identified and evaluated. Accordingly, a discussion of the procedures involved in this decision-making process should be provided and compliance with E.O. 11988 should be discussed in the draft EA.

Further, Table 6-2 (Page 6-30) indicates that floodplains would not be modified. However, based on the flood analyses, it appears that portions of the floodplain may need to be modified. This apparent inconsistency should be addressed.

3-17

Section 3.3.2 Groundwater, page 3-79, paragraph 2

The draft EA states that the ground water system can be characterized and modeled such that overall flow patterns roughly conform to bedrock dip. Data are not presented to support the statement that ground water flow conforms to bedrock dip. This concept is important to the EA from the standpoint of determining ground water flow directions. Ground-water flow does not have to follow bedrock dip. Ground-water flow is determined by hydraulic gradient. Ground water flow could be perpendicular to the direction of bedrock dip or can flow updip. This question could be resolved by either rewording this section of the EA or by presenting data to either support or refute this statement. Also see detailed comment 2-6.

3-18

Section 3.3.2, Ground water, page 3-79, paragraph 2

This section states that the geohydrology of the reference repository location appears to be most influenced by the following: "A large contrast in hydraulic conductivity between flow tops and flow interiors. This feature promotes lateral ground-water movement in the flow tops (aquifers) and vertical flow across basalt flow interiors (aquitards). Actual flow directions depend on the hydraulic head distributions." These statements may not be pertinent to the large-scale ground-water flow in the basalts. The distribution of vertical hydraulic conductivity may vary significantly based on structural and other types of discontinuities in the basalt.

3-19

Section 3.3.2.1.1, Flow interiors, page 3-85, paragraphs 2 and 3

The draft EA states that the vertical hydraulic conductivity of basalt flow interiors at the Hanford site reference repository location is about the same order of magnitude as the horizontal hydraulic conductivity. This conclusion is based on the results of one field test and two indirect analyses. The distribution of vertical hydraulic conductivity has been identified as a critical parameter in repository performance assessment. Vertical hydraulic conductivity must be known to evaluate the potential for ground-water flow to upper aquifers, including flow tops and interbeds. The conclusion regarding the anisotropy ratio of hydraulic conductivity is not supported as explained below.

An initial field test of vertical hydraulic conductivity of a flow interior (Spane, et al., 1983) is cited by the DOE in this section. Spane et al. (1983) reported a vertical hydraulic conductivity of "less than 10^{-10} meters per second" for the Rocky Coulee flow interior. However, the NRC studies (Golder Associates, Inc., 1984) indicate that the test arrangement was not appropriate for the type of tests performed, and therefore there are substantial questions regarding the usefulness of the test results. Furthermore, alternative interpretations (e.g., Brown, 1984) of the test results are possible which could yield a vertical hydraulic conductivity as much as two orders of magnitude greater than the result cited in the draft EA.

The draft EA cites two references which purportedly describe model-calculated and statistical indirect estimates of vertical to horizontal hydraulic conductivity anisotropy ratios. One of the cited documents (DOE, 1982) was apparently misreferenced, as the document contains no discussion of the 2:1 estimate of anisotropy which the draft EA attributes to the document. The other document (Sagar and Runchal, 1982) is a demonstration of statistical technique for analyzing the effects of fracture size and data uncertainties, based on fracture set orientation information gained from a rock sample taken from Gable Mountain. The Sagar and Runchal (1982) document is based on assumptions regarding fracture frequency, aperture and length, which appear to bear no relation to site specific data (Gordon, 1984). In fact, Sagar and Runchal (1982) state that "the calculations ... are intended as an illustrative example and not as a definitive statement on the hydraulic conductivity of the fractured basalt at Gable Mountain." Therefore, the cited anisotropy ratio of 3.5 to 1 derived by Sagar and Runchal (1982) should not be considered to apply, in general, to Hanford basalt flow interiors.

As discussed above, the draft EA has not supported its statement that the vertical hydraulic conductivity is of about the same order of magnitude as the horizontal hydraulic conductivity.

3-20

Section 3.3.2.1.1, Flow interiors, page 3-86, paragraph 1

The draft EA states that preliminary single hole tests have been conducted for evaluating the effects of drilling mud invasion on hydraulic conductivity estimates. Williams and Associates (1984) have noted that the well development procedures used during the hydraulic conductivity evaluation were not the same as those as used on other boreholes or as documented in the DOE test procedure reports. Therefore, the finding that drilling fluid would not have adversely affected hydraulic tests of the deep basalts during single-hole tests has not been supported as of this date.

3-21

Section 3.3.2.1.1, Flow interiors, page 3-86, paragraph 5

It is stated in this section that a localized fracture zone of 3 foot thickness was found to have a "hydraulic conductivity of 10^{-4} m/sec (10^{1} ft/day)." According to Strait and Spane (1983), this zone is considered to be 6 feet thick, and is calculated to have a hydraulic conductivity of 5.2×10^{-4} m/sec (147 ft/day). The final EA should resolve this inconsistency.

3-22

Section 3.3.2.1.2, Use of geometric mean to describe hydraulic conductivities, page 3-88, paragraph 4

In this section, the DOE uses the geometric mean of data from several units of a given rock type (e.g., flow tops) as a measure of the average horizontal hydraulic conductivity of that rock type. This may in some cases be a misleading representation of the properties of an average unit of a given rock type. The geometric mean of a set of hydraulic conductivities from different hydrostratigraphic units will be weighted towards the lowest values, compared to the arithmetic mean. For horizontal groundwater flow, the geometric mean of a set of units of a certain rock type (e.g., flow tops) will not be representative of the average hydraulic conductivity of that set, unless each individual unit displays the same geometric mean as the geometric mean of all of the considered units, and as wide a variance in hydraulic conductivity within a unit as the variance between units. Preliminary data (Stone, et al., 1984) suggest that the geometric means of transmissivity of the Umtanum flow top and the Cohassett flow top, for example, may differ by almost two orders of magnitude. Individual units may not display as wide an internal variability as the variability between units. In order to estimate the horizontal hydraulic conductivity of an "average" unit, it may be more appropriate to use a thickness-weighted arithmetic mean of the set of geometric means of hydraulic conductivities of individual units.

3-23

Section 3.3.2.1.2, Flow contacts and sedimentary interbeds, page 3-88, paragraph 5, and page 3-89, continuing paragraph

The draft EA states that "Geophysical log traces indicate that ground water movement is sometimes channeled along narrow intervals [less than or approximately one meter (3 feet)] as opposed to being averaged across the entire effective thickness of the flow top." The draft EA goes on to state that local values of hydraulic conductivity may be higher than the "equivalent" hydraulic conductivity of the effective thickness of the flow top. During previous data reviews and discussion in workshops with Hanford personnel effective thickness had been defined as the portion of the test interval which has been deemed to supply the majority of the flow during tests. Elsewhere in the draft EA (e.g., page 6-266), "effective thickness" is defined as "the product of an assumed flow top effective porosity ... and the mean apparent thickness...". This represents an inconsistency in the use of the phrase "effective thickness" throughout the draft EA. This inconsistency is significant because transmissivity, derived from hydrologic tests, is converted to hydraulic conductivity based on a determination of the effective test interval thickness. Hydraulic conductivity is an important parameter for determinations of travel time and hence performance assessment. Therefore, the choice of values for "effective thickness" is critical and the language used should be made consistent. This matter could be resolved by defining effective thickness and using the definition consistently throughout calculations of hydraulic conductivity and ground-water travel time in the draft EA.

3-24

Section 3.3.2.1.2, Flow contacts and sedimentary interbeds, page 3-89, paragraph 1

It is stated that two tracer tests have been conducted in the flow top of the McCoy Canyon flow. One of the supporting references given is Gelhar (1982). However, according to Gelhar (1982), page E-31, "The tested interval is about 220 feet above the top of the Umtanum flow of the Grande Ronde Basalt." This places the test interval in the flow top of the unnamed Grande Ronde 9 unit which overlies the McCoy Canyon flow (see Cross, 1983, DC-7/8, page 3 of 5). If both stated references are correct, then the paragraph should be changed to indicate that two separate units have been tested.

3-25

Section 3.3.2.1.3, Bedrock structures, page 3-90, paragraph 3

The draft EA states that "Hydrochemical data suggest that mineralized deep waters may be mixing vertically with more dilute, shallower ground waters along or near this feature." The feature referred to is the Cold Creek hydrologic barrier which is northwest of the reference repository location. The concept of vertical ground-water flow near the barrier is important to the EA with respect to assessment of ground-water flow directions and travel times. Data supporting the concept expressed in the final EA should be presented or referenced.

3-26

Section 3.4.2 Terrestrial and aquatic ecosystems, page 3-96 through 3-104

Figure 3-26 (page 3-59) shows Cold Creek running southeast through the Hanford Site and through the southwest sector of the reference repository location. Approximately one-third of the Hanford site is drained by this system (Section 3.3.1.2). Cold Creek will be the recipient of site runoff and construction-related contamination if construction practices fail to contain erosion, siltation, chemicals, etc. These materials may be carried via Cold Creek to the Yakima River and to the Columbia River. A description of the Cold Creek biological and physical ecosystem on a seasonal basis would be helpful to determine whether impact is mitigated to insignificant levels. Similarly, a description od the biotic ecosystem of West Lake (the only natural pond within the site) would be useful in relation to potential impacts from site activities.

3-27

Section 3.4.2.7.5 Radiation exposures, page 3-109

At the top of page 3-109, the statement is made that soil and vegetation assays taken from the Hanford Site environs have disclosed no discernable differences in the levels of radionuclide concentrations across the geographical area. This statement apparently does not consider the radiological assay information in "Site Ecology and Radiological Descriptions for the Basalt Waste Isolation Project Site Characterization Report," (Landen and Mitchell, 1981). It is suggested that Section 3.4.2.7.5 consider the radiological assay information from this report.

3-28

Section 3.4.2.5 Threatened and endangered species, pages 3-103

This section notes that no federally recognized threatened or endangered species or their critical habitat are known to occur within the reference repository location. The draft EA cites State and FWS lists from 1980 to 1983 but does not show evidence that the DOE has formally contacted FWS under Section 7 of the Endangered Species Act for advice on the presence of species within the project area, including: the reference repository location; the areas where roads and railroad spurs will be placed; the area where the pipeline will be placed that provides water from the Columbia River; the Columbia River; the Cold Creek watershed; and the Yakima River from the confluence of Cold Creek to its confluence with the Columbia River. It is suggested that the final EA state what contacts were made and whether impact areas outside the reference repository location were included.

3-29

Section 3.4.3, Meteorological conditions and air quality, pages 3-109 to 3-116

Severe meteorological conditions are not evaluated. Several severe meteorological phenomena can have an important influence on repository construction and operation, and transport of radioactive material to the site. Among these are high winds, dust storms, fog, and snow and ice. It is suggested that the frequency and duration of these hazardous meteorological conditions be addressed in this section.

3-30

Section 3.4.3.5, Air quality, pages 3-114, second paragraph

Insufficient information is presented in the draft EA to define air quality in the region. This information is necessary for the evaluation of the conclusions regarding air quality. The assessment only refers to the Skagit/Hanford DES for current air quality conditions in the Columbia Basin. It is suggested that a summary table of air quality in the Hanford area be presented in this assessment and compared to the standards presented in Table 3-11 (page 3-117).

Chapter 3 References

Boyer, S.E., and David Elliott, "Thrust Systems," American Association of Petroleum Geologists Bulletin, Vol 66, pp. 1196-1230, 1982.

Brown, A., "Review of SD-BWI-TI-136," enclosure to Letter #71, NRC Contract NRC-02-82-045, NRC Division of Waste Management File No. 3426.1/FINB7373, February 14, 1984.

Caggiano, J.A., "Development of Fault Parameters for Use in Risk Assessment Modeling in the Pasco Basin, Columbia Plateau, South-Central Washington -- A Preliminary Study," RHO-BW-SA-185p, Rockwell Hanford Operations, March 1982.

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NRC, "Safety Evaluation Report Related to the Construction of Skagit/Hanford Nuclear Project, Units 1 and 2," NUREG-0309, Docket Nos. STN 50-522 and 50-523, Supplement No. 3, December 1982.

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RHO-BW-ST-28P see Long, 1984.

RHO-BWI-ST-14 see Meyer, 1981.

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Williams and Associates, "Communication No. 84," Contract No. NRC-02-82-044, NRC Division of Waste Management File No. 3426.1/FINB-7372.

CHAPTER 4 COMMENTS

4-1

Section 4.1.1.3.1, Large-scale hydrologic stress tests, page 4-7, paragraph 3

The term "vertical transmissivity" is used in this paragraph. Transmissivity normally is defined to be hydraulic conductivity times the thickness of the aquifer unit; the term pertains to horizontal flow. No similar concept exists for vertical flow. Use of this term in the draft EA is confusing. Omission of this term from the paragraph would eliminate the problem.

4-2

Section 4.1.1.6.1, Construction, page 4-12, paragraph 2

The draft EA states that the effectiveness of the cement grout seal will be examined directly using boreholes drilled through specially designed portholes in the shaft casing. This statement implies that the effectiveness of the grout seal depends entirely on the continuity of cement grout, and the grout continuity can be successfully tested through specially designed portholes. These implications do not seem reasonable.

Firstly, the effectiveness of the grout seal is not a function of grout continuity alone. It would also be influenced significantly by the integrity of grout bond with rock wall and shaft liner which would be affected by the presence of drilling mud cake. Secondly, plans for testing the continuity of the grout and integrity of liner-grout-rock bond through the portholes may not provide a representative data base. As porthole testing confirms the grout characteristics at the site of the test only, porthole test locations could introduce a large bias into the best results. It is important that porthole testing occurs within and adjacent to aquifers and in areas of good and poor quality rock. The exclusion of testing in any of these areas may give an unrepresentative picture of the grout continuity and bond integrity. Uncertainties associated with overall grout continuity and bond integrity will decrease with an increase in the number of porthole tests performed.

Each of these factors will contribute towards the making of an effective seal which is essential for inhibiting the flow of water into the working areas during shaft break out. Therefore, it is suggested that these factors be considered in the final EA.

4-3

Section 4.1.2.5, Archaeological surveys, page 4-17

The discussion in this section omits reference to required consultation activities. It is recommended that DOE include provision for consultation with the State Historic Preservation Officer and when appropriate, contact with the Keeper of the National Register of Historic Places and the Advisory Council on Historic Preservation to assure compliance with the National Historic Preservation Act of 1966 and 36 CFR 800.

4-4

Section 4.2.1.2.1 Surface-water impacts, page 4-20, paragraph 4

It is stated that approximately twelve hydrologic stress tests discharging an average of 3.2×10^4 cubic meters of water would be applied to the land surface through ponding or spraying. It is then predicted that this quantity of water "will increase plant vitality," "may increase the size and number of desert plants" and that "no adverse impact is expected" and "nonarid species are not expected to be established at these locations."

In Section 6.3.1.1.9 page 6-78 it is stated that the deep basalt groundwater has an electrical conductivity of 1,500 micromho per centimeter which is in the high salinity range for irrigation water. Calculations show that 3.2×10^4 cubic meters of water with a conductivity of 1,500 micromho per centimeter would contain 26.5 tons of salt. Twelve such tests would involve 318 tons of salt. Therefore, the conclusion of "no adverse impact" would depend a lot on the size of the area and timing of the 12 tests, neither of which is specified in the draft EA. It is suggested that DOE consider timing of hydrologic tests and quality of disposed drilling fluids.

4-5

Section 4.2.1.3.1.1, Terrestrial, page 4-25, paragraph 3

It is stated that "More than half the plants within this area were destroyed and all the animals were displaced during construction activities." It is not clear why only about half the plants were destroyed. In most cases the species population will eventually be reduced by the number of individuals the lost habitat supported and will result in a permanent reduction in wildlife populations. It is suggested that emphasis be placed on habitat loss and the associated permanent reduction in wildlife population (Kroodsma, 1985).

4-6

Section 4.2.1.3.1.1, Terrestrial, page 4-27, paragraph 3

While it is mentioned that the Swainson's hawk and long-billed curlew both nest near the proposed exploratory shaft sites there is no discussion of the possible affect of constructing the shafts on these species. Because these two species are candidates for the US FWS endangered or threatened list, it is suggested that an evaluation of the consequences of clearing and grading 8 hectares (20 acres) for constructing the shafts should be considered. This section mentions only two candidate endangered and threatened species while Section 5.2.1.3.1, page 5-43, paragraph 2 mentions a third, the ferruginous hawk. It is suggested there be a consideration of including the ferruginous hawk in this section.

4-7

Section 4.2.1.3.1.2, Aquatic, page 4-27

This section states that the majority of site characterization activities are not conducted in the vicinity of aquatic habitat. It is suggested that impact of activities that will be conducted near aquatic habitat needs to be assessed to determine that mitigation is adequate. Additionally, it is that suggested the impact of withdrawing 30 cfs of water (Section 4.2.1.2.1) from the Columbia River should be examined in relation to important fishery resources.

4-8

Section 4.2.1.3.2, Air quality impacts, page 4-33, second paragraph

Insufficient meteorological data and/or assumptions are presented to review the determination of air quality impacts. This section evaluates the ability of repository activities to meet national air quality standards. A description of the input meteorological data is given for annual average pollutant concentrations (page 4-32). Table 4-5 (page 4-33) presents potential increases in pollutant concentrations for annual average and 1-hour maximum conditions. It is suggested that the input meteorological data used to obtain the 1-hour maximum values be provided. Also, it is suggested that the impact of background concentrations on both 1-hour maximum and annual average concentrations be presented.

4-9

Section 4.2.1.3.3, Noise, impacts page 4-34

The draft EA states that impacts of noise from the project on the general public are said to "meet the requirements of the Noise Control Act of 1972". The Act addresses many noise-related issues and by itself does not establish limits on environmental noise for acceptable impact. It is suggested that the statement should be replaced with more definitive statements that clearly illustrate the intended meaning of the Noise Control Act of 1972. (Also see Section 5.2.1.3.3, page 5-44.)

4-10

Section 4.2.1.3.6 Radiological impacts, page 4-34

This section does not address release of radon-220, radon-222 and their radioactive decay products. These are, however, mentioned on page 5-45, in the third paragraph of Section 5.2.1.3.6 Radiological Impacts, but no estimates of released quantities are provided. The reference (DOE, 1980) gives little information about the basis for the estimates, but it implies that it includes a concept that no radon will be released except during active mining and backfilling, contrary to experience at uranium mines. In addition to continuing releases from the surfaces of the repository drifts and rooms, the stockpiled mined rock fragments will also continue to release radon. It is not expected releases of naturally occurring radionuclides at any of the candidate sites would be significant in terms of doses approaching regulatory limits, unless radon releases are much greater than usual for such rock types. However, a credible indication of the magnitude of the releases can be obtained by monitoring the ventilation pathway during the site characterization process. (Also see section 6.4.1, page 6-217).

4-11

Section 4.2.1.3.6, Radiological impacts pages 4-34, and 4-35

The DOE considers two sources of radiation that originate from site characterization activities:

1. tritium brought to the surface by the drilling; and

2. radioactive tracers that would be used to determine effective porosity and dispersively.

The DOE then concludes, "No major radiological impacts are anticipated due to site characterization activities."

The draft EA does not give a complete description of the radiological environment at the Hanford Reservation. Consequently the DOE's assessment of radiological impacts appears to be incomplete. The draft EA does not note that the shallow depression within the reference repository location, called "U Pond" has received radioactive effluents since the beginning of the Manhattan Project (DOE, 1982). Additionally, five ditches or ponds, all within the reference repository location are used for the disposal of low-level radioactive wastes (W.C.C., 1981). As a result of these discharges, soil, vegetation and near-surface groundwater within the reference repository location have a higher concentration of radionuclides than the median concentration for the Hanford area (DOE, 1982 and W.C.C, 1981).

The draft EA states that the tritium concentration in an unconfined aquifer at the exploratory shaft site is presently less than 2 picocuries per milliliter. Other studies, however, show that groundwater beneath the reference repository location has tritium levels from 30 to more than 3000 picocuries per milliliter (W.C.C., 1981).

The final EA should resolve the discrepancy between the trituim concentration reported in the draft EA and the concentration reported in W.C.C., 1981. The impacts of conducting site characterization in a contaminated area might also be considered. For example, would any of the excavations or drilling exhume low-level radioactive wastes or bring contaminated groundwater to the surface?

Chapter 4 References

DOE, 1980, Final Environmental Impact Statement: Management of Commercially Generated Radioactive Waste," DOE/EIS-0046-F, Vol, I, p. 5.56.

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CHAPTER 5 COMMENTS

5-1

Section 5-1, The repository, page 5-3, paragraph 3

The draft EA states, "The current features of the two phase concept include... a 35-year retrieval option period." The inclusion of the 35-year retrieval option period may cause additional problems in terms of room and emplacement borehole stability due to thermal induced fracturing. The potentially adverse condition stated in DOE Siting Guideline 960.5-2-9(c)(4), although acknowledged to be present, will be further enhanced due to this increase in preclosure period. It is suggested that the effects of the 35-year retrieval option period be discussed in the final EA.

5-2

Section 5.1.2.1, Surface facilities, page 5-18, paragraph 4

Withdrawal of water from the Columbia River can adversely affect the to aquatic biota by means of entrainment and impingement. The addition of two pumps in an existing pump station can increase the impact level of the existing facilities. It is suggested that an assessment be made of the impact potential of water withdrawal on river biota.

5-3

Section 5.1.2.1.1, Ventilation--982 conceptual design, page 5-20, paragraph 2

Cooling towers dissipate dissolved solids called "drift." Drift can have adverse effects on the terrestrial environment depending on its chemical composition and quantity. Therefore, if a cooling tower is utilized, the final EA might consider the potential impact of the drift on the terrestrial environment.

5-4

Section 5.1.4.3, Waste container configuration and packing, page 5-38, paragraph 1

The draft EA states that the packing material around the waste containers is required to limit groundwater intrusion and to reduce radionuclide release. However, it is not possible to evaluate the performance of this packing material because its behavior under high temperature conditions is not adequately presented in the draft EA. Furthermore, the draft EA does not mention the temperature to be expected in the vicinity of the waste package. This high temperature performance becomes important because Allen, et al. (1983) show that at temperatures of 300 C, the basalt/bentonite packing material converts to iron and potasium rich smectites along with secondary silica, albite and zeolites. Further, experimental work by Couture and Seitz (1984) strongly suggests that water vapor causes rapid, apparently irreversible degradation of the swelling capacity of bentonite. The resulting materials are likely to have a lower sorption capacity and reduced volume, both of which may influence radionuclide release rates (see detailed comments 6-25 and 6-27). It is suggested that the final EA include a discussion on the performance of the packing, backfill, and fracture lining materials under expected repository temperature conditions (10CFR60.113a).

5-5

Section 5.2.1, Expected effects on the physical environment, pages 5-38 through 5-44

There is no discussion of mineral resources in this section. All information on mineral resources in the draft EA is presented in detail in section 6.3.1.8, "human interference (natural resources)" which covers siting guideline 960.4-2-8-1. Silence on this issue leaves open the possibility of impacts. It is suggested that the expected effects of site characterization on mineral resources be discussed in this section.

5-6

Section 5.2.1.3.1, Ecosystem impacts, page 5-41, paragraph 1

It is stated that "techniques are available for reclaiming surface-disturbed lands with native seed sources." However, it is not stated whether these techniques will be used where appropriate. We suggest that the sentence be reworded as follows: "Available techniques will be utilized to reclaim surface disturbed lands with native seeds."

5-7

Section 5.2.1.3.1, Ecosystem impacts, page 5-43

The next to last paragraph in this section states that there are no scientific data available to prove a repository will have adverse impacts on fisheries. Potential impacts to aquatic systems (and thus to fisheries) could result from water withdrawal from the Columbia River and from site runoff and chemicals at the site entering the rivers via Cold Creek drainage. It is suggested that potential impacts be assessed in terms of the Native American fishery resources potentially at risk.

5-8

Section 5.2.1.3.2, Air quality impacts, pages 5-43 to 5-44

No quantitative assessments of emissions and air quality impacts during facility construction and operation are presented. Therefore, it is not clear on what basis it is concluded that the site, during facility construction and operation, can meet national air quality standards. It is suggested that emissions and air quality impact evaluations, including models and input data, be provided.

5-9

Section 5.2.1.3.3, Noise impacts, page 5-44

Noise related impacts on people due to the construction and operation of road and railroad access to the proposed site are not discussed. It is suggested that the DOE consider evaluating the transportation noise impacts and their potential for occurrence.

5-10

Section 5.2.1.3.3, Noise impacts, page 5-44

Noise related impacts on wildlife during facility operation are acknowledged but not described qualitatively or quantitatively. The need for mitigation is also not discussed. Similarly, noise related wildlife impacts due to the access roads and railroad are not discussed. It is suggested that the final EA consider the noise impacts of transportation and impacts on wildlife.

5-11

Section 5.2.2, Expected effects of transportation, page 5-46

The impacts from transportation accidents, including the estimated dose to the maximally exposed individual and the estimated number of latent cancer fatalities, are not discussed. It is suggested that the final EA include either an explanation of the use of existing analyses and studies to substantiate the assertion that transportation accident impacts are small, or an analysis of the consequences, probabilities, risks and cleanup costs for a severe transportation accident enroute to the site.

5-12

Section 5.2.2.3, Highway transport, pages 5-48 through 5-50

Certain transportation corridors along the routes to the sites, for example, those with high accident frequency or high waste traffic volume, or adverse weather conditions are a potentially important issue. Although the radiological risks along these special corridors are estimated to be small, such corridors may be subject to increased state and local emergency response actions. This response may be costly and could be disruptive to communities. It is suggested that this type of consideration be included in the DOE's assessment of transportation impacts.

5-13

Section 5.2.2.5, Potential radiological effects, page 5-52, first paragraph

The paragraph implies that under normal conditions of transport, no radioactive material would be released from the shipping containers. While this may be true for the contents of the package, there have been cases of contamination being released from the package surface during transport. It is suggested that the potential radiation doses to radiation workers involved in close proximity to decontamination efforts be addressed in the final EA's.

5-14

Section 5.2.3.1, Population density and distribution, page 5-59, paragraph 1

No indication is given of the uncertainties of the labor force estimates used in the socioeconomic analyses. The size of the labor force during construction, operation, and closure is a major determinant of socioeconomic impacts. Therefore, labor force size and uncertainty would be reflected in the magnitudes and uncertainties of estimates of socioeconomic impacts. It is suggested that the uncertainty in labor force estimates be assessed and if it is sufficiently large, the implications for the estimates of socioeconomic impacts be discussed.

5-15

Section 5.2.3.5 Fiscal, conditions and government structures, page 5-66

The discussion in the section on technical and financial assistance for planning and mitigation should consider how assistance will be provided to assure timely planning. Early planning is necessary to prevent impacts that can be mitigated. Many of the tax benefits cited in this section are during construction when it will be too late to mitigate the impacts of construction.

More emphasis needs to be placed on preplanning potential of financial and technical assistance. Specifically, the DOE grants may be available during site characterization to assist in planning for economic, social, and public health and safety impacts of a repository. This planning would identify potential impacts and requirements well in advance of the beginning of construction and allow timely mitigation. A detailed approach to impact mitigation is needed and plans for the timely implementation of studies should be considered. Mitigation planning is a lengthy process which should take place as early in the repository siting as possible. It is suggested that there be a full discussion of the timing of pre-impact planning assistance available for mitigation.

Chapter 5 References

Allen, C.C., D.L. Lane, R.A. Palmer, and R.G. Johnston, "Experimental Studies of Packing Material Stability," RHO-BW-SA-313P, Rockwell Hanford Operations, November 1983.

Couture, R. A., M. G. Seitz, "Modification of Backfill Materials Under Repository Conditions," in Nuclear Technology Programs Quarterly Progress Report, ANL-84-57, Argonne National Laboratory, 1984.

CHAPTER 6 COMMENTS

6-1

Summary, page 6ii/6-v, paragraph 1/Table 6-B (Geochemistry)

The geochemical data in the draft EA do not appear to adequately support the favorable findings concerning the qualifying condition for geochemistry. For example, hydrothermal experiments show that under elevated temperatures (repository conditions) groundwater solution concentrations of carbonate (Johnston, et al. 1984), and fluoride (Apted and Meyers, 1982) increases. In addition, according to Wood (1983), Wood, et al. (1984), and Allen, et al. (1983), bentonite (which is used as a component to backfill/packing material and typifies fracture filling clays) is beginning to react with groundwater in three months yielding albite. Further, experimental work by Couture and Seitz (1984) suggest that water vapor at high temperatures causes irreversible degradation of bentonite. Also, redox experiments suggest that ambient redox conditions may be no lower than about -0.2 volts, and that lower values are only achieved by reacting engineered barrier materials with (distilled) water (Jantzen, 1983). In addition, Gray (1983 and 1984) reported the production of hydrogen and organic polymers similar to polyethylene in experiments involving Hanford groundwater/gamma radiolysis. Increases in carbonate and flouride concentrations increase radionuclide complexing potential (i.e. which could lead to increases in radionuclide solubility). The transformation of backfill/packing/fracture-filling clays will reduce the sorptive capacity of that material. Redox conditions influence radionuclide solubility and sorption, and canister containment. Further, the production of hydrogen and organic polymers could unfavorably affect waste package stability and radionuclide transport respectively (see detailed comments 6-27, 6-28, 6-32, and 6-33). Thus, assuming that likely geochemical reactions are favorable to long-term isolation biases radionuclide releases and transport in favor of low release and high retardation during transport (see detailed comment 6-25).

As stated in the Hanford draft EA, in order for a favorable condition to be claimed or an adverse condition to be disclaimed, it is necessary for the existing data to clearly or conclusively support that conclusion (draft EA p. 6-4, ¶3 and p. 7-3, ¶3). Further, it is stated that when the data do not provide clear support, conservative assumptions are used to minimize the possibility that later findings will prove the assumptions to be incorrect, and result in radionuclide releases in excess of regulatory limits (draft EA p. 6-4, ¶3 and p. 7-3, ¶3). Because the geochemistry data appear to be insufficient to support a conclusive evaluation of favorable condition 2, 3, 4, and 5 and potentially adverse conditions 1, 2, and 3, a generally conservative line of support should be presented for each condition.

6-2

Summary, Table 6-A, page 6-iii

In Table 6-A, and throughout the draft EA, the DOE states, "The available evidence does not support a finding that the reference repository location is not likely to meet the qualifying condition" (emphasis added). This type of finding, a level 3 finding, is described in Appendix III of the guidelines. Unlike the level 3 finding discussed in the draft EA, however, the level 3 finding presented in Appendix III does not refer to evidence that is "available." Instead, the guidelines require DOE to base its findings on a prescribed level of information, described in Appendix IV, and not on information or evidence that is available[1].

The staff brings this matter to the DOE's attention because one of the Commission's conditions for concurrence in the guidelines was that the DOE should "...indicate the kinds of information necessary for the DOE to make decisions on the nomination of at least five repository sites and subsequently recommending three sites to the President for characterization..." (49FR9650). In response, DOE added Appendix IV to the guidelines. Appendix IV lists, guideline by guideline, the types of information that will be used for, "... evaluations and applications of the guidelines of Subparts C and D at the time of nomination of a site as suitable for characterization." (Appendix IV of 10CFR960).

The staff expects DOE to identify the kinds of information or evidence, as presented in Appendix IV, that was used to support the DOE's finding. The staff suggests that abbreviated description of this information be presented in a third column of Table 6-A with references to where this information can be found. A similar treatment is appropriate for Table 6-B.

[1]Section 960.3-2-3 states that the Secretary of Energy will rely on available information as a basis for his recommendation of sites for characterization. This "available" information, however, is the information required by Appendix IV of the guidelines. The guidelines make no further reference to "available information."

6-3

Section 6.2.1.3, Site ownership and control, pages 6-15 to 6-16

It appears that not all the lands that may be part of the controlled area have been withdrawn under Public Land Order 1273. The qualifying condition should be applied with respect to lands, including acquired lands, that are not covered by that Order. Further, although it is stated that "present ownership and control of the Hanford site reference repository location and all surface and subsurface mineral rights is by the Federal government and the U.S. Department of Energy," the pertinent part of the applicable Public Land Order 1273 qualifies the withdrawal of the land with the introductory phrase "subject to valid existing rights." The staff suggests that the assessment identify and discuss any such existing rights which could interfere with DOE's jurisdiction and control of the site.

6-4

Section 6.2.1.4.4, Potentially adverse conditions, page 6-18

It is not stated that radioactive emissions could be preferentially transported toward localities with higher population densities in the vicinity of the plant. Since the prevailing wind at the Hanford site indicates preferential transport towards Richland, WA, it may not be concluded that this condition is not potentially adverse. Thus, the evidence may not support the conclusion in the draft EA that this potentially adverse condition is not substantively present at the reference repository location.

6-5

Section 6.2.1.4.5, Potentially adverse condition, page 6-18

A potentially adverse condition of Guideline 10CFR960.5-2-3 pertains to extreme weather phenomena in the vicinity of the repository that could significantly effect operational activity at the repository. There is no mention of possible severe weather conditions that may be encountered by trucks or trains en route from the northeastern utilities and crossing the U.S. to get to this repository. It is suggested that the potential for this type of delay be given consideration in the final EA.

6-6

Section 6.2.1.5, Offsite installations and operations, page 6-20

Guideline 10CFR960.5-2-4 pertains to the location of offsite installations and operations and their potential effect on the repository. The draft EA states that the U.S. Army Yakima Firing Center is located 10 miles west of the repository. There are no details about this military installation discussed in the draft EA. It is suggested that more information about the routine functions at this firing range is appropriate in order to evaluate the situation and make a determination as to whether activities there would pose a potential threat to the repository.

6-7

Section 6.2.1.6.3, Favorable conditions, Table 6-2, page 6-27

No assessments of the magnitude of sources and of the air quality impacts resulting from these sources have been made for construction and operation of the repository. In Table 6-2, it is stated that site characterization and other repository activities are not considered to be a major source. Therefore, the conclusion that all repository activities are not expected to be a major source is not complete. It is suggested that an air quality analysis and comparison of the results of the analysis to national air quality standards be performed to determine whether site characterization, construction and facility operation activities constitute a major source.

6-8

Section 6.2.1.6.3 Favorable conditions, page 6-29, Table 6-2,

In Table 6-2, the rows for Endangered Species and for Bald and Golden Eagle Protection Act state that bald eagles nest along the Columbia River. According to our sources bald eagles do not nest along the river in the area of the Hanford site. They are winter visitors only (Blum, 1982).

6-9

Section 6.2.1.7.11, Disqualifying condition, page 6-43, paragraph 6

The analysis of conditions and processes which suggest that with respect to radionculide solubility, "... basalt has the capacity to isolate radionuclides and prevent significant degradation of ground-water quality..." is inappropriate to the discussion of this disqualifying condition. The discussion is applying post-closure solubility arguments to a preclosure condition.

6-10

Section 6.2.1.8.11, Favorable conditions, page 6-52

In the draft EA, it is concluded that a favorable condition regarding meteorological impacts on transportation disruptions is present based only on weather conditions at the Hanford site and vicinity. Evaluation of this condition should consider major transportation routes from the reactors to the Hanford repository. It is suggested that the evaluation include transportation across mountains and, in many cases, transportation across the Great Plains region from nuclear power plants. An analysis of the frequency and duration of delays along the transportation routes due to severe weather and their associated hazards may be desirable.

6-11

Section 6.3.1.1.3, Favorable condition, pages 6-62 through 6-65

This favorable condition is stated as:

> "(1) Site conditions such that the pre-waste-emplacement ground-water travel time along any path of likely radionuclide travel from the disturbed zone to the accessible environment would be more than 10,000 years."

The draft EA notes (page 6-63) that "it can be stated that available data and current understanding of the ground-water system do not support a finding that the reference repository location is not likely to meet the favorable condition."

The evidence available at this preliminary stage, as analyzed by the NRC, suggests there is reasonable doubt that this favorable condition will be met at the Hanford site. The NRC has identified seven problem areas with the travel time calculations that are presented by the DOE to support their finding that this favorable condition is met. These areas are: 1) problems with the applicability of previously published travel time estimates (discussed below); 2) problems with the transmissivity data base and the manipulation of those data for model input; 3) problems with the hydraulic gradient data base and the manipulation of those data for model input; 4) problems with the effective thickness data base and the manipulation of those data for model input; 5) problems with the theoretical basis of the travel time models; 6) problems with the presentation of the results of the travel time models; and 7) problems with the definition of the orientation and lengths of flow paths from the disturbed zone to the accessible environment. These problems are described in detail in the comments on specific portions of chapter 6 provided below.

6-12

Section 6.3.1.1.3, Favorable condition, page 6-62 through 6-65

Seven preliminary studies of pre-waste-emplacement ground-water travel time performed by various DOE-funded and NRC investigators between 1981 and 1984 are cited in the draft EA in support of the finding on the presence of this favorable condition. With the exception of the NRC (1983) study, and the Arnett and Sagar (1984) study, all studies yielded median pre-waste-emplacement ground-water travel times from the edge of the underground facility to the accessible environment in excess of 10,000 years. As discussed below, each of the available studies has been reviewed by the NRC, and each is considered to represent optimistic and non-conservative preliminary predictions of ground-water travel time. Selected comments on each of these documents are summarized below.

The LATA (1981) study is based on a hydrogeologic conceptual model which is now outdated, and offers an overly optimistic assessment of pre-waste-emplacement ground-water travel time, according to data obtained subsequent to the study. The conceptual model adopted by LATA for this study assumed a 244-meter thick aquitard to be present between the repository horizon (assumed by LATA (1981) to be the Umtanum interior) and the Vantage interbed (assumed by LATA (1981) to be the first aquifer above the repository horizon). The Vantage aquifer is assigned a horizontal hydraulic conductivity of 3×10^{-7} m/sec. However, subsequent data collection has indicated the presence of other aquifers, which may provide preferential conduits for ground-water flow, between the Umtanum interior and the Vantage interbed. For example, the Umtanum flow top, Cohassett flow bottom, Cohassett flow top, and Rocky Coulee flow top all appear to have horizontal hydraulic conductivities comparable to or greater than the assumed Vantage interbed horizontal hydraulic conductivity. Preliminary tests suggest that the horizontal hydraulic conductivity of the Cohassett flow bottom is at least two orders of magnitude larger than the assumed Vantage horizontal hydraulic conductivity (Strait and Spane, 1982). Also, the LATA (1981) study assumed effective porosities for both aquifers and aquitards to be at least an order of magnitude greater than the effective porosity suggested by Hanford site tests of basalt flow tops (Gelhar, 1982), Leonhart et al., 1984). Based on this information, the NRC considers the LATA (1981) study to be outdated and optimistic, based on the evidence. It should also be noted that the LATA (1981) study suggests an upward flow path in a northerly direction to the Columbia River. This is contrary to the preferred preliminary conceptual model by the DOE in the draft EA of deep ground-water flow in a southwesterly direction from the RRL.

The Dove, et al. (1981) study also uses effective porosities at least an order of magnitude higher than the Hanford site data (Gelhar, 1982), Leonhart, et al., 1984) suggests. The modeling of each major basalt sequence (Grande Ronde, Wanapum, and Saddle Mountains) as a single ("lumped") layer in the model may also result in inflated ground-water travel time estimates, in that the impact of individual hydrostratigraphic units of higher conductivity, which may be preferential conduits for ground-water flow, on ground-water travel time is masked by the averaging process. Due to these non-conservative assumptions, the ground-water travel time predicted by the Dove, et al. (1981) model, which was intended only as a demonstration of modeling capabilities, is not considered a viable support document for travel times presented in the draft EA. The Dove, et al. study also suggested an upward flow path north to the Columbia River.

The Arnett, et al. (1981) model has also been reviewed by the NRC (Lehman and Quinn, 1982) in a comparative evaluation with the Dove, et al. (1981) model. This model also assumes inappropriately low values for hydraulic conductivities (through lumping of hydrostratigraphic units) and effective porosities. Also, problems also exist with the hydrologic boundary conditions imposed on the Arnett, et al. (1981) document (Lehman and Quinn, 1982; Quinn, 1982). Therefore, this model is also considered to be unreliable and overly optimistic in terms of pre-waste-emplacement ground-water travel time predictions.

The Burnham (1983) document cited in this section of the draft EA contains no modeling, analytical studies, or calculations to support its statement that "it is our conclusion that, in all probability, the Hanford site will demonstrate a pre-emplacement ground-water travel time in excess of 1,000 years when fully characterized." This document thus adds no technical support to the DOE's contention that ground-water travel times are likely to exceed 1,000 years.

The Clifton, et al. (1983) document assumes strictly horizontal flow through a single, "representative" flow top. Clifton, et al. (1983) use ensemble statistics for all flow tops to describe the random variations of transmissivity within the "representative" flow top. The ensemble statistics yield a lognormal distribution of transmissivity with a geometric mean of 1.65 ft^2/day and a standard deviation of log transmissivity of 1.83. The use of the ensemble statistics for identification of the expected pre-waste-emplacement ground-water travel time along "any pathway of likely and significant radionuclide travel" may not be appropriate since, in a layered system, the faster paths of horizontal travel will be within the most transmissive zones, which do not exhibit transmissivities on the low end of the ensemble distribution (see detailed comment 3-22). Therefore, travel time through a flow top of generally higher conductivity may be much lower than that determined by the statistical manipulation of transmissivities for all flow tops. The use of the ensemble statistics may be appropriate for vertical flow in a layered system, or for horizontal flow in a randomly heterogeneous unit which displays the same variance, median, and distribution described by Clifton, et al. for the ensemble of flow tops. However, this type of treatment is inappropriate for describing single randomly heterogeneous units which have a higher median transmissivity and/or a lower variance (see detailed comment 3-22). The high variance assumed in the Clifton, et al. (1983) model is of particular import due to the assumption of a five-kilometer spatial correlation range of transmissivity within the two-dimensional (20 km x 10 km) numerical model (see detailed comments 6-101, 6-102 and 6-103). This results in the median ground-water travel time being higher than the ground-water travel time calculated using the median value of the Clifton, et al. (1983) transmissivity distribution (Clifton, 1984). Further support for this choice of correlation range is appropriate. Additional concerns with the numerical modeling assumptions in the Clifton, et al. (1983) and Clifton, et al. (1984) models are discussed in detailed comments 6-101, 6-102 and 6-103).

The effective porosity assumed by Clifton, et al. (1983) is more than an order of magnitude higher than the limited Hanford data would suggest, resulting in overly optimistic pre-waste-emplacement ground-water travel time predictions. The use of the existing flow top effective porosity data (Gelhar, 1982; Leonhart, 1984) would shift the median ground-water travel time suggested by the Clifton, et al. (1983) study from the calculated 17,000 years to less than 680 years (Gordon, 1984).

The Clifton, et al. (1984) study is similar to the Clifton, et al. (1983) study except that, in addition to transmissivity, effective porosity and hydraulic gradient were also assumed to be random variables. Uniform distributions were chosen by Clifton, et al. (1984) for both variables in order that any value within the specified range would have an equal probability of occurrence. For wide ranges in the input variables, the uniform distribution weights the mean towards the higher values, relative to the loguniform distribution. Therefore, for given ranges in the input variables, a uniform distribution will be non-conservative (compared to a log-uniform distribution) for effective porosity (or effective thickness), and conservative for hydraulic gradient, in terms of the resultant travel time calculations.

The specified range for the regional gradient in the Clifton, et al. (1984) model was chosen to be from 10^{-4} to 10^{-3}; this is considered by NRC to be an inappropriately limited range in that gradients greater than 1×10^{-3} can be inferred from existing data (from DOE, 1982; Yeatman and Bryce, 1984; and Swanson and Leventhal, 1984) (see Table 1 and detailed comment 6-15).

The specified range for effective porosity was chosen by Clifton, et al. (1984) to be from from 10^{-4} to 10^{-2}, with a uniform distribution, having a mean of 0.005; this range is also considered by the NRC to be inappropriate since existing data for the single flow top tested suggest an effective porosity between 10^{-4} and 10^{-3} (i.e., not as high as 10^{-2}) assuming porous continuum flow (as is done in all of the previous cited analyses). The effective thickness in the Clifton, et al. (1984) model has a mean of 0.04 for the assumed 8-meter thick flow top. This is almost an order of magnitude higher than the single measured value for a Grande Ronde flow top. Clifton, et al. (1984) base their choice of the range of effective thickness on the suggestion of Loo, et al. (1984). Loo, et al. (1984) base their suggestion on a combination of the Hanford site test results, laboratory analyses, generic literature values for total and apparent porosities, and the results of a poll of expert panelists. The NRC considers that expert opinion and generic values are less reliable than direct in-situ testing when such testing is feasible, as is the case for effective thickness testing. The range suggested by Loo, et al. is considered by the NRC staff to be non-conservatively biased towards high values, as is the Loo, et al. choice of a uniform distribution for the parameter (Gordon, 1985).

The results of the Clifton, et al. (1984) study suggest a median ground-water travel time for a ten-kilometer long horizontal flow path within a single "representative" flow top of 81,000 years, and less than a 5% probability that the travel time will be less than 1,000 years. However, the individual chosen parameter distributions, as noted above, are considered by the NRC staff to be non-conservative and inconsistent with the existing data. Therefore the results, which compound this optimistic selection of parameters, are considered to be overly optimistic and do not adequately support the draft EA conclusion that ground-water travel times are likely to exceed 1,000 years.

Several additional comments bearing on the reliability of the travel time analyses are common to all of the above analyses. None of the studies cited in the draft EA consider the potential impact of structures and large-scale heterogeneities, nor small-scale heterogeneities such as interconnected fractures and fracture networks, on ground-water travel time. These features may have a positive or a negative effect on calculated ground-water travel times. The LATA (1981) document contains an additional (uncited) study of a single fault scenario; however, the effects of the fault on groundwater flow were masked in the LATA (1981) model by the averaging of the hydraulic properties of a 1 meter wide fault within a 4000 meter x 4000 meter model grid block. As yet there have been no conclusive studies which detail the impact of structural and stratigraphic features on ground-water travel time at the Hanford site. Also, there is currently no site-specific data available on vertical hydraulic conductivities of the basalt units, which are critical parameters for hydrogeologic performance assessment. Finally, the gradients and boundary conditions assumed in the above-cited analyses are based on the assumption that the site hydrology is in steady-state. However, the degree of transience of the hydrogeologic system at the site is as yet unknown. On-site and off-site pumping and disposal activities may be creating a relatively dynamic hydrogeologic system.

The guideline (10CFR960.4-2-1) requires the calculation of ground-water travel time to be applied from the disturbed zone to the accessible environment. The calculated ground-water travel times in the draft EA are all calculated either from the edge of the underground facility, or for a complete ten-kilometer lateral distance. The presence of a disturbed zone, which might extend for a significant portion of the distance between the facility and the accessible environment, has not been accounted for in these calculations. Thus, the travel time calculations appear to be non-conservative with respect to flow path lengths. The NRC acknowledges that further clarification of the definition of the disturbed zone is needed, and is currently preparing further technical guidance on the calculation of the disturbed zone. The distance to the accessible environment as defined in the Guidelines is defined by a semi-infinite cylinder with a maximum radius of ten kilometers from the edges of the underground facility and with the top of the cylinder a the land surface. This is the definition utilized in the draft EA in ground-water travel time calculations. However, as noted in Section 6.4.2.3.5, subsequent drafts of the EPA Standard have suggested an accessible environment boundary as close as two kilometers under certain conditions. Also, page 6-36 of the draft EA indicates that the controlled area at the Hanford site will extend only two kilometers from the surface projection of the underground facility. According to the definition on page G-1, the "accessible environment" would therefore begin at the two-kilometer limit of the control zone. Pre-waste-emplacement ground-water travel times calculated on the basis of a ten-kilometer distance from the calculational origin to the accessible environment may therefore be overestimated if either a significant disturbed zone exists or if the distance to the accessible environment is less than ten kilometers.

6-13

Section 6.3.1.1.5 Favorable condition, pages 6-66 to 6-69

The draft EA states, "While characterization is not expected to be easy, a basalt environment does have potentially favorable attributes including the following:

- Large-scale hydraulic testing will rely on developed saturated-flow hydraulic theory..."

The theory used in the analysis and performance of large-scale testing at Hanford may have to be developed beyond the current state-of-the-art to account for the special features of the basalts at the Hanford site, including well depths, effects of large temperature differences between the surface and deep units, the effects of dissolved solids and methane gas, and the fractured nature of the basalts. Existing theories used in large-scale test analysis are not well-developed in terms of these features, which the NRC studies indicate may be very significant for interpretation and performance of dynamic tests (Coleman and Gordon, 1984; Golder Associates, 1984).

The draft EA quotes from the NRC draft Site Technical Position on Hydrologic Testing Strategy for BWIP (NRC 1983b). The quotation is not considered relevant to the discussion which precedes it about the stage of development of theory for large-scale testing. The cited sentence states only that direct testing is desirable.

The statement about relying on "developed theory" in future site characterization might be revised in the final EA to indicate the limitations of currently-developed testing and analysis methods in deep, high-temperature, gas-enriched ground water in fractured basaltic media. Also, citation of the statement from the NRC draft site technical position on hydrologic testing strategy might appropriately be deleted from this section, as it does not appear to be relevant to the section. However, if cited, the NRC draft Site Technical Position should be correctly referenced as "draft."

6-14

Section 6.3.1.1.5, Favorable condition, page 6-68, paragraph 3

The draft EA states that the "principals involved believe that the reference repository location has a high likelihood of being characterized." The principals noted include the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission. The NRC has not taken a position on the likelihood of the site being characterizable. The testing approach outlined in the NRC (1983) represents, in part, a hypothesis testing program which might reveal substantial difficulties in characterization of the reference repository location.

6-15

Section 6.3.1.1.6 Favorable condition, pages 6-70 through 6-75

This favorable condition is stated as:

"(4) For disposal in the saturated zone, at least one of the following pre-waste-emplacement conditions exists:

(i) A host rock and immediately surrounding geohydrologic units with low hydraulic conductivities.

(ii) A downward or predominantly horizontal hydraulic gradient in the host rock and in the immediately surrounding geohydrologic units.

(iii) A low hydraulic gradient in and between the host rock and the immediately surrounding geohydrologic units.

(iv) High effective porosity together with low hydraulic conductivity in rock units along paths of likely radionuclide travel between the host rock and the accessible environment."

The draft EA considers that subconditions (ii) and (iii), and half of subcondition (i), are met at the reference repository location, and therefore that the favorable condition is met. There may be substantial uncertainty in the support for this finding. The evidence is inconsistent, and alternative findings on these subconditions are possible with existing data.

Problems with the reliability of the DOE's preliminary tests of horizontal hydraulic conductivity for both flow interiors and flow tops have been identified by the NRC staff in the past (NRC, 1983a; Coleman and Gordon, 1984; Williams and Associates, 1984; Golder Associates, 1984). These problems include those caused by irregularities in test procedures, improper test analysis, temperature effects, effects of dissolved gas and solids, and the effects of large and small-scale heterogeneities. The NRC staff has also questioned the representativeness of the single-hole test data for the larger scales of interest in repository performance assessment (NRC, 1983b). The DOE notes that "horizontal hydraulic conductivities measured [within flow interiors] were generally less than or equal to 10^{-11} meter per second (10^{-6} feet per day)." However, horizontal hydraulic conductivities as high as 147 feet per day have been measured within flow interiors (Strait and Spane, 1983), which is more than eight orders of magnitude higher than the generally reported values. Thus, the generally reported values may not be representative of certain significant anomalous zones of high hydraulic conductivity.

No reliable field data currently exists with regard to vertical hydraulic conductivities for flow interiors or flow tops. An initial field test of vertical hydraulic conductivity of a flow interior (Spane, et al., 1983) is cited in this section. Spane, et al. (1983) reported a vertical hydraulic conductivity of "less than 10^{-10} meters per second" for the Rocky Coulee flow interior. However, the NRC studies (Golder Associates, 1984) indicate that the test arrangement was not appropriate for the type of tests performed, and therefore there are substantial questions regarding the usefulness of the test results. Furthermore, alternative interpretations (e.g., Brown, 1984) of the test results are possible which could yield a vertical hydraulic conductivity up to two orders of magnitude greater than that calculated for the draft EA.

The draft EA cites two references which describe model-calculated and statistical estimates of vertical to horizontal hydraulic conductivity anisotropy ratios. One of the cited documents (DOE, 1982) is apparently misreferenced, as the document contains no discussion of the 2:1 estimate of anisotropy, which the draft EA attributes to the document. The other document (Sagar and Runchal, 1982) is a demonstration of a statistical technique for analyzing the effects of fracture size and data uncertainties, based on fracture set orientation information gained from a rock sample taken from Gable Mountain. The Sagar and Runchal (1982) document is based on assumptions regarding fracture frequency, aperture and length, which bear no relation to site specific data (Gordon, 1984). In fact, Sagar and Runchal (1982) state that "the calculations ... are intended as an illustrative example and not as a definitive statement on the hydraulic conductivity of the fractured basalt at Gable Mountain." Therefore, the cited anisotropy ratio of 3.5 to 1 derived by Sagar and Runchal (1982) should not be considered to apply, in general, to Hanford basalt flow interiors.

Considering the lack of information on host rock vertical hydraulic conductivities, and the unreliability of the existing information on host rock horizontal hydraulic conductivities, the NRC staff can not determine at this point whether the first half of subcondition (i) of this favorable condition (low hydraulic conductivity of host rock (i.e., candidate flow dense interior)) exists at the Hanford site, contrary to the draft EA finding.

Regarding hydraulic gradients (subconditions (ii) and (iii)), the statement in this section that the gradients are downward or predominantly horizontal appears to be contradicted on page 6-231, where it is stated that a slightly upward natural gradient exists across the preferred candidate horizon. Also, Clifton, et al. (1984, page 13) state that "the overall vertical hydraulic gradient in the Grande Ronde basalts from the Umtanum flow top to the Ginkgo flow top was estimated to be approximately 2×10^{-3} as measured in three piezometer nests during late August, 1984 (Bryce and Yeatman, 1984)." This suggests a relatively high upward gradient compared to the horizontal hydraulic gradient. On page 6-72, it appears that the vertical gradient is downward in the upper basalt layers and upward in the lower basalt layers. Under the assumed steady-state flow conditions, this would require some kind of vertical flow sink at the point of gradient reversal, for which no mechanism has been suggested. The hydrologic baseline monitoring program currently underway at the Hanford site may provide additional resolution of the question of the three dimensional distribution of hydraulic gradients.

The magnitude of the hydraulic gradient in and between the host rock and surrounding geologic units, based on existing data (see Table 6-1) may be estimated to be higher than 1×10^{-3} foot per foot, rather than approximately 1×10^{-4} foot per foot, as the draft EA suggests. The areal gradient

TABLE 6-1
COMPARISON OF APPARENT AREAL GRADIENTS FOR
SELECTED BASALT FLOWS IN THE GRANDE RONDE BASALT

Stratigraphic flow interval	Comparison of observed heads (ft above MSI)		Average head gradient between boreholes within interval	Approximate Direction of inferred average head gradient between boreholes within intervals
	Head In RRL-2	Head In DC-22		
Rocky Coulee	401 to 402	396 to 397.5	3.5×10^{-4} to 6×10^{-4}	Northwest
Cohassett	397	401 to 401.5	4×10^{-4} to 4.5×10^{-4}	Southeast
	Head In RRL-2	Head In DC-19		
Cohassett	397	400 to 400.5	1.6×10^{-4} to 1.8×10^{-4}	Northwest
	Head In RRL-2	Head In DC-20		
Rocky Coulee	401 to 402	402.5 to 403	6.0×10^{-5} to 2.4 to 10^{-4}	Southwest
Cohassett	397	402.5 to 403	6.6×10^{-4} to 7.2×10^{-4}	Southwest
	Head In RRL-2	Head In RRL-14		
Rocky Coulee	401 to 402	402 to 405	0 to 4.8×10^{-4}	Southeast
Cohassett	397	409	1.4×10^{-3}	Southeast

TABLE 6-1 (Continued)
COMPARISON OF APPARENT AREAL GRADIENTS FOR
SELECTED BASALT FLOWS IN THE GRANDE RONDE BASALT

Stratigraphic flow interval	Comparison of observed heads (ft above MSl)		Average head gradient between boreholes within interval	Approximate Direction of inferred average head gradient between boreholes within intervals
	Head In DC-22	Head In RRL-14		
Rocky Coulee	396 to 397.5	402 to 405	1.7×10^{-3} to 3.5×10^{-3}	North
Cohassett	401 to 401.5	409	2.9×10^{-3} to 3.1 to 10^{-3}	North
	Head In DC-19	Head In DC-22		
Cohassett	400 to 400.5	401 to 401.5	1.7×10^{-5} to 5.1 to 10^{-5}	Southeast
	Head In DC-12	Head In DC-19		
Cohassett	407	400 to 400.5	3.1×10^{-4} to 3.3×10^{-4}	Northwest
Rocky Coulee	401 to 402	401 t0 407.5	0 to 9.3×10^{-3}	Northeast

is calculated by comparing heads between individual pairs of boreholes. This procedure may be questionable, because hydraulic gradients should be calculated in the direction of flow, which may or may not be along a path between boreholes. Therefore, the draft EA may underestimate the actual hydraulic gradient, because the gradient calculated between boreholes will be less than, or at most equal to, the actual gradient. The direction of the gradient can not be determined at this time. In any case, there is substantial uncertainty with respect to the gradient and the degree to which subconditions (ii) and (iii) are satisfied.

The draft EA states on page 6-75 that, because flow tops may be expected to have a higher effective porosity than dense interiors, "radionuclide movement would have taken place in basalt layers having both high and low effective porosities." The results of preliminary testing in a flow top indicate that flow tops may also have a low effective porosity relative to other geologic media. Therefore, we suggest that the statement quoted above might be reworded to read "radionuclide movement would have taken place in layers having both higher and lower effective porosities."

The above information, we consider that the available information suggests that there is substantial uncertainty in the technical support for the finding on this favorable condition made in the draft EA.

6-16

Section 6.3.1.1.6, Favorable condition, page 6-73, Table 6-5

Borehole DC-12 appears to have been omitted from the tabulation of head data provided in the draft EA. Borehole DC-12 lies between boreholes RRL-2 and DC-15. The NRC staff noted in NRC (1983a) that a direct line gradient between RRL-2 and DC-15 is inappropriate because the head derived from the drill and test sequence at DC-12 is higher than the head in either of these boreholes. This is important to the development of a conceptual model of ground-water flow in the Pasco Basin.

6-17

Section 6.3.1.1.6, Favorable condition, page 6-75, paragraph 3

This section of the draft EA discusses the field tracer experiment for determination of dispersivity and effective porosity. This section states that the effective thickness of the test horizon ranges between $2x10^{-3}$ and $3x10^{-3}$ m (0.006 to 0.01 ft). The definition of effective thickness, used in this section, is inconsistent with the definition which was used during previous data gathering and workshop meetings with Hanford personnel. This problem can be resolved by defining the phrases used in the analyses and presentation of data and adhering to these definitions. Also, refer to detailed comment 3-24 which questions the statement that, to date, two tracer tests have been performed within the McCoy Canyon flow top.

6-18

Section 6.3.1.1.8, Potentially adverse condition, page 6-76

This potentially adverse condition is stated as:

> "(1) Expected changes in geohydrologic conditions - such as changes in the hydraulic gradient, the hydraulic conductivity, the effective porosity, and the ground-water flux through the host rock and the surrounding geohydrologic units - sufficient to significantly increase the transport of radionuclides to the accessible environment as compared with pre-waste-emplacement conditions."

The draft EA does not appear to adequately consider the possible changes in geohydrologic conditions compared with pre-waste-emplacement conditions in reaching the finding that this potentially adverse condition does not exist. For example, ground-water usage, irrigation practices, waste-water disposal activities, and repository-induced effects do not appear to be adequately considered.

The regional hydraulic gradient may be changed as a result of ground-water use such as pumping (for irrigation, etc.), injection or wastewater application outside of the controlled area. These practices are not considered. As an example of the impact of ground-water usage on the hydrologic conditions in adjacent basins, ground-water usage is increasing in regions to the northeast, east, and west of the Hanford reservation, causing 200 to 300 foot drops in the height of the water table in the adjacent Quincy Basin (Cook, 1984). The projected water usage outside of the controlled area within the Pasco Basin and surrounding region should be considered by the DOE in applying this guideline.

Irrigation using Columbia river waters would also be a factor in providing artificial ground-water recharge. Within some areas influenced by the Columbia Basin Irrigation Project, significant rises in unconfined water levels occured. Potentiometric levels in underlying basalt aquifers rose as much as 20 to 40 ft/yr after the beginning of irrigation (Gephart, et al., 1979).

Previously the DOE has investigated the probable impacts of constructing water control structures along reaches of the Columbia that lie within the Hanford reservation (DOE, 1982). One proposed project which had been intensively studied was the Ben Franklin Dam (Harty, 1979). If constructed, this reservoir would be sited along the Hanford Reach of the Columbia about five miles north of North Richland. Such a structure would greatly increase water levels in the unconfined aquifers underlying the northeastern portion of the Reservation. Water levels in the unconfined system underlying the reference repository location would be increased by as much as ten feet if the dam was to be maintained at a pool elevation of 400 feet (Harty, 1979).

The effect of repository-induced thermal loading has also not been adequately addressed in this section. For instance, the draft EA states, that

> "this loading is predicted to extend a limited distance (several hundred meters) from the repository. Such a lateral distance is a relatively small portion of the 10 kilometers (6.2 miles) separating the repository from the accessible environment. Therefore, any change in the local hydraulic characteristics resulting from thermal loading should not have a significant impact on the total ground-water travel time calculate from within the flow top of the host rock to the accessible environment."

First of all, the staff considers that "several hundred meters" may be a significant portion of the distance to the ground surface, which serves as the upper boundary to the accessible environment. Furthermore, if, the draft EA states on page 6-36, the controlled area will extend only two kilometers from the surface projection of the repository, the lateral boundary of accessible environment as defined on page G-1 will be substantially closer to the facility.

Secondly, the repository-induced thermal loading will affect the dynamic viscosity, the density, and the kinematic viscosity (the ratio of dynamic viscosity to density) of the ground water. These changes will cause an increase in hydraulic conductivity (due to a decrease in kinematic viscosity) and an increase in the vertical hydraulic gradient due to fluid buoyancy. The NRC studies suggest that these post-emplacement changes can have a significant effect on ground-water travel time (Wang, et al. 1983; Gordon and Weber, 1983; Tsang, et al., 1984).

Another possible source of future hydrologic changes is the practice of onsite liquid waste disposal. Disposal activities have been conducted at numerous sites within the reference repository location and have continued at varying discharge rates up to the present. Figure 3-26 on page 3-59 of the draft EA depicts surface water bodies on the Hanford Site and includes the locations of a number of man made ditches and ponds used for the routine disposal of wastewaters. This figure shows only two disposal sites within the perimeter of the reference repository location. However, many more locations within the reference repository location have previously been used as disposal sites. Some of these sites are depicted in Figure 6-1, based on data from ERDA, 1975.

Newcomb, et al. (1972) quote Belter (1963) in stating that between 1945 and 1959 over 40 billion gallons of radionuclide-bearing liquid wastes were discharged to groundwaters of the Hanford Site. In a more recent technical review (CRWM, 1978) it was reported that as of January 1975 about 130 billion

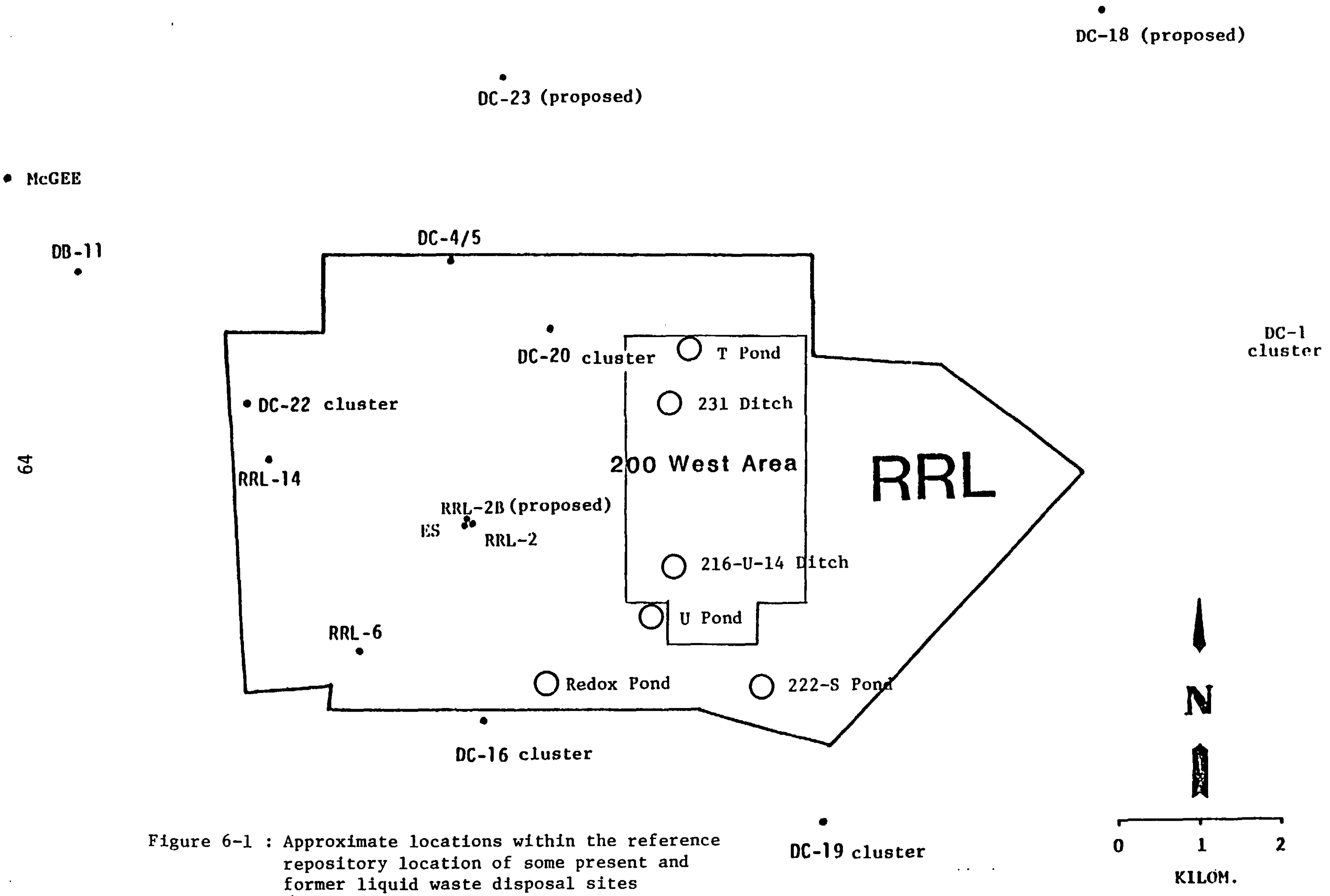

Figure 6-1 : Approximate locations within the reference repository location of some present and former liquid waste disposal sites (based on data from ERDA, 1975).

gallons of effluent had been percolated, largely in and near the two 200 areas. These activities generated ground-water mounds in the unconfined hydrologic systems which received the liquid wastes. Newcomb, et al. (1972) refer generally to the "eastern" and "western" mounds, and to smaller mounds generated at other locations. The so-called "western" mound was recharged at 3 or more surface locations which were within the defined area of the reference repository location. In 1961 the "western" mound reached a peak height of 60 ft. above the natural water table and had a basal area of about 15 square miles (Newcomb, et al., 1972).

The NRC staff considers that these disposal activities may have caused significant changes in the geohydrologic regime, including the confined aquifers which underlie the reference repository location. Figure 5-41 of the DOE's Site Characterization Report (DOE, 1982) shows 10 hydraulic head measurements collected using drill and test techniques in borehole RRL-2, located in the heart of the reference repository location. According to this Figure, hydraulic heads decrease with depth from the Mabton Interbed down to the upper Grande Ronde basalts, then increase with depth down to the Umtanum Basalt. A similar trend reversal appears to exist in data from borehole DC-16A (Figure 5-40, DOE, 1982). Data from each of the newly constructed (1984) piezometer clusters at DC-19,20,22 also show decreasing heads with depth down to the Priest Rapids member of the Wanapum Basalt.

These changes in heads constitute anomalies which suggest transient hydrologic responses. Downward recharge appears to be the most likely explanation for these gradient changes at depth. It is entirely possible that a downwardly-progressing change in hydraulic heads occurs in response to four decades of liquid waste disposal. In other words, heads measured near the reference repository location, and perhaps at other locations onsite, may not be representative of pre-1940 steady-state conditions. If this conclusion is correct, it may have significance with regard to the isolation potential of the layered basalts at Hanford.

There is a question concerning the statement in the draft EA that if the ground-water travel time calculations described in Section 6.4.2.3 were to take credit for fluid movement through the flow interior of the host rock, then "travel times to the accessible environment would be much longer than now predicted." Due to the very small (at most, tens of meters) likely distance of travel through the flow interior of the host rock, and the very low effective porosities that are expected within the interior, the ground-water travel time through the dense interior to the overlying flow top may be insignificant in comparison to lateral travel time through the flow top to the accessible environment. This is based on the draft EA conceptual model of horizontal flow through an overlying flow top to the accessible environment, which may or may not be reflective of actual hydrologic conditions at the reference repository location.

Based on the evidence, the statement that "no significant post-waste-emplacement changes to [the calculated pre-waste-emplacement] travel times are expected," is also questionable. The effects of long-term geologic conditions and processes on ground-water flow is dealt with in more depth in detailed comment 6-49.

There have been insufficient studies to reach definite conclusions on the potential for significant increases in transport of radionuclides to the accessible environment as compared with pre-waste-emplacement conditions. However, the available evidence [Wang, et al. 1983; Gordon and Weber, 1983; Mercer, et al., 1982] suggests that there is (as yet unquantified) potential for significant increases in radionuclide transport caused by post-waste-emplacement, repository- and man-induced changes in geohydrologic properties. Therefore, based on the limited existing information, there is reasonable doubt that this potentially adverse condition may be dismissed for the Hanford site reference repository location.

6-19

Section 6.3.1.1.8, Potentially adverse condition, page 6-76, paragraph 2

The draft EA states that this potentially adverse condition regarding changes in geohydrologic conditions does not appear to be present. However, this appears to conflict with the finding on draft EA page 6-144 in which it is assumed that the potentially adverse condition regarding impacts of human activities on the ground-water flow system could be present. As described in the draft EA, the foreseeable human activities include ground-water withdrawal, extensive irrigation, subsurface injection of fluids, underground pumped storage, military activities, or the construction of large-scale surface-water impoundments.

This apparent discrepancy merits consideration in preparation of the final EA.

6-20

Section 6.3.1.1.9, Potentially adverse condition, page 6-77

The assessment of this condition does not appear to take into account information on the actual chemistry of groundwater taken form the Grande Ronde or other zones in Washington and Oregon for crop irrigation purposes. While the Grande Ronde water may not be ideal for irrigation purposes, it appears to be of better quality (according to Table 3-6) than some water which has been used for irrigation in arid areas of the U.S. (Federal Water Pollution Control Administration, 1968).

In addition, it might be appropriate in some areas to utilize the average or mixed water chemistry for all sources between the water table and the deepest zone of interest. For example, deep irrigation wells could draw water from several strata (i.e., borehole dilution), mixing it in the process and thereby more efficiently using the entire available water resource.

Re-evaluation of this potentially adverse condition might be considered in the final EA.

6-21

Section 6.3.1.1.11, Disqualifying condition page 6-79

The draft EA makes a level 1 finding against the disqualifying condition for groundwater travel time. The finding states, "The available evidence does not support a finding that the reference repository location is disqualified (level 1)" (emphasis added). The level 1 finding stated in the draft EA refers to "available" evidence while the level 1 finding required by the guidelines does not. The apparent inconsistency should be resolved in the final EA.

6-22

Section 6.3.1.1.11.2, Radionuclide releases, page 6-82-83, paragraph 3, 4/1 and Section 6.3.1.1.11.3, Reducing data uncertainty, page 6-84, paragraph 1

The discussion of geochemistry and radionuclide solubility in these sections do not appear to relate to the disqualifying condition being addressed, i.e., "a site shall be disqualified if . . . groundwater travel time is . . . less than 1000 years." Groundwater travel time appears to be addressed in this section rather than radionuclide solubility.

6-23

Section 6.3.1.1.12, Conclusion on the qualifying condition page 6-85

The draft EA states: concludes, "--- the available evidence does not support a finding that the site is not likely to meet the qualifying condition (level 3)."

The favorable geochemistry of the deep basalts is cited as a major factor that supports the finding on the qualifying condition for geohydrology: "The geochemical characteristics of the deep basalts appear favorable for reducing radionuclide concentrations and limiting radionuclide migrations and extending waste canister lifetimes." However, the qualifying condition deals with geohydrology, not geochemistry.

The discussion might appropriately address how groundwater flow, rather than geochemistry, would influence the concentration and migration of radionuclides and the lifetime of the waste canister.

6-24

Section 6.3.1.1.12, Conclusion on qualifying condition, page 6-85

Several of the factors which the draft EA cites in support of the preliminary finding on this condition have been discussed in preceding comments. In particular:

- As noted in detailed comment 6-11, there is reasonable doubt that ground-water travel time from the disturbed zone to the accessible environment is in excess of 10,000 years along flow paths of likely and significant radionuclide travel.

- As stated in Section 6.3.1.1.5, and discussed in detailed comment 6-13, the site does not appear to be readily amenable to characterization or modeling with reasonable certainty. The statement in the second bullet of Section 6.3.1.1.12 seems to contradict this previous statement in Section 6.3.1.1.5.

- As noted in detailed comment 6-15, the hydraulic gradients in any direction may be higher or lower than the cited value of 10^{-4}, depending on the well pair used in the calculation.

- Detailed comment 6-18 notes that human- and repository-induced changes that could affect the deep hydrogeologic system have been inadequately addressed in applying this guideline.

Consideration of these points seems appropriate before making a finding on the presence of this qualifying condition.

6-25

Section 6.3.1.2, Geochemistry (Section 960.4-2-2), page 6-87-88, paragraph 3,4/1,2

The geochemistry data do not appear to fully support an evaluation that the likely geochemical reactions between the basalt rock, ground-water and the materials that would be emplaced are favorable for long-term isolation.

Five examples of non-supportive data are cited in this paragraph: (1) hydrothermal experiments show that under elevated temperatures (repository conditions) groundwater solution concentrations of carbonate (Johnston, et al., 1984), and fluoride (Apted and Myers, 1982) increases; (2) according to Wood (1984) and Wood, et al. (1984), bentonite (which is proposed as a component of backfill/packing material and typifies fracture filling clays) is beginning to react in three months, under repository conditions, to yield albite; (3) according to Couture and Seitz (1984), water vapor (steam) has great ability to rapidly alter clays; (4) redox experiments suggest that ambient redox conditions may be no lower than about -0.2 volts (Jantzen, 1983); and (5) Gray (1983) reports the production of hydrogen, and organic polymers similar the polythylene, in experiments involving Hanford-groundwater/gamma radiolysis.

These data are non-supportive of conditions favoring waste isolation for the following reasons: (1) increases in carbonate and fluoride increase radionuclide complexing potential, which could lead to increases in radionuclide solubility; and (2) the observed alterations of backfill/packing/fracture-filling clays leads to minerals that have less sorptive capacity than the original materials; (3) site redox conditions have not been shown to be chemically active; and (4) the production of hydrogen by radiolysis of water, and the production of organic polymers from groundwater methane as a result of the repository radiation environment, could affect waste package stability and radionuclide transport repectively.

Also, According to Long and Davidson (1981) and Benson and Teague (1982 and 1984), pyrite is a minor secondary mineral. The availability of ferrous minerals to interact with groundwater is key to determining the reducing potential of the basalt/rock system and thus the capacity of the system to consume oxygen after closure. In addition, some radionuclides, while not readily reduced in groundwater, can be reduced on the surface of fresh ferreous minerals (Bondietti, 1979; Meyer, et al., 1984; and others). Thus, an overestimate of pyrite or other ferrous minerals could lead to false assumptions concerning future redox conditions, and an overestimate of retardation for those radionuclides effected by the reducing capacity of the rock and not the water (i.e., technetium and neptunium).

Furthermore, there is not clear support that the site redox conditions will promote precipitation and will maintain radionuclides in their least mobile state. It is the reducing or oxidizing capacity and kinetics of the basalt/water system not "redox conditions" that determine the oxidation state of radionuclides. For example, Garrels and Christ (1965) and Early, et al. (1982) indicate that uranium carbonate species can exist in an "oxidized" state under "reducing" conditions as low as -0.4 volts. Since oxidized species are more soluble and less readily sorbed than reduced species, the reducing capacity of the system is fundamental in determining radionuclide transport characteristics. Also, the draft EA does not adequately consider the movement of radionuclides that may be transported as particulates or colloids. Finally, experiments that used hydrazine to provide some indication of how radionuclides would react in a reducing environment (Salter, et al. 1981, Barney, 1984), should not be used until the validity of the data is established. Important concerns with this data are (1) the reaction between hydrazine and any reducible radionuclide is undefined, thus the effective redox condition is unknown; (2) hydrazine hydrate dissociation to release hydroxide anions likely dominates the groundwater pH, so the pH is no longer representative of in-situ conditions; (3) hydrazine could react with bicarbonate in the groundwater to form the carbomate anion, which may form radionuclide complexes; (4) hydrazine is an agressive chemical and attacks polycarbonate test tubes causing the tubes to crack/break, or result in brown-colored degradation products; (5) hydrazine may alter or disaggregate clay mineral structures, and change the secondary minerals in the test; and (6) considerable uncertainty exists as to the solid phase or solution species formed by the reaction of hydrazine with some radionuclides such as technetium (Kelmers, 1984).

6-26

Section 6.3.1.2.4, Favorable condition (2), page 6-90, paragraph 2, 3 and 5

It is not clear whether the data support a conclusive evaluation that geochemical conditions "that promote . . . precipitation . . . sorption . . ." are present. For example, it is not clear that the reference repository location has chemically reducing conditions that will promote precipitation and will maintain radionuclides in their least mobile state (see detailed comments 6-28 and 6-33). Further, the presence of reducing conditions alone does not mean that reduced species will be present in the system. The assumption that the ground-water system has the capacity to reduce radionuclides to their least mobile state, biases radionculide release calculations in favor of low releases. Thus, in order to take credit for having reduced radionuclides in the repository system (i.e. high precipitation and high sorption), the EA should consider data that address the reducing capacity and redox kinetics of the geochemical environment, on a radionuclide-by-radionuclide basis. If the data is insufficient for a conclusive evaluation, a generally conservative line of reasoning may be appropriate.

6-27

Section 6.3.1.2.5, Favorable condition (3), page 6-91, paragraph 2

The data do not appear to fully support an evaluation that site mineral assemblages will remain unaltered or would alter to mineral assemblages with equal or increased capability to retard radionculide transport. According to the DOE-sponsored work, Wood (1983) and Wood, et al., (1984), bentonite (a backfill/packing material/clay which is similar to montmorillonite which is a common host rock secondary mineral) would react under repository conditions, to yield small amounts (less than 1%) of albite. This suggests that bentonite and groundwater and basalt would react to yield albite ± chlorite ± paragonite ± illite ± quartz + H_2O; and at this point the new sheet silicates may be hidden as mixed layers in the reacting bentonite. If this is the case, then at 300°C, even a 0.1% reaction (in three months), proceeding at a constant rate, would alter 40% of the bentonite in 100 years. In fact, Wood (1983) suggests that at 140°C as much as a 20% change would be expected in the 1000 years. In addition, according to Couture and Seitz (1984) bentonite reacted in steam shows a decrease in swelling capacity. Such changes, would alter the character of backfill/packing/fracture filling clays, affecting anticipated sorption reactions and water flow through characteristics.

Also potassium is leached from basalt at higher temperatures and potassium is known to decrease the stability of smectites (montmorillanite) under hydrothermal conditions and to be an effective competitor with cesium for sorption sites (Erberl and Hower, 1977 and Salter, et al., 1981). Further, according to Charles and Bayhurst (1983) and Myers, et al. (1984), Grande Ronde basalt reacts readily at all temperatures to form both illite and smectite. Finally, mineralogic changes of bentonite to illite, or alteration products that armor ferrous host rock minerals, decrease the capability of the site to retard radionuclides and, thus results in increases in calculated releases. (See detailed comment 6-32.)

6-28

<u>Section 6.3.1.2.6, Favorable condition (4), page 6-91 to 6-92, paragraph 6, continuing paragraph</u>

The data do not appear to support the evaluation that geochemical conditions constrain the dissolution of the total radionuclide inventory (at 1000 years) to less than 0.001 percent. The analysis was performed using "expected conditions" (ie redox = -0.3 volts) and assumed that radionuclides were released in their least soluble state. According to Early, et al. (1982 and 1984) and others, data concerning redox conditions in the Grande Ronde range from +0.35 volts to -0.4 volts; therefore, -0.3 volts may not be a valid expected value. Many radionuclides are orders of magnitude less soluable as reduced species than they are as oxidized species. For example, Early, et al. (1982) calculated that uranium solubility at -0.40 volts has a concentration of 1.0E-10 mol/l, while at -0.0 volts it is around a concentration of 1.0E-5 mol/l (and becomes more soluble as redox conditions become more oxidizing). Garrels and Christ (1965) show that uranium and other radionuclide species can exist in an oxidized state under "reducing conditions" as low as -0.4 volts. Also, according to Jockwer (1984), Pederson, et al. (1984); and Simonson and Kuhn (1984), actinide solubilities may be altered by alpha and gamma radiolysis through changes in Eh/pH. It is not clear that credit for such low redox values and associated low solubilities can be supported (see detailed comment 6-33).

Further, experiments determining "steady-state" radionuclide concentrations in basalt/rock/water experiments could underestimate solubility. As would be expected, the presence of basalt tends to lower the "solubility" of radionuclides in groundwater due to sorption type reactions. Also, "steady-state" arguments pertain only to very slow moving or no flow systems where steady-state conditions can predominate. Finally, it is implied that since spent fuel is mostly reduced uranium, it will remain relatively insoluable in the Hanford redox environments. However, according to experiments by Grandstaff, et al. (1984) and Myers, et al. (1984) reaction products from basalt/water experiments include weeksite or boltwoodite. Weeksite (boltwoodite) is an oxidized (U^{+6}) uranium phase and thus is more soluble than uranium oxide (UO_2^{+4} --the assumed phase under "expected" redox conditions of -0.3 volts). Also, experimented studies have shown that some radionuclides (Cs, I) are released into solution at a faster rate than the rate of dissolution of spent fuel matrix (UO_2^{+4}--uranium oxide) (Johnson, 1982). Consequently, the expected dissolution at 1000 years can be expected to be greater than those calculated using redox conditions of -0.3 volts.

6-29

Section 6.3.1.2.7 Favorable condition (5), page 6-92/93, paragraph 4, 5/1

The analysis of favorable condition (5) considers only reversible sorption. The guideline asks for "any combination of geochemical and physical retardation processes that would decrease the predicted peak cumulative releases of radionuclides to the accessible environment by a factor of 10 as compared to those predicted on the basis of ground-water travel time without retardation" [960.4-2-2(b)(5)]. According to the DOE (1984), cumulative releases of radionuclides mean "... the total number of curies of radionuclides entering the accessible environment in any 10,000 year period...". The peak cumulative release of radionuclide refers to "the 10,000 year period during which any such release attains its maximum predicted values." By considering only reversible sorption (without regard to radioactive decay or dispersion, or any other combination of geochemical and physical retardation processes), the predicted peak cumulative release of radionuclides has not been decreased with respect to that predicted on the basis of groundwater travel time, it has only been delayed. Also, the analysis of radionuclide retardation is inaccurate because it assumes that the entire bulk chemistry of the host rock is available for sorption. Since transport will be through fractures, the predominant minerals that will be available for sorption reactions will be the secondary fracture filling materials.

The absence of a substantive analysis does not allow a finding on favorable condition 960.4-2-2(b)(5), and thus could impact the overall qualifying condition for geochemistry [960.4-2-2(a)]. The DOE might reconsider favorable condition 960.4-2-2(b)(5) in the terms specified in the guideline. This means an assessment of the reduction (by a factor of 10), of the total number of curies entering the accessible environment for that 10,000 year period in which the peak release has been re-calculated to occur, as compared to the total number of curies originally calculated in the absence of geochemical and physical retardation processes. An analysis relevant to this favorable condition should consider geochemical processes which immobilize as well as delay radionuclides, rather than conditions which only delay their release.

6-30

Section 6.3.1.2.8, Potentially adverse condition (1), page 6-93, paragraph 4, through page 6-95, paragraph 3

The analysis presented in the draft EA does not address the subject of the "...solubility or the chemical reactivity of the engineered barrier system..." as called for in potentially adverse condition 960.4-2-2(c)(1) (see draft EA pp. 6-93-94). However, the draft EA states that, "Ground-water conditions in the host rock that could affect the solubility or the chemical reactivity of the engineered barrier system should not compromise expected repository performance...". This statement is substantiated by citing various studies that examined the following: (1) solubility for radionuclides; (2) complexes with radionuclides; and (3) migration of radionuclides; and (4) adsorption of radionuclides after they have been released from the engineered barrier system. The draft EA does not discuss how groundwater conditions may affect the engineered barriers' performance. In particular, the draft EA does not examine how groundwater may affect the corrosion rate of the waste canister, the leach rate for the waste form or other engineered materials. Radionuclide solubility/complexing/sorption/migration are not engineered barriers. The absence of an analysis of the effects of geochemical conditions on engineered barriers does not allow a finding on potentially adverse condition 960.4-2-2(c)(1), and thus, in its present form, adversely affects the draft EA finding on the overall qualifying condition [960.4-2-2(a)] for geochemistry. The final EA might assess how groundwater conditions at Hanford effect the "...solubility or the chemical reactivity of the engineered barrier system..." and evaluate how this may influence the containment of radionuclides within the engineered barrier system and the release of radionuclides from the engineered barrier system. The DOE could then reconsider the guideline finding.

6-31

Section 6.3.1.2.8, Potentially adverse condition (1), pages 6-93, paragraph 4, and 6-94, paragraph 2

The draft EA refers to the possible upward migration of deep ground water in the vicinity of the reference repository location. This statement is based on the understanding that sodium and chloride concentrations are relatively enriched here. Data are not presented to support this hypothesis. This topic is pertinent to the EA findings because it affects the direction of inferred ground water flow in the vicinity of the reference repository location. The direction of ground water flow is particularly relevant to the performance assessment based on ground water travel times and directions of flow.

6-32

Section 6.3.1.2.9, Potentially adverse condition (2), page 6-95, paragraph 5

The data concerning sorption and mineral stability do not show that the geochemical conditions, will not reduce sorption of radionuclides. According to Wood (1983) and Wood, et al., (1984) fracture filling clay minerals do have a tendency to alter to less sorptive minerals (see detailed comment 6-27). In fact, over a period of 1000 years Wood et. al. (1984) suggests that the conversion of smectite clays minerals to illite could exceed 20%. Further, according to Charles and Bayhurst (1983) and Myers, et al. (1984), fresh basalt reacts readily to form both smectite and illite. Illite is less sorptive than smectite clays (see detailed comment 6-25). In addition, redox conditions are assumed to control redox sensitive radionuclides to their most sorptive oxidation state. However, these conditions cannot be clearly shown to exist (see detailed comment 6-33).

6-33

Section 6.3.1.2.10, Potentially adverse condition (3), page 6-96, paragraphs 1 through 4

The data do not appear to support the evaluation that "pre-waste-emplacement ground-water . . ." are not ". . . chemically oxidizing." For example, the DOE analysis of redox conditions and reactions at Hanford, as presented in the draft EA (pages 6-90 to 92, 95, 96) and cited portions of references, do not support an evaluation that expected redox conditions (1) are as reducing as the -0.3 volts used for draft EA calculations, or that (2) expected reactions will maintain redox sensitive radionuclides in low solubility and high sorption states.

With respect to point (1), Early, et al. (1982 and 1984) and DOE (1982), report that measured redox conditions range from about +0.35 volts to -0.2 volts, and that calculated values range as low as -0.4 volts. Redox measurements on natural waters are difficult to interpret, therefore a calculated redox conditions of -0.3 volts (and lower) are used in the draft EA as expected site conditions based on three arguments:

(a) The coexistence of titano-magnetite with ferrous secondary iron-bearing phases such as pyrite, and the lack of naturally occurring ferric iron-bearing phases such as hematite;

(b) Occasional occurrences of sulfide ions coexisting with sulfate ions, and methane coexisting with carbon dioxide; and,

(c) Data from rock/water interaction experiments.

The essence of argument (a), is that hematite is stable only in moderately to strongly oxidizing environments; while in chemically reducing environments, pyrite or magnetite is stable (Krauskopf, 1967). However, Benson and Teague (1979), report that an oxidized iron phase, possibly hematite is present within smectite at Hanford (smectite is a common, fracture-filling secondary clay mineral). Argument (b) suggests that the redox couples sulfide/sulfate and methane/carbon dioxide are another source of (indirect) evidence that supports the presence of reducing (i.e. non-oxidizing) conditions at the site. However, equilibrium between sulfide/ sulfate, and methane/carbon dioxide is unusual, because such reactions require biological mediation; and furthermore, the couples are not generally found to be electrochemically active (Hostettler 1984; Ohmoto and Lasaga 1982; Stumm and Morgan 1981; and Hem 1975). Thus, neither observable mineral assemblages and/or redox couples are sufficient to indicate that site redox conditions are chemically reducing and not chemically oxidizing.

Finally, argument (c) suggests that hydrothermal experiments reported by Jantzen (1983) support the existence of a redox potential of -0.4 volts at Hanford (which coincides with the calculated values). This low value was achieved by using finely crushed basalt and deoxygenated and deonized water. However, in the same series of experiments by Jantzen (1983) runs with basalt chunks and simulated site groundwater produced redox conditions of only about -0.2 volts (which coincide with the lower bound of the measured conditions). Further, the Siting Guidelines (960.3-1-5, p. 47757) preclude taking credit for engineering measures, such as those simulated by reactions with crushed basalt and distilled water, to overpower less advantageous site conditions (i.e. chemically oxidizing vs. chemically reducing conditions). Therefore, these particluar experimental results are not a basis for suggesting that site redox conditions are as reducing as -0.3 volts, or are not chemically oxidizing.

Concerning point (2), the draft EA has assumes that the redox conditions at the Hanford site will reduce virtually all redox sensitive radionuclides to their least soluable and most sorptive state. However, Eh cannot be treated as a master variable, because it cannot be assumed that all redox sensitive elements will be in chemical equilibrium within the system (Stumm, 1966, Lindberg and Runnels, 1984, Hostettler, 1984). Therefore, even if redox conditions are established, it does not follow that redox sensitive radionuclides will be reduced to their least mobile state. This concern is further supported by experiments that show that several redox sensitive radionuclides exist in their more oxidized state under "reducing" conditions of -0.3 volts and lower (Kelmers, 1984; and Meyer, et al., 1984).

The question of whether the redox data support an evaluation that the reference repository has chemically reducing conditions that will maintain radionuclides in their least mobile state is critically important support for draft EA findings concerning geochemistry favorable condition 960.4-2-2(b)(2) ("... conditions that promote the precipitation.., or sorption of radionuclides, ..") and 960.4-2-2(b)(4) (the dissolution rate of the radionuclide inventory); and potentially adverse condition 960.4-2-2(c)(3) (conditions that are not chemically oxidizing); and associated geochemical modeling. The finding on favorable condition 960.4-2-2(b)(2) is based on assumptions of low radionuclide solubilities and high sorption. The finding on favorable condition 960.4-2-2(b)(4) is based on assumptions of low radionuclide solubilities. The DOE finding on adverse condition 960.4-2-2(c)(3) is based on the assumption that site redox conditions are not chemically oxidizing. Use of less optimistic results could have a significant effect on findings for each of these conditions, and thus could have a significant impact on the overall qualifying condition [960.4-2-2(a)] for geochemistry.

The NRC/Staff considers that existing redox data are insufficient for a conclusive or clear evaluation of site redox conditions and reactions; or to support the associated assumption that those redox conditions are chemically reactive and thus predetermine that radionuclides will be present in their least mobile state. However, the draft EA states (page 6-4, ¶3 and 7-3, ¶3) that in the absence of clear or conclusive support, findings are to be based on "...existing data and conservative assumptions..." Under this approach, DOE needs to reconsider data on site redox conditions and reactions as well as the findings on the geochemical favorable and potentially adverse conditions discussed in the previous paragraph, and the overall qualifying condition for geochemistry.

6-34

<u>Section 6.3.1.2.11, Conclusions, page 6-97, paragraph 1/bullet 1, 2, and 3</u>

Evidence does not conclusively support the "highly sorptive" characteristics of the alteration phases of the basalt for radionuclides, the reducing capacity of the basalt environment, or the dissolution rate of the radionuclide inventory. According to Barney (1981), Ames and McGarrah (1981) and Salter et al. (1981), the sorption of radionuclides is highly dependent on their oxidation state (i.e., reduced species = high sorption, oxidized species = low sorption), and the availability of sorptive minerals (see detailed comments 6-25 and 6-26). However, "reducing" conditions do not necessarily lead to low steady-state radionuclide concentrations and high sorption (see detailed comment 6-33). Further, not all clay mineral alteration phases are highly sorptive (see detailed comments 6-27). Finally, the indication that less than 0.001 percent per year of the total radionuclide inventory will dissolve from a repository in basalt is highly dependent on the reducing capacity of the basalt system (i.e., that radionuclides will be released in a reduced state); this has not been conclusively established (see detailed comment 6-28). The assumption that radionuclides will be released in their more sorptive, less soluble state leads to low steady-state concentrations and calculations of low radionuclide release.

6-35

<u>Section 6.3.1.3.5, Potentially adverse condition, page 6-100, paragraph 7</u>

The draft EA states that potentially adverse condition 960.4-2-3 (c)(1) is not present at the Hanford site. This adverse condition deals with technology being reasonably available for the construction, operation, and closure of the repository to ensure waste containment or isolation. However, with regard to shaft sealing requirements, the discussion does not support a conclusion about the absence of this adverse condition. Discussion on pages 6-104 through 6-106 regarding the emplacement procedure for long-term seals system during repository closure does not address: (1) The procedures for replacement of operational grout between shaft liner annulus with long term sealant; and (2) the durability of long term sealants.

The repository shafts and the voids, joints, and fractures around them will require adequate sealing over the long-term because they are potential pathways for radionuclide release to aquifers and the accessible environment. The repository shaft itself could possibly be adequately backfilled to retard radionuclide migration. However, the interface between the shaft liner and the rock wall, and the voids, joints and fractures in the rock around the shafts must also be sealed effectively with a durable sealant. The performance of the long term seals may depend on how completely the sealant has replaced the operational grout between the shaft liner and the wall rock.

These points should be considered in the final EA.

Such consideration might include discussions on (1) sealing procedures, (2) sealing materials and their long-term properties, and (3) testing and monitoring procedures to verify long-term performance of seals.

6-36

<u>Section 6.3.1.3.5, Potentially adverse condition, page 6-106, paragraph 1</u>

It is stated in the draft EA that the hydraulic conductivity of the disturbed rock zone around the shafts would be reduced using a system of grout curtains and bulkheads constructed from the shaft interior. These are to be constructed using "grout curtain construction techniques similar to those used to improve rock foundations at dam sites." For installation of the bulkhead, "portions of the liner, the liner-supporting grout, and the damaged host rock liner grout interface would be removed." Because of these additional activities associated with grouting it is not appropriate to relate grout curtain construction at dam sites to grouting the disturbed rock zone around the shafts.

While, the basic technique of drilling holes and injecting grout in the disturbed rock zone may be similar to those at a dam site, the methods of adequately ensuring the horizontal flow of grout to effectively fill all void spaces, cracks and joints around the shafts (illustrated in Figure 6-4, Section 6.3.1.3.5, page 6-105) can be substantially different. In addition, grouting of the disturbed rock zone will encounter unique problems associated with: removal of the high strength steel liner and the liner-supporting grout; installation of the low-permeability bulkhead; and the limited space to perform work. Finally, the seal materials in the shaft are required to be durable over a long-term. Such constraints are not required in the grouting of dam sites.

Effective sealing of the disturbed rock zone around the shaft is crucial because the zone can provide a potential pathway for radionuclide release to the accessible environment. The possible need to utilize a technology substantially different than that of grouting a dam site might be considered in drawing a conclusion about the potentially adverse condition 960.4-2-3(c)(1).

6-37

Section 6.3.1.3.7, Potentially adverse condition, page 6-109, paragraph 9

The draft EA states, "As credit is not presently taken for the isolation potential of the Cohassett flow dense interior, thermal-induced fracturing around the emplacement boreholes or emplacement rooms, therefore, would not adversely affect the projected ability of the host rock to provide isolation". Yet, on page 6-263, paragraph 1, the future option of taking partial credit is maintained. If such credit is taken, thermal induced fracturing may affect the ability of the host rock to provide isolation.

Thermal-induced fracturing will influence the stability of the emplacement boreholes, and may also significantly affect container integrity and create pathways for radionuclides. Evaluation of "not present" conclusion for potentially adverse condition (960.4-2-3 (c)(3)) does not consider all the flow paths created by thermal induced fracturing around emplacement boreholes and rooms. Therefore, it is suggested that the statement regarding thermal-induced fracturing and its impact on the ability of the host rock to provide isolation be expanded to discuss the potential travel paths for radionuclides.

6-38

Section 6.3.1.4, Climatic changes, pages 6-111 to 6-113

The principal assumption for the discussion of the impacts of climatic change is that the climatic changes that took place during the Quarternary Period bound the extreme conditions expected over the next 10,000 years. This assumption does not appear to be adequately supported in this section. According to many authors (e.g., Imbrie and Imbrie, 1979), the atmospheric warming induced by increasing atmospheric concentrations of carbon dioxide will likely result in a "super-interglacial" period with a higher mean global temperature than that estimated during the last interglacial period (about 125,000 years before present) and which would last several thousand years. Eventually, the "super-interglacial" period would be overwhelmed by orbital-climate relationships. It is suggested that the discussion of paleoclimate and climate change might be expanded to include this possible "super-interglacial" period, particularly with respect to identification of comparable paleoclimates with mean global temperatures of about 63°F (compared to about 61°F estimated during the last interglacial period and observed at present).

6-39

Section 6.3.1.4.6, Potentially adverse condition, page 6-117 and 6-118, continuing paragraph

The draft Ea states that the potentially adverse condition of significant hydrogeologic perturbations over the next 10,000 years due to climatic changes is not present. This finding is supported in the draft EA with the following statements:

- "The climate of the Hanford Site region is not expected to significantly change over the next 10,000 years. Thus, the present ground-water flow system is expected to remain relatively unaffected."

- "Proglacial catastrophic flooding....appears to be the most probable disruption scenario associated with climatic changes that could affect the hydrologic system. There is little chance of significantly renewed glaciation in the State of Washington in the next 10,000 years."

- "The very short transient nature of catastrophic floods....is such that significant long-term effects at the repository depth are not expected."

The draft EA finding is not wholly consistent with geologic and paleoclimatic studies of the Holocene Epoch in the Pacific Northwest. Large-scale floods of the magnitude of the Late Pleistocene events are not likely to recur during the next 10,000 years and thus would not be expected to be a factor in influencing the geohydrologic system. Those spectacular flooding events were indirectly caused by late growth and ablation of the continental Cordilleran Ice Sheet. However, smaller scale pulsations of alpine and valley glaciation in response to climatic changes could significantly alter the hydraulic characteristics and discharges of the Columbia and its tributaries. Aggradational processes may ensue with the possibility of invoking river channel migrations over the next 10,000 years. The occurrence of future channel displacements within the area of the Hanford Reservation could dramatically alter regional patterns of recharge and discharge and could significantly change flux conditions within local basalt and interbed aquifers of the Pasco Basin.

Channel diversions may also be caused by other means. The reach of the Columbia that is located east of Gable mountain is susceptible to impoundment and diversion should future block slumpage occur in bluffs on the eastern side of the river. Areas of particular concern are located in sections 11 and 14 of T. 13 N. and R. 27 E. (Newcomb, et al., 1972).

Apart from the potentially significant effects of channel migrations, the hydrologic regime of the Pasco Basin could be affected in more subtle ways by periodic episodes of cooler and moister climates. Such episodes may be expected to alter areal patterns of recharge and discharge. Infiltration rates (recharge) would likely increase due to the cumulative effects of lowered evaporation rates and increased amounts of precipitation. For example, local recharge in the Pasco Basin is presently considered to be greatest on the margins of the basin in structurally high and deformed zones of exposed basalt, especially anticlinal areas (draft EA, page 3-78). However, coupled effects of increased precipitation and reduced evaporation may substantially increase the proportion of total recharge that occurs within the larger, structurally low areas of the Pasco Basin.

Significant changes have taken place in the course of the Columbia River over the last 10,000 years. This was an erosional period in which the alluvial system incised the glaciofluvial sediments deposited earlier, creating riverbank terraces. It is evident that significant meandering of the Columbia took place along the reaches that occur in the northern part of the reservation. One paleochannel is south of Gable Mountain within the Cold Creek Syncline along the 460 ft topographic contour (Newcomb, et al., 1972). West Lake, the only natural (water-table) lake reported within the reservation, occurs in a low area along this old channel. The presence of a major channel of the Columbia within the Cold Creek Syncline would have significantly altered regional patterns of recharge and discharge. This would likely have changed flux conditions within the basalt and interbed aquifers of the Cold Creek Syncline.

The present-day channels of the Columbia near the site are relatively stable, aided largely by the presence of numerous reservoirs to the north that were constructed for the purposes of flood control, irrigation and hydroelectric power generation. These engineering projects allow substantial regulation of discharge rates and reduce the suspended sediment load of the Columbia to a minimum. These reservoirs provide engineered controls that cannot be presumed to remain in existence on a scale of millenia.

Based on present-day topographic contours, it appears that reaches of the Columbia River located within the Hanford Reservation would be susceptible in varying degrees to channel migration should aggradational processes ensue over the next 10,000 years. Those lower reaches of the Yakima River that occur northwest of and adjacent to Richland are also susceptible to migration on this time scale.

A return to conditions of highly variable seasonal and yearly discharges and sediment loads may take place over the next 10,000 years. In particular, a large increase in discharges and bedloads could be caused by the future ablation of reactivated alpine and valley glaciers. An aggradational period may ensue, creating conditions which would favor the meandering of channels. Glaciers which presently occur in the northern headwaters of the Columbia would expand in size given cooler and moister conditions favorable to growth. Only small-scale temperature changes would be needed to initiate the growth of alpine glaciers that presently exist in the northern headwaters of the Columbia.

Paleoclimatic evidence from palynological investigations suggests that significant changes in average temperatures and precipitation levels may have occurred since the relatively recent retreat of the Cordilleran Ice Sheet late in the Pleistocene Epoch. For eastern Washington, three intervals within the post-glacial period have been interpreted as being cooler and moister than today's climate:

13,000 - 10,000 yrs. B.P.	Nickmann (1979)
7,800 - 6,700 yrs. B.P.	Nickmann and Leopold (1980)
4,100 - 125 yrs. B.P.	Nickmann (1979)

The most recent interval shown above is somewhat controversial. Mack, et al. (1978) conclude from data collected at a site in northeastern Washington that there is no evidence of a shift to conditions cooler and moister than today during the period from about 5000 yrs. B.P. to Present. The apparent cooling trend from 7800-6700 yrs. B.P. was first reported by Nickmann and Leopold (1980), who speculate that an unconformity may exist for the same time interval at previously studied sites. This interval, if verified, is significant because it appears to interrupt the Hypsithermal (ca 9,000-3,000 yrs. B.P.) period which generally is considered to have been warmer and drier than at present.

While future temperature fluctuations can be expected, climatologists are not in agreement as to the short-term or long-term direction of climatic change (i.e., cooling or warming), or even whether clearly discernable trends exists. This is the result of an extremely complex interaction of natural- and human-induced variables which include but are not limited to the following:

<u>Natural parameters</u>

- volcanic injection of atmospheric dust
- area and duration of snow and ice cover in the northern hemisphere
- atmospheric and oceanic circulation patterns (changes in temperatures, precipitation, evapotranspiration, and cloud cover)
- orbital characteristics (or elements) of the Earth
- variations in solar insolation
- alteration, retention, or release of atmospheric components by the biosphere (marine and terrestrial)

<u>Human-induced parameters</u>

- carbon dioxide production through the burning of fossil fuels
- deforestation

- release of fluorocarbons
- thermonuclear devices
- sunlight reflection from jet contrails

The likely long-term effects of human-induced changes are presently unknown. The potential for these changes to either accelerate or retard the onset of the next major climatic cooling stage is also dependent on the future duration of human industrial and technologic activities and on the relative ability of the biosphere to partially compensate for transient atmospheric changes.

It would appear to be appropriate for the evaluation of expected geohydrologic changes caused by climatic variations over the next 10,000 years to be based on conservative assumptions. A conservative approach could involve evaluating the likely effects of future cooling and warming trends, both of which have the potential to change ground-water fluxes within the Pasco Basin by the large-scale alteration of amounts and patterns of ground-water recharge.

Based on the above analyses, DOE could then re-evaluate the finding on the potentially adverse condition.

6-40

Section 6.3.1.7.2, Evaluation process, page 6-127, paragraph 2

This part of the draft EA does not fully consider or reference published geophysical information about geophysical anomalies. This item states that "interpretation of geophysical anomalies in the area of the reference repository location are ongoing." Geophysical anomalies may be geologic structures such as faults or may represent such things as data processing problems. However, due to other evidence suggesting faults, it is possible that many of the geophysical anomalies do represent faults (see detailed comment 3-11). The existence of faults may impact conditions: 960.4-2-1 (b)(1), 960.4-2-1(b)(4)(ii), 960.4-2-7(b), 960.4-2-7(c)(3), 960.4-2-7(c)(6). It is suggested that the final EA state what geophysical anomalies are being investigated, where they are located, that they have already been interpreted as faults in several instances (Long and Davidson, 1981, and Emerald Exploration and what the potential significance is to the reference repository location in terms of ground-water flow and ground motion.

6-41

Section 6.3.1.7.3, Favorable condition, page 6-127 and 6-128, paragraph 1

The draft EA presents a favorable finding for condition 960.4-2-7(b) by using long-term, low average deformation rates to indicate that tectonic processes such as faulting will not adversely affect waste isolation for 10,000 years after closure. However, the Rattlesnake Wallula Alignment (RAW), a significant fault zone (115 to 140 km long) with Quaternary movement deemed capable of a large magnitude earthquake (6.5M_s) has been omitted from consideration in this section (NUREG-0309). This omission makes the preliminary finding for condition 960.4-2-7(b) in the draft EA questionable.

Rattlesnake-Wallula Alignment (RAW), a northwest to southeast trending zone, is part of the Cle Elum-Wallula deformed belt (CLEW), a 40 kilometer (25 mile) wide zone that has a northwest to southeast trending trace from Cle Elum, Washington, southeast to the Blue Mountains, a length of about 200 kilometers (125 miles) (draft EA, page 3-52). RAW is the southern part of CLEW, and extends from Rattlesnake Hills - Umtanum Ridge to the southern termination of the Wallula fault (NUREG-0892 and NUREG-0309).

The Cle Elum-Wallula deformed belt coincides with the central one third of a topographic lineament termed the Olympic Wallowa Lineament (OWL) (RHO-BWI-ST-4). The Olympic Wallowa Lineament (OWL) extends for 640 kilometers (400 miles) in length, from the Straits of Juan de Fuca in northwestern Washington to the Wallowa Mountains in northeastern Oregon. The structural significance of OWL, if any, remains controversial but OWL has been postulated to have regional tectonic significance (RHO-BWI-ST-4).

Although the structural significance of OWL is controversial, Davis, 1982, notes that the existence of a disturbed plateau structural zone (including the Wallula fault zone) coincident with the central third of OWL cannot be questioned (i.e., CLEW). Kienle, 1977, states that the Yakima Fold Belt is generally only gently folded except along CLEW where the deformation is more intense. The increased intensity of structural deformation within CLEW is believed due to the greater relative mobility of the crust (Barrash, et al., 1983). Several faults occur within and at the boundaries of the CLEW zone of deformation (NUREG-0309).

The overall tectonic nature of RAW remains uncertain, however, much of its length is typified by faulting. Several faults have been mapped along the northeastern limb of Rattlesnake Mountain (Fecht, 1984). In addition, the southeast extension of the Rattlesnake Mountain aeromagnetic lineament probably expresses faulting along much of the RAW (RHO-BWI-ST-4). At least one basalt exposure has fault breccia up to 1000 feet wide along RAW (RHO-BWI-ST-4). Quaternary surface faults exist along RAW (NUREG-0309).

The local seismicity of RAW is indicated by the microearthquake swarm in the northern area of Rattlesnake Mountain and other swarms in the southeastern part of the Rattlesnake Mountain area (SD-BWI-TI-247). As shown by Fecht, 1984, in report SD-BWI-TI-247, Figure 5-4, these and other recent events produce an apparent vertical alignment which approximates the RAW and could indicate fault movement along this trend. An earthquake (M_L 3-3.5) occurred on the edge of the southwest corner of the repository (SD-BWI-TI-247, Figure 5-1). This is where RAW may pass along the abrupt western terminous of Yakima Ridge.

RAW may begin where Umtanum and Yakima Ridge anticlines plunge abruptly below the basin sediments (NUREG-0892 and NUREG-0309). Laubscher, 1981, indicates that RAW joins CLEW in the vicinity of the east end of Yakima Ridge. Many references place the north end of RAW near the north face of Rattlesnake Mountain. At this time the possibility that RAW extends even further to the northwest than Umtanum Ridge has not been ruled out.

The NRC staff previously postulated in NUREG 0309 and NUREG 0892 that RAW may range in length from 115 to 140 kilometers and the north end of RAW may begin from Umtanum Ridge to Rattlesnake Hills. For the purposes of earthquake magnitude calculations, a total length of 120 kilometers for RAW was used by the NRC staff. Unfortunately, the rock in the area between eastern Umtanum Ridge and Rattlesnake Mountain is virtually unexposed (RHO-BWI-ST-4, Geologic Maps) and direct observation of the northern extent of RAW is precluded. The rock in the area northwest of Umtanum Ridge up to Sentinel Gap is also largely unexposed (RHO-BWI-ST-4, Geologic Maps).

The eastern topographic surface expression of Yakima Ridge terminates abruptly along the northwest projection of RAW and the termination is likely due to a northwest trending fault (Cochran, 1982). Faulting was also proposed as an explanation for the linear escarpment and structural displacement of east Yakima Ridge (Kienle, 1977) and (Bond, et al., 1978). The postulated northwest trending fault might (according to RHO-BWI-ST-4) be associated with a northwest continuation of the Rattlesnake Mountain fault, or other faults along RAW, through the northeast corner of Snively Basin. Further, it is indicated in RHO-BWI-ST-4 that Rattlesnake Mountain fault is probably related to faulting along much of RAW.

According to the draft EA, page 3-51, paragraph 2, the same northwest trending fault along east Yakima Ridge could explain the down-dropped offset of the Benson Ranch syncline betweeen Yakima Ridge and Rattlesnake Mountain. The postulated fault also approximates the Cold Creek hydrologic barrier (draft EA, Figure 3-1). Rattlesnake Springs exists where the postulated northwest extension of RAW fault intersects a known east-west fault along the southern flank of Yakima Ridge. This postulated northwest extent of RAW is less than a mile west of the reference repository location.

The northwest trending postulated fault is labeled as a major structure in document RHO-BWI-ST-14, Figure 8-8, and is shown to be connected to a major structure corresponding to RAW along the base of Rattlesnake Hills. This connection suggests that the northwest trending major structure is the northern segment of RAW. Such a relationship is supported by a pronounced aeromagnetic lineament extending from the eastern ends of Umtanum and Yakima Ridges and continuing along the entire trace of RAW (RHO-BW-ST-19P).

The significance of separating RAW from the northern segment of CLEW is that RAW is considered "capable" of fault movement under the criteria of NRC's Reactor Site Criteria, 10 CFR 100, Appendix A but CLEW is not currently considered "capable" north of RAW using 10 CFR 100, Appendix A. However, the

Siting Criteria for Disposal of High-Level Radioactive Wastes in Geologic Repositories are different and are under 10 CFR 60, Section 60.122. In evaluating a site for high level waste disposal using 10 CFR 60, all of CLEW may be significant in evaluating potentially adverse conditions.

A significant result of ground motion or of existing faults along the CLEW/RAW zone of influence could be the existence of or changes in groundwater flow paths. Increased vertical flow could be caused by disruption of relatively impervious clay fillings in the prolific, vertically oriented cooling joints of the basalt (see joint spacings in the draft EA, on Table 6-16, page 6-166). Additional information on the effects of structure on groundwater are in detailed comment 6-49.

It is suggested that the proximity and impact of CLEW and RAW on waste isolation and design be reconsidered, in view of the information discussed above, and revision be made to this section of the EA as appropriate.

6-42

Section 6.3.1.7.3, Favorable condition, page 6-127, Paragraph 4

Available data on deformation rates has not been adequately considered. This finding of the draft EA is based largely on the occurrence of deformation at long-term low average long rates since the Miocene. Statements about long-term low average deformation rates since the Miocene are also on the following pages in the draft EA: 6-128, paragraph 1; 6-129, paragraph 3; 6-130, paragraph 1; 6-130, paragraph 2; 6-131, paragraph 1; 6-132, paragraph 2; 6-135, paragraph 4; 6-137, paragraph 1; 6-210, paragraph 5; and 6-214, paragraph 4. The NRC staff's concerns with the view that deformation has been at long-term low average rates since the Miocene are in detailed comment 2-5. An adequate basis for finding a favorable condition regarding the potential impacts of future deformation does not appear to have been presented in this section of the draft EA.

6-43

Section 6.3.1.7.3, Favorable condition, page 6-128, paragraph 3

The text refers to the results of a Delphi analysis that is of little importance to the favorable condition being assessed because this analysis did not consider faulting. Jointing and faulting are the most likely deformations to occur during the 10,000 year period of consideration. The Delphi analysis tested the judgment of experts on the question of whether the present pattern and style of deformation that exists in the Pasco Basin will continue. The data base for their judgments was derived from deformation based on fold growth, without considering the effects of fault displacement. The final EA might consider the effects of faults on ongoing deformation. Such analysis could affect the following conditions: 960.4-2-7(b), 960.4-2-7(c)(3), 960.4-2-7(c)(6), 960.4-2-7(d), 960.5-2-11(c)(1), (c)(3), 960.5-2-11(d) and 960.4-2-1(b)(1).

6-44

<u>Section 6.3.1.7.4, Potentially adverse condition, page 6-129, paragraph 3</u>

This section of the draft EA does not consider available information that indicates significant synclinal deformation (see detailed comments 3-11 and 3-13). This section states: "Deformation appears to be concentrated on the steeper limbs of anticlinal folds with little or no deformation occuring in synclinal troughs like the Cold Creek syncline." Statements suggesting synclinal stability are also on the following pages: 6-130, paragraph 1; and 6-136, paragraph 3. The Cold Creek Syncline is the area where the proposed repository is to be located. Evidence indicates the possibility of deformation in this syncline, and this is important to assessing the following conditions: 960.4-2-1(c)(1), 960.4-2-7(b),(c)(3), (6)(d), 960.5-2-11(c)(11) (c)(3). It is suggested the EA be revised to describe known and inferred synclinal deformation.

6-45

<u>Section 6.3.1.7.4, Potentially adverse conditon, page 6-129, paragraph 4</u>

This part of the draft EA does not appear to consider the available, relevant information. It states: "No faults have been identified in the reference repository location." However, significant evidence for faults exists (see detailed comment 3-11). The existence of faults is important to assessing conditions: 960.4-2-1(b)(1), (b)(4)(ii), 960.4-2-7(b), (c)(3),(c)(6), and 960.5-2-11(c)(3).

Statements in the draft EA, suggesting that the reference repository is located away from faults and structures also appear on the following pages: 3-79, paragraph 2; 6-136, paragraph 3; and 6-214, paragraph 1. It is suggested that the EA be revised to qualify these statements by recognizing that interpreted faults have been identified and other evidence of shearing displacement is indicated by the presence of "tectonic breccia" in all deep boreholes in the reference repository location and in all other deep boreholes in the Cold Creek syncline (RHO-BWI-ST-14).

6-46

<u>Section 6.3.1.7.5, Potentially adverse condition, page 6-130, paragraph 6</u>

The finding for this potentially adverse condition is based on an unsupported statement that a large (magnitude and acceleration not specified) historical earthquake is not expected to affect waste containment or isolation. Also, the finding involves two incomplete applications of the potentially adverse condition because the guideline condition specifies the "geologic setting," not just the reference repository location, and calls for consideration of "historical earthquakes," not just a singular large historical earthquake.

Due to evidence associating microearthquake swarm activity with the Cold Creek syncline (see detailed comment 3-15 and the paragraph below), there is no reason to believe that micro-earthquake swarms are unlikely to occur in the reference repository location over the next 10,000 years. The affects of micro earthquake swarms on waste containment or isolation are not addressed.

Since 1969, swarm microearthquakes in the Pasco Basin have occurred at Wooded Island (15 miles S.E. of the RRL) at Coyote Rapids (5 miles N of the RRL), and Rattlesnake Hills (3 miles south of the RRL). The Wooded Island swarm is associated with synclinal structure because this swarm area occurs along the mapped (dashed as inferred) Cold Creek syncline axis (RHO-BW-ST-19P). The Coyote Rapids swarm occurs on the mapped (dashed as inferred) axis of the Wahluke syncline (RHO-BW-ST-19P).

Adequate consideration of historical earthquakes in the geologic setting might affect assessment of this condition 960.4-2-7(c)(1). It is suggested this section of the draft EA be revised to provide an analysis of the effects of microearthquakes in the geologic setting on waste containment and isolation.

6-47

Section 6.3.1.7.5, Potentially adverse condition, page 6-130, paragraph 1

Not considered in the seismic design for the site are the effects of small earthquakes occurring within the geological repository operations area (GROA). The most common mode of seismic activity observed in the Pasco Basin vicinity, since the installation of a relatively close-spaced network of stations in 1969, is the release of seismic energy by microearthquake swarms. These swarms have been observed (Malone, et.al, 1975) to occur at very shallow depths, nearly to the surface, and on multiple-inferred fault planes. Although no swarms have occurred entirely within the RRL, no analysis is presented in the draft EA on the possibility of such swarms in the future.

Since the centers of energy release in a microearthquake swarm are not precluded from occurring at repository depth, special consideration should be given to the effects of source accelerations (tens to a few hundreds of meters) near to the underground repository structures. Many seismologists and geophysicists currently believe that at or very near the rupture surface peak accelerations become essentially independent of earthquake magnitude (Ambraseys, 1969, 1973, 1978; Brune, 1979,; Dietrich, 1973; Trifunac, 1973;

Jennings and Guzman, 1975; Hanks and Johnson, 1976; Bolt, 1978; Midorikawa and Kabayashi, 1978; Seekins and Hanks, 1978; Hanks, 1979; Aki and Richards, 1980; Hadley and Helmberger, 1980; McGarr, 1981; McGarr, et al, 1981). In the very near source region where magnitude becomes a less important factor in characterizing the ground motion, the state of stress and the ability of the rock to store energy prior to failure during an earthquake become important factors.

McGarr, 1984, has recently considered the effect of stress regime and depth on ground motion at very small distances from underground structures and has found that near-source accelerations in compressive regimes, such as is present in the Pasco Basin, may exceed near source accelerations in extensional regimes by as much has a factor of 3. He also proposed an upper bound surface acceleration of 1.9g very near the source for events in a compressive regime, with significantly higher accelerations at depth.

Matters such as these might be considered in the final EA in an assessment of the possible effects of microearthquake swarms in the GROA.

6-48

Section 6.3.1.7.6, Potentially adverse condition, page 6-131, paragraphs 6 and 7, page 6-132, paragraph 3

The finding does not appear to take into consideration:

1. The nature of CLEW/RAW (see detailed comment 6-41)

2. That long-term, average deformation rates since the Miocene are not likey to be indicative of episodic ranges of deformation rates.

3. That small earthquakes do not occur only on small faults.

4. A preliminary analysis of plate tectonics processes in the vicinity of the Yakima Fold Belt and Columbia Plateau.

5. The possibility that there may be recently active faults at Toppenish Ridge (Campbell and Bentley, 1981);

6. The applicability or nonapplicability of the possibility that the seismological and geological methods may yield different results on earthquake frequency. (For example the evaluations of Schwartz and Coppersmith in 1984 suggest that the historical seismological record may underestimate earthquake frequency and potential for large earthquakes.

Considerations such as listed above could impact the finding. It is suggested that items 1 through 6 above be considered in this section of the final EA.

6-49

Section 6.3.1.7.9, Potentially adverse condition, page 6-135, paragraph 3

This section of the draft EA finds that over the next 10,000 years tectonic deformations are not expected to adversely affect the regional groundwater flow system. The NRC staff considers that the potential for faulting (see detailed comments 2-5, 3-11 and 6-41) to have with possible adverse impacts on regional groundwater flow makes the preliminary finding on conditions 960 4-2-7(c)(6) in the draft EA questionable.

The draft EA states that leakage along structural discontinuities is a factor in regional recharge to deep basalts (page 3-79). The draft EA recognizes the possibility that Yakima Fold Belt areas like the Cold Creek syncline may be crossed by strike-slip faults with linear extents of tens of kilometers, and these may hydraulically connect flow systems or form flow barriers (page 3-89).

Possible vertical groundwater exchange along known and inferred structures is recognized in the draft EA. Umtanum Ridge-Gable Mountain anticline may play a role in vertical groundwater mixing (draft EA, page 3-82). It should be noted that this structure has been found to have Quaternary movement (see detailed comment 3-9). The Cold Creek barrier is believed to be a structural discontinuity, and although its exact nature is undefined it appears to align with a possible northwest extension of RAW (see detailed comment 6-41). Hydrochemical data suggest deep groundwaters are mixing vertically with shallow groundwaters at an undefined rate (page 3-90) along the Cold Creek barrier.

In summary, the information cited above indicates potential faulting or other tectonic deformations could adversely affect the regional groundwater flow system. It is suggested that this finding be reexamined after consideration of the information cited above has been documented.

6-50

Section 6.3.1.7.5, Potentially adverse condition, page 6-131, bullet 3

This section of the draft EA implies that microearthquake swarms are limited to the marginal area of the Pasco Basin. This is of questionable accuracy. The three Pasco Basin swarms mentioned in this section are all located well within the boundaries of the Pasco Basin and are appropriately refered to as being in the central Pasco Basin. This is important because the Pasco Basin is the basin where the reference repository is located and understanding the seismic potential of this basin may affect the EA assessments of tectonic stability. In addition, microearthquake swarm events have occurred astride the northern boundry of the RRL and in the middle and, southern part of the RRL (see detailed comment 3-15). It is suggested that this section of the EA be revised to provide and evaluate the microearthquake swarm locations that are in the Pasco Basin.

6-51

Section 6.3.1.7.10, Disqualifying condition, page 6-136, paragraph 3

This section of the draft EA does not appear to consider the available information relevant to condition 960.4-2-7(d). This section of the Draft EA indicates that the RRL was sited away from areas of known or suspected faulting. Also, it is stated that little or no deformation has occurred in synclinal troughs and that rupture planes from small earthquakes are not expected to lead to a loss of waste isolation. Small earthquakes do not necessarily occur only on small faults (see detailed comment 2-5). Other detailed comments are made on faulting in and near the RRL (see detailed comments 3-11 and 6-41) and on synclinal structures (see detailed comment 3-13). Possible impacts on ground-water conditions are discussed in detailed comment 6-49.

It is suggested that consideration of the points brought out in the detailed comments referenced above and this comment, be considered in evaluation of the finding for this disqualifying condition as presented in the final EA.

6-52

Section 6.3.1.8, Qualifying condition, page 6-137, paragraph 3

The DOE does not consider structural hydrocarbon traps formed by steeply dipping faults, such as that which may exist along the southeastern corner of the repository (see detailed comment 6-41), as well as possible others within the repository itself. Potential traps other than anticlines could include feeder dikes. Although such dikes are reportedly found only south and east of the site where exposures allow their detection, numerous others, like the Ice Harbor dike near Pasco (USGS, 1979), may lie buried beneath the repository area.

In addition, (RHO-BWI-ST-19P) reports that magnetotelluric results indicate that the basalt doesn't reflect the basement structure and there is great relief on the pre-basalt surface. Consequently, the lack of surficial anticlines does not necessarily imply the absence of deeper structural targets within the Cold Creek syncline. Although such structures are hidden from conventional geophysical methods, the November, 1984 issue of the American Association of Petroleum Geologists Explorer credits the current exploration "boom" on the Columbia Plateau to rapid technical advancements in magnetotelluric methods, capable of detecting structure beneath the basalts. This is significant because loss of waste isolation could occur from exploratory drilling in or near the reference repository location.

It is suggested that this section of the final EA recognize that currently undetected sub-basalt anticlines may be found and that assessments be made for hydrocarbon traps other than anticlines.

6-53

Section 6.3.1.8.3, Favorable condition, page 6-139, paragraph 2

No mention is made anywhere in Section 6.3.1.8.3 of the fact that ground-water samples from the Grande Ronde Basalt formation, Cohassett flow ("preferred candidate horizon") are about 50 percent saturated with methane gas (page 6-187 of the draft EA). Only the Wanapum and Saddle Mountains basalt formations are discussed. The Saddle Mountains and Wanapum Basalt are said to have methane from carbonaceous interbeds. The Grand Ronde Basalt formation is not interbedded with terrestrial carbonaceous matter and methane is not indigenous to basalt rock (draft EA page 6-187). The gas in the Grande Ronde formation may originate in sediments below the basalt. This is supported by the presence of methane in sediments below the basalt found during exploration in the vicinity of the Saddle Mountains (draft EA page 6-187). Deep sources of methane make exploratory drilling through the Grande Ronde, the unit in which waste emplacement is proposed, a possibility.

Section 6.3.1.8.3 of the EA might be revised to consider that methane gas has been found in the Grande Ronde formation and that it may originate from below-basalt sediments; and that there is a reasonable possibility for exploratory drilling through the repository host rock.

6-54

Section 6.3.1.8.3, Favorable condition, page 6-139, paragraph 4

This section of the draft EA does not adequately consider available information indicating methane gas exists in the reference repository location. This section indicates that any hydrocarbons generated under the Pasco Basin should have migrated away from the synclinal area to the anticlinal ridges. However, this is not consistent with the existence of methane gas in groundwater in the Pasco Basin, Cold Creek syncline, reference repository location (Hydrochemical Data Base, Jan., 1984). There are no sedimentary interbeds in the Grande Ronde basalt which is the formation the reference repository is in. Methane is not indigenous to basalt (page 6-187). The gas may have migrated from sediments below the basalt. This section indicates that the sedimentary sequence beneath the basalt is the hydrocarbon exploration target. Potential deep exploratory targets for gas below the Cold Creek Syncline impact human intrusion assessments for the Hanford site.

It is suggested that this section of the EA should be revised to recognize and provide an interpretation for the existence of methane gas in the Cohassett Flow ("preferred candidate horizon").

6-55

Section 6.3.1.8.3, Favorable condition, page 6-139, paragraph 4

This section of the draft EA indicates that the anticlinal ridges are hydrocarbon exploration targets and the nearest anticline to the RRL is Yakima Ridge listed as being 2 miles west. Actually, Yakima Ridge has a buried subsurface extension which is one half mile southeast of the reference repository location, (RHO-BWI-ST-14). According to the draft EA, overall groundwater flow is believed to be to the southeast (draft EA, page 3-80). A potential hydrocarbon target structure this close to the reference repository location, along the overall groundwater flow path, is significant to human intrusion assessments. It is suggested that this section of the EA be revised to recognize the proximity of the buried Yakima Ridge anticlinal structure.

6-56

Section 6.3.1.8.5, Potentially adverse condition, page 6-141 and 6-142

Available information is not adequately considered here. A potentially adverse condition exists at a site if naturally occurring materials are present whether or not actually identified in such form that economic extraction is potentially feasible during the forseeable future. The draft EA finds that this potentially adverse condition does not exist for Hanford. Unmentioned in this section is methane that occurs in the reference repository location at repository depths, from an unidentified source.

The lack of analysis regarding methane in the reference repository location seriously impedes assessment of this condition. It is suggested that this section of the EA be revised to include information indicating the presence of methane in the reference repository location. After this information is included, the finding should be reconsidered.

6-57

Section 6.3.1.8.9, Potentially adverse condition, page 6-143, last paragraph

The DOE states that the potentially adverse condition regarding impacts of forseeable human activities on the ground-water flow system could be present. This appears to conflict with the finding on draft EA page 6-76 regarding expected changes in geohydrologic conditions. (See detailed comment 6-18).

The final EA should resolve this apparent disparity in findings under the relevant guidelines.

6-58

Section 6.3.1.8.11, Disqualifying condition, page 6-145, paragraph 5

This part of the draft EA makes a statement of questionable accuracy. It states that natural gas is not present within the vicinity of the RRL. Methane (CH_4) is a natural gas that occurs in the RRL at repository depths (Hydrochemistry Data Base, Jan. 1984). The possibility for exploration because methane gas exists within the vicinity of the reference repository location should be documented in this section because it may affect the assessment. It is suggested that the statement referenced above be reconsidered.

6-59

Section 6.3.2.3, Conclusion on qualifying condition, page 6-149, paragraph 1/bullet 3

Preliminary performance results, which suggest that basalt has the capacity to isolate radionuclides, are based on insufficient data and optimistic assumptions. Based on inconclusive theoretical calculations of redox conditions; in the absence of data on the kinetics of the expected redox reactions; and without discussion of the reducing capacity of the basalt/water system, it is assumed that radionuclides are released in their least soluble, most sorptive state (see detailed comments 6-25 and 6-33). Performance assessments based on such assumptions are likely to lead to underestimates of radionuclide releases to the accessible environment.

6-60

Section 6.3.2.3, Conclusion on qualifying condition, page 6-149, paragraph 1

The conclusion on the system guideline (960.4-1; section 6.3.2.3) appears to be inconsistent with the conclusion on the potentially adverse condition concerning human activities affecting the ground-water flow system (960.4-2-8-1(c)(5); section 6.3.1.8.9). The conclusion on the system guideline states that the system is unlikely to be altered unfavorably by human-induced events or processes (bullet 4); however, section 6.3.1.8.9 states that the potentially adverse condition of human activity adversely changing the ground-water flow system could be present at the site. This apparent inconsistency should be resolved in the final EA.

6-61

This comment was incorporated elsewhere in the comment package.

6-62

Section 6.3.3.1.5, Potentially adverse condition, page 6-151
Section 6.3.3.3.4, Favorable condition, page 6-205

The draft EA concludes that surface facilities will be located in areas subject to only minor and infrequent flooding and that this flooding can be mitigated during repository construction and operation. Based on this conclusion, the draft EA finds that (1) surface characteristics that could lead to the flooding of surface facilities are not present at the site (Potentially Adverse Condition 960.5-2-8) and (2) there is the absence of surface water systems that could potentially cause flooding of the repository (Favorable condition 960.5-2-10).

Review of the draft EA and supporting flood analyses (Skaggs and Walters, 1981) presented in the draft EA indicates that the information presented is not adequate to support the conclusions; the draft EA acknowledges that a potential for site flooding exists and that engineering measures will be required for flood protection. The draft EA bases its findings with respect to the guidelines on the ability to implement flood protection measures which mitigate flood effects. The guidelines, however, address the question of site flooding, rather than the feasibility of engineering measures to control flooding. Hence, it appears that consideration of potential flooding of surface facilities at this site may alter the conclusion that the favorable condition is present and that the unfavorable condition is not present. The final EA should either reconsider the findings associated with these guidelines, or support the conclusions with further documentation and analyses that clearly show that site flooding will not occur.

6-63

Section 6.3.3.2.3, Favorable conditions, page 6-157, paragraph 3

The draft EA claims that favorable condition, 960.5-2-9 (b)(1) is present. This favorable condition deals with the host rock being sufficiently thick and laterally extensive to allow significant flexibility in selecting the depth, configuration, and location of underground facility. Although the data presented in the draft EA indicate that the preferred candidate horizon (Cohassett flow) thickness exceeds the 21 meter minimum thickness criterion stated on page 6-154, the discussion on pages 6-153 to 6-157 appears to be misleading because of the following reasons:

(1) In stating that the Cohassett flow provides more than twice the minimum thickness (21 meters or 70 feet) necessary to construct the repository, the draft EA assumes that the entire dense interior is suitable for repository construction. A DOE sponsored study by Long and WCC (1984, page I-52) appears to discredit this assumption with the following statements:

> "The entire dense interior of the Cohassett flow also was not considered because of the laterally continuous vesicular zone, which is considered to be avoidable during repository construction. Thus it was deemed appropriate to compare only the thickness of the lower

dense interior of the Cohassett flow to the thickness of dense interior of the other candidate horizons."

Furthermore, Long and WCC (1984, page II-19) states that "the repository panel area would always be sited in the dense interior below the internal vesicular zone."

(2) The draft EA takes credit for the ability to exercise the "option to select from three other candidate horizons (Rocky Coulee, McCoy Canyon, and Umtanum flows)". Because of this option, a claim is made on "further flexibility" in selecting a host rock horizon at depth. This claim may not be appropriate especially since on page 6-157, paragraph 3, the draft EA states that "...these flows do not appear to have sufficient minimum thickness...".

The thickness of the host rock has an impact on the findings for DOE Siting Guidelines 960.5-2-9(b)(1) and 960.5-2-9(c)(1).

The final EA should include a discussion as to whether or not construction within the vesicular zone will be necessary in evaluating the DOE Siting Guidelines 960.5-2-9(b)(1).

6-64

Section 6.3.3.2.4, Favorable condition, page 6-169, paragraph 1

The draft EA states, "When the effect of thermal-induced stresses were included in the Barton analysis,..., the support requirements did not increase significantly." However, the draft EA does not include a discussion on the decreased performance of the rock bolts due to the increased thermal load.

An increase in the temperature in the waste emplacement rooms will increase the thermal stresses resulting in a larger support requirement. Furthermore, an increase in temperature may significantly reduce the strength of concrete and resin grouted rock bolts. Research on resin grouted rock bolts indicates that they are not suitable for use above 212°F. Similar research on concrete and concrete grouted rock bolts indicates that the differences in thermal expansion of the bolt, rock and grout may cause the bond between the rock and the bolt to be broken (Kendorski, 1984).

The draft EA concludes that favorable condition, 960.5-2-9 (b)(2) is not present at the reference repository location, however, ground control problems associated with the presence of a high thermal load might still be appropriately evaluated in the final EA.

6-65

Section 6.3.3.2.6.1, Shaft construction, page 6-173, paragraph 4

For the feasibility of blind-hole drilling, the draft EA cites three factors, one of which is the experience gained from other blind-hole drilling projects with constraints similar to those at the reference repository location (Table 6-20). A review of Table 6-20 indicates a potential problem with this statement, in that, the geologic conditions and/or dimensions of the shafts in the examples are very different to those planned at Hanford.

The problem is illustrated by examples of: the Agnew shaft, where drilling of a 14-foot diameter shaft was stopped far short of the projected 3,378-foot depth due to equipment failure (page 6-179, paragraph 4); and the Amchitka shaft, where the total drilled depth was 6,150 feet, but the shaft diameter was only 7.5 feet. It is evident that the drilling method to be utilized at Hanford would involve different geologic and drilling parameters (such as drill rig torque requirements, size of drill pipe, drilling mud requirements, bottom hole cleaning procedures, aquifer conditions, and effect of the in situ stresses) than those in the cited case histories.

Case history examples presented in the draft EA do not substantiate the view that engineering measures beyond reasonably available technology are not needed for construction of shafts as stated in the DOE Siting Guideline 960.5-2-9 (c)(2). It is suggested that drilling plans discussed in Morrison-Knudsen, Co., Inc., 1984, be included in the final EA, such that the uncertainties associated with and the feasibility of drilling the shafts at Hanford can be evaluated.

6-66

Section 6.3.3.2.6.1, Shaft construction, page 6-175, paragraph 3

The draft EA states, "...high degree of success in drilling small-diameter boreholes on the Hanford site is a positive indication that drillability, hydrologic conditions, and stability concerns can be managed in excavating exploratory and repository shafts." While it is accepted that the geologic and hydrologic conditions encountered in drilling would be the same for small-diameter boreholes (3 to 17 inches) and large-diameter shafts, the assumption that their influence on drillability would be same is questionable.

Case histories of drilling small-diameter boreholes cannot be cited as evidence of large-diameter shaft constructibility. For example, a large-diameter shaft would: intersect a greater number of fractures; encounter a larger volume of water inflow; and require drilling equipment with considerably larger capacity for drilling than small diameter boreholes. An increase in the number of fractures intersected by shafts increased the probability of rock spalling or sloughing. Furthermore, Morrison-Knudsen (1985), in discussing Hanford, stated that it is difficult to predict the behavior of shaft walls based on information gathered during drilling of small diameter boreholes.

The evidence presented in the draft EA concerning the success of drilling small-diameter boreholes should not be considered a basis for the "not present" conclusion on the DOE Siting Guideline 960.5-2-9 (c)(2).

6-67

Section 6.3.3.2.6.2, Construction of an underground facility, page 6-184, paragraphs 5 and 6

This section of the draft EA refers to the provision for emergency pumps in the shaft to provide the capability of removing "appropriate quantities of ground water." It is not clear what is meant by an appropriate quantity of ground water. The potential exists for high rates of inflow into the shaft upon penetration of high hydraulic conductivity flow tops. The possibility also exists for encountering high hydraulic conductivity zones in the basalt flow interiors due to structural discontinuities or other similar features. The sixth paragraph on page 6-184 refers to the avoidance of large ground water inflows. The methodology for avoiding potentially large ground water inflows is not described. A possible approach is to extend pilot drill holes in advance of drift development.

No discussion is included in the draft EA on temporal changes in inflow rates that might result from seismically-induced changes in head and/or hydraulic conductivity. Figure 3-24 on page 3-55 shows the magnitudes of relatively shallow (less than 4 km focal depth) earthquakes which occurred in the vicinity of the RRL from 1969 through March of 1983. As described on page 3-54, paragraph 3, there have been areas of swarm-type seismic activity within 10 km of the reference repository location, including some events at focal depths of less than 2 km. Given that the proposed repository would be constructed at a depth of approximately 1 km in relative lateral proximity to seismically active zones, it is prudent to consider and evaluate the potential effects of seismic events which could occur during the repository's operational period and may also occur during the construction phase. Refer to detailed comments 6-46 and 6-50.

6-68

Section 6.3.3.2.7, Potentially adverse condition, page 6-191, paragraph 3

The draft EA states that the presence of potentially adverse condition 960.5-2-9(c)(3) requiring extensive maintenance of underground openings during repository operation and closure is not expected. This conclusion is not substantiated by the case histories presented on page 6-191, paragraph 5 of the draft EA.

Examples are presented in the draft EA of openings in basalt that require little maintenance. However, these openings (Snoqualmie Falls turbine chambers and railroad tunnels) are at shallow depths where in situ stresses and temperatures are much lower than expected repository conditions. Deep mines in the Coeur d'Alene mining district are cited as requiring little support; however, in that region, displacement of rock in the shaft causes millions of dollars of damage per year to timber and shaft sets (Bues and Board, 1984). Also Barton's Q-system classifies the Cohassett dense interior rock mass as very poor to fair and the RMR system classifies the rock as fair to good (page 6-165). Therefore, neither the classification system, nor the examples given, appear to rule out the possibility of extensive maintenance of repository openings.

6-69

Section 6.3.3.2.7, Potentially adverse condition, page 6-193, paragraph 2

The draft EA states, "Many joint surfaces show only partial coatings of infill material with basalt-to-basalt contacts." This statement seems to be at variance from the statements made on page 6-100, paragraph 6, and page 6-110, paragraph 8.

On pages 6-100 and 6-110, the host rock permeability is believed to be decreased by fracture sealing from hydrothermal alteration of minerals along the fractures. However, on page 6-193, the basalt-to-basalt contact across joints, due to a lack of infilling, is believed to decrease the amount of movement along joints which reduces the need for continued maintenance.

The presence of fracture infilling, or the lack thereof, may have an impact on conclusions on the DOE Siting Guidelines 960.4-2-3 (b)(2) and 960.5-2-9 (c)(3). It should be indicated whether most fractures are filled or not, and credit for either fracture sealing or reduced creep potential should be accordingly taken.

6-70

Section 6.3.3.2.8, Potentially adverse condition, page 6-194, paragraph 2

The draft EA acknowledges that potentially adverse condition 960.5-2-9 (c)(4) is present. However, it states that safety hazards or difficulty in retrieval can be handled by using "standard practices." This assumption appears to be optimistic.

Retrieval of canisters after they have been in the repository for period of up to 50 years is not a "standard practice". Procedures to reduce the radiological and safety hazards associated with retrieval will encounter unique problems associated with the following.

- Thermal-induced fracturing, and hydration and dehydration of mineral components in the fractures is possible around waste emplacement boreholes. This can cause water inflow which may turn to steam in the borehole and pose a threat to personnel safety during the retrieval operation.

- Container integrity could be jeopardized by rock failure, possibly resulting in breached containers and resulting radiologic hazards.

6-71

Section 6.3.3.2.9, Potentially adverse condition, page 6-195, paragraph 2

The draft EA states that " ... the flow tops above and below the Cohassett dense interior would be avoided during construction by monitoring the distance between the flow tops and excavation by means of exploratory drilling." This could be a potentially dangerous procedure due to the high pressure fluids expected to be present in flow tops which would be encountered when drilling from the drifts. It is not clear how the distance will be monitored without drilling into the flow tops.

6-72

Section 6.3.3.2.10, Disqualifying Condition, page 6-197, paragraph 2

The draft EA states, "While some water inflow into excavated openings is anticipated, the volumetric flow rate is expected to be minimal based on current knowledge". The statement does not seem to be consistant with statements made in RKE/PB (1983).

RKE/PB (1983) states, "In the case of development seepage water, where flows up to 2500 gal/min (9460 l/min) may be encountered...". This statement suggests that substantial flow rates of incoming water are possible. However, no bounding ranges for the quantity of water inflow are presented in draft EA.

The possibility of substantial water inflow under high temperature and pressure raises serious implications on the conclusions regarding disqualifying condition 960.5-2-9(d). It is suggested that the following topics be discussed in this section:

- the types of anomalies that may be encountered during repository construction and estimates of inflow that may result from each type, and

- case histories to demonstrate that these magnitudes of water inflow under high pressure and temperature can be handled with available technology. The problems associated with grouting and freezing in repository panels should be detailed.

- discussion of the kinds of available technology that would be used to mitigate reasonably expectable water problems.

6-73

This comment was incorporated elsewhere in the comment package.

6-74

This comment was incorporated elsewhere in the comment package.

6-75

Section 6.3.3.4.2, Evaluation process, page 6-210, paragraph 1

The subject paragraph states that "The adverse tectonic condition that could preclude development of a repository is that of an active fault (either seismically active or creeping)."

As outlined in detailed comment 6-41 a major seismogenic fault zone (i.e. RAW) likely exists within one mile of the repository. Seismic reflection results suggest that faults which may represent portions of that zone may exist within the repository (SD-BWI-TI-177). In addition, many other faults have been interpreted within the repository detailed comment 3-11. Unless the interpreted faults are decoupled from the ongoing tectonic deformation of the Pasco Basin (detailed comment 2-5), they would be expected to creep. Consequently, the evidence suggests that development of a repository at the currently planned location may be incompatible with the statement quoted above.

6-76

Section 6.3.3.4.2, Evaluation process, pages 6-209 - 6-210

This section does not adequately consider the available information about faulting and the seismic evaluation. Much of the subject section involves the potential impact of faulting and seismicity on repository design. According to EA page 2-41, most effects from fault rupture occur within 8 km of the fault and that underground design for such effects are generally difficult, so that active faults should be avoided by 8 km. Detailed comment 6-41 summarizes substantial evidence to support the possible existence of a major active fault zone (RAW) less than a mile southwest of the reference repository location. According to the 8 km criterion (draft EA, p. 2-41), most effects of future movement on that fault would affect about two-thirds of the reference repository location.

As outlined in detailed comment 6-41, current tectonic activity corresponding to the postulated fault zone is indicated by recent seismic activity. Given the length of the feature, it is considered capable of generating a major earthquake, potentially involving substantial fault rupture and shaking. Such underground impacts might include roof falls, local ground shifts, disturbance of the clay fracture fillings of the prolific cooling joints (page 2-5, paragraph 2; see also joint spacings of Table 6-16, page 6-165) and displacement of shears or faults within the workings. It is suggested that the potential effects of faults (including geophysically interpreted faults) in or near reference repository location be considered in the final EA.

6-77

Section 6.3.3.4.3, Favorable condition, page 6-210, paragraph 4

This favorable condition is met when the faulting and seismicity in the geologic setting of a site for geologic disposal of nuclear waste are significantly less than these generally allowable for nuclear facilities. As support for a finding that this condition is present, the draft EA relies heavily on the existence of numerous nuclear facilities at Hanford since 1943.

However, this favorable condition does not appear to be adequately assessed. The draft EA does not compare the magnitude and intensity of the seismicity in the geologic setting with the magnitude and intensity that is generally allowed for the construction and operation of nuclear facilities. The comparison of nuclear power plan WNP-2 at Hanford to some west coast plants (draft EA, p. 6-211) is not as comprehensive as comparisons made at other sites, such as at Richton Dome. For example, the draft EA for Richton Dome apparently considers data from all licensed nuclear power plants in the U.S. (draft EA, Richton Dome, p. 6-146). The design requirements for a waste repository may not reflect those required for nuclear power plants. The design requirements of structures important to safety will comply with 10CFR60 and appropriate EPA regulations.

It is suggested this section include estimates of seismic magnitudes and intensities in the geologic setting, such as directly along RAW, and show these estimates are significantly less than generally allowable for the construction and operation of nuclear facilities.

6-78

Section 6.3.3.4.5, Potentially adverse condition, page 6-212, paragraph 3

This section of the draft EA does not consider all applicable data. This section states that the potentially adverse condition of high accelerations at the reference repository location is not present because of the low to moderate seismicity of the Columbia Plateau. Campbell and Bentley (1981) have mapped a

Holocene age zone of scarps 32 km in length on one of the Yakima Folds, Toppenish Ridge. Using the relationships of Slemmons and others (1982) and Bonilla (1984) for rupture length versus magnitude, the causative event could have been about Magnitude 7.2. McGarr (1984) suggests that an event this size would have a considerable volume on both sides of the fault plane that would experience accelerations in excess of one g. It is suggested that consideration be given to: (1) the data of Campbell and Bentley (1981), (2) the calculations of McGarr (1984), and (3) the possibility of a large earthquake near the site (e.g., along RAW, the Horse Heaven Hills structure, or the Saddle Mountains).

6-79

<u>Section 6.3.3.4.5, Potentially adverse condition, page 6-212, paragraph 5</u>

Adequate consideration of available data is not given. This section states that subsurface facilities are generally not adversely affected by earthquakes large enough to cause damage to surface facilities, that detrimental effects are noted only if the rupture intersects the underground opening, and that earthquakes affect ground-water flow. Earthquakes originating at several kilometers from a locality where surface and subsurface effects can be compared, support the first statement. This is because the higher frequency portions of the ground motion spectre attenuate rapidly with distance away from the hypocenter. Surface facilities are affected more by the relatively lower frequency ground motion spectre that attenuate rapidly with distance away from the hypocenter.

McGarr, et al., 1981, in a study of earthquakes and ground motion in a mine in South Africa measured high, very short duration acceleration pulses (up to a maximum of 12g) from earthquakes originating within a kilometer of the accelerometer. These earthquakes with magnitudes less than M_L1.5, did not cause significant damage to the mine workings even though they involved high acceleration pulses. However, an M_L3.7 did cause substantial damage. The geologic setting of the Hanford site has had a recorded M_L4.4 event. The largest event recorded within the Pasco Basin, 13km from the reference repository, was M_L4-4.5 (Fecht, 1984), paragraph 4). The subsurface conditions in South Africa are not expected to necessarily be closely analogous to the Hanford site but the basic concepts and findings of McGarr's work have significant implications for seismic hazard assessment.

It is suggested that magnitudes and accelerations which may occur in the immediate vicinity of the repository be assessed using analyses based on the larger events recorded since 1969.

6-80

<u>Section 6.4.1.4.2 Analysis of releases under routine operations, page 6-222 through 6-224</u>

The source term presented for routine operational releases is only one of the source terms expected from the various operations indicated in the facility description, Section 5.1. There are apt to be other source terms associated with cleaning and decontamination of shipping casks, with the handling of DHLW containers and TRU packages, with the processing of 17000 gallons per day of radioactive liquid wastes (Table 5-1), and with the management of the solid low-level radioactive wastes generated on site. Spent fuel when removed from the reactor has a layer of radioactive crud on its outer surfaces that provides a source term for fuel handling operations even if no leaky fuel pins are present. Leaky fuel pins are present in most spent fuel pools and must also be disposed of also. In the contamination found in spent fuel pool water the predominant radionuclides are usually Cesium-134, Cesium-137, Cobalt-58, Cobalt-60, and Ruthenium-106, depending upon the history of the spent fuel and the pool water.

It is suggested that the final EA present an assessment that considers the source terms originating in the various cleaning, handling, packaging, and processing operations that might be conducted in the Waste Handling and Packaging Facility, the expected emissions after cleanup in the HVAC and any other gaseous waste handling systems, and the resulting radiological impacts in the environment (NUREG-0695).

6-81

<u>Section 6.4.2, Postclosure guideline analysis: A preliminary system performance assessment, pages 6-226 through 6-288</u>

The DOE may not have fully assessed the second half of the postclosure system guideline (960.4-1) which states that "the site will allow for the use of engineered barriers." In places, the draft EA appears not to address the possible effects of the natural system on components of the engineered barrier. These components include the waste package (see detailed comments 5-4, 6-1, 6-95, and 6-109); the packing (see detailed comment 6-94); the grouting (see detailed comment 4-2); and the general repository design (see detailed comment 3-11).

The final EA, the DOE should consider in more specific terms, the manner by which the site allows for engineered barriers.

6-82

This comment was incorporated elsewhere in the comment package.

6-83

<u>Section 6.4.2.1, Scope and objectives, page 6-227/6-228, continuing paragraph</u>

A probabilistic approach requires either an extensive data base that is large enough so that realistic distributions of the data can be observed, or a limited, but quality data base; that, according to a consensus of expert opinion, appropriately bounds expected geochemical conditions/reactions. (See detailed comment 6-90.)

6-84

Section 6.4.2.2.1 Waste package subsystem description, page 6-229, paragraph 2

The Hanford Site draft EA does not discuss the site's ability to limit releases for the alternate waste form of commercial high-level waste. Instead, only releases from spent fuel are discussed. Figure 6-8, page 6-180, of the Deaf Smith County Site draft EA shows that the commercial high-level waste form could well be hotter after emplacement than the spent fuel waste form. Although, a full assessment of commercial high-level waste form may be inappropriate at this time, an initial comparison with the spent fuel waste form would make the Hanford Site EA more complete and more easily compared to the salt sites.

6-85

Section 6.4.2.2.1, Waste packages subsystem description, page 6-229, paragraph 4

The main function of the packing surrounding a waste container, as defined in this section appears to be inconsistant with material presented in Section 5.1. This section (6.4.2.2.1) suggests that packing is needed for "maintaining reducing (i.e., low Eh) conditions in which many radionuclides have low solubilities . . ." draft EA Section 5.1.4.3.1 (page 5-38 paragraph 1) maintains that packing material is required for"... controlling ground-water Eh..." This is an important distinction, for the latter suggests that the packing is imposing redox conditions on the system that are different than "ambient," and thus imposing low radionuclide solubilities on release calculations.

6-86

Section 6.4.2.3, Subsystem performance assessment, pages 6-232 to 6-237 and 6-242 to 6-243

This section of the draft EA summarizes subsystem performance assessment for the Hanford repository using a probabilistic approach and models referenced in several Hanford documents. The degree of conservatism suggested in the draft EA is not supported by the data. Assumptions for the analysis are listed in p. 6-233 with the suggestion of conservatism because the assessment leads to:

"(1) an underestimation of container lifetime,

(2) an overestimation of the amount and (or) rate of radionuclide release from the engineered barrier system, and

(3) an underestimation of groundwater travel time."

Conservatism is also suggested to be present in the container failure analysis based on generalized corrosion because of the following three factors (pp. 6-242 to 6-243):

"° The container is assumed to fail when 7.5 centimeters (3 inches) of the wall thickness has corroded.

° The factor of limited oxygen supply available in the waste package subsystem has not been considered.

° The corrosion calculation did not take credit for the corrosion resistence provided by the oxide film formed in the air steam environment."

The overall conservatism of waste package analysis is not supported by all the available data. Available data which have not been given adequate consideration include data on (1) redox/reducing environment, (2) localized corrosion, and (3) packing stability. These are discussed in comments on performance of the packing (detailed comment 6-94); waste package environment (detailed comment 6-93); and use of the uniform corrosion equation (detailed comment 6-95).

The significance of inadequate consideration of these factors could mean that the degree of conservatism suggested may not be present. As as example, the draft EA container failure criterion is based on the wall thickness (0.8 cm) corresponding to axisymmetric yield. A cylindrical container subject to external pressure will normally fail prior to this by non-axisymmetric elastic buckling (Gill, 1970). Using the Von Mises equation, elastic instability of the spent fuel container is predicted to occur after 7.2 cm of corrosion, i.e., a wall thickness of 1.1 cm. Also, discontinuity and weld stresses do not appear to be taken into account in the draft EA. These could cause failure near the maximum allowable stresses corresponding to a wall thickness of 2.2 cm.

The DOE should reconsider the degree of conservatism claimed with respect to the uncertainties in the data for repository environmental conditions and waste package failure modes.

Section 6.4.2.3, Subsystem performance assessment, page 6-233, continuing paragraph

This list only indicates those items for which credit was not taken in the performance analysis fo the systems. The list should also present those processes, conditions and assumptions for which credit is taken. For example, based on inconclusive estimations of redox conditions and, in the absence of data on the reducing capacity of the basalt/water system, it is assumed that radionuclides are released in their least soluble, most sorptive state and credit (unstated) was, therefore, taken for low redox conditions and reactions. Performance assessments based on such assumptions are likely to lead to underestimations of radionuclide releases to the accessible environment (see detailed comments 6-28 and 6-33).

6-88

Section 6.4.2.3, Subsystem performance assessment, page 6-233, item 3, bullet 2

The draft EA states that the fact that the system performance assessment does not take credit for the effects of matrix diffusion on radionuclide transport leads either to an overestimation of the amount and (or) the rate of radionuclide release from the engineered barrier system, or an underestimation of ground-water travel time.

Matrix diffusion acts as a retardation mechanism relative to the velocity of radionuclides in individual fractures. However, the hydraulic conductivities calculated in the draft EA are applied as an average over the hydrostratigraphic unit or fractured interval, and not to individual fractures. The effective porosity interpreted from field tracer tests which consider the medium as a porous continuum adjusts the calculated linear fluid velocity and account for fracture flow velocities. However, the expected value of effective porosity assumed in the draft EA in the modeling analyses does not correspond with the value derived from the Hanford site tracer tests. Therefore, the statement in the draft EA that consideration of matrix diffusion would decrease the release rate of radionuclides from the total isolation system does not appear appropriate because the ground-water velocity calculated by the DOE using their assumed effective porosity distribution would not correspond to the velocity in individual fractures.

6-89

Section 6.4.2.3.1, Stochastic analysis methodology, pages 6-234 to 6-235

The methodology for waste package performance assessment places great emphasis on a single failure mode of a single barrier, i.e., general corrosion of the overpack. In the belief that the overpack will provide containment for an expected 6100 years and a minimum of 5000 years, the waste package assessment methodology is greatly simplified. As a result some analyses have been omitted. These are discussed in this comment.

No analysis is done for delays in basalt resaturation time, for packing penetration time, or for penetration of fuel rod cladding (or glass form dissolution). Not accounting for the time resulting from these delays could be regarded as reasonable if the overpack could, by itself, provide all the containment needed. However, the overpack lifetime estimates provided by the Hanford draft EA may not be supportable. They are based on purely empirical equations derived from limited experimental data.

The omission of other failure modes (e.g., pitting and crevice corrosion, corrosion in the Air/steam environment human intrusion, earthquakes, etc.) makes the analysis inadequate to support confidence in the results of the calculations. In particular, it does not consider early failure (e.g., initial flaws, human intrusion, and earthquakes). These modes have low occurrence probabilities but potentially severe consequences and should not be eliminated without a satisfactory assessment.

An assessment methodology is needed which can incorporate all failure modes relevant to a given barrier in a systematic, unified procedure for assessing that barrier. Moreover, the assessment methodology should be capable of integrating the individual barrier performances into an overall waste package evaluation. The overall evaluation should take into account the multibarrier redundancy of the package and the protection offered inner barriers by the outer barriers and the possible deleterious effects of barrier interactions.

Once a satisfactory waste package assessment methodology has been developed, waste package lifetimes should be calculated including uncertainty analysis of the predictions. The results of such calculations should be reconciled with the 960.4-1(a) Postclosure Guideline that requires that the site be amenable to the use of engineered barriers.

6-90

Section 6.4.2.3.1 Stochastic analysis methodology, page 6-235

The preliminary performance analysis in the draft EA uses relatively new computer codes and process models (e.g., Corrosion Model (Fish-1983), CHAINT-MC, MAGNUM-MC, REPSTAT, and EPASTAT) that have not been validated. This is acknowledged in the draft EA. However, it is not possible to perform technically thorough checks on the results given in the draft EA without validating the codes against equally complex engineering problems and having the codes available for independent use. It is suggested that documentation of the computer codes/models and of validation studies be released for use by others for independent evaluation.

6-91

Section 6.4.2.3.2, Identification of radionuclides used in performance assessment pages 6-235 through 6-237

In the Hanford draft EA, the method used in the screening procedure to select radionuclides used in the performance assessment is based on the initial inventory, the half-life, solubility, and the adsorption of radionuclides. There is no present requirement that the treatments of this subject in the EA be consistent with requirements in 10 CFR 60 in controlled release, but such consistency will be necessary at such time Hanford may be under licensing consideration.

In the first step of the screening procedure, "radionuclides with inventory fractions of 1.0 percent or less were eliminated from further consideration." "... because radionuclides with inventory fractions of less than 1.0 percent are unlikely to contribute significantly to the total release...." This criterion is contrary to that set by 10 CFR 60.113(a)(ii)(B) which states that the one part in 100,000 per year release requirement "does not apply to any radionuclide which is released at a rate less than 0.1% of the calculated total release rate limit." It is suggested that results of analysis be discussed in the final EA to illustrate that the "1.0 percent or less criterion" does not compromise the criterion set by 10 CFR 60.113(a)(ii)(B).

In the second step of the screening procedure, nuclides with half-lives of less than 100 years are omitted from consideration since the inventory at approximately 5000 years will be less than 10^{-13} percent of its initial inventory. This assumption fails to consider the uncertainties in containment time and the potential for breach of containment at shorter times (i.e., 300 years).

In the third step, radionuclides with low solubility are assumed to contribute insignificantly to cumulative release. The same criterion of less than or equal to 1.0 percent is again used. The substantial uncertaintly in the environment (see detailed comment 6-93) will impact the solubility assumed. The potential existence of transportable colloids that can migrate through a porous packing material (see detailed comment 6-96) could have a substantial impact on meeting the radionuclides release limits. Similarly, organo-complexes formed from organic materials in the bentonite may have enhanced solubility.

In the fourth step, adsorption of radionuclides by packing is assumed to increase radionuclide travel times and reduce radionuclide release. Large uncertainties in the properties of packing material and the waste package environment across the waste package boundary are discussed in detailed comments 6-93 and 6-94. In particular, there are no experimental data for the proposed compressed backfill of 75% basalt and 25% bentonite. Also, the use of data from dilute solutions may not apply near the edge of the waste form where many nuclide solution concentrations are expected to be near their solubility limits (see detailed comment 6-96). If this is the case, the solid may approach saturation and adsorb a smaller fraction of nuclides from solutions (Salter, 1984) and therefore, retardation is decreased and transport is faster (Pescatore, 1984).

Selection of radionuclides for performance assessment is a crucial step in the process of arriving at the Level-3 finding for the 960.4-1(a) Postclosure Guideline, with regard to demonstrating for the reference waste package design that the site is amenable to the use of engineered barriers. The final EA, should consider a discussion of these issues in relation to the Postclosure System Guideline 960.4-1.

6-92

Section 6.4.2.3.2, Identification of radionuclides used in performance assessment, page 6-237, and paragraph 2 and 3

The radionuclide solubility and sorption values are for the "expected" redox conditions (-0.3 volts) (Salter and Jacobs, 1983). The use of -0.3 volts as the expected condition when modeling radionuclide transport predetermines that radionuclides will be in a less soluble more sorptive state. Low radionuclides solubilities are apt to lead to low calculations of release and faulty conclusions concerning the determination of radionuclides of concern.

6-93

Section 6.4.2.3.3, Waste package subsystem performance, pages 6-238 to 6-273

Waste Package Environment: Uncertainty in Near Field Conditions: The interaction between the waste package and its immediate environment affects the lifetime of the containment barrier and the rate of radionuclide release from the engineered barrier system. During the pre-closure period there is a potential for high temperature, oxic conditions to prevail. The effects of these pre-closure conditions on waste package performance are not discussed in the draft EA. It is not clear how uncertainty in these conditions are accounted for in Hanfords's waste package subsystem performance analysis.

During post-closure, temperature and radiation effects can alter the nature of the immediate package environment. Work done by Gause (1984) and Wood (RHO-BW-ST-21P, 1982) indicate that changes could occur around the package or in the packing material as a result of temperature and irradiation. While some work (Wood, et al., 1983) has indicated the reducing nature of basalt environment in that oxygen will quickly be removed from the basalt waters, this work did not include the effects of radiolysis which will generate oxidants.

Calculations have been done to predict the time-temperature profiles for a waste package in basalt (RHO-BWI-ST-18, 1981). In this work, it has been noted that the prediction of waste package temperatures, which are sensitive to the thermal conductivity of packing materials, should include a coupling of heat and moisture flow within the packing and the very near field basalt. Because such a coupling was not considered, there are uncertainties in the predicted temperatures and, therefore, in the anticipated performance of barrier materials, especially in light of the recent change in packing material design (i.e., the use of preformed annular shaped packing).

Radiolysis effects can potentially enhance or restrict corrosion of the carbon steel container. Alpha-radiolysis can result in oxidizing conditions and lower pH and increased radionuclide solubility (Pederson, 1984). The formation of hydrogen in radiolysis can lead to hydrogen assisted failure of the container. The formation of large molecular weight organics from radiolysis of CH_4 present in the groundwater (Nelson, J. L., 1984; BNL-NUREG-34220, 1984; Gause, E. P., 1984) may also affect radionuclide solubility and transport.

No estimates of the radiation dose rates with time and distance have been given for a basalt repository. A recent estimate of the dose rate at the surface of the carbon steel overpack in a salt repository (Jansen, G., 1984) is almost two orders of magnitude lower than that estimated in an earlier study (AESD-TME-3131, 1982). Uncertainties of this magnitude combined with uncertainties in the temperature could be magnified as uncertainties in the performance of the barrier materials.

A discussion of the anticipated waste package environment, uncertainties in the environment and how these affect the performance of the containment barrier and release from the engineered barrier system would be appropriate in the final EA.

6-94

Section 6.4.2.3.3, Waste package subsystem performance, page 6-238

Performance and Uncertainties in the Performance of the Packing Material: Although the draft EA states that no credit is taken for radionuclide transport or adsorption in the packing, the waste package subsystem performance conisders (see page 6-229, last paragraph on the main function of packing) that the packing makes a positive contribution to the waste package lifetime and the retardation of the transport of radionuclides. There is evidence, however, that makes the packing's contribution questionable. In particular, chemical degradation of the packing through hydrothermal diagenesis, aging, selective dissolution or interaction with components of the groundwater may alter the ability of the packing material to perform as anticipated. This could detrimentally affect the container lifetime and releases from the package (NUREG/CR-2482, BNL-NUREG 51494, Vol 4, 1983).

It is known that bentonite undergoes alteration to illite, a non-swelling clay, at relatively low temperatures (Pusch, 1983; Eberl, 1978), although the rates may be slow. Of greater significance is the observation by Couture (1984) that, in the presence of steam, alteration to a non-swelling form occurs rapidly.

Most Hanford tests to date have involved basalt/water and bentonite/water systems and little attention has been paid to precompacted basalt/bentonite packing annuli which are be used in the current waste package design. If this packing is altered by steam, as shown by Couture (1984), the assumption on which canister corrosion is based might be significantly different. Similarly, the transport of radiochemical species will depend on the characteristics of the packing. A completely altered material would have a much larger hydraulic conductivity than an intact material.

In order to assure that the precompacted packing does not detrimentally affect container corrosion and radionuclide release, physical properties such as swelling pressure, hydraulic and thermal conductivity, etc., need to be quantified for the range of anticipated waste package conditions. Such data may then be used in assessing the performance of the waste package with respect to regulatory criteria. It is recommended that the final EA acknowledges the uncertainties of the contribution, (both positive and negative) by the packing on waste package performance in the context discussed in this comment.

6-95

Section 6.4.2.3.3, Waste package subsystem performance, page 6-238

Use of Uniform Corrosion Equations: The draft EA states that the corrosion model is that of Fish and Anantatmula (Fish, 1983). This model is an empirical one, based on data (Westerman, 1984) recorded for experiments of a few weeks' duration under conditions that may not represent actual repository conditions. The empirical coefficients are not related to any phenomenological model. The validity of using this model to extrapolate short-term results to hundreds of years is of question.

The model of Fish and Anantatmula is actually two models, one for oxidizing and one for reducing conditions, and the draft EA does not state which of the two is used. Furthermore, the data on which the model is based is unusual in that at high temperature (250C) the corrosion rate is lower than it is at low temperature (125C). The applicability of this phenomena in the repository is unknown, because of the lack of defensible mechanism to account for it and the uncertainty of the repository environment and to what extent different conditions would alter the observations.

There are basic problems with the approach used in this draft EA to assess time to failure of the waste package due to container corrosion. Although a range of corrosion rates are used to generate a probability distribution function (pdf) of canister lifetime, this range is not explicitly dependent on the relevant corrosion conditions such as pH and Eh. That is, there is no phenomenological modeling. Instead, the influence of pH and Eh are assumed to be incorporated into the range of corrosion rates. The influence of radiation is incorporated by multiplying the corrosion rate by an unsupported empirical factor which is independent of the dose and decreases linearly with time from 1.75 to 1 after 300 years after resaturation. Finally, the temperature dependence is treated by assuming that corrosion proceeds at one rate above 125C and at another rate below 125C. The high temperature dependence is roughly one-half the low temperature rate. The shortcomings of this model are acknowledged in the document by Sagar (Sagar, 1984) which supports the conclusions drawn in the EA. There, it is suggested that the quantitative results of this model are preliminary in nature and subject to change as better data and models become available.

The fact that no phenomenological modeling of the observed corrosion results has been achieved makes the extrapolation of the rates to 1000 years and beyond suspect. In the Fish and Anantatmula model, as applied by Anantatmula (1984), the empirical relationship has a single parameter to which a 10-percent uncertainty is applied arbitrarily. Because the corrosion equations are linear, whatever uncertainty is assigned will translate into essentially the same percentage uncertainty in the lifetime.

Using different assumptions about the onset of corrosion, the rate of corrosion under different but plausible conditions, and the enhancement of corrosion under radiation, it might be possible to arrive at a failure time less than 1000 years, in which case quite different results would occur in the selection of radionuclides.

Because neither the environmental conditions and their potential variations, nor the corrosion rates and their uncertainties, nor the effects of radiation and its uncertainty, are stated and justified, the canister lifetime pdf presented lacks justification. A calculation of the canister lifetime using the best available judgment of the impact of these effects and their uncertainties should be made and the results reconciled with 960.4-1(a) Postclosure Guideline that requires the site to be amenable to the use of engineered barriers. In particular, the geochemical, redox, radiation environment, and the range of uncertainty in the corrosion rates implied by the potential variations in the conditions should be considered in the final EA.

6-96

Section 6.4.2.3.3, Waste package subsystem performance, pages 6-238 to 6-273

Uncertainties in Radionuclide Concentrations at Waste Package Interface: The performance assessment for release rates and releases to the accessible environment assumes that the concentration of nuclides at the breached package will be solubility limited. It is not clear how uncertainties related to solubility and the formation of colloids are accounted for.

Large uncertainties exist in the assumption of solubility limited release. These uncertainties are due primarily to the uncertainties in the solubilities of nuclides and uncertainty in the assumption that only dissolved nuclides can be transported. The solubility of an individual element will be affected by the character of the solid phase (Strickert, 1982), the presence of common ions, the pH (Rai, 1983; Ogard, 1981), the Eh (Pigford, 1983), the temperature, the presence of concentrated electrolytes and of radiolysis which may alter the oxidizing-reducing nature of the environment (Pederson, 1984).

Strickert and Rai (1982) measured the solubilities of two solid forms of Pu over a pH range from 4 to 8 and under oxidizing conditions. $Pu(OH)_4$ was found to have a higher solubility than c:ystalline PuO_2,and both forms exhibit a change in solubility of 3 orders of magnitude in the pH range investigated. Cleveland, et al. (1983) have recently reported solubilities for Pu and N_p in basalt waters, that exceed those exhibited in other synthetic groundwaters.

Solubilities for Americium are ambiguous (Pigford, 1982). Measured solubilities of Am vary over eight orders of magnitude as the pH changes from approximately 9 to 6 (Rai, 1983). Ogard (1981) estimates that at pH 4 the solubility of uranium in deionized water may vary 20 orders of magnitude depending on whether conditions are oxidizing or reducing. Neptunium, like uranium, exhibits a wide range in the solubilities depending on Eh and the crystallinity of solid NpO_2 (Pigford, 1982). Phases may exist which exhibit retrograde solubilities and the presence of colloidal species may alter releases from the engineered barrier system.

It has been shown also that colloids may be formed during dissolution of the waste forms, whether UO_2 or glass (Olofsson, 1981), and the colloids may not be subject to adsorption in the same way that molecular species are (Bonano, 1984; Behrens, 1982). It is known that uranium and other actinides can form soluble complexes with a variety of organic substances, including the organics that are present in the bentonite clay.

In the final EA, a summary of current data on solubilities in the anticipated environment near the waste package and uncertainties in that data would be useful. The impact of these uncertainties on controlled release rates should be evaluated.

The potential for radionuclide organo-complex and colloid formation should be addressed. The impact of radiolysis should be acknowledged and the solubility ranges used in the assessment should be reconciled with the uncertainties that would arise from this source in addition to the lack of knowledge of solubility under known conditions.

There are currently no data which indicate the magnitude and uncertainty in the concentration of nuclides at the package interface under anticipated conditions. These conditions would include a degraded packing material, corrosion products and temperatures between approximately 100°C and ambient repository temperatures. Further testing should involve a documentation of this source term under conditions anticipated during the post containment period.

6-97

Section 6.4.2.3.3, Waste package subsystem performance, pg. 6-238 and Table 6-28, pg. 6-249

Packing Transport Parameters: The transport of radionuclides to the accessible environment is controlled by groundwater flow and by adsorption in the packing and the host rock, as discussed in the draft EA. However, the delay in reaching the accessible environment, as well as the quantity reaching it, are strongly dependent on the transport parameters assumed for the packing. This aspect of the assumption is not clearly discussed in the draft EA.

The draft EA uses a hydraulic conductivity of $10^{-12} ms^{-1}$ and an apparent diffusion coefficient of $10^{-6} cm^2 s^{-1}$. These are stated to be assumed values although there are available experimental data. In particular, Westsik and others (Westsik, 1983) report a hydraulic conductivity of $7 \times 10^{-12} ms^{-1}$ for a highly compact (dry density of 2.1 gcm^{-3}) 75-percent sand, 25-percent bentonite mixture. It is reasonable to expect that a basalt/bentonite mixture would behave similarly. Given the uncertainty in the realistically achievable packing density during overpack emplacement, a hydraulic conductivity substantially greater than this value may occur. Such larger values could result in substantial advective flow, contrary to the statement made in the draft EA. Similarly, Neretniecks (1977) and Tostenfelt (1982) have reported apparent diffusion coefficients for radionuclides as large as $3 \times 10^{-4} cm^2 s^{-1}$, a value much greater than that used in the draft EA.

The increase in flow rate and the decrease in time to reach the host rock that could occur if these larger values of diffusion coefficient and hydraulic conductivity are used could alter the predicted performance of the packing in a major way. The effect of these parameter uncertainties could lead to an expanded set of radionuclides that would require detailed consideration, particularly in view of detailed comment 6-94 on performance of the packing material.

These data should be considered in the final EA. To the extent possible, the effect of values for the parameters discussed above and the uncertainties therein should be considered by DOE and reconciled with the Level-3 finding for the 960.4-1(a) Postclosure System Guideline with regard to supporting, for the given reference waste package design, that the site is amenable to the use of engineered barriers.

6-98

Section 6.4.2.3.3, Waste package subsystem performance, page 6-247, Table 6-27

Values of adsorption coefficients used for technetium may be too high, thus underestimating the release of technetium. The DOE, in choosing their adsorption coefficients used for technetium, cites results of experiments in which hydrazine was used to create a reducing environment (Salter et al. 1981; Barney, 1981, 1984). These results may not be applicable because a hydrazine-rich environment may be different from the repository environment. Experiments do show that technetium may plate out on reduced ferrous material in the surrounding rock, but it is not known if such material would be present. Reactions between hydrazine and solution, hydrazine and container walls, and hydrazine and radionuclides have not been characterized. Recent work by the NRC subcontractors (Kelmers, et al., others, 1984) suggests that sorption ratios (adsorption coefficients) measured in solutions containing hydrazine may be not representative. (See detailed comment 6-25 and 6-33.)

In the final EA the experimental results that are available and their validity to site conditions when choosing adsorption coefficients should be considered.

6-99

Section 6.4.2.3.3, Waste package subsystem performance, page 6-248, paragraph 1, and Section 6.4.2.3.4, Repository Seals Subsystem Performance, page 6-258, paragraph 2

The solubility values in Table 6-27 are different than the values in the cited reference and are not readily traceable to their sources. Some of the values may be non-conservative.

A footnote to Table 6-27 states: "Taken from Salter and Jacobs (1983)." The reference Salter and Jacobs (1983), contains a tabulation of both expected and conservative values to be used for modeling activities. Many of the "conservative" solubility values given in Salter and Jacobs (1983) were stated to be experimentally measured solubilities; thus, there would seem to be little justification for using solubility values which are lower than these "conservative" numbers. The solubility values in the draft EA Table 6-27 are not in good agreement with the values presented in Salter and Jacobs (1983) and, in some cases, are lower than the recommended conservative values, as shown below. Another footnote to Table 6-27 states that the solubility values were adjusted for the radionuclide fraction, but it is not clear what this means or how the solubilities were computed. Table 6-2 compares the draft EA with Salter and Jacobs (1983).

Table 6-2

Solubility (mol/L)

	Draft EA Table 6-27	Salter and Jacobs (1983), Table 1 Conservative	Expected
C-14	4.0E-6 to 4.0E-9	1.0E-3	1.0E-6
I-129	1.0E0 to 1.0E-2	1.0E0	1.0E-2
Np-237	1.0E-7 to 3.0E-9	1.0E-5	1.0E-10
Pu-239	1.2E-8 to 1.8E-11		
Pu-240	6.0E-9 to 9.0E-12		
Pu-242	2.0E-9 to 3.0E-12		
Pu-total	2.0E-8 to 3.0E-11	1.0E-5	1.0E-9
Tc-99	5.0E-4 to 2.0E-8	1.0E-5	1.0E-9
Se-79	1.0E-4 to 1.0E-8	1.0E-3	1.0E-7
Sn-126	3.0E-6 to 3.0E-11	1.0E-5	1.0E-10

As can be seen, the radionuclide solubility values given in the draft EA Table 6-27 are in several cases one or more orders of magnitude lower than the "conservative" solubility values recommended by Salter and Jacobs (1983). Without an understanding of how these data were "adjusted", they cannot be evaluated with respect to realism or conservatism.

6-100

Section 6.4.2.3.3, Waste package subsystem performance, page 6-256

Unsupported Statement on Containment of Radionuclides by the Waste Package: The draft EA states (page 6-256), "It can be qualitatively concluded that the waste package can be designed to provide substantially complete containment of the radionuclides for longer than 1000 years." Given the uncertainties in calculation of waste package lifetime and the limited state of knowledge regarding repository conditions and processes, this statement would appear to be unsubstantiated. The major support for this statement comes from the report by Sagar (Sagar, 1984) which states in its summary (Sagar, 1984 Page 4, 1st paragraph): "The container corrosion model and site data used in applying the methodology described in this report are preliminary and are based on a small number of observations. Therefore, the numerical results reported herein are not definitive of the final expected performance of the waste package subsystem. Rather, the objective of the report is to present a methodology for performance assessment, and through application of this methodology, obtain an understanding of the parametric sensitivity."

At the present state of knowledge substantial uncertainties remain in various aspects of waste package performance. It is suggested that any conclusionary statement, in the final EA, about waste package performance reflects the uncertainty.

6-101

Section 6.4.2.3.5, Site subsystem performance, pages 6-261 through 6-268

The detailed comments 6-11, 6-12, 6-15, 6-24, 6-102, 6-103, and 6-105 indicate that a reasonable doubt exists concerning the reliability and applicability of the hydraulic property data and travel time estimates presented in the EA. Detailed comment 6-102 illustrates the sensitivity of the calculated travel times to variations in the assumptions and techniques of the hydrologic modeling. This comment presents a parametric analysis which forms part of the basis for the NRC's questions regarding the validity of findings in the draft EA with respect to the pre-emplacement ground-water travel time favorable condition (expected travel time greater than 10,000 years along any path of likely radionuclide travel) and disqualifying condition (expected travel time less than 1,000 years along any path of likely and significant radionuclide travel).

Detailed comment 6-12 discusses the results of previous the DOE-sponsored travel time estimates for the Hanford site. Most of these estimates are deterministic in nature; a simple equation was used to calculate a ground-water velocity based upon single input values of transmissivity, hydraulic gradient, and effective thickness. This velocity was then divided into the distance along the flow path to the accessible environment to determine the desired travel time estimate. This method does not provide any measure of the uncertainty associated with the travel time estimates.

The travel time presentation in the draft EA, based upon a two-dimensional modeling study (Clifton, et al. (1983); Clifton (1984); Clifton, et al. (1984)) constitutes a departure from the previous studies; the hydrogeologic input parameters are treated as stochastic variables and travel time distributions are generated utilizing repeated operation of a numerical model. The NRC staff consider that the stochastic approach of these models is an improvement over the deterministic models with respect to their ability to impart an appreciation of the uncertainty in the travel time estimates. The stochastic models presented by in the draft EA are also intended to provide some estimate of the likely value of the pre-emplacement travel time based on current information, in addition to the evaluation of the uncertainty in the travel time. However, we have significant questions with respect to the formulation and operation of the models presented in the draft EA, as well as the choices of parameter input values. These questions raise doubt about the accuracy and applicability of the estimates of median travel time presented in the draft EA. Problems associated with the formulation and operation of the travel time models presented in the draft EA are discussed in detailed comment 6-102. In this comment, a simple analysis of the numerical results for median travel times calculated with the DOE models (Clifton et al. (1984)) is presented which indicates that 1) the results appear to be inconsistent with the theoretical basis of the model and 2) an alternative analysis based on reasonable assumptions for the input parameters would yield estimates of median travel time substantially lower than the 81,000 year estimate which is considered in the draft EA most representative of the current state of site hydrologic knowledge.

The spread in the distribution of travel times plotted in Figure 6-22 of the draft EA illustrates the wide range of uncertainty surrounding current travel time estimates. This uncertainty is due to the scarcity of data on key hydraulic parameters such as effective porosity and vertical hydraulic conductivity, and the questionable reliability and representativeness of existing data on other key hydrologic parameters such as horizontal hydraulic conductivity and hydraulic heads. Because of this wide range in uncertainty, at present no travel time estimates can be considered to be reliable or representative of true site hydrologic conditions. This is recognized by the DOE in the draft EA by noting the highly preliminary nature of all current ground-water travel time estimates. However, the NRC staff considers that the preliminary estimate of the median value of ground-water travel time in the draft EA analysis is based on questionable assumptions regarding the key hydraulic parameters noted above (horizontal hydraulic conductivity, effective porosity and gradient), and may not be the most representative estimate of the present state of knowledge. The assumptions the DOE uses in reaching the 81,000 year estimate of the travel time are discussed below.

Detailed comments 3-22, 6-15, 6-103 and 6-105 indicate that the assumed median and distribution of flow top transmissivities as applied to ground-water travel time calculations are questionable; the draft EA bases its assumed transmissivity distribution on the assumption that the median and statistical variation between all flow tops is identical to the median and statistical variation within each flow top. The draft EA does not provide support for this assumption of statistical homogeneity between different flows. There are some indications (Long and WCC, 1983) that the medians and distributions within a given flow top may vary significantly between flow tops, as discussed in detailed comments 3-22 and 6-105. Specific flow tops with a higher median transmissivity or a lower variance may provide faster, preferred flow paths to the accessible environment. An expected travel time for each significant flow path must be calculated separately according to the guidelines which state that the travel time should be calculated along <u>any</u> path of likely and significant radionuclide travel. The median (equal to the geometric mean, assuming a log-normal distribution) of the ensemble transmissivity distribution used by in the draft EA analyses is .15 m^2/day; for the assumed 8-meter thick flow top, this translates to a median horizontal hydraulic conductivity of 1.9×10^{-2} m/day. Individual flow tops may have median hydraulic conductivities orders of magnitude higher than this value (see detailed comment 3-22). The draft EA also assumes that the transmissivities have a spatial correlation range of 5 kilometers; there is no data presented in the draft EA or its supporting documents to support this assumption.

In the draft EA stochastic models, it is assumed that effective porosity has a uniform distribution within a range from 10^{-4} and 10^{-2}. This type of distribution yields a median value of effective porosity for the model of 5×10^{-3}. The only value measured for a Hanford site basalt flow top is about 2×10^{-4} for the tested interval (McCoy Canyon flow top) (Leonhart, et al., 1984). The difference between the median effective porosity assumed in the draft EA and the single measured value amounts to a factor of 25; use of the measured value rather than the assumed value in the analysis would therefore reduce the travel time estimate by a factor of 25. We also note that the uniform distribution assumed for effective porosity is strongly skewed towards the upper limit of the effective porosity range. In the case of the draft EA analysis, the median value used in the model is a factor of five higher than the geometric mean, which would be the median value of a logarithmic distribution with the same range (e.g., a log-uniform distribution). Since the current uncertainty in the median value of flow top effective porosity spans many orders of magnitude (Davis, 1984), it appears that the uncertainty distribution is logarithmically, rather than arithmetically, distributed, and that a geometric mean of the appropriate range should be used as the median value, rather than the arithmetic mean. Furthermore, there is some evidence that the spatial variation of effective porosity may be logarithmically distributed (Loo, et al., 1984).

The assumption in the draft EA in the subject travel time analysis regarding the magnitude of hydrologic gradients is also questionable, since in the draft EA attempts are made to estimate the gradients based on head differences between well pairs, rather than along flow paths, as discussed in detailed comment 6-15. The draft EA assumes a uniform probability distribution of the hydraulic gradient with a range from 10^{-4} to 10^{-3}, yielding a median gradient of about 5.5×10^{-4}. Reasonable estimates of the median hydraulic gradient along flow paths can be at least twice that value based on some of the existing head data.

The travel times that would be calculated by direct substitution of the assumed median input values for the hydrologic parameters into the ground-water travel time equation is about 13,000 years, rather than the 81,000 years yielded by the the draft EA model. This disparity in the medians is contrary to what one would expect analytically, according to the recent work of several authors, as discussed below. Ground-water velocity is determined by dividing calculated flux with the value of effective porosity for the flow path. Calculated flux is directly dependent on the predicted head distribution and the effective hydraulic conductivity along the flow path (as defined in the paper of Smith and Freeze, 1979). The work of Dettinger and Wilson (1981) indicates that, to first order, estimates of expected hydraulic heads derived from stochastic methods are identical to those that would be predicted by deterministic methods. Second order effects on the head distribution are generally small (Townley, 1984). The effective hydraulic conductivity of a physically heterogeneous hydrostratigraphic unit with homogeneous statistics (as are assumed in the draft EA model), even with spatial autocorrelation, has been shown to be given by the geometric mean of a log-normally distributed hydraulic conductivity (Dagan, 1984). Therefore, it is reasonable to expect that the median value of travel time should be given by the direct substitution of the assumed median values of the head gradient, hydraulic conductivity, and effective porosity in the travel time equation. The fact that this is not the case for any of the three stochastic models should be considered in the final EA. The effective hydraulic conductivity of the draft EA model, derived from back-substitution in the travel time equation, is about 3×10^{-4}, which is almost two orders of magnitude lower than the median and geometric mean (1.9×10^{-2}) of the assumed conductivity distribution. This potential problem is explored in more depth in detailed comment 6-102.

Since the median value can theoretically be approximated with a deterministic calculation, as described in the preceding paragraph, several simple calculations can be performed to illustrate the impact of the DOE's assumed parameter distributions on the resulting median value of travel time. If the parameter distributions assumed in the draft EA were maintained, as noted above, the NRC staff would calculate a ground-water travel time of about 13,000 years. If the geometric mean of the effective porosity range were used rather than the arithmetic mean, as discussed above, this travel time would be reduced to about 2500 years. If the single measured value of effective porosity were used rather than the value assumed in the draft EA, a travel time of about 600 years would result. If the measured value of effective porosity, and a more conservative value of the hydraulic gradient magnitude (1×10^{-3}) were used, this estimate would be reduced to less than 300 years. Since the measured effective porosity value may be specific to the interval tested (McCoy Canyon flow top), it may be more representative to limit this calculation to that flow top; in that case, one would obtain a median travel time estimate for this flow top of about 1,500 years (assuming the same hydraulic gradient used in the draft EA of 5.5×10^{-4}, an effective porosity of the flow top of 2×10^{-4} (or an effective thickness of about .002m for the 11m interval) (Leonhart, et al., 1984), and a geometric mean hydraulic conductivity of 6.5×10^{-3} m/day (or a transmissivity of 6.5×10^{-2} m/day for the same interval) (Long and WCC, 1984). If one assumed the slightly more conservative gradient of 1×10^{-3}, a travel time estimate of about 850 years would result. These estimates indicate that substantially lower estimates of median travel time can be made based on reasonable, non-extreme assumptions that are consistent with the existing data, even within the limitations of the draft EA conceptual model (horizontal flow for a full ten kilometers to the accessible environment). Most of these estimates are less than 10,000 years, and some are less than 1,000 years, which causes the NRC staff to question the DOE's evidence for the findings on favorable condition 960.4-2-1(b)(1) and disqualifying condition 960.4-2-1(d).

The major reasons for the difference between the travel time estimates discussed above and the travel times calculated in the draft EA appear to arise from the difference in effective porosities assumed in the calculations (different, in some cases, by a factor of about 25), and in apparent problems with the two-dimensional numerical modeling used in the draft EA (which result in an apparent overestimation of the travel time by an additional factor of about six; this is discussed in more detail in a following comment). A report has been prepared a document to support the choice of effective thickness values used in the draft EA modeling studies (Loo, et al., 1984). This document suggests a range of likely values for effective porosity of flow tops based on a combination of Hanford site data, laboratory core analysis of total and apparent porosity, expert opinion, and available generic literature. The range and distribution of effective porosity of flow tops suggested by Loo et al. for use in performance assessments are considered to be non-conservative (Gordon 1985). The NRC staff considers that direct in-situ testing should be relied on in evaluating site hydrogeologic parameters such as effective porosity, when such testing is feasible. The reliability and representativeness of the effective porosity values gained from the two tracer tests performed at the Hanford site is therefore a key question in evaluating the suitability of the site with respect to this disqualifying condition.

It must be emphasized that the above parametric analysis is intended only as an aid in reviewing the conclusions reached by the DOE through their treatment of the existing hydrogeologic data in the draft EA. The NRC staff does not consider the estimates provided by the above parametric analysis to offer accurate or reliable predictions of site hydrologic conditions, due to the questionable reliability and representativeness of the underlying data base (see detailed comment 6-15), and due to the inherent simplifications of the calculations presented. The results of this analysis do, however, raise significant questions regarding the defensibility of the DOE's conclusion that the ground-water travel times can preliminarily be inferred, based on the existing data, to be well in excess of 10,000 years, or that there is a high probability that the travel times would be greater than 1,000 years.

It is suggested that the final EA provide further explanation of the difference between the median travel time value that would be derived analytically and the median that is yielded by Clifton's modeling studies. Also, it is suggested that the final EA reexamine and provide further support for their choice of medians and distributions of the input parameters, especially effective porosity.

6-102

Section 6.4.2.3.5, Site subsystem performance, pages 6-261 through 6-269

Several problems appear to affect the stochastic analysis of travel times as presented in the draft EA. These problems may be classified as: 1) reference availability problems, 2) theoretical problems associated with the development and operation of the models, 3) data input problems associated with the applicability of the transmissivity, effective thickness, and hydraulic gradient values used in the models and 4) presentation problems associated with understanding the significance and limitations on the travel time values presented in the draft EA. All of these problems contribute to the NRC staff having reasonable doubt with respect to the accuracy and applicability of the travel time estimates for evaluation of the Hanford site suitability.

The stochastic travel time models presented in the draft EA are based on the work of Clifton, et al. (1983), Clifton (1984), Clifton, et al. (1984a), and Clifton, et al. (1984b). Additional important references include Loo, et al. (1984) and Arnett, et al. (1984). Five of the six references were officially released in mid-January, 1985. The release of these critical reports after the release of the draft EA during the NRC draft EA review made evaluation of the modeling efforts very difficult. The draft EA alone does not include sufficient detail to allow an evaluation of sensitivity of the travel time estimates to specific input factors and model construction decisions.

Analysis of theoretical problems with the modeling effort requires presentation of a brief description on the model construction and operation.. The stochastic modeling approach described on pages 6-261 through 6-268 of the draft EA is based on the operation of a finite element model. The model includes 10 elements in the directions transverse to flow and 20 elements in the direction parallel to flow. All elements are 1 km square. The initial step in the modeling is the input of transmissivity values utilizing a multivariate normal random number generator with the of mean log-transmissivity and the unconditional covariance matrix (Clifton, 1984, p. 23). A correlation range for transmissivity of 5 km is assumed to represent the spatial continuity/variability of hydraulic properties within the basalt. This correlation range is assumed in the absence of sufficient data on each candidate horizon to do a spatial statistical analysis (Clifton, et al., 1983, p. 7). The finite element model is then operated under steady-state conditions using the input hydraulic gradient values as boundary conditions to calculate an associated head distribution for the model. The calculated head distribution then is used to determine a flow path that represents ground water movement from the repository site to the accessible environment, a linear distance of 10 km. The velocity of ground water movement from element to element along the flow path then is determined using the input transmissivities, the calculated head values and the input effective thickness values. Calculation of the travel time along the flow path involves summing the travel times through each to element along the flow path through the model. The entire process is then repeated with the generation of a new transmissivity array and the associated calculation of a new travel time. The repetition of this process 600 to 1000 times creates the travel time data presented for the three models on page 6-268 of the draft EA.

The travel time array created utilizing the stochastic model appears to be dependent on both the characteristics of the model (number of elements, size of elements) and the magnitude and characteristics of the input. Clifton (1984) did a study of the sensitivity of results to geometry, correlations and cross correlations. His analysis included the effect of the size of the model element, the size of the model area, the correlation range of log-transmissivity, and cross-correlations between transmissivity and effective thickness. Clifton's results indicate that the mean travel time reduces from 21,500 years to 16,000 years with an increase in element size from a 1 km square to a 5 km square (Clifton (1984), p. 45). Different domain (model area) lengths produced little change in travel time while doubling the width of the model reduced the travel time by one third (Clifton (1984), p. 50 and 52). The magnitude of the correlation range of log-transmissivities in the EA model has a strong impact on median travel times. The draft EA models are dependent upon a 5 km correlation range. According to Clifton (1984, p. 56) the median travel time is decreased by more than 40 percent with a reduction in the correlation range from 5 to 2 km. An increase in correlation range from 5 to 10 km results in an increase in travel time calculated by the DOE stochastic model of about 40 percent. As discussed in detailed comment 6-101, it is not clear to the NRC staff why the two-dimensional model should be this sensitive to the correlation length. It is suspected that the sensitivity is an artifact of the chosen numerical model geometry, i.e., the domain size and node spacing, relative to the correlation length. Clifton's results suggest that calculated travel times from the draft EA models are sensitive to a number of model construction decisions. Changes in travel time estimates of up to 40 percent, due to grid design and correlation range, are possible without changing the physical (hydrologic) input parameter distributions.

Clifton (1984, p. 30 & 31) also presents example outputs of head configurations based upon model operation. Figure 12 on page 31 (reproduced as Figure 6-2) illustrates a potential problem with the travel time models in the draft EA. The head values show that the model has created a localized zone of low transmissivity at right angles to the direction of flow. This "damming" effect acts to retard ground water flow and extend travel times. It is unknown whether this plot is representative of model outputs. It is possible that the low transmissivity zone (evidenced by the steep gradient) is created by a combination of the size of the elements, size of the modeled area and size of the correlation range. The NRC staff also notes, regarding this particular figure, that the presence of the closed head contours within the model boundaries appears erroneous, since this would require a source or sink within the model.

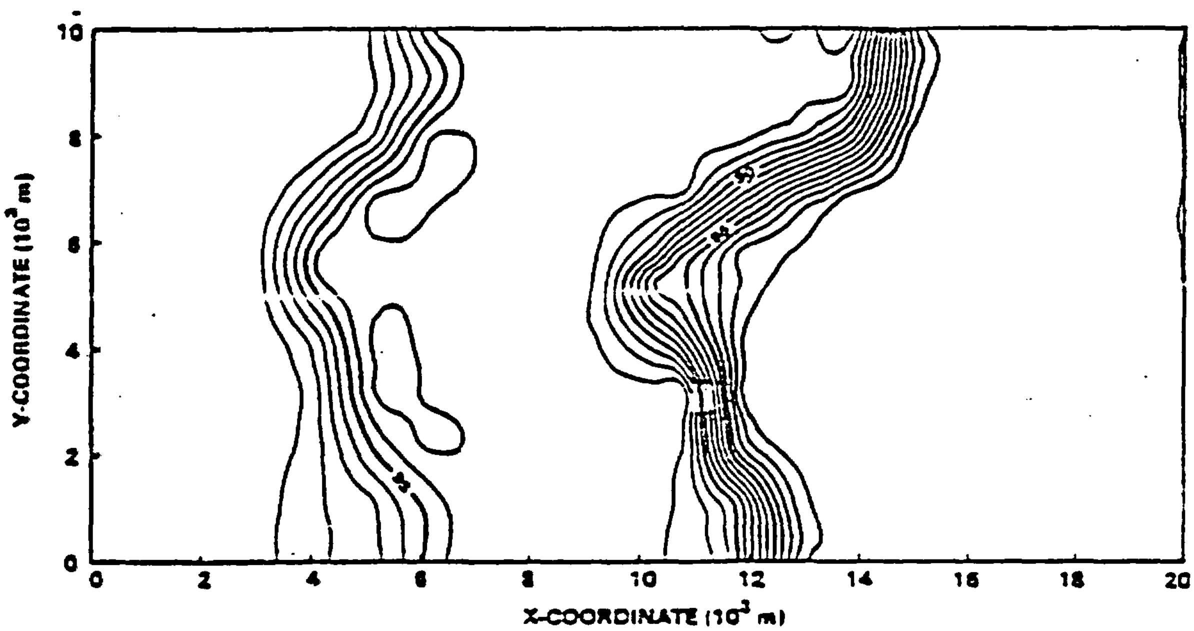

Figure 6-2. Hydraulic Head Field Realization, Reference Case Analysis (Clifton, 1984).

Arnett, et al. (1984) demonstrate the sensitivity of travel time calculations to seemingly minor changes in input data. They show how a change in effective thickness from 4 x 10^{-2} m (Loo, et al. (1984), Clifton, et al. (1984)) to 2 x 10^{-3} (measured in the McCoy Canyon flow top in DC 7/8) can reduce the travel time from 71,000 years to 3,000 years (Arnett, et al., 1984, pp. 23-24). The sensitivity of travel time modeling to changes in input factors is further illustrated in detailed comment 6-102.

6-103

Section 6.4.2.3.5, Site subsystem performance, page 6-261 to 6-269

In stochastic studies of ground-water travel time (Clifton, et al. (1984)) cited in the draft EA, the flow path from the disturbed zone to the accessible environment is considered to occur horizontally within the flow top above the repository horizon. Clifton, et al. (1984) performed a sensitivity study to determine the effect of the vertical to horizontal hydraulic conductivity anisotropy ratio on ground-water travel time. They concluded that vertical flow segments along the flow path to the accessible environment would increase the travel time, compared to the horizontal flow assumption, and therefore that the horizontal flow assumption is the most conservative.

The NRC staff considers this conclusion to be questionable for several reasons. First, Clifton, et al. (1984) assumed each flow top to have the same transmissivity distribution. If certain flow tops above the candidate horizon are of particularly high transmissivity, vertical flow can result in decreased ground-water travel time. Second, Clifton, et al. (1984) assumed the accessible environment to be ten kilometers laterally distant regardless of the distance of vertical travel. However, the distance to the accessible environment, as defined in Working Draft 4 of the EPA HLW standard, would drop from ten kilometers in the deeper aquifers (below 2500 feet depth) to two kilometers in the upper aquifers (above 2500 feet depth). Therefore, the travel time to the accessible environment in the upper aquifers would be less than that calculated by Clifton, et al. (1984). The distance to the accessible environment would also be less than ten kilometers if local ground-water flow to the land surface were found to occur.

Third, neither the vertical gradients nor the hydraulic conductivities (especially vertical hydraulic conductivities) are known with sufficient certainty to conclusively support the draft EA's conclusions. Finally, structures and other discontinuities may provide preferential vertical conduits which have not been taken into account.

Based on the above items, the NRC staff considers that the assumption of horizontal ground-water flow may yield ground-water travel times that are unrealistically long.

6-104

EA Section 6.4.2.3.5, Site subsystem performance, page 6-261, paragraph 2

The EA refers to the dependence of ground-water travel time calculations on transmissivity, effective thickness (or effective porosity), and hydraulic gradient. The NRC staff has questioned the lack of consistency in the use of the term effective thickness in other comments in this review of the draft EA. The definition of effective thickness used in the DOE (1982) was that portion of the test interval which was deemed to be the portion of the interval contributing flow. In this section effective porosity is incorporated into this definition. A standard definition in the final EA would be helpful to readers.

6-105

Section 6.4.2.3.5, Site subsystem performance, page 6-266, paragraph 1

The NRC staff has identified several apparent inconsistencies regarding the nature and use of the transmissivity (T) data base in the draft EA. Statistics for a governing lognormal probability distribution for T are presented, based on Strait and Mercer (1984). The draft EA then states that it was assumed that distributions governing T within each candidate horizon flow top are the same as the distribution of the ensemble of T values from all Grande Ronde flow tops tested to date. This assumption implies that the T statistics (geometric mean = 0.15 m^2/day and standard deviation of log T = 1.83) shown on page 6-266 are based on data from most or all of the tested Grande Ronde flow tops. On page 7-10 of the draft EA it is further implied that more than 50 T values were incorporated within the analysis (see detailed comment 7-1).

The NRC staff observes that Strait and Mercer (1984) contains T estimates for 42 depth intervals, and of these only 14 relate to basalt flow tops and flow bottoms. The remainder are estimates for intraflow and interbed intervals. In fact, only 8 estimates of T relate specifically to flow top intervals. Of the group of 14 flow top and flow bottom T estimates, only 3 T values were reported to have been verified by internal and/or external peer review. Strait and Mercer (1984) recommend that the use of data not verified by peer review should be limited to conceptual modeling. Therefore, it seems inconsistent to ignore the advice of the quoted authors in utilizing preliminary data in the quantitative travel time analyses presented in Section 6.4.2.3.5 of the draft EA.

Based on the fact that only 8 T estimates in Strait and Mercer (1984) relate to flow tops, a question remains regarding the origin of the quoted T statistics. We consider it likely that other sources may have been used. Stone, et al. (1984) contains 23 estimates of T obtained from the following units: Rocky Coulee flow top, Cohassett flow top and flow bottom, and the Umtanum flow top. Although this reference cites Strait and Mercer (1984) as its data source, less than half of the data in Stone, et al.(1984) are contained within Strait and Mercer (1984). With regard to obtaining a governing lognormal distribution for T it would have been logical to utilize data from Stone, et al. (1984). According to the authors, Table 1 of this reference contains "best" estimates of T based on the professional opinions of hydrologists who conducted the field tests. It also contains 9 more estimates of T for flow tops and bottoms than are found in Strait and Mercer (1984).

The NRC staff has recalculated the statistics for an assumed governing log-normal distribution of T, based on all data presented in Table 1 of Stone et al.(1984). T data from the Cohassett flow bottom were included because in the NRC's staff view, the basalt flow bottoms, insofar as they can be differentiated from underlying flow tops, equally represent viable flow and transport paths and they should be treated in the same manner as flow tops. The results are presented below:

$$\text{T geometric mean} = 0.27\ m^2/\text{day}$$
$$\text{Standard deviation of log T} = 1.44$$

The use of these statistical parameters to define the governing distribution for T would have decreased the median travel times in all of the draft EA's stochastic analyses of Section 6.4.2.3. In this regard it is also useful to calculate, assuming a log-normal distribution of T, the confidence interval for the geometric mean (median) of T. Based on the properties of the Student-t distribution, the limits of the 95% confidence interval for the median value of T are $6.3 \times 10^{-2}\ m^2$ /day and $1.1 \times 10^{0}\ m^2$ /day. In other words, it may reasonably be implied that the median ensemble T value, based on 23 samples, is known only within an uncertainty range that exceeds 1 order of magnitude. This uncertainty translates directly to calculated median ground-water travel times based on the T data. Of course, uncertainty in the calculated travel times is also derived from the other variables of effective thickness and hydraulic gradient.

The NRC staff recommends caution regarding the assumption that the distribution of the ensemble of flow top T values is the same as the distributions governing T within each candidate horizon flow top. This assumption would minimize the impact on calculated ground-water travel times of a more highly transmissive Grande Ronde flow top, and is thus non-conservative. Statistical tests used to evaluate differences among sample means and differences among variances, based on data from Stone, et al. (1984), fail to reject (alpha = 5%) the hypothesis that parameters governing the flow top T distributions are the same as those of the ensemble T distribution. From this it can only be stated that there is no evidence to conclude that significant differences exist among the means and among the variances. However, based on this, an assumption that these parameters are essentially the same will entail an unknown risk of Type II (Beta) error. It should be pointed out that when sample sizes are small, as in this case, differences among means and among variances must be very significant in order to reliably reject a null hypothesis of no difference. Also, the hypothesis testing procedure is based on the properties of a normal distribution and will be inappropriate if the log-transformed T values are not normally distributed.

The NRC staff suggests that the final EA should reexamine the data base used to derive the T statistics and determine if calculated parameters are truly representative of stated assumptions regarding an ensemble T distribution. It appears likely that other data sources besides Strait and Mercer (1984) were used to obtain the T statistics. These sources should be referenced in the final EA.

6-106

Section 6.4.2.3.5, Site subsystem performance, Page 6-266, paragraph 2

The draft EA notes that two of the three factors involved in the estimate of travel times, effective thickness, and regional hydraulic gradient, are either "difficult to determine accurately" or "uncertain." However, the uncertainty inherent in these two parameters is not in the discussion on page 6-268 and other places in the draft EA where output of the travel time stochastic models is presented.

6-107

Section 6.4.2.3.4, Repository seals, subsytem performance, Page 6-273/277 paragraph 1, 2, and 3/continuing paragraph-bullet 1

Radionuclide solubility and sorption values are for "expected" redox conditions The expected redox condition is considered to -0.30 volts and lower. The use of these expected condition predetermines that radionuclides will be in a less soluble more sorptive state (see detailed comment 6-28 and 6-33). Low solubility and high sorption values are apt to lead to low calculations of release.

6-108

Section 6.4.2.4.3, Performance of the site subsystem, page 6-278, paragraph 2

This analysis was performed using "expected conditons" (i.e. redox = -0.30 volts). It is premature to take credit for such low redox values (i.e. low solubility/high sorption). According to Early, et al. (1982) and other data concerning redox conditions in the Grande Ronde range from +0.35 volts to -0.4 volts. Many radionuclides are orders of magnitude less soluable as reduced species than they are as oxidized species. For example, Early, et al. (1982) calculated that uranium solubility at -0.40 volts has a concentration of 1.0E-10 mol/l, while at -0.0 volts it is around a concentration of 1.0E-5 mol/l (and becoming more soluble as redox conditions become more oxidizing). The use of redox conditions which predetermine that radionuclides will have low solubilities are apt to lead to low calculations of release.

6-109

Section 6.4.2.5, page 6-279, Human intrusion and disruptive events,page 6-281, Table 6-34, Early Failure Probability and Consequences

Early Failure Probability and Consequences: Table 6-34 lists the disruption scenarios that have been identified for further study. The consequences of some of these scenarios could contribute to waste package failures. However, they have not been included in the assessment of canister life (Section 6.4.2.3.3 and Figure 6-16 p. 6-244). The occurrence of items 13, 15, 16 and 17 could generate potential shearing of canisters from tectonic offset of joints and fractures. Item 38 relates to "premature failure or omission of waste package engineered system." Presumably, this could include waste package early failures resulting from flaws in the waste packages as manufactured.

Another scenario with possible adverse consequences in post-closure faulting as discussed in detailed comments 6-42 and 6-43, geologic evidence suggests the existence of a major fault zone, the Rattlesnake Wallula Alignment (RAW), adjacent to the southwest corner of the present repository location. The evidence further suggests that the zone is active and capable of a potentially large earthquake, which could involve substantial steeply-dipping fault offsets of the bedrock, including the repository horizon. According to page 2-41 of the draft EA, most of the serious effects from fault rupture occur within 8 km of the fault, which in this case would encompass about two-thirds of the present repository location. It would seem that such fault rupture could generate discrete offsets of pre-existing fractures, or faults within the reference repository location.

The consequences of a low probability early failure from any cause would be substantially greater than a "normal" failure. Therefore, early failure is an important consideration in waste package performance.

The final EA should consider the potential impact of premature credible failures: possible major faulting near the repository and the presence of undetected flaws in manufactured packages.

6-110

Section 6.4.2.6.2, Radionuclide release rate, page 285, paragraph 2

Preliminary performance results, which suggest that basalt has the capacity to isolate radionuclides are based on insufficient data and non-conservative assumptions. For example, based on inclusive theoretical calculations of redox conditions and, in the absence of data on the reducing capacity of the basalt/water system, it is assumed that radionuclides are released in their least soluble, most sorptive state (detailed comment 6-33). Performance assessments based on such assumptions are likely to lead to underestimates of radionuclide releases to the accessible environment. Thus, where data are insufficient for a conclusive evaluation of geochemical conditions and processes, a generally conservative approach to performance assessments should be taken and justified.

6-111

This comment was incorporated elsewhere in the comment package.

Chapter 6 References

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CHAPTER 7 COMMENTS

7-1

<u>Section 7.2.1.1, Geohydrology, Favorable conditions for geohydrology, page 7-5, last paragraph; and page 7-10, continuing paragraph</u>

It is stated that ground-water travel time calculations for the Hanford site are based on probability distributions for more than 50 known site-specific values of transmissivity. The paragraph then restates the ground-water travel times to the accessible environment which were calculated in Section 6.4.2.3.5. A reader of the draft EA could get the impression that these travel times are based on more than 50 transmissivity values. (Note, the travel times were calculated for basalt flow tops.)

The principal reference, Strait and Mercer (1984), discusses the transmissivity data base and is cited in the first paragraph of page 6-266. This reference contains 42 transmissivity range estimates. Of these, only 14 represent basalt flow tops or flow bottoms. Of the 14, only 3 data values were reported to have been verified by internal and/or external peer review (Strait and Mercer, 1984, page 8).

The stated number of 50 transmissivity values should be reconsidered so that the reader may know the actual number of values used in the travel time calculations. Also refer to detailed comment 6-105 which contains a preliminary review of the draft EA cited reference on the transmissivity data base.

7-2

<u>Section 7.2.1.1, Geohydrology, page 7-10, paragraph 1</u>

The travel times noted in the draft EA are the results of stochastic modeling discussed in Chapter 6. As noted in preceding detailed comments 6-11, 6-12, 6-15, 6-24, 6-101, 6-102, 6-103, and 6-105 there is reasonable doubt concerning the accuracy and applicability of the travel times presented in the draft EA.

Chapter 7 Reference

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