97-0002174

Department of Energy
Washington, DC 20585
June 30, 1997

The Honorable John T. Conway
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, N.W.
Suite 700
Washington, D.C. 20004

Dear Mr. Chairman:

Enclosed is a memorandum of acceptance and a compliance evaluation for the "Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds," WHC-SD-WM-TI-730, August 1996. Site completion and Headquarters review and action on this performance assessment is a deliverable pursuant to the commitment in Task Initiative VII.B.5.b.1 identified in the Department of Energy's (DOE's) Implementation Plan, Revision 1, for the Defense Nuclear Facilities Safety Board Recommendation 94-2.

The assessment evaluates the performance of the 200 East Area burial grounds relative to the low-level waste performance objectives contained in DOE Order 5820.2A. The Headquarters review found that, with conditions, the assessment is acceptable and provides a reasonable expectation of meeting the DOE 5820.2A performance objectives. This assessment is the first step in the process to complete an evaluation of projected impacts to the public and to issue a disposal authorization statement for the 200 East Area burial grounds.

In the past year, cesium contamination in the vadose zone beneath tank farms was found deeper than previously predicted. (Your staff has recently been briefed on the status of the tank farm vadose zone contamination issue.) The 200 East Area performance assessment treats cesium as relatively immobile based on studies of its behavior under conditions similar to those in the burial grounds, as opposed to the altered conditions that occur as a result of a tank leak. Through the performance assessment maintenance process, the Richland Operations Office Waste Management organization will continue to evaluate the significance of cesium mobility associated with tank leaks and its relevance to the performance assessment analysis of the burial grounds.

DOE has completed the actions for the 200 East Area Burial Ground performance assessment identified under this commitment and proposes that this part of the commitment be considered complete.

Sincerely,

Alvin L. Alm
Assistant Secretary for
Environmental Management

Enclosure

cc:
Mark Whitaker, S-3.1

Attachment

Compliance Evaluation of the "Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds," WHC-SD-WM-TI-730, August 15, 1996

1.0 Summary

The Office of Planning and Analysis (EM-35) concludes from its review of the "Performance Assessment for the Disposal of Low-Level Waste in the 200 East Area Burial Grounds," additional information provided by Hanford Site personnel after the performance assessment was submitted, and the Performance Assessment Peer Review Panel meeting minutes and report, that there is a reasonable expectation that the DOE Order 5820.2A low-level waste performance objectives will be met. The results are based on the assumptions, justified in the performance assessment, that the groundwater plumes from the two disposal facilities analyzed will not overlap and that the burial grounds will be closed as Category 3 facilities. Category 3 facilities will have a cover at least 5 m thick that limits infiltration to 0.5 cm/yr. The base case analysis results in the following calculated doses relative to the performance objectives:

- 0.02 mrem/yr and 0.009 mrem/yr all-pathways doses under Category 3 conditions for burial grounds 218-E-10 and 218-E-12B, respectively, versus a performance objective of 25 mrem/yr. Sensitivity/uncertainty analyses are conducted by identifying the modeling parameters to which the results are most sensitive and individually evaluating the impacts of using higher and lower input values than those used for the base case. For each of the parameters evaluated, the least conservative parameter value yields results that are lower than the performance objective.

- <0.0002 mrem/yr dose via the air pathway for either 218-E-10 or 218-E-12B for Category 3 conditions versus a performance objective of 10 mrem/yr. The maximum radon flux during the time of compliance is calculated to be 0.0002 $pCi/m^2/s$ versus a limit of 20 $pCi/m^2/s$.

- 0.02 mrem/yr and 0.00005 mrem/yr intruder doses from chronic exposure for 218-E-10 and 218-E-12B burial grounds (assuming Category 3 disposal conditions) respectively, versus an intruder performance objective of 100 mrem/yr. Doses from acute exposure are expected to be less, relative to their respective performance objectives, than those for chronic exposure. Therefore, the 500 mrem performance objective for acute exposure of an intruder will also be met.

- 0.02 mrem/yr and 0.008 mrem/yr doses via the drinking water pathway under Category 3 conditions for burial grounds 218-E-10 and 218-E-12B, respectively, versus an assumed performance measure of 4 mrem/yr from radionuclides migrating from the disposal facility through the groundwater. Sensitivity/ uncertainty analyses identify the modeling parameters to which the results are most sensitive, and individually evaluate the impacts of using higher and lower input values than those used for the base case. Because parameter values selected for the base case tend to be in the conservative end of their respective ranges (i.e., yielding the largest doses), the uncertainty analysis calculates a maximum impact of doubling the base case dose.

Sensitivity/uncertainty analyses show that the values of parameters used in the base case, and the results of the base case are in the conservative portions of their respective ranges. This supports the premise that the analyses are conservative and that the performance objectives can reasonably be expected to be met.

2.0 Performance Measures

This evaluation is developed in relation to the requirement in DOE Order 5820.2A, Chapter III, 3.b.(1), which states, "Field organizations with disposal sites shall prepare and maintain a site specific radiological performance assessment for the disposal of waste for the purpose of demonstrating compliance with the performance objectives stated in paragraph 3a." The Department has developed a document called the *Interim Format and Content Guide and Standard Review Plan for U.S. Department of Energy Low-Level Waste Disposal Facility Performance Assessments* (DOE, 1996a) that interprets how the performance objectives are to be applied.

2.1 Performance Objectives

Consistent with DOE 1996a, the following three performance objectives in DOE Order 5820.2A, Chapter III, paragraph 3.a are applicable to the evaluation of this performance assessment:

> Assure that external exposure to the waste and concentrations of radioactive material which may be released into surface water, ground water, soil, plants and animals results in an effective dose equivalent that does not exceed 25 mrem/yr to any member of the public. Release to the atmosphere shall meet the requirements of 40 CFR 61. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as reasonably achievable.

Assure that the committed effective dose equivalents received by individuals who inadvertently may intrude into the facility after the loss of active institutional control (100 years) will not exceed 100 mrem/yr for continuous exposure or 500 mrem for a single acute exposure.

Protect ground water resources, consistent with Federal, State and local requirements.

Consequently, the performance assessment is reviewed and evaluated primarily to determine whether it provides a reasonable expectation that the above-listed performance objectives will be met. The determination involves comparison of the results of a base case with the performance objectives and performance measures that have been developed to supplement or interpret the performance objectives (see Section 2.2). The sensitivity/uncertainty analyses are evaluated to ensure that the base case is reasonably conservative (i.e., the values of the parameters selected for the base case are generally in the conservative portion of the range of acceptable values and results of the base case analyses are generally in the upper range of results from the sensitivity/uncertainty analyses, but not necessarily at the highest end of the range). Also, the results of the sensitivity/uncertainty analyses, taken together, should indicate that there is a reasonable expectation that the performance objectives will not be exceeded (i.e., results of the sensitivity/uncertainty analyses lie below as well as above the base case).

In addition to this performance assessment, the Department has committed to preparing a composite analysis that evaluates the impacts of the other sources that add to the dose resulting from low-level waste disposal facilities. The Hanford Site is scheduled to complete a composite analysis which considers the effects of the 200 East Area Burial Grounds and other facilities on an offsite hypothetical member of the public (DOE, 1996b). That analysis is to be reviewed and approved by Headquarters prior to issuing a disposal authorization statement for the 200 East Area Burial Grounds.

2.2 Performance Objective Interpretation

This section interprets the application of the performance objectives in the evaluation of the Hanford 200 East Area Burial Grounds performance assessment. Each of the performance objectives will be discussed with respect to interpretation and how it is considered in the remainder of this compliance evaluation.

The first performance objective addresses three topics; exposure of a member of the public via all pathways, releases to the atmosphere, and maintaining releases to the environment as low as reasonably achievable. These will be referred to as performance measures in order to distinguish them from the verbatim performance objectives in DOE Order 5820.2A. They will be addressed separately in the disposal facility performance section (Section 4.0) of this compliance evaluation.

The first performance measure is for protection of a member of the public. In order to distinguish a "member of the public" from an intruder, the member of the public is assumed to reside outside the boundary of the land controlled by the government. In the Hanford 200 East Area Burial Ground performance assessment, a point of assessment has been selected that is 100 m from the disposal facility. This is conservative in that it is within the current and expected future site boundary; it is also consistent with the requirements in the draft revised DOE Order on radioactive waste management (DOE, 1997). The performance assessment is to provide a reasonable expectation of not exceeding the 25 mrem in a year dose limit for 1000 years following closure of the facility. Additionally, consistent with the draft DOE Order (DOE, 1997), the peak dose and time of occurrence are to be provided if the peak occurs after 1000 years. This compliance evaluation considers the peak calculated beyond 1000 years as a means of providing confidence in the conclusion regarding acceptability of the performance assessment. A peak dose exceeding the performance measure of 25 mrem/yr would result in additional constraints on waste operations only if it occurred very soon after the 1000 year time of compliance or was extremely large. Finally, in calculating the all-pathways dose, the contribution from radon and its progeny may be omitted. Control of radon is addressed in a subsequent performance measure.

Evaluation of exposure via the air pathway is to be in accordance with 40 CFR 61, the National Emission Standards for Hazardous Air Pollutants. These regulations establish a 10 mrem/yr limit for DOE sites and specifically exclude radon from the dose evaluation. Therefore, the air pathway dose analysis, and the all-pathways analysis, may omit radon. Instead radon is evaluated separately using the a ground surface flux limit from the Uranium Mill Tailings regulations as a surrogate limit for low-level waste disposal facilities. Acceptable limits for disposal or evolution of radon in the disposal facility are based on a flux limit of 20 $pCi/m^2/s$ at the ground surface. As with the all-pathways limit, the time of compliance for both elements of the air pathway performance measure is 1000 years. The point of compliance for the 10 mrem/yr dose limit is the same as for the all-pathways limit, 100 m from the disposal facility. The point of compliance for the radon flux is at the ground surface over the disposal facility.

For inadvertent intruder analyses, it is generally assumed that a hypothetical, temporary intrusion into the waste site could occur shortly after 100 years, the time of active institutional control in DOE Order 5820.2A. The time of intrusion is not to be assumed to occur beyond the 1000 years time of compliance. With an adequate justification, the time of intrusion can be extended beyond the default value of 100 years based on passive controls such as disposal system design or land use controls.

The reasonableness of intruder analyses is based on current DOE philosophy which places less emphasis on extensive intruder analyses because of the intent to maintain active institutional control of contaminated lands indefinitely. Instead, the focus is on selecting reasonable scenarios and reasonably conservative parameter values. Thus, although the 200 East Area Burial Ground performance assessment includes sensitivity/uncertainty analyses, they are not needed to assess compliance with the intruder performance objectives.

In this evaluation of the intruder analyses, doses to the intruder are assumed to come from external exposure to ingestion, and inhalation of material exhumed from the site. This may occur via a variety of pathways, but the analysis is not expected to include consumption of contaminated groundwater. The impacts of groundwater contamination are evaluated with respect to the all-pathways and groundwater protection performance objectives.

A tiered approach is used in determining compliance with the groundwater protection performance objective. The first tier is compliance with applicable federal, state, or local regulations for groundwater protection from the low-level waste disposal facility. The second tier is compliance with negotiated agreements. The final tier of the groundwater protection hierarchy is for a site to be consistent with its groundwater protection plan as developed under DOE Order 5400.1. Unless otherwise prohibited, the potential use of groundwater can be taken into account in evaluating compliance with a groundwater performance measure. As with the previous public exposure performance measures, the point of compliance is at 100 m from the disposal facility and the time of compliance is 1000 years.

3.0 Technical Adequacy Review

Headquarters staff concludes that the combined performance assessment and supplemental information provided in the Richland Operations Office (Teynor, 1997a and Teynor, 1997b) provide for a technically acceptable analysis of the long-term performance of the 200 East Area Burial Grounds. This conclusion is based on review of the information and the review and report of the DOE Low-Level Waste Performance Assessment Peer Review Panel (PRP).

At Headquarters request, the PRP performed a preliminary review of the 200 East Area Burial Ground performance assessment while it was in draft form. The PRP provided comments to be considered in finalizing the performance assessment. The preparers considered and responded to these comments. The resolution of the comments is addressed in Appendix G of the performance assessment.

Upon submittal of the current version of the performance assessment, Headquarters requested that the PRP conduct a review of the performance assessment for consistency and technical quality. Over the course of 4 months, the PRP completed its review. The PRP reported the results of its review in a letter to Headquarters (Wilhite, 1997c). In the course of its review, the PRP requested additional information and analyses from the Hanford Site personnel. The information was requested to resolve technical concerns raised by the panel regarding derivation of the existing and projected radionuclide inventory; the rationale and justification for analyzing the 218-E-10 and 218-E-12B burial grounds separately and for analyzing the submarine reactor compartment trench separately from the rest of the 218-E-12B burial ground; the screening of radionuclides to be included in the detailed analysis; and the potential for and impacts of subsidence. Two information supplements (Teynor, 1997a and Teynor, 1997b) were provided in

response to these requests and constitute part of the basis for the PRP's finding that the performance assessment is technically adequate.

The PRP recommended that, "if utilization of the 200 East Area burial grounds increases, or is projected to increase, to exceed the radionuclide inventory analyzed in the performance assessment, then the performance assessment should be revised, as part of the performance assessment maintenance program, to include the increased inventory. The revision must consider the uncertainty in the inventory, both in the past disposals and in projected disposals, to ensure that adequate waste acceptance criteria are developed."

4.0 Disposal Facility Performance

Disposal facility performance relative to the performance objectives is discussed below. An abbreviated restatement of the performance measures is given in italics. These correspond to the performance measures discussed in Section 2.2.

The disposal facilities addressed by this performance assessment are two burial grounds 218-E-10 and 218-E-12B, in the 200 East Area of the Hanford Site. The burial grounds consist principally of trenches running north and south. In addition, there is a large burial pit used exclusively for the disposal of reactor compartments from submarines being decommissioned by the U.S. Navy.

There are a number of features worth noting about the approach taken by Hanford Site personnel in developing the performance assessment. A "base case" was established using a set of reasonably conservative parameters. This is opposed to a "best case" that would employ a set of parameters that are judged to be most likely to occur. A number of different parameter sets are analyzed to determine their effects on the results. By evaluating the assumptions and results of the base case, the other cases analyzed, or both, a conclusion can be drawn regarding a reasonable expectation that the performance objectives will be met.

Another feature of the Hanford 200 East Area Burial Grounds performance assessment is that unit factors (either concentration or quantity) were used in the initial analyses in conjunction with an assumed trench section. This allows the results of the initial analyses to be scaled based on disposal trench dimensions and performance objectives to arrive at waste acceptance limits for the various radionuclides. The performance assessment notes that acceptable radionuclide concentration and total inventory limits are employed to ensure that performance objectives will not be exceeded. In the final analysis, the site used projected waste volumes and radionuclide inventories to compare to the performance objectives of the order. The performance assessment describes Hanford 200 East Area burial ground disposal operations and expected waste receipts in Sections 2.3 and 2.5.

Acceptance of the following results is predicated on technically valid analyses having been performed. As noted in Section 3.0, it is the conclusion of this review that a technically valid analysis has been performed.

4.1 *Dose to a member of the public to be less than 25 mrem in a year.*

In addition to the all-pathways performance measure of 25 mrem in a year, the performance assessment also includes evaluation of the drinking water only pathway with a performance measure of 4 mrem in a year. Based on the analyses in the performance assessment and supplemental material, there is a reasonable expectation that the dose limit of 25 mrem in a year via all pathways, and the self-imposed performance measure of 4 mrem in a year through the drinking water pathway alone, will be met. This conclusion is based on the assumption that the burial grounds will be closed as Category 3 facilities, i.e., will have a 5 m thick cover above the waste that limits infiltration to no more than 0.5 cm/yr.

In the performance assessment, the two burial grounds (218-E-10 and 218-E-12B) are analyzed separately. Separate analyses of the burial grounds is justified by the future expected groundwater flow patterns. Data from pre-Hanford groundwater well measurements and modeling indicate that when the effects of large volumes of liquid waste disposed on the 200 Area plateau dissipate, the hydraulic gradient will be small and the flow paths from the burial grounds will not overlap.

A single pit in the 218-E-12B burial ground, used exclusively for the disposal of Navy submarine reactor compartments, is analyzed separately from the rest of the burial ground. This is justified based on the uniformity of waste type, the single release mechanism assumed (corrosion-controlled), the timing of the release, and the fact that the deeper disposal cell has a shorter travel distance to the water table.

The analysis implies that the groundwater will be the dominant means of potential exposure to an offsite member of the public. This is based on analyses showing that the potential impacts from radionuclides transported to the surface by vapor or liquid diffusion, or capillary action are inconsequential. The point of exposure is assumed to be at a point 100 meters down-gradient of the edge of the burial ground.

In the all-pathways analysis, it is assumed that groundwater is drawn from a well and used for drinking (730 L/yr), watering crops, and watering livestock. Dose results from external exposure, ingestion and inhalation. In the drinking water-only analysis the only dose considered comes from consumption of the contaminated groundwater. In both scenarios, there is no credit taken for groundwater dilution resulting from drawing in uncontaminated water when groundwater is pumped to the surface.

In the base case, the infiltration rate for waste disposed of as Category 1 was assumed to be 5 cm/yr. For waste disposed of as Category 3, which has a cover system that is more effective at recycling moisture back to the atmosphere, the infiltration rate is assumed to be 0.5 cm/yr. Both of these infiltration rates are considered to be at the high end of the ranges of infiltration expected for the Category 1 and Category 3 conditions.

In evaluating the groundwater pathway, the analysts used a screening process to show that many radionuclides would not result in significant doses through the groundwater pathway. Radionuclides were eliminated due to their short half-life, the long travel time to the point of compliance due to their immobility in Hanford soils, or a combination of both factors. Therefore, the focus of the groundwater analysis is on a reasonably small set of mobile nuclides, most with long half-lives. The mobile nuclides that were analyzed in detail and limited by the concentration in the groundwater were H-3, C-14, Cl-36, Se-79, Tc-99, I-129, Re-187, and uranium. In the supplemental information provided in response to questions from the Peer Review Panel, Mo-93 was also identified as a mobile radionuclide that should also be considered relative to groundwater-controlled inventory limits. Based on the assumption of a distribution coefficient of 0 and a dose conversion factor equal to that of Tc-99, it was concluded in this evaluation that the impacts of Mo-93 would likely be acceptable (see Section 5.0).

The total inventory limits established for the burial grounds are based on the drinking water only pathway. This is acceptable and defensible for all of the mobile nuclides except Cl-36. With the exception of Cl-36, the drinking water pathway is more limiting, relative to its performance measure, than exposure via all pathways. For Cl-36, the exposure through all pathways is calculated to be more limiting so should be the basis for the Cl-36 limit (see Section 5.0).

With two exceptions, the base case analysis and the basis for establishing inventory limits assumes that radionuclide release from the waste is advection controlled, i.e., that all of the inventory is immediately available for transport. The exceptions are the release and transport of uranium and the radionuclides in the reactor compartments which are concentration controlled by either solubility limits or corrosion rates.

Sensitivity analyses were conducted to determine which parameters most affected the release of radionuclides from the disposal facility, transport through the vadose zone, and affect the concentration in the groundwater at the receptor well. These include:

- response to changes in infiltration rate;
- effect of sorption on time and magnitude of peak groundwater concentration;
- influence of varying soil stratigraphy;

- the presence of clastic dikes (representing a potentially preferential flow path in the vadose zone);

- the impacts of packages with higher concentrations of radionuclides than is assumed as average in the trench;

- impacts of the dimension of the trench parallel to the direction of groundwater flow; and

- the effects of pumping which dilutes the concentration of radionuclides by drawing in more clean water.

The uncertainty analysis focused on those factors which had the potential of affecting the conclusions drawn from the base case analyses. In the following discussion, it should be recognized that impacts on peak concentration would result in proportional impacts to calculated doses. The factors and the uncertainty analyses are summarized as follows:

- the length of the trench section parallel to the direction of groundwater flow is taken as 20 m in the analysis. The effect of this assumed dimension was evaluated by doubling and quadrupling the length. For advection-controlled release, each doubling of the trench length resulted in a 5% decrease in peak concentration.

- the infiltration rates of 5 and 0.5 cm/yr for Category 1 and Category 3 disposal configurations are considered the maximum for the corresponding cover conditions. The decrease from 5 to 0.5 cm/yr results in a decrease in the peak groundwater concentration by a factor of 4. Site experimental data indicate that the actual infiltration rates are closer to 1.0 and 0.1 cm/yr for Category 1 and Category 3 conditions, respectively. If the lower infiltration rates are assumed, the analysts conclude that there would be a corresponding reduction in peak groundwater concentrations by a factor of 2.

- saturated hydraulic conductivity values used in the performance assessment were below the range of values measured around the two burial grounds. If a value for the hydraulic conductivity equal to the greatest reported for the 200 East Area is used, the peak concentration drops by a factor of 5 and 1.5 for 218-E-10 and 218-E-12B, respectively.

- effects of an increase in hydraulic gradient is evaluated because the assumed post-Hanford conditions are for a fairly flat water table. The hydraulic gradient could be increased by irrigation or increased precipitation. The effect of an increased hydraulic gradient is to add to the amount of water in which radionuclides are mixed, so it is expected that there would be no increase in groundwater concentration;

- uranium is the only nuclide whose release was considered to be solubility controlled. Considering the variability in uranium solubility and other factors affecting the peak groundwater concentration, the bounds on peak concentration are calculated to be a factor of 2 higher to a factor of 30 lower relative to the base case.

- a review of the method of deriving inventory estimates from radiation readings of a major contributor to the existing waste inventory revealed some potentially nonconservative assumptions. A different assumption regarding location of the radiation source in the waste package was evaluated. The analysis showed a potential increase in estimated inventory of 10%. It was assumed that a different assumption regarding the effects of shielding might increase the estimate by another 10% for a total increase of in estimated inventory of 20%.

The estimated doses for the two performance measures are presented in the following table. These estimates are based on the projected inventories to be received in the burial grounds which assume that the waste characteristics will be the same as those of waste received since 1989. The doses are calculated assuming the burial grounds would be closed as Category 3 facilities. The following estimates include no contribution from the Navy's submarine reactor compartment disposal since release from these waste packages is not expected to occur in the 1000 year time of compliance. Ignoring the time of occurrence, the peak dose calculated for the buried reactor compartments is 0.0005 mrem/yr.

Performance Measure*	**218-E-10** Estimated Dose (assuming Category 3 conditions)	**218-E-12B** Estimated Dose (assuming Category 3 conditions)
All-pathways (25 mrem in a year)	0.02 mrem/yr	0.009 mrem/yr
Drinking water (4 mrem in a year)	0.02 mrem/yr	0.008 mrem/yr
* The first performance measures is a performance objective directly from DOE Order 5820.2A. The second performance measure was self-imposed by the site to evaluate the groundwater pathway.		

The analysts included an evaluation of the potential for increased doses beyond the 1000 year time of compliance. For the above performance measures, the maximum calculated impact occurs during the time of compliance.

4.2 *Dose via the air pathway to comply with 40 CFR 61; radon flux to be less than 20 pCi/m^2/s*

Based on the analyses in the performance assessment and supplemental information, there is a reasonable expectation that the doses to an offsite member of the public via the air pathway will be far below the limits of 40 CFR 61, that is, 10 mrem/yr exclusive of doses from radon. There is also a reasonable expectation that the burial grounds will meet the 20 pCi/m^2/s flux limit performance measure selected to evaluate radon emanation.

For the air pathway, performance is evaluated against 10 mrem/yr for H-3 and C-14, two radionuclides which can become available through vapor diffusion to the ground surface. The other scenarios for migration of these nuclides to a receptor were found to be more limiting than the air pathway and form the basis for establishing waste acceptance and inventory limits. The inventories of H-3 and C-14 projected to be in the waste result in the air pathway being a negligible contributor to an offsite receptor.

The emanation of radon from the disposal system is compared to a flux rate of 20 pCi/m^2/s. This limit, used in the uranium mill tailings program, is accepted as a surrogate limit for low-level waste disposal facilities. Radon will evolve from certain uranium decay chain isotopes. Based on the analysis, it is not necessary for limits established for the parent isotopes as a result of other pathways analyzed to be further constrained by the radon limit.

In the performance assessment, the radionuclide concentration and mix received at the 200 East Area Burial Grounds since 1989 were extrapolated over the projected waste to be received from PUREX, B-Plant, and the tank farms. The calculated results for the base case conditions are shown in the following table. No radon flux is projected for the 218-E-10 burial ground because there are no projected disposals of uranium waste in the burial ground. These results are projected to occur within the 1000-year time of compliance.

Performance Measure*	**218-E-10** Estimated Dose (assuming Category 3 conditions)	**218-E-12B** Estimated Dose (assuming Category 3 conditions)
Air pathway (10 mrem in a year)	<0.0005 mrem/y	<0.0002 mrem/y
Radon emission (20 $pCi/m^2/s$)	0 $pCi/m^2/s$	0.0002 $pCi/m^2/s$
* The first performance measure is a performance objective directly from DOE Order 5820.2A. The second performance measure is used in this review for radon emission.		

The analysts included an evaluation of the potential for increased doses beyond the 1000 year time of compliance. For the above performance measures, the maximum calculated impacts are less than the performance measures. The air dose impact is assumed to be able to occur at any time. The maximum radon flux of 0.12 $pCi/m^2/s$ is calculated to occur at 1 million years.

4.3 ***Dose to intruder to be less than 100 mrem in a year for chronic exposure. Dose to intruder to be less than 500 mrem for an acute exposure.***

Based on the analyses in the performance assessment there is a reasonable expectation that the dose limits of 100 mrem in a year from chronic exposure of a hypothetical intruder and 500 mrem from an acute exposure of an intruder will not be exceeded. Consistent with the guidance to evaluate a reasonable set of intruder scenarios, the performance assessment represents consideration of five scenarios. These include acute exposure from excavation for a basement, chronic exposure from residing and gardening following basement excavation, acute exposure from drilling a well, chronic exposure from residing and gardening following well drilling, and consuming crops whose roots penetrate the waste material. Based on other work (reference section 3.1.1), two of the

scenarios were selected for analysis because they are calculated to result in the most significant hypothetical doses. The scenarios selected were resident gardening scenarios following excavation to build a house and following the drilling of a well. Recognizing DOE's intent to control the land on which low-level waste is buried as long as the waste remains dangerous, these scenarios are considered to be extremely conservative and unlikely. Relative to their respective performance measures, the two chronic exposure scenarios are calculated to result in greater doses to the hypothetical intruder than any of the acute exposure scenarios considered, so compliance with the acute exposure limit can be assumed if the chronic exposure limits are met.

The concentration of radionuclides in the garden soil is a function of the amount of waste exhumed, the depth of mixing of this waste with the surface soil, and the garden size. In the excavation-resident garden scenario, an area 900 ft^2 is assumed to be excavated to a depth of about 10 ft. In the well drilling-resident garden scenario, it is assumed that a 1 ft diameter well is drilled, i.e., large enough to supply irrigation water. The exhumed waste is assumed to be mixed with six inches of soil in both scenarios. The garden size over which the exhumed waste materials are distributed is 2500 m^2, or about a half acre. Although this seems quite large, it appears to be consistent with the assumption that 25% of the hypothetical intruder's vegetables and fruit come from the garden.

The exposure pathways considered for the intruder are external exposure, inhalation of contamination, and ingestion of contaminated food matter and some amount of soil. Consistent with DOE performance assessment practice, consumption of water was not considered one of the exposure pathways for the intruder. Evaluation of contaminants in the groundwater is adequately addressed in the dose analysis for the member of the public via all-pathways and the drinking water pathway.

The intruder analysis considered a very large set of radionuclides with half-lives greater than 5 years. The performance assessment preparers consider it implausible that nuclides with half-lives less than 5 years would be present in sufficient quantity that a reduction in inventory of about a million-fold that occurs during the assumed 100 years of active control would leave enough of the nuclide to be significant to an intruder evaluation.[1]

Doses were calculated for three different times of intrusion: 100, 300, and 500 years after closure. The analysts note that for radionuclides with half-lives less than thirty years that the differences in dose affected by the time of intrusion is an order of magnitude or greater. For nuclides with half-lives greater than 100 years, there is an insignificant difference in the dose as a function of time of intrusion. The DOE Order

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[1] The one exception to not considering radionuclides with half-lives less than 5 years in PA-derived waste acceptance criteria (WAC) development is curium-242. This nuclide has a specified limit in 10 CFR 61 which is adopted in the Hanford burial ground waste acceptance criteria.

5820.2A allows analysts to assume that active institutional control will be maintained over a disposal site for 100 years. In the performance assessment, the analyst further assumes that passive controls will prevent an intruder from drilling a well for an additional 400 years. This extended time for intrusion is based on the assumption that the facilities will be covered by a minimum of 5 m of soil, the use of markers, and land control records. Due to the depth of burial, intrusion from excavation and root intrusion is effectively excluded.

The analyses were carried out assuming a 1 Ci/m^3 initial concentration. The results can then be scaled to allow direct comparison with the performance measures. In conducting sensitivity analyses, it is noted that certain parameters are important to certain radionuclides, principally because there is a dominant pathway by which the intruder is exposed, i.e., inhalation is dominant for one radionuclide while ingestion is dominant for another. All radionuclides are sensitive to the initial concentration of radionuclides in the soil which is a function of the amount of waste exhumed, mixing depth, area of distribution, and amount of leaching. All of the concentration limits were based on the assumption that no leaching occurs.

Since DOE will control the land where the 200 East Area Burial Grounds are located, an inadvertent intruder is an unlikely event that would occur for only a short period of time. The scenarios and parameters selected are considered adequate for concluding that there is a reasonable expectation of meeting the performance measures. The performance assessment presents sensitivity/uncertainty analyses of various parameters used. However, these analyses are not used in making a determination of compliance. The analyses showed that using more conservative values for all of the parameters considered could increase doses about 10 times.

The performance assessment presents an additional analysis for consideration relative to the intruder. Due to the ingrowth of radioactive daughter products of long-lived radionuclides (e.g., uranium isotopes) the dose to an intruder in the distant future can be greater than during the prescribed time of compliance. The performance assessment shows that in the calculated dose at 190,000 years is still less than the intruder dose limit in DOE Order 5820.2A.

Doses to an inadvertent intruder are calculated based on current inventory and waste receipts projected to be received from PUREX, B-Plant, and tank farms. The resulting doses relative to the performance measures are shown below:

Performance Measure	**218-E-10** Estimated Dose (assuming Category 3 conditions)	**218-E-12B** Estimated Dose (assuming Category 3 conditions)
100 mrem/yr chronic exposure	0.02 mrem/yr	0.00005 mrem/yr
500 mrem acute exposure	less than the chronic exposure (see p 3-2)	less than the chronic exposure (see p 3-2)

The principal nuclides responsible for the calculated intruder doses are Sr-90 and Cs-137 and their daughters.

Due to the hardness of the submarine reactor compartments, it is unlikely that an intruder would be able to drill through the compartment and bring material to the surface. However, a dose of 0.7 mrem/yr, primarily from Ni-63, is calculated for such a scenario.

The maximum impact to an intruder from isotopes other than uranium daughters would occur prior to the 1000 years time of compliance. A maximum impact to an intruder from radon would occur at 190,000 years. In both cases the maximum impact is less than the performance measure.

4.4 *Protect groundwater.*

There is a reasonable expectation that the groundwater at the Hanford Site will be protected because the projected dose to an offsite member of the public through the drinking water pathway is well below 4 mrem/yr as discussed in Section 4.1 above.

The Department has established a tiered protocol for determining compliance with the groundwater protection performance objective as discussed in Section 2.2. There are currently no applicable Federal regulations addressing protection of the groundwater from low-level waste disposal facilities. The Richland Operations Office's position is that DOE, rather than the State, has the authority and responsibility to regulate Atomic Energy Act materials. Therefore, there are no applicable state or local regulations. Richland Operations Office personnel confirm that there are no agreements (e.g., Tri-Party Agreement, 216 discharge agreement) that are applicable to the subject of groundwater protection as it relates to low-level waste disposal.

Therefore, compliance with the performance objective defaults to the last tier of the groundwater protection protocol, that is for sites to be consistent with their groundwater protection plan as developed under Order DOE 5400.1. The Richland Operations Office

has issued a *Hanford Site Ground Water Protection Management Plan,* (DOE-RL, 1995a) and a *Hanford Site Ground Water Remediation Strategy,* (DOE-RL, 1995b). These plans do not explicitly address radionuclide limits for groundwater protection from low-level waste disposal facilities. Richland Operations Office plans on revising these documents in 1997 and will include a discussion of solid waste sources.

The *Hanford Site Ground Water Remediation Strategy* states that a key element of the strategy is to "(c)ontrol the migration of plumes that threaten or continue to further degrade ground water quality beyond the boundaries of the Central Plateau" [where the 200 East Area is located]. Establishing a future boundary around the Central Plateau is consistent with the recommendations of the Hanford Future Sites Working Group, an ad hoc group of local stakeholders. In conducting the analysis of projected future waste receipts versus a 4 mrem/yr dose limit as discussed in 4.1 above, it is the conclusion of this evaluation that the performance assessment has shown that there is a reasonable expectation that groundwater will be protected. This conclusion is based on the self-imposed performance measure of 4 mrem/yr being a reasonable surrogate in lieu of specific limits being provided in the *Hanford Site Ground Water Protection Management Plan* plus a recognition that additional attenuation will occur between the performance assessment-established point of compliance (100 m from the edge of the burial ground) and a future boundary around the Hanford Central Plateau (10 to 15 km away).

In reaching this conclusion, it is recognized that the cleanup limits in the *Hanford Site Ground Water Protection Management Plan* are based on the Title 40 Code of Federal Regulations Part 141, "National Primary Drinking Water Regulations" drinking water standards and that they differ from the values used in the performance assessment. The relationship of these two sets of concentration limits was evaluated previously in the performance assessment for the disposal of low-level waste in the 200 West *Area Burial Grounds.* Both the current drinking water standards in the *Hanford Site Ground Water Protection Management Plan* and the concentration limits used in the performance assessment are based on a dose limit of 4 mrem/yr. However, because the performance assessments use a more current dose assessment methodology, the specific concentration limits are different. Although the projected groundwater concentration of I-129 (1.93 pCi/l) in the 200 West Area performance assessment exceeds the current drinking water standard limit (1 pCi/l), there are a number of reasons that this is not considered a concern. First, the Environmental Protection Agency proposed a revision to the drinking water standards that was based on the more current dose methodology. Under the revised dose methodology, the I-129 concentration limit would be 20 pCi/l. Second, the analyses that result in the projected concentration are believed to be conservative on a number of accounts. The inventory estimates for I-129 are believed to be high because they do not account for losses due to the volatility of iodine. Release of the iodine from the waste is also assumed to occur all at one time rather than being spread over time. The transport analysis is also conservative in assuming that the distribution coefficient for iodine in soil is 0, i.e., that the iodine isotopes move with water through the vadose zone and are not retarded by chemical interactions with the soil. The performance assessment analysts

have laboratory sorption data that suggest the distribution coefficient of iodine may be greater than 1 ml/g. This would result in the concentration being reduced by a factor of 15. Lastly, as noted above, there will be additional dilution prior to the groundwater reaching the boundary at which the drinking water standards would be applied.

4.5 *Reasonable effort to maintain doses as low as reasonably achievable.*

Due to the conservatism used in the performance assessment analysis, the very low projected doses relative to the performance measures, and the commitment to employ enhanced waste forms for future receipts of Category 3 uranium wastes, it is the conclusion of this compliance evaluation that projected doses are as low as reasonably achievable.

5.0 Conditions for Acceptance

The following conditions on the operation of the 200 East Area Burial Grounds are established based on the Headquarters review of the performance assessment:

1. In order to ensure that conditions at the burial ground are consistent with the performance assessment analyses, Hanford must maintain a waste receipt and tracking system. The system shall ensure that specific approval is required before accepting and disposing of waste that exceeds the concentration limits established through the performance assessment in order to ensure that the average concentration of radionuclides is maintained below the limits. It shall also enable routine evaluations to determine that the total activity limits for the burial grounds are not exceeded.

2. The Cl-36 limits shall be established based on the technical analysis in the performance assessment. The performance assessment shows that the drinking water pathway is the most constraining for all long-lived, mobile radionuclides except Cl-36. Therefore, the total activity limits are based on the drinking water analysis. In the case of Cl-36, the all-pathways analysis is the more constraining. It is suggested in the performance assessment that the Cl-36 limits also be based on the groundwater pathway for purposes of consistency. This suggestion is rejected and the inventory limits, and any waste acceptance limits derived from the inventory limits, for Cl-36 are to be changed to be consistent with the technical analysis.

3. The burial grounds are to be closed as Category 3 facilities unless the Richland Operations Office submits and gains approval of other analyses. In performing the calculations to compare with the performance measures, the analysts assumed Category 3 conditions because most of the waste currently disposed, and by extension, that projected to be disposed, is Category 3 waste. Therefore, the conclusions of the performance assessment and this compliance evaluation are based on Category 3 conditions only. An alternate disposal configuration would have to supported by an analysis that provides a reasonable expectation of meeting the performance measures for alternate closure conditions.

4. The performance assessment maintenance program must include continued evaluation of the assumption that intrusion would not occur in a Category 3 facility for at least 500 years. The performance assessment assumes that an inadvertent intruder would not drill a well through a Category 3 facility for at least 500 years. This assumption is consistent with the current expectation that the Central Plateau will be controlled due to radiological hazards indefinitely. Although the Richland Operations Office has a recommendation from the Hanford Future Site Uses Working Group that supports the use of the Central Plateau for consolidation of radioactive contamination as the Hanford Site is remediated, there is not a published site land use plan that commits the Central Plateau indefinitely. As part of the performance assessment maintenance program, the developments in land use planning need to be considered and assumptions regarding access to the site need to be revised if necessary to be consistent with the land use plans. To the extent that it demonstrates defense in depth, the site should include analysis and discussion of the performance of stabilized Category 3 waste forms in deterring intrusion as part of the maintenance program.

5. Limits for Mo-93 need to be developed and provided. Molybdenum-93 was identified as a long-lived, mobile radionuclide in the first supplement of information (Teynor, 1997a). However, it was not included in the list of radionuclides evaluated for impacts via the groundwater pathway. Waste receipt and inventory limits for this nuclide must be developed as was done for other long-lived, mobile radionuclides.

6. The Richland Operations Office shall complete and document a review of the adequacy of waste characterization relative to the data needs of the 200 East Area Burial Grounds performance assessment. The reliability and accuracy of waste characterization data was an item of concern raised during the review of the performance assessment.

7. An addendum or revision to the performance assessment is to be issued within 6 months to capture information developed in the supplements and to address conditions 2, 5, and 6 above. In developing this addendum, an explanation or interpretation of the significance of the revised submarine reactor compartment inventory on the analysis and conclusions of the performance assessment must be included.

6.0 References

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Confirmed: _____

Date: 6/16/97