A Review and Comparison of Low-Level Radioactive Waste Disposal Facilities

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With: <u>Analysis of USDOE's "Performance Assessments" for Low-Level Radioactive Waste Burial Grounds</u>
by Gerald Pollet, JD; Executive Director, Heart of America Northwest**, appended**

Draft for Review

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1.0 Introduction

1.1 Background

In 2002, the Department of Energy (DOE) released the draft Hanford Solid Waste Environmental Impact Statement (DOE 2002). That draft called for the disposal of over 12 million cubic feet of low-level radioactive waste (LLRW) at Hanford in unlined near-surface disposal trenches. The draft EIS was withdrawn by USDOE following public comment, as urged by numerous official agency, advisory board and public commentators. In April, 2003, USDOE issued the Revised Draft Hanford Solid Waste EIS, which forecast that USDOE would dispose of up to 12.3 million cubic feet of LLRW in near-surface burial trenches.[1]Sixty three percent (63%) of this LLRW would be imported to Hanford for burial. At an undefined future date, the Revised Draft EIS proposed that LLRW would be buried together in new trenches with up to 5 million cubic feet of Mixed Low-Level Waste, which is Low-Level Radioactive Waste mixed with hazardous chemical wastes.[2] To develop a technical position on the proposal for use of Hanford newr-surface burial for Low-Level Wastes, Heart of America NW wanted to know if the Low-Level Radioactive Waste Burial Grounds meet the basic engineering requirements for such facilities and how they compare with other similar facilities and alternative potential disposal sites available to USDOE for these wastes. As such, ***this report represents the first independent, publicly available Cross-Site Comparison of USDOE Low-Level Radioactive Waste Burial Ground Alternatives.***

Performing a complete engineering review of multiple facilities was clearly beyond the potential budget capacity so a proposal was proffered to limit the investigation to the geotechnical aspects of representative LLRW disposal facilities. This type of focused review was accomplished by visiting the sites and reviewing documentation on the sites. Performance standards and review criteria were identified and the disposal facilities were evaluated to determine how well they meet the performance standards. This is the basis for a comparison of the facilities.

This report presents the results of this study.

This work was funded under grant number MTA-03-002 from the Citizens' Monitoring and Technical Assessment (MTA) fund that is managed and administered by RESOLVE, Inc. This fund was created as a part of a 1998 court settlement between the U.S. Department of Energy and 39 non-profit peace and environmental groups around the country (Joint Stipulation and Court Order, Civil Action No. 89-1835 (SS)(AK) dated December 12, 1998, U.S. District Court for the District of Columbia). The purpose of the fund is to provide monies to eligible organizations to procure technical and scientific assistance to perform technical and scientific reviews and analyses of environmental management activities at DOE sites and to disseminate those reviews and analyses.

[1] Revised Draft Hanford Solid Waste EIS, USDOE, 2003 (DOE, 2003) Table 3.3, Page 3.19. Note: USDO, in the EIS, reports figures in cubic meters, although most USDOE documents, analyses and other comparisons – including those that the public is used to – utilize cubic feet. To get cubic feet from cubic meters, multiply by 35.3.
[2] DOE, 2003, Table 3.4, page 3.20.

1.2 Purpose and Scope

The general objective of this study is to develop an understanding of the basic engineering components of some LLRW facilities and to evaluate the facilities as to how well they meet the requirement and standards. The standards used for this study are loosely adopted from Nuclear Regulatory Commission (NRC) and DOE requirements.

The intent of the review is to explain the characteristics of several LLRW disposal facilities and show how at each facility, they have solved the inherent long-term and short-term waste isolation problems using a combination of natural features and landfill design functions.

The original scope of this study was to review and compare only the DOE low-level radioactive waste facilities. However, it was decided to include the DOE's mixed waste Environmental Restoration Disposal Facility (ERDF) because the ERDF represents current DOE technology and construction at Hanford and there are minimal appreciable differences between the LLRW and the mixed waste facilities from an engineering or waste isolation standpoint. Also, access to the DOE LLRW site at Nevada Test Site was not possible due to increased security at that facility.

As a result of the changes, this study was limited to a review of the following four facilities[3]:

1. Envirocare of Utah site near Clive, UT (mixed and low-level);
2. USDOE Environmental Restoration Disposal Facility (mixed and low-level) at Hanford, WA ("ERDF");
3. US Ecology: Northwest Interstate Compact LLW Disposal Facility located on land leased by the State of WA at Hanford, and operated by US Ecology, Inc.;
4. USDOE's low level waste facilities at Hanford ("Low-Level Burial Grounds", or, "LLBGs").

1.3 Approach

The approach to conducting this study and the principal review criteria, were taken from work performed by the U.S Army Waterways Experiment Station (WES) for the Nuclear Regulatory Commission (NRC). The WES prepared a series of documents where they developed the review criteria and procedures and then performed a review of several alternative methods of disposal of LLRW (see USACE 1984, 1987, 1988). These were alternatives to near surface land burial disposal. In that work, the WES showed how to perform the reviews of the LLRW disposal facilities and how to evaluate the facilities relative to the performance requirements or standards. This work by the WES eventually became review plans for the NRC to perform reviews of license applications.

The WES approach for a technical review of a LLRW facility is adopted for this report with some differences. Unlike the WES study, an attempt is made to limit the review to the geotechnical aspects of the facilities. And, because the budget and personnel to perform this review are limited, the focus of this review is clearly limited by one person's ability to obtain,

[3] The Performance Assessment for the Nevada Test Site Low-Level Burial Grounds was reviewed by Gerald Pollet in regard to evaluation of the standards utilized. This documentation took a year to obtain from the Nevada Test Site.

assemble, analyze and report a lot of information, making this review significantly less comprehensive than the WES reviews.

Section 2 of this report identifies the review criteria and the basic requirements or standards which the facilities must meet or satisfy through facility design. Only those requirements listed in Section 2 are considered in this review. Specific review criteria or subject areas for this review are listed and explained. These review criteria are adopted from NRC criteria in an attempt to make this review similar an NRC license application review.

With the requirements and review criteria established, descriptions of the four facilities are provided in sections 3 through 6. Again, emphasis in these sections is on the requirements and facility components that are directly related to the geotechnical aspects of the facility. Details of such things as facility waste acceptance criteria are only considered if they are determined to be a critical factor for meeting the site performance requirements.

Section 7 provides evaluations of the facilities where each review criteria is considered to determine if the facility meets the performance requirements. Evaluations of the criteria use engineering experience and practice to determine if the disposal facility component provides reasonable assurance for meeting the performance standard for the disposal system.

Section 8 is the comparison of the facilities according to the review criteria. This comparison is not a comparison of disposal sites as potential alternatives. Rather it is a comparison of disposal systems to show what is good and bad about each facility relative to each other and to the requirements. This cannot be taken as a basis for a recommendation to develop alternatives for consideration in an EIS for instance.

The comparison is not rigorous or numerically based as that type of an approach to this study was not permitted by budget constraints. The comparison is also not as comprehensive as the subject matter considered by the WES or the NRC for formal evaluation of license applications. Instead, this is a more general explanation of the differences in the features of each landfill with reference or general comparison to current landfill technology.

This approach of reviewing each facility and then comparing the different features is used to educate the readers about the different LLRW disposal facilities, touching on the critical aspects of the facility designs, and to inform the reader of potential risks at each facility. The comparison hopefully shows where potential operational or design improvements could be achieved at each facility or why such improvements may or may not be needed. In this manner, this report is intended to provide the reader with the technical basis for preparing informative comments on DOE plans and operations.

The information provided in this document does not get into extensive detail about specific features of a particular landfill such as a detailed assessment of a contaminant transport model or specific design parameters. However, it does include a fairly extensive bibliography for each waste site to which a reader is referred for more comprehensive details.

Limitations of the report result from the fact that the study was conducted by a single author with the content biased by the author's limitations. It is extremely difficult to capture all pertinent details of a facility with the very limited time frame, budget and personnel.

Although this report may not meet all of the client's honorably grand expectations, it should give the reader a good primer on the specific landfill technology and provide a means to gauge the differences in the landfills.

Any real or implied opinion is entirely the author's. Comments and/or critique of this review are appreciated and honored with a response if requested. Please email or send comments to:

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2.0 Review Criteria and Facility Requirements

Review criteria covered in this review include eight non-exclusive subject areas as follows.

Site Suitability
Site Design
Site Operations and Closure
Environmental Monitoring
Performance Demonstration
Defense-in-Depth System Design
ALARA compliance
RCRA Compliant Liner and Cover

The requirements or standards applied in each category come from NRC requirements or DOE guidance documents.

Requirements for commercial LLRW disposal facilities under the jurisdiction of NRC are codified in 10 CFR Part 61. Commercial facilities are required to meet the basic performance objectives listed in Subpart C. Substantial requirements relating to the geotechnical aspects of LLRW facilities are found in Subpart D. These requirements are taken directly from the regulations and organized into the criteria categories of Site Suitability, Site Design, Site Operations and Closure, Environmental Monitoring and Performance Demonstration.

The NRC requirements are relatively comprehensive in terms of facility functional design requirements and performance goals. They represent the minimum frame of reference in terms of site performance and they establish the same defense-in-depth approach to assurance of the site performance as that used in the commercial nuclear power industry that is also regulated by the NRC.

For the purpose of this review, the NRC requirements and criteria are applied in all of the facility evaluations because they represent the most comprehensive standards for a LLRW facility. If a DOE facility does not substantially meet the letter or intent of the NRC requirements, there is a good argument for changes to be made to the design or siting of the particular facility.

DOE policies, guidelines, and minimum requirements for management of LLRW and mixed waste are specified as policy statements in DOE Orders. Although these are not codified as legal requirements as are the NRC regulations and they don’t have the same enforcement capacity, they still form the primary requirements for facility design considerations.

USDOE’s Order 435.1 replaces Chapter III of DOE Order 5820.2A in identifying basic performance objectives for LLRW facilities at USDOE sites, instead of establishing standards as does 10 CFR 61. The particular areas of interest for this review include the following.

> "Protect public health and safety in accordance with standards specified in applicable EH Orders and other DOE Orders"
>
> "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 result in an effective dose equivalent that does not exceed 25 mrem/yr to any member of the public. Releases to the atmosphere shall meet the requirements of 40 CFR 61. Reasonable effort should be made to maintain releases to the general environment as low as reasonably achievable"
>
> "Assure that the committed effective dose equivalents received by individuals who may inadvertently intrude into the facility after the loss of active institutional control (100 years) will not exceed 100 mrems/yr for continuous exposure or 500 mrem for a single acute exposure"
>
> "Protect groundwater resources, consistent with Federal, State, and local requirements."

The portions of Order 5820.2A quoted above establish, in general terms, the performance objectives for LLRW disposal facilities. These are not standards per se and each DOE facility is required to develop their own criteria showing how they fulfill these performance goals. However, this DOE Order makes it clear that the NRC requirements are also implicitly applicable to DOE facilities from either a regulatory standpoint or from a functional design standpoint by using the same or similar performance objectives and by requiring consistency with other (Federal) requirements.

Requirements in DOE Order 5400.5 "Radiation Protection of the public and Environment" establish exposure limits for contamination of environmental media and guidelines for radiation protection. The overriding rule or guideline is the ALARA guideline where contamination of environmental media and potential exposure must be kept "as low as reasonably achievable". Of course this immediately brings up the question of what is reasonable, making this a subjective issue. But, that question is something that can be answered and should be answered by the educated layperson and should not require a comprehensive assessment of legal, technical or economic arguments or such arguments should be presented in a regulatory type of alternative selection process. In other words, if an ALARA guideline based alternative is at all appropriate, it should be assessed in the site documentation.

The only additional requirements for consideration in this report focus on the fact that the DOE facilities must develop a combination of environmental reports, performance assessments and environmental monitoring to estimate potential future dose and impacts of the waste sites and to demonstrate compliance with the above standards. The performance demonstration is required by the DOE Orders and by other regulatory requirements (RCRA, CERCLA). In this report, reviews of the performance assessments are covered under the performance demonstration criteria.

The review criteria are discussed for each facility in section 4 to assess how well the facilities meet the criteria requirements. That assessment as to how well they meet the requirements is this authors judgment, reflecting information obtained from this review.

2.1 Site Suitability

Site Suitability requirements are from 10 CFR 61 Subpart D which states

> "The purpose of this section is to specify the minimum characteristics a disposal site must have to be acceptable for use as a near-surface disposal facility. The primary emphasis in disposal site suitability is given to isolation of wastes, a matter having long-term impacts, and to disposal site features that ensure that the long-term performance objectives of Subpart C of this part are met, as opposed to short-term convenience or benefits."

Please note that the phrase "minimum characteristics" is applied to the following requirements of this section.

1. 10 CFR 61.50 (a)(2) The disposal site shall be capable of being characterized, modeled, analyzed, and monitored.

2. 10 CFR 61.50 (a)(3) Within the region or state where the facility is to be located, a disposal site should be selected so that projected population growth and future developments are not likely to affect the ability of the disposal facility to meet the performance objectives of Subpart C of this part.

3. 10 CFR 61.50 (a)(4) Areas must be avoided having known natural resources which, if exploited, would result in failure to meet the performance objectives of Subpart C of this part.

4. 10 CFR 61.50 (a)(5) The disposal site must be generally well drained and free of areas of flooding or frequent ponding. Waste disposal shall not take place in a 100-year floodplain, coastal high-hazard area or wetland ...

5. 10 CFR 61.50 (a)(6) Upstream drainage areas must be minimized to decrease the amount of runoff which could erode or inundate waste disposal units.

6. 10 CFR 61.50 (a)(7) The disposal site must provide sufficient depth to the water table that ground-water intrusion, perennial or otherwise, into the waste will not occur.

7. 10 CFR 61.50 (a)(8) The hydrogeologic unit used for disposal shall not discharge ground water to the surface within the disposal site.

8. 10 CFR 61.50 (a)(9) Areas must be avoided where tectonic processes such as faulting, folding, seismic activity, or volcanism may occur with such frequency and extent to significantly affect the ability of the disposal site to meet the performance objectives of Subpart C of this part ...

9. 10 CFR 61.50 (a)(10) Areas must be avoided where surface geologic processes such as mass wasting, erosion, slumping, landsliding, or weathering occur with such frequency and extent to significantly affect the ability of the disposal site to meet the performance objectives of Subpart C of this part ...

10. 10 CFR 61.50 (a)(11) The disposal site must not be located where nearby facilities or activities could adversely impact the ability of the site to meet the performance objectives of Subpart C of this part or significantly mask the environmental monitoring program.

2.2 Site Design

Site Design requirements from 10 CFR 61 include the following.

1. 10 CFR 61.51 (a) (1) Site design features must be directed toward long-term isolation and avoidance of the need for continuing active maintenance after site closure.

2. 10 CFR 61.51 (a) (2) The disposal site design and operation must be compatible with the disposal site closure and stabilization plan and lead to disposal site closure that provides reasonable assurance that the performance objectives of Subpart C of this part will be met.

3. 10 CFR 61.51 (a) (3) The disposal site must be designed to complement and improve, where appropriate, the ability of the disposal site's natural characteristics to assure that the performance objectives of Subpart C of this part will be met.

4. 10 CFR 61.51 (a) (4) Covers must be designed to minimize to the extent practicable water infiltration, to direct percolating or surface water away from the disposed waste, and to resist degradation by surface geologic processes and biotic activity.

5. 10 CFR 61.51 (a) (5) Surface features must direct surface-water drainage away from disposal units at velocities and gradients which will not result in erosion that will require ongoing active maintenance of the future.

6. 10 CFR 61.51 (a) (6) The disposal site must be designed to minimize to the extent practicable the contact of water with waste during storage, the contact of standing water with wastes after disposal, and the contact of percolating or standing water with wastes after disposal.

2.3 Site Operations and Closure

Site Closure requirements from 10 CFR 61 include the following.

1. 10 CFR 61.52 (a) (1) Wastes designated as Class A pursuant to 10 CFR 61.55, must be segregated from other wastes by placing in disposal units which are sufficiently separated from disposal units for the other waste classes so that any interaction between Class A

wastes and other wastes will not result in the failure to meet the performance objectives in Subpart C of this part.

2. 10 CFR 61.52 (a) (2) Wastes designated as Class C pursuant to 10 CFR 61.55, must be disposed of so that the top of the waste is a minimum of 5 meters below the top surface of the cover or must be disposed of with intruder barriers that are designed to protect against an inadvertent intrusion for at least 500 years.

3. 10 CFR 61.52 (a) (4) Wastes must be emplaced in a manner that maintains the package integrity during emplacement, minimizes the void spaces between packages, and permits the void spaces to be filled.

4. 10 CFR 61.52 (a) (5) Void spaces between waste packages must be filled with earth or other solid material to reduce future subsidence within the fill.

5. 10 CFR 61.52 (a) (6) Waste must be placed and covered in a manner that limits the radiation dose rate at the surface of the cover to levels that at a minimum will permit the licensee to comply with all provisions of 10 CFR 20.105 of this chapter ...

6. 10 CFR 61.52 (a) (7) The boundaries and locations of each disposal unit (e.g., trenches) must be accurately located and mapped by means of a land survey. ...

7. 10 CFR 61.52 (a) (8) A buffer zone of land must be maintained between any buried waste and the disposal site boundary and beneath the disposed waste. The buffer zone shall be of adequate dimensions to carry out environmental monitoring activities specified in 10 CFR 61.53 (d) of this part and take mitigative measures if needed.

8. 10 CFR 61.52 (a) (9) Closure and stabilization measures as set forth in the approved site closure plan must be carried out as each disposal unit (e.g., each trench) is filled and covered.

9. 10 CFR 61.52 (a) (10) Active waste disposal operations must not have an adverse effect on completed closure and stabilization measures.

10. 10 CFR 61.52 (a) (11) Only wastes containing or contaminated with radioactive materials shall be disposed of at the disposal site

2.4 Environmental Monitoring

Environmental Monitoring requirements in 10 CFR 61 include the following.

1. 10 CFR 61.53 (a) At the time a license application is submitted, the applicant shall have conducted a preoperational monitoring program to provide basic environmental data on the disposal site characteristics. The applicant shall obtain information about the ecology, meteorology, climate, hydrology, geology, geochemistry, and seismology of the disposal site.

2. 10 CFR 61.53 (b) The licensee must have plans for taking corrective measures if migration of radionuclides would indicate that the performance objectives of Subpart C may not be met.

3. 10 CFR 61.53 (c) During the land disposal facility site construction and operation, the licensee shall maintain a monitoring program. Measurements and observations must be made and recorded to provide data to evaluate the potential health and environmental impacts during both the construction and the operation of the facility and to enable the evaluation of long-term effects and the need for mitigative measures. The monitoring system must be capable of providing early warning of releases of radionuclides from the disposal site before they leave the site boundary.

4. 10 CFR 61.53 (d) After the disposal site is closed, the licensee responsible for post-operational surveillance of the disposal site shall maintain a monitoring system based on the operating history and the closure and stabilization of the disposal site. The monitoring system must be capable of providing early warning of releases of radionuclides from the disposal site before they leave the site boundary.

Note that there are two general goals of environmental monitoring. One is to obtain and develop the monitoring data in support and demonstration of the site performance. The other reason for environmental monitoring is to detect inconsonant conditions or identify something unexpected that has caused or could cause a failure in a component of the disposal system.

2.5 Performance Demonstration

Performance Objectives requirements come from Subpart C of 10 CFR 61. All of the NRC performance requirements are considered in this review criteria along with a general assessment of the quality or comprehensive nature of the performance demonstration.

1. 10 CFR 61.40 - General Requirement. Land disposal facilities must be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to humans are within the limits established in the performance objectives in paragraphs 61.41 through 61.44.

2. 10 CFR 61.41 - Protection of the general population from releases of radioactivity. Concentrations of radioactive material which may be released to the general environment and ground water, surface water, air, soil, plants or animals must not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.

3. 10 CFR 61.42 - Protection of individuals from inadvertent intrusion. Design, operation, and closure of the land disposal facility must ensure protection of any individual

inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls over the disposal site are removed.

4. 10 CFR 61.43 - Protection of individuals during operations. Operations at the land disposal facility must be conducted in compliance with the standards for radiation protection set out in Part 20 of this chapter, except for releases of radioactivity in effluents from the land disposal facility, which shall be made to maintain radiation exposures as low as reasonably achievable.

5. 10 CFR 61.44 - Stability of the disposal site after closure. The disposal facility must be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate to the extent practicable the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required.

2.6 Defense-in-Depth System Design

The defense-in-depth approach to the design of a radioactive waste burial ground utilizes a succession of standards and practices for site suitability, facility design, operations, closure and waste form to assure that failure of a single component in the system will not result in a failure of the total system. This defense-in-depth approach allows for flexibility in the application of design criteria to satisfy the requirements and it provides a layered defense to the potential excessive or uncontrolled release of radionuclides.

This review criteria is applied largely because some of the waste disposal facilities are not designed per se for isolating the waste. Instead, they rely on the natural system to provide isolation and their demonstration of regulatory compliance is entirely based upon the contaminant transport models instead of performance as determined by an in-depth configuration design. Experience has shown that reliance on a predictive model as the sole means of performance demonstration with all of their inherent assumptions, simplifications and potential inaccuracies, can produce results that drastically differ from reality especially when dealing complex natural systems, complex source terms and unknown waste configurations.

The defense-in-depth design approach to satisfy the requirements is adopted as a review criteria in this report with the understanding that this review is not as comprehensive as a normal regulatory review would be such as one by the NRC. An evaluation of the defense-in-depth criteria is limited in this review to determining if that type of design approach was used in the facility design and to identifying obvious potential failures in the defense-in-depth principles.

2.7 ALARA

The concept of making radiation exposure “as low as reasonably achievable” should be applied throughout the facility to everything from facility siting, design, construction, operations, closure and long-term performance. Doing an intensive ALARA review of the each facility is clearly beyond the scope of this limited review and well beyond the reviewers capability.

For this limited review and in a manner similar to the defense-in-depth criteria, the review and assessment of ALARA compatibility or compliance at the facilities will be limited to an assessment of whether or not the ALARA principles were used in the facility design and to identifying any apparent violations of the basic ALARA principle.

2.8 RCRA Compliant Liner and Cover

All of the requirements identified above are applicable to mixed waste facilities either by direct citation of the regulations, by implied application of the requirements or by codification of the same or similar language. Mixed waste facilities must also comply with the basic requirements of the Resource Conservation and Recovery Act (RCRA).

For this review, the only additional requirements for mixed waste sites that will be considered are the RCRA requirements for a double liner system and for a regulatory compliant cover. These requirements are the most significant addition requirement relating to the geotechnical aspects of the facilities. This is only considered for the mixed-waste facilities.

2.9 Radiation Release Standards and Cancer Risk

As discussed above, NRC and USDOE performance standards for both operational periods and the long-term protection of human health and the environment are fundamentally based on maximum allowable radiation dose levels, e.g., 10 CFR 61.41, setting a maximum annual radiation dose to the public of 25 millirem. DOE Order 435.1 (and 5820.2A, previously) and NRC standards set a post-closure allowable dose of 25 millirem, which increases to an annual dose of 100 millirem when institutional controls over the burial ground fail and a dose of up to 500 millirem for intrusion.

What do these doses mean to the public in terms of cancer risk?

NRC estimates that an annual radiation dose of 25 millirem causes 5 additional fatal cancers in every 10,000 exposed adults. This is an increased incidence of fatal cancers in adults of 5 in 10,000, or 5E-4 in scientific notation. For children, BEIR V and independent researchers show increased cancer risks of 5 to 10 times higher for a given annual radiation dose.

Use of a dose based performance standard contrasts with the health risk and ecological risk based standards utilized in two other settings: a) hazardous waste landfills, including closure; and, b) landfills where there has been a release or threatened release of hazardous substances, including radionuclides.

In essence, the USDOE and NRC performance standards allowing 25 to 500 millirem annually of radiation dose from releases (i.e., from groundwater contaminated by the facility, or from airborne releases due to cap failure), are creating new hazardous waste Superfund sites that will have to be cleaned up. The facilities are built and operated to meet a performance standard that far exceeds the allowable risk to the public from such facilities under federal and state hazardous waste laws, the federal Superfund law (CERCLA, 42 USC 9601 et seq), and state toxic waste cleanup statutes (e.g., Washington's Model Toxics Control Act, Chapter 70.105D, RCW).

<u>USDOE's Performance Assessments Use Criteria for Acceptable Health Impacts Which Exceed Legal Limits for Radiation Exposure and Health Risk to the Public:</u>

- Washington State's Model Toxics Control Act (Chapter 70.95D, R.C.W.; and implementing regulations at Chapter 173-303 WAC) set applicable health based standards for public exposure to "hazardous substances" and carcinogens released from disposal sites. Included in hazardous substances are radionuclides.
- Washington State limits exposure, and requires cleanup, if exposure would result in a total carcinogen risk (from all sources at the site) greater than **one in one hundred thousand**.[4] Thus, if more than one exposed person in one hundred thousand would get cancer, additional cleanup is required. (This is often expressed in scientific notation as 1E-5). The State limit applies at federal Superfund sites in Washington.
    - This is one additional cancer in the most sensitive exposed population, per 100,000 exposed; i.e., children or Native American children who consume large quantities of water and food from the site.
- United States Environmental Protection Agency (EPA) sets a more relaxed standard utilizing a risk range allowing between one additional fatal cancer per ten thousand and one in one hundred thousand. (1E-4 to 1E-5).[i]
- USEPA has issued a formal opinion that exposure to 25 millirem per year of radiation from pollution at a federal Superfund site is not protective of human health or the environment, calling that level of exposure "unacceptably high" because it would result in 5 additional fatal cancers per ten thousand exposed adults (5E-4).[ii]
    - EPA has formally found that a proposal to allow 100 millirem exposure annually "could create unacceptable health risks to the public… and potentially result in the creation of new Superfund sites."[iii]
    - The EPA and Washington State standards are applicable to the Hanford Low-Level Waste Burial Grounds because:
        1) The burial grounds have released wastes to the environment, and have illegally been used to dispose of hazardous wastes – subjecting them to RCRA and Washington Hazardous Waste Management Act requirements for permitting and remediation. Washington State utilizes the MTCA standard for RCRA permit actions – consistent with the philosophy that we should not create new Superfund sites requiring cleanup.
        2) The burial grounds are in the midst of the federal designated Superfund National Priority List site and MTCA designated site.

<u>The USDOE's Performance Assessment – and Hanford Site Solid Waste EIS – are Based on Performance Objectives that "create unacceptable health risks to the public… and potentially result in the creation of new Superfund sites":</u>

[4] WAC 173-340-705 sets the maximum carcinogen risk from any single sugbsance remaining on the site or released to the environment at one in one million, or 1E-6.

USDOE's Performance Assessment is based on the burial grounds meeting "Performance Objectives" that allow radiation doses of 25 mrem per year to the public and continuous exposure to 100 mrem per year of radiation following reasonably foreseeable intrusions into the waste sites. Doses of 500 mrem per year are considered acceptable by USDOE for a single exposure following intrusion.

Rather than designing the burial grounds to meet the applicable EPA and Washington State standards, USDOE sets "performance objectives" (which are not regulatory rules) in DOE Order 5820.2A for general public exposure from all pathways and post-intrusion exposures.[iv]

EPA has specifically called the 25 mrem per year annual exposure an "unacceptable health risk".[v] This radiation dose is fifty times the allowable carcinogen risk under Washington's Model Toxics Control Act.

EPA has concluded that radiation doses of 15 millirem from landfills with release that expose the public are "not protective under CERCLA". 15 millirem, EPA estimates, using NRC analyses, results in 3 fatal cancers for every 10,000 adults exposed to this dose; and, 25 millirem would be expected to cause 5 fatal cancers for every 10,000 adults exposed (5E-4).[5]

USDOE's performance objective for reasonably foreseeable continuous annual exposure after intrusion into the burial grounds results in 2 fatal cancers for every 1,000 adults exposed. It is now generally accepted that children are 5 to 8 times more susceptible to cancer from ionizing radiation exposure than adults. For children, post intrusion risk deemed acceptable under USDOE's performance objective could be as high as 1 in 100. (Washington State law sets the standard as 1 additional cancer in 100,000 from all carcinogens remaining on the site).

Consequently, a site designed to meet a performance standard allowing releases that result in annual doses of 25 millirem cannot be said to be protective of human health and the environment. A facility which only meets the performance standard utilized by USDOE or NRC will exceed the cleanup action level and cleanup standard under CERCLA and the National Contingency Plan, requiring cleanup (remedial) action to protect public health.

The concentration of a substance released into the environment does not, by itself, tell us what the human health risk will be. Rather, it is necessary to examine the "maximum reasonable exposure scenarios" for the sites to determine risk. A release from Site A may be at higher concentrations than a releases from Site B, yet the release from Site A may not exceed the relevant risk based standard while the release from Site B may exceed these standards.

For all the sites we compared, the maximum reasonable foreseeable exposure scenario is dependent over the long-term upon three key factors: development pressures; Native American Treaty rights; and desirability of the use of affected natural resources, especially ground water.

Both NTS and Envirocare are far from populations that may reasonably be forecast to create development pressures. However, while the ground water at Envirocare is not potable (not usable for drinking water), the NTS sits above a valuable aquifer, where water is scarce and viewed as a significant development resource. At Hanford, water is scarce (withdrawals from the Columbia

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[5] Stephen D. Luftig, Director Office of Emergency & Remedial Response, US EPA, "Memorandum: Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination" OSWER No. 9200.4-18 page 3(August 22, 1997).

for new development will be limited, and the Yakima River is seriously oversubscribed) and is a valuable resource. The groundwater under Hanford is owned by the state, not the federal government. It represents the largest unclaimed water resource in the Mid-Columbia region. However, in the Revised Draft Hanford Solid Waste EIS, USDOE claims that an undefined very large area of groundwater will be "irreversibly and irretrievably committed" and unavailable for drinking water or irrigation due to contamination. There will be pressure long after USDOE leaves the Site for the development of this resource – despite the contamination.

Both Hanford and NTS sites are subject to Treaty rights guaranteeing access and use of the land and resources by Native Americans, if the land is not withdrawn from the public domain. For the Hanford commercial US Ecology site, Washington Ecology estimated a fatal cancer potential as high as 3% for Native American children due solely to releases and foreseeable exposure from this one site (dependent upon which one of several proposed caps was utilized).[6] Only the Envirocare site is free of immediate population pressure for development, does not have Treaty rights leading to reasonably foreseeable exposures, and does not have a valued ground water resource which may reasonably be foreseen to be exploited.

Releases from the multiple Hanford Low-Level Burial Grounds are reasonably predicted to exceed the releases and risks from the commercial site at Hanford. Chemical and hazardous wastes continued to be disposed in the LLBGs for years after applicable laws were complied with at the commercial, regulated site. Further, the cumulative impact of all the burial grounds, and the proposed addition of 12 million cubic feet of LLW to the soil, must be considered in calculating risk for Hanford's burial grounds. The cumulative risks from all exposure sources for a Native American or a non-native seeking to utilize groundwater and other resources and living on-site has never been calculated.

The cleanup standards, which apply in the event of a release or a threatened release, also include application of **ecological risk** standards to protect the environment. However, the NRC and USDOE standards have no such provision for protection of environmental receptors and natural resources. The ERDF facility, because it was authorized under a CERCLA (Superfund) Record of Decision for cleanup wastes, does apply the CERCLA standards for ecological risk (however, as noted elsewhere, the performance assessment for ERDF only considered radionuclides, and not hazardous wastes. Nor did the ERDF authorization utilize the Washington State MOTCA standard, which will require cleanup action if releases reached the maximum allowable carcinogen risk relied upon in the authorization).

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[6] WA Ecology and WA Health, November, 2000; Draft EIS on the Closure Plan for the Hanford Commercial Low-Level Waste Site. See comments of Heart of America NW available at www.heartofamericanorthwest.org

Summary Cross-Site Comparison of Low-Level Waste Disposal Sites:

Standards Applied and Potential Human Health Exposure Risk

	Hanford USDOE's Low-Level Waste Burial Grounds (LLBGs) [location: Hanford site in 200 East and West areas]	Hanford Environmental Restoration Disposal Facility (ERDF) [location: in between Hanford's 200 East and West areas]	Hanford Commercial Low-Level Waste Site, operated by US Ecology, Inc. [location: in between Hanford's 200 East and West areas]	Nevada Test Site Low-level WasteBurial Grounds [location: USDOE's Nevada Test Site]	Envirocare of Utah, Inc. commercial, regulated Low-Level Waste Site [location: Utah, East of Great Salt Lake in Tooele County]
Is Dumpsite Lined, or Unlined?	UNLINED Soil Trenches	LINED	UNLINED (but, liner requirement under consideration by Washington State)	UNLINED	LINED and elevated for monitoring
Leachate Collection System?	NO	YES	NO	NO	YES
Independently, Externally Regulated?	NO	YES	YES	NO	YES
Groundwater Contaminated?	YES	NO	YES	YES (indicated)	NO
Evidence of illegal hazardous waste disposal (including early disposal of hazardous wastes)	YES	NO	YES	YES	NO
Accepts Offsite Wastes?	YES	NO	YES (limited by federal law to Northwest and Mountain States)	YES	YES
Buries highly radioactive wastes (remote handled, Class C or Greater than Class C wastes - as hot as High-Level Wastes)?	YES	NO	Limited	YES	NO
Does Generator Have to Pay Long-Term Monitoring and Closure Fund Costs?	NO	NO	YES	NO	YES
Is there a legally compliant Groundwater monitoring system capable of detecting releases (per RCRA)?	NO - many groundwater wells around LLBGs are dry	YES	NO - but Washington State requiring investigation	NO	YES

	Hanford USDOE's Low-Level Waste Burial Grounds (LLBGs)	Hanford Environmental Restoration Disposal Facility (ERDF)	Hanford Commercial Low-Level Waste Site, operated by US Ecology, Inc.	Nevada Test Site Low-level WasteBurial Grounds	Envirocare of Utah, Inc. commercial, regulated Low-Level Waste Site
Is there a Closure plan and disclosure of waste quantities and constituents for analysis of impacts?	NO	YES	Pending	NO	YES
Maximum allowable cancer risk or radiation dose allowed from future pollution from dump:	DOE asserts 100 millirem = fatal cancer risks of 2 in 10,00 adults; Native American risk and child risk not calculated	15 millirem; calculated for Native American exposure; cancer risk of 3 in 10,000	Disputed: whether 15 or 25 millirem applies, and whether must use State standard to protect children	100 millirem; risks of Native American exposure not calculated	15 millirem for exposed critical population (NRC rule is 25, but CERCLA waste rules apply as well)
Do Native American Tribes have treaty rights to use land, water, resources that will be contaminated by burial grounds?	YES	YES	YES	YES	NO

3.0 Summary of Envirocare of Utah, Inc. Facility

3.1 General

The Envirocare of Utah, Inc. site is a commercial facility located near Clive, UT which is about 70 miles west of Salt Lake City and just south of Interstate 80. It is situated in a large valley basin on an essentially flat topography. This is a semi-arid region where the average annual rainfall of 6 to 10 inches is exceeded by the average potential evapotranspiration rate of 60 to 70 inches. With this high evaporation rate, the groundwater in the area is saline and the dominant hydrologic feature in the region is the Great Salt Lake. This area is very hot in the summer and relatively mild in the winter.

The Envirocare facility includes embankment landfill cells for disposal of commercial Low Activity Radioactive Waste (LARW), 11e.(2) waste from uranium mill tailings and other uranium mining operations, and a mixed radioactive and hazardous waste embankment.

The waste cells are called "embankment fills" because they are essentially above ground fills surrounded and covered by an isolation fill material and a cover system. Figures 3.1 and 3.2 provide a schematic of the site and close up view of an embankment cell.

The Envirocare facility is contained within a one square mile Section shown in Figure 3.1 (from Envirocare, 2000a). Within that section is the LARW disposal cell, the RCRA Landfill Area (mixed waste cell), the 11e.(2) disposal cell and the "Vitro Embankment". The Vitro Embankment is an older DOE disposal cell for the Vitro uranium mill tailings that is now closed and is not a part of the commercial facility. The northwest portion of the Section is identified for future LARW.

Envirocare began waste disposal operations in 1988. They accept only Class A waste into their LARW cell. A permit was recently denied by the Utah State government that would allow Envirocare to accept Class B and C low level waste which are both higher radioactivity waste but still classified as "low level". Class A waste includes any commercial waste from hospitals, low-level waste from commercial power plants and laboratory waste from commercial labs. Waste from DOE facilities and labs is not disposed of at Envirocare.

The state of Utah is a part of the Northwest Compact of states. According to the legislated compact agreement, all commercial low level waste generated by the Northwest Compact states is required to go to the US Ecology, low level waste facility at Hanford, WA. That is, unless approval is granted by the compact. As a result, most of the low level waste disposed of in the LARW cell is from states from other compacts that do not have low level burial grounds in their states or from "non-compact" states that are not a part of the compact agreement.

The 11 e.(2) waste disposal cell is for the clean-up and disposal of uranium mill tailings and uranium mining operations. This is for either private party material or smaller scale government clean-up operations, both of which pay a disposal fee for disposing of their materials in the cell.

The RCRA landfill area shown in Figure 3.1 is the mixed waste embankment fill for both low-level radioactive and hazardous waste. Northwest compact waste acceptance restrictions and requirements also come into play with the mixed waste embankment although mixed wastes are not accepted at the US Ecology facility.

Envirocare also has other capabilities at the facility to enhance disposal options and to meet certain disposal requirements such as the waste emplacement requirements and compaction requirements. These facilities include a waste encapsulation facility (both micro and macro encapsulation), a waste compaction facility, a liquid segregation facility and some specialized industrial hygiene and cleaning capabilities such as a rail car washing system and various monitoring and equipment cleaning systems. The Envirocare facility is in a remote location and they have attempted to provide all services that would be needed for a viable facility.

3.2 Site Geology and Hydrogeology

Regional Geology

The Envirocare site sits within an hydrologically closed basin that is a part of the Basin and Range geologic province. The geology of the Basin and Range province is characterized as north-south trending structural uplift mountain ranges surrounded by large vast sediment filled basins. This same geologic province covers western Utah and extends through most of Nevada.

The basins are depositional areas where sediments from the mountain ranges are accumulating within the basins. These sediments are up to a few thousand feet thick in some of the basins and greater than 700 ft thick in the basin at the landfill site.

The centers of the basins contain lacustrine (lake) deposits of very fine sand, silt and clay along with varying quantities of evaporite salts. The margins of the basins or the areas closer to the mountain ranges have greater quantities of gravels and sands deposited primarily by runoff or river water action.

The Envirocare facility sits at a base elevation of about 4270 ft on a lacustrine deposits from Lake Bonneville which was a much larger version of the Great Salt Lake during the late Pleistocene or about 15,000 years before present. This area was subjected to temporal rise and fall of the lake level and to changes in the rate of sediment accumulation. The last time water (saline) had reached the base elevation at the landfill site was about 13,000 years before present when it reached what is called the “Provo level” of 4740 ft elevation. The current elevation of Great Salt Lake is 4200 ft.

Envirocare Site geology

The site geology and hydrology are reported in the site hydrogeologic report (Envirocare, 2000). This report provides data from a comprehensive characterization program that includes over 80 groundwater monitoring, sampling and characterization boreholes within the square mile section. (see Figure 3.2).

The sediments underlying the landfill area are described in the hydrogeologic report as four separate units based on grain size and sediment textural characteristics.

Unit 4 is at the top of the section and makes up the base of the landfill. This unit is composed of silt and clay that is between 6 and 16.5 ft deep with an average depth of 10 ft. There is a minor amount of sand within the silt and clay and some evaporite mineral content. The silt and clay composition of this unit causes it to be quite impermeable so that water does not readily pass through it. It acts as the base of the landfill cells and is used as a natural liner and radon barrier.

Unit 3 underlies Unit 4 and is predominantly a silty sand that is between 7 and 25 ft thick with an average of 10 ft thickness. The shallow unconfined aquifer of saline water is found within this unit at an elevation of about 4250 ft.

Unit 2 is beneath Unit 3 and is composed of clay with occasional lenses or interbeds of silty sand. Unit 2 is between 2.5 and 25 ft thick and is saturated with saline groundwater.

Unit 1 is the lower-most strata and is composed of silty sand with interbedded clay and silt layers. The total depth extent of this unit is not known because boreholes are limited in depth at the site to less than 300 ft.

From the data in the hydrogeologic report, there appears to be some spatial variability of the sediment with respect to the individual units described above. That variability is the result of minor textural variations such as the differences between a sandy silt and a silty sand or variations in the clay content. In general, the horizontal variability of these lake bed deposits is minor and the density of characterization boreholes probably exceeds characterization requirements.

Envirocare Site Hydrology

The groundwater at the site is found in the form of a salt water aquifer within Unit 3. This aquifer has a low-permeability between the surface and the groundwater. The depth to groundwater is between 20 and 30 ft deep at an approximate elevation of 4250 ft.

There is a slight horizontal groundwater gradient across the site from the south-west to the north or north-east. This gradient is calculated for the unconfined aquifer by considering the variation in the density of the saline water due to variations in salt content. Thus, across the one square mile site, there is a net drop in fresh water equivalent elevation of about 7 ft or an average gradient just greater than 1/1000. This precision in the water level determination is required to establish the groundwater flow direction which is required for groundwater monitoring purposes.

The hydraulic conductivity of Unit 3 where the unconfined aquifer is found, was determined by field measurement in about 80 boreholes. The average hydraulic conductivity of Unit 3 is 2.7 ft/day (10^{-5} cm/s). Combining that conductivity value with the gradient discussed above and an average groundwater flow velocity of 0.003 ft/day is determined. This groundwater flow velocity is a general number that gives one an idea of how fast contaminants could move through the natural subsurface soil-groundwater system.

The groundwater beneath the site has a total dissolved solid (TDS) content of 40,500 mg/l with sodium and chloride making up the great majority of the cations and anions, respectively. Sea water has a typical TDS content of 35,000 mg/l. So, this water has a higher salt content than normal sea water.

There are no detectable radionuclides (other than natural) or other contaminants in the groundwater (see Envirocare 2001a). This is the baseline for the groundwater monitoring for contamination detection purposes. There is no indication from the groundwater contaminant monitoring data, that any of the disposal cells on the site have leaked and there has been no adverse impact to the groundwater as a result of the embankment waste fills.

3.3 Waste Disposal and Isolation Engineered Approach

The basic approach to providing long-term disposal and isolation of both the LARW cell and the mixed waste cell at the Envirocare Site is to surround the waste with geologic barriers using a liner and cover system. The liner and cover systems are engineered so that the cover has a lower permeability and a lower potential moisture flux than the liner. This minimizes the possibility of water accumulation within the waste in the embankment cell system. Regardless of this, the cover is designed to prevent moisture movement through the cells with a low permeability layer and drainage layers so there is no measurable moisture flux into the waste cell (see Envirocare 2000b and 2001b).

Also, because the liner and cover systems are engineered systems, contaminant migration rates, moisture flux rates and the associated contaminant migration travel times are easier to model and predict. This is in contrast to utilization of a natural system for isolation where the natural system may not be comparatively predictable due to inhomogeneities in the natural system.

The basic design timeframe is to provide 1000 years of isolation when reasonably achievable with a minimum of 200 years as required by NRC and State regulations. The 1000 year design life goal has been adopted by Envirocare as a minimum and shown to extend to 10,000 years. They are also required to show a groundwater protection timeframe of 500 years minimum for radionuclides and 200 years minimum for heavy metals. This too has been extended to 10,000 years. The primary method of demonstrating compliance with the above isolation time standards is with the use of contaminant transport models.

The Envirocare facility design for the mixed waste embankment is provided in their engineering justification report (Envirocare 2001b) and details of the LARW embankment are provided in the construction project plan (Envirocare 2002) and in the contaminant transport model report (2000b). In these reports, they list the design requirements and criteria, including the requirements listed in section 2 of this report, and they show the method of performance to assure compliance with each specific requirement. For instance, the facility is required to minimize contact with standing water during operation. This is accomplished by providing surface drainage and by limiting the meteoric water exposure time by doing a cut and cover operation, i.e. covering as the waste is placed. One result of this specific requirement is a maximum of 4 year exposure time before the waste material must be covered.

The Envirocare design documents list the design requirements and identify the specific components of the system or functions that are used to assure compliance with each specific requirement. In most cases, there are multiple design features, functions components that assure performance or compliance with each requirement. This design approach is quite transparent making it easy to understand the reasons for the different components and making it easy to review the system and assure compliance with all of the regulatory or functional requirements. This design approach clearly constitutes a defense-in-depth design.

Design documents for critical systems such as the liner, include a liner design engineering report, a liner QA/QC manual, and a liner as-built report. These documents each require formal approval by the State of Utah Division of Radiation Control (DRC), their primary regulator.

The basic cover design requirements are to minimize infiltration, allow runoff over and around the cover, prevent desiccation, limit frost potential and prevent bio-intrusion. Differential settlement of the cover is limited to 0.02 or 2 ft vertical in 100 ft horizontal. This requirement creates waste placement criteria as well as backfill and compaction criteria.   Each cell or section of the landfill is an engineered lift with distinct criteria for compaction, waste placement and QA requirements depending on the type and form of waste to be placed.

The cover design is provided in a separate engineering report. It too is governed by a QA/QC manual and a final cover design report is approved by the State DRC before the embankment is closed.

An open cell modeling analysis was used to assess the impact of maintaining the cell without a cover during waste filling operations. This provided an engineering estimation of potential enhanced infiltration into the waste and provides a basis for establishing the time frame for a requirement to place a cover over the waste. From this report, the maximum open cell time is conservatively set at four years.

A construction project plan includes work elements regulating waste placement and compaction criteria. Waste placement is governed by a QA/QC manual.

3.4 LARW Embankment Facility Design, Construction and Operation Summary

Details of the low activity radioactive waste embankment including the liner and cover systems construction are provided in Envirocare 2000a, 2000b, 2001a and 2002. The liner and cover system as well as the actual waste placement construction criteria and quality assurance specifications and details are provided in Envirocare 2002.

The low activity radioactive waste (LARW) embankment construction begins by excavating into the native soil material to remove the vegetation and establishing appropriate elevations for the embankment base. This base is compacted to specified criteria and prepared for the lower liner. Compaction of the base prevents future settlement, reduces permeability and creates a stable base for the lower liner. Compaction specifications are rigorous and testing is completed for quality assurance purposes using standard ASTM geotechnical testing methods.

The lower liner is composed of 2 feet of compacted clayey soil. This material must meet a field hydraulic conductivity test (permeability) specification of 10^{-6} cm/sec and, like the base, it is compacted to specified ASTM field testing criteria performed under QA/QC requirements. A construction test pad is used to test compaction procedures prior to placement. Liner placement tests are documented for QA purposes and final approval of liner placement is required by the State of Utah Dept. of Radiation Control (DRC) before waste placement begins.

The DRC has an office on-site to review the documentation, observe portions of the quality assurance procedures and construction processes and approve actions and/or processes as construction proceeds. In this manner the State DRC maintains an active role in the construction process oversight and they have documentation verifying the landfill construction process.

Waste material is placed on top of the lower liner to a maximum total thickness or height of 54 ft. Granular waste material (such as soil) is placed in lifts of 12 inches thick with verified compaction between lifts and compaction quality control procedures. Irregular shaped objects and debris that are too big for conventional compaction are placed to minimize void spaces surrounding the objects and the void spaces are filled with controlled low strength material (CLSM) which is basically a cement grout mix. This grout is pumped into place and allowed to harden. Equipment or debris with internal void space is filled with the same grout material or it is encapsulated with void filling foam. Irregular shaped debris material is not allowed within 1 ft of the lower liner to prevent damage to the clay liner.

Containerized waste such as that in High Integrity Containers (HIC) are placed in the cell according to criteria specifying such things as proximity to other containers, surrounding fill material placement and elevation and location. These criteria are designed to prevent settlement of the containers and the surrounding soil and to provide documentation of the locations of each container.

Care is taken in waste material placement and compaction to minimize settlement and prevent creation of voids within the waste zone that could potentially damage the overlying cover. This is particularly important at the LAWR because the cover is not designed to be self supporting over a void. All of the waste placement and filling processes require review and approval by the State DRC.

Once the waste material fill is complete, cover construction begins with placement of the radon barrier. This barrier is a two layer cover material with a very low permeability. This cover comprises the primary barrier to both moisture inflow and radon gas outflow from the waste material. The two layers are composed of 1 ft of clayey soil with an hydraulic conductivity of $5x10^{-8}$ cm/sec or less and 6 ft of soil with an hydraulic conductivity of 10^{-6} cm/sec or less.

The material used for the radon barrier has specifications for grain size gradation, plasticity index, and of course, hydraulic conductivity. Quality control for placement of the barrier include criteria for compaction, lift thickness, moisture content, and size gradation. In addition, the placement and compaction methodology are tested by placement of a construction test pad which is used to test and verify hydraulic conductivity and density/compaction criteria.

Overlying the radon barrier is a lower 6 inch layer of Type B filter material. This material is basically a poorly graded coarse sand and fine gravel mix. The filter material has a high permeability to allow moisture to migrate off the radon barrier and around the embankment. It also allows for the free flow of soil vapor.

Above the lower filter layer is a 1 ft thick layer of sacrificial soil intended to prevent freezing of the lower filter material. This is simply a silty sand and gravel with specific grain size gradation requirements.

The last soil layer is another filter layer composed of a 6 inches of coarse sand to gravel to cobble material. This layer allows evaporation of water and is primarily designed to protect the underlying layers from damage due to freeze/thaw or erosion.

The final cover layer is an 18 inch layer of rip rap rock. This cap rock layer is exposed to the wind and weather and prevents erosion of the embankment. The rock used for this layer must meet specified ASTM rock quality requirements and it has a size gradation from 0.75 to 4.5 inch diameter.

3.5 Mixed Waste Embankment Facility Design, Construction and Operation Summary

The mixed waste embankment is not much different from the LARW embankment other than in the design of the liner and cover systems. The same care and quality control is exercised regarding waste placement, soil backfill and in the development of the principal design features. Details of the mixed waste embankment are provided in Envirocare (2001b).

The mixed waste embankment is designed for a minimum of 1000 years of isolation. Man-made components of both the liner and cover are not considered in performance estimations of the system as nobody really knows how long the man-made geotextiles will last.

The mixed waste liner is a RCRA compliant double liner system composed of the following layers listed from the waste material downward to the native soil.

Mixed waste material
2 ft protective soil cover
Non-woven geotextile
Tertiary drainage net
Tertiary 80 mil HDPE liner
2 ft protective soil cover
Non-woven geotextile
Primary drainage net
Primary 60 mil HDPE liner
Secondary drainage net
Secondary 60 mil HDPE liner
3 ft Clay liner (10^{-7} cm/sec)
Existing compacted clayey soil foundation

As with the LARW embankment, all liner construction activities at the mixed waste embankment are governed by a QA/QC manual, a suite of QC tests and review and approval by the State DRC.

The mixed waste material placement is governed by the embankment Engineering Justification Report (Envirocare 2001b) and operations are governed by the Construction Project Plan. All bulk soil waste is moisture conditioned and compacted and debris packages are placed to minimize void spaces and backfilled with CLSM grout.

The cover of the mixed waste embankment is also a multi-layer system composed of natural soil material and man-made geotextiles. The following is list of the layers from the top down to the mixed waste fill material.

18 in. Rip-Rap erosion barrier
6 in. "Type A" Upper filter zone (coarse gravel)
12 in. Sacrificial soil (freeze/thaw barrier)
6 in. "Type B" Lower filter zone (coarse sand to fine gravel)
Non-woven Geotextile
60 mil HDPE liner
2 ft Clay barrier ($5x10^{-8}$ cm/sec)
Mixed waste material

Each of these layers has a particular function relative to the principal design requirements of the cover. For instance, the sacrificial soil freeze/thaw layer has a specific obvious function.

The cover is constructed and the layers are placed according to the same QA/QC requirements of the LAWR cover with the same review and approval by the State DRC.

3.6 LARW Infiltration and Contaminant Transport Model (LARW)

An infiltration and contaminant transport model was developed for the Envirocare low activity radioactive waste cell by Whetstone Associates, Inc. of Lakewood Colorado (Envirocare 2000b). A similar model was developed for the mixed waste embankment (Whetstone Associates, 2000) but it was not reviewed for this report.

The basic function of the LARW model is to predict the migration of moisture through the embankment system and predict the potential transport of radioactive and hazardous contaminants for 500 and 200 years, respectively. The 500 and 200 year time frames are established by NRC and EPA (RCRA) criteria. This analysis time frame is currently being extended to 10,000 years. The ultimate goal is to determine potential dose to man and environmental impacts. The dose standard is conservatively set at 4mrem/yr instead of the 25 mrem/yr required by NRC standards. This assumes ingestion of saline water.

There are three basic components to the Envirocare model. First the infiltration is modeled using the HELP model. This HELP model program was developed by the EPA to predict infiltration through cover systems at landfills. Its primary use at the LARW is to establishes the long-term steady state moisture levels within the waste material as a result of infiltration through the embankment cover system. This establishes the amount of moisture within the waste that can cause contaminant transport.

The HELP model predicts an infiltration through the top of the embankment of 0.104 inches per year under a steady state. That value is conservatively high because of the high values used as the annual precipitation rate and because of spatial parameters used in the model.

An additional part of the infiltration modeling with the HELP model involves performing a sensitivity analysis. This basically varies numerous cover design parameters and environmental parameters such as precipitation and cover layers to determine what aspects of the design most significantly effect the net infiltration. This type of sensitivity analysis is used to guide the design of the cover system and to improve on it, thereby assuring the design is adequately conservative.

The second part of the modeling involves the use of the UNSAT-H model to predict the moisture content and moisture flow rate through the vadose zone from the bottom of the waste to the top of the saturation zone (approx. 30 ft). Since moisture or water is the basic carrier of contaminants and the main cause of contaminant migration (excluding gaseous phase migration), knowing the moisture content and the net moisture movement rates in the unsaturated zone is critical to the overall prediction of contaminant levels at an exposure point. The UNSAT-H model was specifically designed to model this aspect of the unsaturated zone dynamics.

The UNSAT-H modeling takes the infiltration value calculated with the HELP model and predicts the moisture content profile through the liner and through the unsaturated zone system to the groundwater.

Of the three major components of the total model, the unsaturated zone modeling probably has the greatest uncertainty and provides the best opportunity for inaccuracy. That is because the model uses the physical properties of the soil layers as input to the calculations. Determination of those properties is often difficult and those properties can be quite variable both spatially and as measured in the laboratory. However, in an engineered system such as the LARW where the soil properties are well characterized, homogeneous and essentially controlled, the uncertainty of the model is significantly reduced.

The last major component of the model is the modeling of the contaminant transport. For the LARW, this was done a modeling code called PATHRAE. This code was used to calculate a constant rate uptake of contaminants, transport the contaminants through the saturated zone and deliver them to a point of compliance monitoring well located 90 ft away. Certain assumptions are made in the PATHRAE model to estimate the quantity of contaminant uptake and to account for geometric differences in the embankment between the side slopes and the top slope. The results of this portion of the modeling is to produce estimations of contaminant concentration at the compliance monitoring well.

The net result of the modeling at the LARW embankment is that all radionuclides are predicted to remain below groundwater protection levels within 500 years at the 90 ft compliance monitoring well. There are limitations placed on the disposal of nine radionuclides at the landfill to prevent potentially exceeding groundwater protection levels. These nuclides include Al-26, Bk-247, Cf-249, Cf-250, Cl-36, Re-187, Tb-157 and Tb-158. All are relatively obscure and are not likely to be in the waste material as significant sources.

This short review does not get into the details of the modeling and there is much more to the modeling effort than what is reviewed above. A great portion of the work focused on performing sensitivity analyses of various components and providing refinements of the isolation systems design. Modeling of the transport of metals was also completed to assure compliance with requirements for isolation of these waste materials.

In summary the modeling of the LARW is relatively comprehensive and useful. They attempted to cover several possible scenarios for contaminant release and to utilize the modeling to improve the design of the embankment isolation systems. The model was basically a homogeneous model of a homogeneous environment with exceedingly low moisture flux and highly sorbing soils. It showed that the combined properties produce a contaminant migration level that does not come close to producing a dose near the criteria.

The accuracy of the groundwater contamination predictions of each radionuclide was not investigated in this review as they should be and probably were by the State. This should always be questioned considering the current level of knowledge of the geochemistry and thermodynamics of the soil system as it relates to radionuclide migration at these low concentrations. This is obviously one of the limitations of modeling.

The modeling of the Envirocare facility has effectively demonstrated with a very conservative model that they have designed a good facility at a favorable site that easily complies with dose limitations.

3.7 Environmental Monitoring

Environmental monitoring of the Envirocare embankment systems includes suite of radiation monitoring, soil and vegetation monitoring, vadose zone moisture monitoring, groundwater monitoring and monitoring of the leachate from the leachate collection systems for the RCRA waste embankment. Other types of monitoring is also done for various reasons including precipitation and weather monitoring, and various types of compliance monitoring for verification or quality assurance purposes such as subsidence or settlement monitoring of the cover.

Groundwater monitoring requirements arise from a State Groundwater Quality Discharge Permit for low activity waste and from RCRA Part B Permit requirements. Both are regulated by the State of Utah.

Both the mixed waste embankment and the LAWR embankment are surrounded by groundwater wells with spacings between monitoring wells on the order of 400 ft (see Figure 3.2). Although a geostatistical analysis and a modeling assessment of the groundwater monitoring well placement was not done, if one considers the relatively homogeneous nature of the natural soils and man-made barriers, the number of groundwater monitoring wells could be considered to be excessive for the intended purpose of detecting contaminants in the groundwater.

Groundwater samples are obtained quarterly and analysis is conducted for constituents listed in the permits. Also, as is typical with a groundwater monitoring system, groundwater elevations, salinity, temperature and other pertinent physical and chemical parameters are quantified with each monitoring session. The permits also identify detection limits and compliance levels for specific contaminants.

All groundwater sampling and laboratory work is conducted under a quality assurance program which is basically standard for this type of work. In addition, there is considerable State oversight of the site monitoring program.

Three suction lysimeters are used to extract vadose zone moisture samples to quantify contaminants or constituents within the vadose zone moisture. Figure 3.2 shows the three lysimeters located just to the west of the active LARW embankment. It is not known why the lysimeters were located as shown or more specifically, why they are not dispersed around the different embankments. The intent of the vadose zone monitoring lysimeters is to detect contaminants migrating in the vadose zone gas.

The leachate collection and monitoring system is considered a monitoring system because it collects any moisture that has migrated through the waste material zone. This water primarily originated as water added in the waste compaction process. Once the cell is filled and covered, residual leachate should disappear and any new leachate would indicate a failure in the system. This leachate collection and monitoring scheme provides a means of monitoring the vadose zone contamination source directly before it reaches the sediment or groundwater. Leachate collection and monitoring occurs only at the mixed waste embankment cell.

Envirocare also developed and built an embankment test cell (see Orton, 2001?). This cell is analogous to the full size LARW cell except that it is much smaller in area and it is filled with monitoring instrumentation. The test cell undergoes the same environmental conditions as the full size cell and provides a record of thermodynamic and moisture profile changes with time.

4.0 Summary of the DOE Environmental Restoration Disposal Facility at Hanford

4.1 General

The Environmental Restoration Disposal Facility (ERDF) is a below ground, near-surface disposal facility that was designed and constructed in the mid to late 1990's for disposal of contaminated materials resulting from the CERCLA clean-up operations at Hanford.

This is a massive landfill that was designed and sized for disposal of about 28 million cubic yards (750 million cu. Ft.) of contaminated material resulting from clean-up of old waste site soil, building demolition material and other miscellaneous contamination. The eventual total footprint of the ERDF will cover about 1.6 mi^2. The location of ERDF on the Hanford site is shown in Figure 4.1. The first phase of ERDF began with the construction of two disposal cells on the west end with a total capacity of 1.2 million cubic yards.

The alternative to build the ERDF originated when it was determined that a disposal facility would be needed for contamination from clean-up operations along the Columbia River. Contamination inventories and material quantity estimations for the river corridor clean-up as well as other areas at Hanford indicated that a large landfill would be needed for a comprehensive clean-up of all areas. As a result, a Remedial Investigation/Feasibility Study (RIFS) was prepared that assessed different disposal options (DOE 1999) and a Record of Decision (EPA, 1995) was issued directing the construction of a single large disposal facility. The ROD authorized construction of the first two cells of the ERDF. Later amended or new RODs are required as the landfill is expanded.

This facility was designed and constructed with Hanford waste site clean-up funds and is only used to dispose of wastes that originate from on-site CERCLA clean-up work. The RIFS and the associated performance assessment provide the justification for its construction as well as the basis for establishing its environmental protectiveness. Waste acceptance criteria were developed along with the RIFS and performance assessment. The use of the ERDF for disposal of wastes not covered in the RIFS or performance assessment may require revision of these documents as well as the waste acceptance criteria.

The ERDF was designed and is licensed to accept both low level radioactive waste as well as hazardous waste. This was done because much of the material from the clean-up operations contains both and segregation of the materials is usually not possible or economically justified. In addition, the conceptual design work and performance assessment models showed that aside from regulatory requirements for the liner and cover designs, there are no appreciable design differences between a low level waste facility and a mixed waste facility.

The Environmental Protection Agency (EPA) has the primary responsibility for regulation of CERCLA clean-up operations at Hanford under the Hanford Tri-Party Agreement. They are the primary regulatory agency providing oversight of ERDF operations.

The ERDF design and construction details are found in the conceptual design report (USACE, 1994) and in the construction specifications (USACE, 1995). General design requirements for the ERDF are found in the Record of Decision (EPA, 1995). A detailed design and operations procedures exists for the facility but they were not available for this review.

4.2 Site Geology and Hydrogeology

Extensive details of the ERDF site geology, hydrology, and meteorology are provided in the RIFS report (DOE/RL, 1993) and additional information on the Hanford site geology and hydrology are provided in Delaney (et. al. 1991) and Lindsey (et. al. 1992).

Summary information and certain specific details about the site pertinent to this report are provided below. The reader is referred to the above documents for additional information or clarification and this author apologizes beforehand to the authors of the referenced documents for the over-simplified discussion below.

Hanford Site Geology and Hydrology

The Hanford site sits within the Pasco basin of the Columbia Plateau in southeast Washington State. This region of the state has an arid climate as a result of the Cascade Mountains blocking precipitation from weather systems traveling from west to east. This area receives an average rainfall of about 6.3 in of precipitation per year and it is hot in the summer and mild in the winter.

This summary of the Hanford site geology is described from the lowest basement rock to the upper most sediments in the chronological order of the deposition of the formations.

The Hanford site sits on basalt bedrock that originated as massive volcanic flood eruptions during the Miocene. Some of these basalt lava flows are hundreds of feet thick. These layered basalt flows were then subjected to a predominantly north-south compression, creating the Yakima fold belt which is a series of NW to SE trending anticline uplifts and syncline depressions in the basalt bedrock.

In the late Miocene, the volcanic eruptions ceased and sediment began to accumulate on top of the basalt. This sediment overlying the basalt is the Ringold formation which is composed of layers of silt, sand and gravel that accumulated in the valleys as fluvial (river) or lacustrine (lake) deposits. The Ringold formation sediments are classified according to the type of material and depositional environment or facies. Distinct Ringold sediment facies include fluvial gravel, fluvial sand, overbank mud, lacustrine mud and basaltic gravel.

The Ringold formation is up to about 600 feet thick on the Hanford site and is usually separated into characteristic layers called the upper, middle and lower Ringold.

Over the west portion of the 200 Area plateau on the Hanford Site, the Ringold formation is overlain by a relatively thin unit called a Palouse soil or the Plio-pleistocene unit. This is a distinctive sand and silt layer that contains variable amount of caliche or carbonate material characteristic of a quiescent evaporating lake.

Next, during the late Pleistocene, the Plio-pleistocene unit was eroded in places and the Hanford formation sediments were deposited. The Hanford formation sits on top of either the Ringold formation or the Plio-pleistocene unit if that unit is present.

The Hanford formation is composed of sands, silts and gravels that were primarily deposited from cataclysmic floods. These floods occurred when ice dams creating glacial Lake Missoula, breached. This created massive flooding all across the northwest. This flooding is episodic in that it occurred many times during multiple glaciation events.

The result is that the Hanford formation is made up of everything from silt size material to coarse gravel and cobble. Sediment grain size is related largely to the velocity of the water that deposited the sediment with the high velocity or high energy environment depositing large gravel to cobble material and the lower energy water depositing silts and fine sand. Fluvial structures such as cross-bedding, and river channel depositional structures are found through much of the Hanford formation.

As with the Ringold, the Hanford formation sediments and individual units or beds are classified according to the dominant sediment facies. The three most common facies of the Hanford formation are a silt dominated, sand dominated and gravel dominated.

After the last glaciation event, the surface of the Hanford site has been reworked to varying degrees by rivers and streams and by wind (eolian) erosion or deposition. River action has created large ancient river terraces around the basalt uplifts of Gable Mountain on the northeast and Rattlesnake Mountain on the west. One large terraced area is a plateau area where the 200 Area process facilities are located.

Much of the current surface of the Hanford site is composed of reworked fine grained eolian sand and silt.

The hydrology of the Hanford site is dominated by the Columbia and Yakima river systems that cut through the site, creating the principal drainage systems. There are no other continuous streams on the Hanford site due to the low precipitation.

Groundwater beneath the Hanford site is found within the Ringold formation. On the 200 Area plateau, the groundwater is from about 200 ft deep in the 200 West Area to about 350 ft deep in the 200 East Area. Some perched water may exist in places on top of impermeable layers such as the previously mentioned plio-pleistocene unit.

The direction of groundwater flow is influenced somewhat by the bedrock topography or the height of the uplifts in the basalt bedrock (subcrops). The general direction of groundwater flow on the Hanford Site is to the east or southeast toward the Columbia River and south toward the Yakima River.

<u>ERDF Site geology</u>

The ERDF site sits on the 200 Area plateau where the surface soil in this region is composed of up to 10 ft of wind deposited (eolian), clean fine sand.

Hanford formation sediments, underlying the near-surface sand, are from 135 to 320 ft deep at the ERDF site. The gravel, sand and silt dominated facies are all found in the Hanford formation beneath the ERDF site with the sand dominated facies most common. Fluvial structures are also found in the Hanford formation at the ERDF site. The excavated pit section at the ERDF shows extensive cross bedding and laminations typical of fluvial deposition. In addition, clastic dikes are common in the fine grained sand beds of the upper portion of the Hanford formation. These are irregular, near vertical structures have been filled with coarse sand material. They are of particular concern because they can promote vertical movement of moisture under near-saturation conditions.

The Ringold formation underlying the Hanford formation and is from 230 to 360 feet thick at the ERDF site. It is composed of predominantly fluvial gravel sequences or units with sands and silty sand or mud layers. The various distinct units of the Ringold are continuous across the ERDF site except for the upper Ringold unit which was subjected to erosion.

The Plio-pleistocene unit is found between the Hanford formation and the underlying Ringold formation, only in the western portion of the ERDF site. This carbonate and mud unit is about 35 ft thick in the west portion of the site and pinches out to the east.

<u>ERDF Site Hydrology</u>
The unconfined aquifer beneath the ERDF site is found within the sands and gravels of the upper Ringold formation from 230 to 330 ft deep. Groundwater flows primarily from west to east and the hydraulic conductivity of the aquifer is on the order of 6 to 8×10^{-3} cm/sec which is typical of slightly silty to clean sands.

No surface streams or lakes are found at the ERDF site. Little, if any, recharge from precipitation is thought to occur on the site because of the horizontal layering of the soil and the high rate of evapotranspiration from the site vegetation (see Rockhold et. al. 1995). However, previous work by some researchers has shown situations where infiltration can occur with changes in the vegetation and site surface conditions (Gee, 1987). In its natural vegetated state, no infiltration recharge would be expected at the ERDF.

<u>Groundwater Contamination</u>
The groundwater beneath the ERDF site contains contaminants that originated from at least three locations in the 200 West Area. Data on the pre-ERDF contamination in the soil and groundwater are provided in Bechtel (1995).

Significant contaminants in the groundwater include nitrate, carbon tetrachloride, chloroform, trichloroethylene, tritium, technetium-99, iodine-129, and uranium. These contamination plumes originate from the U-Plant cribs, the S-Plant cribs, and the Z-Plant cribs (carbon tetrachloride). These contamination plumes move with the groundwater in the general west to east direction and are currently found in the groundwater primarily on the west portion of the site. The reader is referred to the Bechtel (1995) report for review of the contamination plume maps.

Some historical groundwater contamination data that was not included in the baseline characterization report (Bechtel, 1995) shows additional contamination that could be significant relative to the ERDF groundwater monitoring program. Older historical groundwater monitoring data from borehole 699-38-70, located near the northwest corner of the ERDF site and reported in DOE/RL(1993b) showed very high concentrations of cesium-137. Other contaminants identified in the groundwater beneath ERDF and not listed in Bechtel, 1995 include cobalt-60, and strontium-90. The historical data shows Cs-137 at 790,000 pCi/L in 1960 decreasing to 500 pCi/L about a year later and then to 17 pCi/L in 1975. This rapid decline may be an indication of the presence of mobile cesium in the groundwater.

This contamination likely originated from the U-plant cribs. If cesium and other co-contaminants are detected in the ERDF downstream monitoring wells in the future, it could be misinterpreted as an indication of a leak from the ERDF.   This contamination should be identified in the baseline characterization report for future monitoring program concerns.

The surface soil at ERDF showed a very low degree of contamination. However, this is based on soil sampling from only two locations and from a surface radiation survey (Mitchell, 1995). Primary surface soil contamination sources are wind blown sources from the 200 West Area and, on the east side, surface contamination at the BC cribs.

Subsurface sediment making up the vadose zone beneath the ERDF site shows no contamination from a very limited sampling.

4.3 ERDF Waste Disposal and Isolation Engineered Approach

Requirements for the design and performance of the ERDF facility are listed in extensive detail in the Remedial Investigation Feasibility Study for the ERDF (DOE 1993).   Applicable or relevant and appropriate requirements (ARAR's) listed in the RIFS report are derived from RCRA and CERCLA regulations and other federal regulations, from WA State regulations, and from DOE Orders.   The reader is referred to the RIFS report for specific language and details of each requirement.

From a geotechnical standpoint, RCRA regulations identify the most significant minimum technology requirements for the design and operation of the ERDF.   Because this is a mixed waste facility, RCRA regulations require a composite liner system along with a leachate collection system.   The basic design approach using the RCRA liner is not to make the liner more permeable than the cover as with other liners. Instead the idea is to make the liner and cover as impermeable as possible and utilize a leachate collection system to prevent the collection of water above the liner.

RCRA also specifies operation practices such as waste characterization requirements, waste segregation, waste placement and compaction requirements, monitoring and inspections as well as methods to verify adherence to RCRA regulations. RCRA closure requirements include installation of a cover system to minimize the infiltration and moisture flux through the waste material. Environmental monitoring requirements include groundwater monitoring and a leak detection system in addition to monitoring of other environmental media.

Additional general requirements as well as some very specific requirements influencing the design and configuration of the ERDF are found in the Record of Decision (EPA, 1995).

The manner in which the ERDF satisfies the requirements mentioned above, is really determined or specified in the RIFS as opposed to the conceptual design report (USACE 1994). The RIFS provides the basic design requirements and identifies most of the design functions. However, the RIFS is not a design document but an alternative selection document. Assurance of compliance with the requirements or a method of performance is not provided in either the RIFS or the conceptual design report.

The approach used at the ERDF to assure isolation of the wastes from the accessible environment is to surround the waste with engineered barriers including a liner and cover system. The ERDF is a below ground facility where a large pit is excavated and a man-made liner system is installed, along with the leachate collection system, before the waste is placed in the pit. The liner extends up the sides of the pit and a cover system will be constructed over top of the waste, extending out beyond the lined sides of the pit. The cover system is designed to inhibit infiltration as well as discourage intrusion into the waste zone after the institutional control period.

4.4 ERDF Facility Design, Construction and Operation Summary

The final design documents and drawings for the ERDF were not available for review in preparation of this section. However, construction specifications and the conceptual design report provide enough information to summarize the principal geotechnical features of the ERDF.

The construction of the ERDF began with the excavation of the trench or pit for waste landfill. The base of the excavation which is the sub grade of the landfill, was compacted to specified soil density requirements and tested as specified in a construction quality assurance plan by a qualified quality assurance engineer. The compacted sub grade was graded to slope down to a common leachate collection point.

The liner was then constructed on top of the compacted sub grade. A schematic of the ERDF liner is shown in Figure 4.2.

The first or lower-most layer of the liner is composed of an admixture of on-site sandy soil with 10 to 14% bentonite clay. Admix preparation and verification requirements assure an homogeneous mix with a moisture content appropriate for compaction (USACE, 1995). The admix is placed and compacted to at least 95% of the maximum attainable density (ASTM 1557) using specified placement and compaction methods. The construction specifications require the admix to achieve an in-place permeability of 10^{-7} cm/sec, although no permeability testing requirements are specified.

Above the admix layer, two HDPE geomembrane layers are placed. Both geomembrane layers are covered with a protective geotextile and then with a one foot layer of drainage gravel to allow free liquid (leachate) above the geomembranes to drain off to the leachate collection sumps. These two geomembrane/drainage layers are a principal RCRA requirement for hazardous waste landfills. Leachate collection piping for the upper leachate collection system, is placed at the bottom of the upper drainage gravel layer to aid free liquid drainage.

Above the geomembrane and gravel layers, a three foot thick layer of soil is placed as an operations layer. The operations layer provides protection of the cell liner system from mechanical damage by machinery used for waste placement. The operations layer is composed of on-site soil with specified grain size gradation characteristics. This layer is also placed and compacted to specified criteria.

All liner materials including the geomembranes, geotextiles, soils and gravel layers, have material specifications and tolerances listed in the construction plan. All liner materials and layers are placed according to specific requirements and then tested to assure compliance with specifications. In this manner, all components of the liner system are engineered and the construction methods and quality are controlled.

The construction contractors were required to establish and maintain an effective QA/QC program composed of plans, procedures and an organization necessary to assure production of an end product that complies with all of the construction requirements. A Contractor Quality Control plan was submitted and reviewed as an integral part of the construction bidding process. Key elements of the QC plan were specified in the construction specifications.

Record drawings were maintained during construction showing any approved changes or addenda to the construction plans. These drawings created the facility “as-built” drawings of record for the facility and they were submitted to DOE after completion of the work.

Waste Placement

Specifications and requirements for placement of the waste materials in the landfill were not in the conceptual design report or other documents available for review. However, during a visit to the site, the reviewer had the opportunity to discuss waste placement with the Bechtel operations manager.

Soil waste material is placed in shallow lifts and compacted with a large track dozer. Compaction of the soil is verified with either a nuclear-density gauge (ASTM D-2922) for fine grained material or with a sand cone method (ASTM D-1556).

Irregular shaped materials such as construction debris, metal containers and other items are placed so that waste soil can be placed and compacted around these materials. Voids within mechanical items are filled with a controlled density grout. Waste placement and void filling is controlled at the landfill to help prevent settlement damage to the cover.

The rigor and quality assurance of the waste placement and void filling operations is not known.

Cover system

The cover system design has not yet been finalized. However, the ROD indicates that the cover will be either a RCRA compliant cover or a modified RCRA cover. The modified RCRA cover adds features such as a layer of rip-rap rock to help deter intrusion into the waste and other features such as an infiltration barrier designed to enhance evapotranspiration in the Hanford climate.

Adequate specifications are provided in the ROD to assume for this review, that the cover system will be constructed with the same care and quality control as the liner.

Additional features

Additional features of the ERDF relevant to the geotechnical aspects of the facility include a decontamination facility for waste hauling canisters and a surface runoff and drainage system that helps to control potential contamination along haulage roads and off-load areas.

Another important aspect of the facility is that the EPA has and continues to provide active oversight of the ERDF construction and operation. The extent and depth of the oversight has not been explored.

4.5 Infiltration and Contaminant Transport Model

Two types of exposure models were calculated for the ERDF. One model was developed for and contained in the RIFS (DOE 1993a).   This model was developed for the purpose of evaluating potential environmental impacts of the ERDF that would need to be addressed in the ERDF design and later in a more comprehensive performance assessment. The RIFS model was used to compare potential environmental impacts of differing alternatives.

The second model (Bechtel 1995) is the more comprehensive performance assessment estimation. It was used to estimate primarily human exposure risk and to help determine environmental impacts of the ERDF after the final design and configuration was selected.

RIFS Risk Assessment

The RIFS risk assessment model is indicated as a conservative model because it uses a source term that contains the maximum concentrations of contaminants that are reported in the limited field investigations. This model is also conservative in that it does not consider the liner system or an intrusion barrier. An infiltration moisture flux of 0.5 cm/yr is used as a conservative value for a landfill that has an engineered cover over the waste material.

The RIFS model is used to evaluate human exposure to the groundwater and to evaluate the effects of inadvertent intrusion into the waste. The purpose of this evaluation is to identify contaminants of concern that need to be addressed with the remedial action and in the ERDF design. This model was primarily developed to allow a rudimentary comparison of the various remedial action alternatives including a comparison to the alternative of leaving the contamination in place along the Columbia River and elsewhere on the Hanford Site.

The resulting human health risk is evaluated as either a hazard quotient (HQ) or an incremental cancer risk (ICR). The HQ is a ratio of the projected potential groundwater intake of the contaminant to the chronic does. An HQ greater than 1 establishes the contaminant as a contaminant of concern (COC) for the ERDF. The ICR is a numerical assessment of the potential to cause a cancer. An ICR greater than 10^{-6} establishes the contaminant as a COC.

Three exposure scenarios were evaluated including human exposure to groundwater at some time in the future, human and ecological media exposure to contaminated soil as the result of inadvertent intrusion, and human and ecological media exposure to contamination via a drilling intrusion scenario. Details on the calculations including the methods, assumptions, contaminant transport methodology and equations are provided in the RIFS (DOE 1993a).

For the groundwater exposure scenario, the following contaminants are identified as COC's due to either an HQ greater than one or an ICR greater than 10^{-6}.

Antimony, Arsenic, Chromium, Fluoride, Nitrite, Selenium, C-14, Tc-99 and Uranium.

The risk from exposure to contaminated soil via inadvertent intrusion is evaluated using the conservative assumptions that the ERDF cover does not inhibit intrusion. This produced a relatively long list of contaminants of potential concern.

Once the contaminants of potential concern were identified in the risk assessment, potential remedial technologies were explained and remedial action alternatives were developed. This was the basic point of performing this risk assessment, that is, to help develop and help select the remedial action alternatives.

ERDF Performance Assessment

Once the ERDF remedy was selected and a design was finalized, a more comprehensive performance assessment (PA) was completed (Bechtel, 1995). This PA establishes the geotechnical basis of operation for the ERDF by evaluating its capability to comply with principal requirements established in DOE Order 5820.2A and in the DOE Richland Office supplemental Order 5820.2A.

The PA does not consider or evaluate any of the hazardous constituents that are included in this mixed waste facility. It is assumed that the alternative selection process and the risk assessment utilized in the RIFS demonstrates compliance with the mixed waste requirements (40 CFR 264 and 265 and WAC 173 303). Review and assessment of the hazardous constituent aspects of the ERDF is not a review criteria for this report.

The PA performs a calculation of dose-to-man from radionuclides released through the soil, water (groundwater) and air pathways. No other environmental dose calculations are considered or needed to satisfy the performance requirements. Dose calculations are only performed for radionuclides that approach the performance objective limitations as a way to demonstrate compliance and to establish limitations for waste acceptance criteria. This is done in the following manner.

First, the source term for the modeling was derived from the source inventory estimation (DOE/RL 1994). This source inventory is based on the limited field investigations which are acknowledged to be less than comprehensive.

Calculations were run to quantify the performance of the disposal system with the inferred source inventory. Then the model was assessed to determine its sensitivity relative to the source term. In other words, if an increase in a particular source term caused a significant increase in environmental dose, then that source term is deemed sensitive and it was modeled further. If a particular source term was shown to be limiting in terms of its potential impact, the concentration or quantity of that contaminant was constrained in the waste acceptance criteria. In this way, the PA is used as a basis for the waste acceptance criteria and vice-versa. Based on the PA calculations, no waste form enhancement or immobilization is required provided the waste acceptance criteria are satisfied.

Waste acceptance criteria are specified and based on calculations performed for specific concentration limits in terms of activity per volume (curies/cubic meter) for isotopes with a half life greater than 5 years and for the net total activity and total projected inventory for all long-lived radionuclides.

Two basic radionuclide release scenarios are developed in the PA calculations including direct intrusion into the waste zone and leaching of contaminants through the soil, into the groundwater and ingestion of the groundwater.

The intrusion scenario is considered to occur after the end of institutional control (100 years) and for up to 500 years later. This scenario ultimately only considered a scenario of drilling a groundwater well through the waste zone to groundwater and bringing contaminated soil to the surface to cause the exposure. It did not consider a large scale excavation such as the excavation of a basement for a home as a viable scenario. The intrusion scenario exposure occurs as a result of acute exposure to direct radiation from the contaminated soil or from the intake of contaminated dust. Chronic exposure is modeled as intake of food crops grown in contaminated soil.

The intrusion scenario dose calculation showed that the dose received was directly proportional to the initial radionuclide concentration in the waste zone. As a result, radionuclide concentration limits were established as waste acceptance criteria in order to meet maximum dose allowed by the performance objectives (DOE 5820.2A).

The groundwater contamination exposure scenarios were pared down to a calculation of the most significant dose; that resulting from ingestion of contaminated groundwater near the facility. This calculation was extended from 1000 years and carried out to 10,000 years. The point of compliance in this calculation is "the nearest groundwater well". The basis of the location of the reception well is not clear. Because the travel distance in the groundwater and the associated dispersion and diffusion of contaminants in the groundwater is critical to dose or a sensitive parameter, a conservative model should place the uptake well directly adjacent to or under the facility. The groundwater dose calculation does not consider the RCRA compliant double liner in the ERDF but it does include the sandy soil and clay admixture liner.

The groundwater model is composed of four basic parts. First a steady state moisture flux through the cover and waste zone is established at 0.5 cm/yr. Next, different source release mechanisms and quantities are estimated making the source available for transport. The contamination is then transported through the vadose zone and into the groundwater to a receptor well. The final calculation is the intake and dose-to-man calculation.

The calculations use a finite element modeling program called VAM3D-CG for determining the steady state moisture flow and for the contaminant transport calculations through the vadose zone and groundwater. This program creates a simplified two dimensional model that uses conservative values for soil properties. All soil layers are homogeneous, constant thickness layers with consistent recharge rate and steady state moisture flow in the vertical direction. The only variation in the model for different radionuclides is the sorption coefficient.

Sensitivity analysis of the model indicates that the primary controlling factors for dose quantity are the magnitude of moisture flux through the soil column, the cover permeability, the soil permeability and the hydraulic gradient.

The model does not consider small scale variations in the hydrologic properties of the soil such as the pore pressure or the Van Genuchten function constants that are found in the heterogeneous fluvial sediment strata. The model does use conservative values for the homogeneous soil property variables such as the sorption coefficients but there is some question as to whether or not the heterogeneous soil can be modeled accurately a homogeneous model.

The small scale variations in the soil texture and hydraulic properties are known to cause an irregular, non-homogeneous distribution of contaminants in the fluvial soil. This high spatial variability and irregular distribution of contaminants in the soil is seen at virtually every subsurface contamination plume at Hanford including the tank farms plumes and the crib sites including the BY cribs located just east of the ERDF site.

However, in favor of the conservativeness of the model is the fact that the ERDF facility is lined with not only a double RCRA compliant liner but also a homogeneous, and carefully constructed clay and soil admixture liner. There is high confidence that the engineered admixture liner can be modeled as a homogeneous material and the migration of contaminants through that material can be effectively predicted.

Groundwater pathway dose modeling shows that long-lived radionuclides that have low sorption in the sandy soil could cause a dose in excess of the performance requirements. Therefore, total activity limits were established in the waste acceptance criteria (Bechtel, 2002) for the radionuclides C-14, Tc-99 and Uranium.

A sensitivity analysis was used to help establish limitations in the waste acceptance criteria (Bechtel, 2002). The sensitivity analysis indicated limitation should be placed on specific radionuclides in terms of either total quantity in the ERDF or maximum concentration. There is a potential uncertainty in the sensitivity analysis in that the radionuclides selected for assessment may not have included all of the radionuclides to be delivered to the ERDF in significant quantities as the selection was based on quantities reported in the limited field investigations. Also, the limited field investigations also do not allow determination of contaminant migration rates, constants and behavior in the soil. The models only consider textbook sorption coefficients and soil chemistry but they cannot consider unknown or unexplored combinations of radionuclides and waste chemistry that cause non-conforming contaminant migration that is known to occur at Hanford. The model calculations and the associated sensitivity analysis assumes adequate knowledge of the radionuclides concentrations in the contaminated soil being delivered to the ERDF as well as knowledge of contaminant behavior in the vadose zone. Those assumptions may not be appropriate.

Although it is beyond the scope of this review to assess the quality of the site characterization work, there is concern about the adequacy of the site characterization work being conducted in the 100 Areas, the 300 Area and especially in the 200 Areas. The standard site characterization methodology for the 100 Areas has been to do a limited field investigation by assay drilling a few boreholes while attempting to intercept the highest concentration material. The site characterization identifies contaminants that could be in the waste from specific sites and provides a general profile of the waste type. Additional limited characterization is done during excavation of the contaminated material, primarily for health and safety reasons.

This limited characterization and the later characterization on-the-fly is not quantitative, not comprehensive and may not be adequate to identify inconsonant conditions that could promote contaminant migration. There are a few site characterization data requirements in the waste acceptance criteria that would prevent disposal without adequate knowledge of the behavior of the combinations of waste in the soil.

One waste acceptance criteria requires knowledge of the presence of radionuclides in the waste that are greater than 1 pCi/g. It is highly unlikely that the current site characterization programs or site specific operational monitoring satisfies the 1 pCi/g requirement with any degree of certainty.

A saving grace for the ERDF disposal system is that the complete system provides a defense-in-depth for this situation. The ERDF liner system and conservative modeling parameters help to assure a conservative defense-in-depth. However, the waste acceptance criteria could do more to specify site characterization data quality requirements and the waste sites could be better characterized for sensitive parameters before the waste is accepted for ERDF disposal.

4.6 Environmental Monitoring

Current environmental monitoring includes groundwater and leachate monitoring, surface contamination monitoring and air monitoring. The surface and air monitoring are performed as a part of the overall Hanford site environmental monitoring program and they were not reviewed.

The ERDF groundwater monitoring program currently consists of semiannual sampling of 4 groundwater monitoring wells located as shown in Figure 4.1. The list of analytes, laboratory methods and statistical information are provided in the most recent groundwater and leachate monitoring report (Bechtel 2002). It is reported that the list of analytes was determined with consideration of the current groundwater contamination from previous operations in the 200 West Area and the baseline characterization report (Bechtel, 1995) is referenced.

The number and distribution of groundwater sampling wells (4) is probably compliant with regulatory requirements at the current size of the cell filling operations but considering the groundwater contamination beneath the ERDF there is a good argument for increasing the monitoring well density around the current waste cells if groundwater monitoring is used to monitor site performance. It would be beneficial to have additional wells on the south, the north and at the northwest corner of Cells 1 through 4. This is particularly important considering the uncertainties of the historical groundwater contamination in this area as discussed in section 4.2 above. Consideration of this previous contamination could cause Cs-137, Sr-90 and Co-60 to be added to the list of groundwater analytes.

Groundwater contaminant trends show a slight increase in some contaminants due to migration of contaminant plumes from 200 West Area. Also, there is a gradual decrease in groundwater table elevation due to the cessation of releases of effluent in the 200 West Area.

Leachate sampling shows an increase in the C-14, Tc-99 and total Uranium concentration as sampled at the leachate collection sumps. This leachate originates from precipitation into the open cell added to the water that is used for dust suppression and soil and waste compaction. The volume of leachate obtained during each sampling interval is not reported in Bechtel (2002). This information would be useful to better understand trends in the leachate contaminant data.

The only other monitoring of the ERDF is proposed moisture monitoring beneath the cover as suggested in the performance assessment (Bechtel 1995). This would involve installing moisture monitoring instruments or horizontal instrumentation tubing beneath the cover as the cover is being built. Measurement of moisture content changes in the landfill just below the cover would help to demonstrate the performance of the cover. Cover monitoring will likely be considered in the cover design phase.

5.0 Summary of the DOE Low-level Waste Facilities at Hanford

5.1 General

The DOE has eight separate burial grounds at Hanford that are used for near-surface disposal of low-level radioactive wastes. These eight burial grounds are collectively referred to as the Hanford low-level burial grounds (LLBG). They are located in the 200 East Area and in the 200 West Area as shown in Figures 5.1 and 5.2.

These facilities are simply pits or trenches that were dug into the surface soils at convenient locations within the 200 Areas. Trench excavation and burial locations were largely selected based on the proximity to the main processing operations that they were intended to support and an absence of any other facilities in the immediate area. Burial grounds were close to the facilities to allow quick disposal thereby limiting personnel exposure to radiation. Waste materials were literally dumped into the trenches and covered over with the soil that was initially removed to create the trenches.

Disposal of waste in some of these burial trenches began in 1942 at the start of nuclear process operations at Hanford. Initially, all waste including hazardous waste, transuranic waste and all types of low-level waste was buried in these trenches along with various forms of liquid waste which was usually packaged in drums. Typical waste, if there is such a thing for these burial grounds, included clothing, plastics, construction materials, filters, and failed or decommissioned equipment. One burial trench (Trench 94) in the 200 East Area is sized for disposal of decommissioned nuclear reactor compartments from naval vessels.

The characteristics, the use and the types of material disposed or to be disposed, varies considerably, making it very difficult to provide a good summary of these facilities in this short review.

Documentation of past disposal practices and the characteristics of the waste is very limited, especially for the early years. A good, comprehensive description of the previously disposed waste materials, type of waste and characteristics was not found in any site documentation including the most recent Solid Waste Environmental Impact Statement (DOE 2003). In addition, an uncertainty estimation of the waste materials in the landfill was not found.

Documentation on post 1988 disposal practices and materials is considerably better. Table 5-1 through 5-3 from the draft EIS provides an estimation of the radionuclide content of the more recent and potential future waste to be placed in the 200 East Area burial grounds. Current waste disposal is governed by relatively strict waste acceptance criteria (WHC, 1993) that specifies waste characterization requirements and sets limits on concentrations and total quantities of some radionuclides.

Prior to 1970, transuranic waste was buried with low level waste as no distinction was made between the two. Since 1970, virtually all TRU waste was placed in the burial grounds in a manner that would facilitate later retrievable.

Liquid waste was segregated from the solid waste beginning in the early 1980's. It is assumed that prior to the early 1980's liquid waste was dumped as free liquid or placed in 55 gal steel drums for disposal. Again, no details or references are found in the draft EIS. It is not known if the practice of free liquid disposal ceased in the early 1980's or if that practice continued for a short time after segregation practices were adopted.

In 1987, regulations established the category of mixed hazardous and low level radioactive waste and disposal of mixed waste in the unlined trenches was no longer allowed. Current practice is to dispose of mixed waste in the RCRA compliant mixed waste trench in the 200 West Area or in the ERDF.

The current total volume of waste in all of the burial grounds is about 10 million cubic feet. This covers about 348 acres which is about one third of the total land area that is currently designated as low level burial grounds (1050 acres).

This report deals primarily with the current waste disposal practices and facility engineering as it is intended to review only the current operational practices and performance. Dealing with past chemical and radiological contaminants from past practices involves an entirely different set of review criteria. The CERCLA program at Hanford will develop alternatives to deal with the portions of the LLBGs that were filled prior to the early 1980's.

5.2 Site Geology and Hydrology

The general geology and hydrology of the Hanford site are summarized in Section 4.2. Specific details of the geologic sections beneath the East and West Area LLBGs are provided below.

The 200 East Area LLBG trenches sit in the upper portion of the Hanford formation. In this region, the Hanford formation is broken up into three distinct units based on sediment facies. The uppermost unit 1 is a gravel facies material with interstratified horizons of sand dominated facies and horizontal silt beds up to 3 ft thick. Unit 1 is from 35 to 120 ft thick. Unit 2 is a sand facies underlying Unit 1and is up to 180 ft thick. It is predominantly a fine sand material that is interbedded with silt layers and gravel layers. Clastic dikes, pinch outs and discontinuous gravel lenses are common throughout Unit 2 along with discontinuous perched water zones. Unit 3, below Unit 2, is a gravel facies material that is from 40 to 150 ft thick at the landfill areas. It is composed of predominantly gravel and fine sand. The unconfined aquifer is found within the Unit 3 gravel facies at a depth of 200 to 230 ft below surface.

In the northern portion of the 200 East Area, the Hanford formation sits directly on top of a basalt lava flow and Ringold formation sediments are not present. The basalt surface has an irregular subsurface topography and the unconfined aquifer is horizontally confined by the basalt subcrops or topographic high areas. Where the upper portion of the Ringold is present on top of the in the lower elevation basalt flows, it is composed predominantly of fine to medium sand facies.

The 200 West Area stratigraphy is shown in the schematic of 5.3. In the region of the 200 West burial grounds, the cataclysmic flood deposits of the Hanford formation are composed of interbedded coarse gravels to fine sand materials with a chaotic distribution of subfacies units. These subunits are small layers of fine silt or sand material that are from 10 to 20 ft thick and have a lateral extent of hundreds of feet or less. Cross-borehole correlation of these layers is difficult due to their short lateral extent.

Beneath the Hanford formation and above the Ringold formation, are found the Palouse Soil and the underlying Plio-Pleistocene unit. The Palouse Soil is thought to be primarily of eolian origin, and is composed of fine sand and silt with clay and is often described as a mud. The Plio-Pleistocene unit is a high carbonate, silty sand lacustrine deposit. It is eroded away in places and often a local perched water zone is found on top of this unit.

The upper Ringold, when it is present beneath the 200 West Area, is a medium to fine sand up to about 35 ft thick. The underlying middle Ringold is predominantly a coarse gravel with fine sand and is up to 300 ft thick. The unconfined aquifer is found beneath the 200 West Area about in the middle of the middle Ringold at a depth from 200 to 250 ft. The lower Ringold is another mud layer, composed of fine sand and silt up to about 40 ft thick. This unit is not continuous throughout the 200 West Area. The basal Ringold, shown schematically in Figure 5.3 just above the basalt, is composed of layered subunits of coarse and fine gravel with sand.

5.3 Waste Disposal and Isolation Engineered Approach

The method of disposal at the DOE low level burial grounds is to place the waste in an unlined trench dug into the sandy soil at a depth of about 20 ft. Category 1 wastes are usually packaged into 55 gal steel drums or wood or cardboard boxes that are either randomly dumped or stacked to within about 8 feet of the original surface. Category 3 waste is placed in concrete high integrity containers or grouted in place.

A cover composed of existing site soils is placed over the waste to approximately the original elevation. Category 1 waste is covered with 8 feet of soil and category 3 waste is covered with at least 15 feet of soil. No cover design criteria exist and a detailed cover design was not prepared as the primary function of the site soil cover is to limit infiltration. This is accomplished with a simple soil cover.

Reactor compartments disposed in Trench 94 are quite different in that the compartments themselves are sealed and shielded containers. They that are equivalent to high integrity casks used for Category 3 wastes, in terms of isolation of the radioactive materials within the containers.

A conceptual design or a detailed design detailing a facility configuration design or explaining methods of performance was not found for the low level burial grounds. The facility engineering appears to be limited to sizing the trenches to provide optimum volume efficiency and to optimizing material handling and efficient placement operations.

The method of meeting performance requirements at the DOE LLBGs is to utilize the sorptive properties of the existing site soils and the extensive depth to groundwater to assure adequate containment of the waste material. Performance assessments are used to demonstrate compliance with regulatory requirements (Wood et al., 1995, 1996).

5.4 DOE LLW Facility Design, Construction and Operation Details

Details on the DOE LLBG disposal operations are provided in Pratt (1998) in the draft EIS (DOE, 2002, 2003) and in the performance assessments (Wood 1995, 1996).

The typical burial grounds are multiple trenches of the same or similar dimensions and arranged with a common orientation to optimize volume efficiency. Typical trench dimensions are 40 ft wide and 12 to 20 ft deep. The trenches have either V groove bottoms or flat bottoms with side slopes near 45 degrees. With multiple parallel trenches the operational trench can be covered with material removed from the next trench excavation.

Category 1 waste is placed in wood boxes or steel drums and either randomly placed in the trench or stacked to optimize volume. Each tier or stack of waste (drums or boxes) is covered with at least 1 ft of soil and subjected to dynamic compaction. Multiple tiers are used for some types of waste and a foot of soil is also placed between tiers. The waste is placed to within 8 ft of the original surface providing at least 8 ft of on-site soil cover. No compaction specifications are identified in the operations plan (Pratt, 1998) and none were found in other documents.

Current proposals in the draft EIS are calling for deeper trenches with corresponding larger horizontal dimensions to accommodate more low-level waste.

Category 3 waste is placed in high integrity containers or it is surrounded by concrete forms and grouted in place with low strength grout. The high integrity containers are concrete cylinders with a lid or rectangular boxes that also have a concrete lid. This waste is placed in a single tier and covered with 15 ft of soil. Category 3 waste is segregated from other low level waste.

The reactor compartment trench (Trench 94) is very large (exact dimensions are not readily available), it has a level bottom and it is constructed with a large ramp to allow delivery and placement of the massive reactor compartments in the excavation. Reactor compartments are transported into the pit and set on prepared concrete forms. Soil is backfilled around and over the compartments.

The 200 East Area LLBG performance assessment (Wood et al. 1996) indicates that subsidence stabilization may be required prior to cover installation. Details of the subsidence stabilization methods to be employed are not identified.

5.5 Infiltration and Contaminant Transport Model

Two separate and relatively comprehensive performance assessments (PA) were used to calculate the radionuclide dose for the LLBGs, one for the 200 East Area and one for the 200 West Area. The PAs are very similar as they have the same performance objectives, similar release scenarios and similar hydrogeologic parameters, radionuclide mobilities and intruder dose scenarios. They differ in that they have different geologic computation sections and the source terms differ, primarily due to the Naval reactor compartments in the 200 East Area pit.

The goal of the PAs is ultimately to estimate radionuclide dose to man as a means to show compliance with DOE Order 5820.2A dose criteria. The PAs only consider post 1988 waste disposal as pre-1988 waste falls under CERCLA programs and are the subject of a composite performance analysis that is beyond the scope of this review. Two types of sources are considered in the PA calculations, one for the category 1 waste and one for category 3 waste. For both types of waste the calculations estimate potential dose to man from releases to the surrounding environment.

The category 1 waste is assumed not to have an engineered liner or an infiltration limiting, engineered cover other than a simple site soil cover. The assumed infiltration rate for the base modeling condition was set at 2 inches per year. This infiltration rate is based on previous site infiltration studies including controlled lysimeter infiltration experiments. The category 3 waste is assumed to have an infiltration limiting cover and the base condition infiltration is set at 0.2 inches per year.

Two basic release and exposure scenarios were developed for the PA calculations. The first being a natural groundwater exposure scenario involving the leaching of radionuclides from the landfill by infiltrating water. The contamination travels through the vadose zone, into the groundwater and travels to a groundwater well that is postulated to be at a point 300 ft from the burial ground. A significant dose is only received by ingestion of groundwater near the facility. Compared to this, a Columbia River exposure scenario is insignificant. This calculation was carried out for a time period of 10,000 years as virtually all of the maximum groundwater concentrations occurred before 10,000 years.

The calculation used a 2-dimensional homogeneous earth model with steady state infiltration, migration and transport to the groundwater. Once contaminants reach the groundwater, advective dispersion, and mixing occurred to dilute the concentration and produce a calculated dose 300 ft away at the uptake well.

An initial sensitivity analysis of the groundwater exposure scenario eliminated all but the highly mobile and long-lived radionuclides as potential contributors of dose. The radionuclides of principal concern include C-14, Cl-36, tritium, I-129, Re-187, Se-79, Tc-99, Uranium, Np-237, Pa-231 and Po-209.

A sensitivity analysis was performed by varying the properties of the model in very specific ways to test the conservative base condition and determine what parameters significantly affected dose. The results indicated the parameters affecting dose, roughly in the order of significance are: infiltration rate, soil permeability (saturated zone), the moisture content/permeability relation (unsaturated zone), degree or influence of heterogeneities, the regional groundwater gradient, the degree of high radiation zones or concentrations in the source material, the sorption coefficients and the individual radionuclide solubilities. The sensitivity analysis indicated the radionuclide concentrations in the groundwater could exceed the base case by a factor of 10. As a result, waste acceptance criteria were established for the total inventory levels of the above radionuclides. The sensitivity analysis demonstrated the significance of an infiltration limiting cover for the category 3 waste. It also showed the importance of the dilution and dispersion action as the radionuclides enter the groundwater, in limiting the potential dose received in the groundwater well located 300 ft from the landfill.

The other potential release and exposure scenario considered in the PA is a combination of intrusion scenarios. There are basically two intrusion scenarios considered. One involves excavating for a basement causing an acute exposure by direct contact to the waste and a chronic exposure by living in the home. This intrusion scenario is only considered for the category 1 waste as it is assumed that the greater depth of burial of category 3 waste (16 ft) is adequate to prevent this type of an event. This intrusion scenario is assumed to occur 100 years after closure of the landfill.

The second type of intrusion considered in the PA is the drilling of a well through the waste and into the groundwater for irrigation and drinking. The exposure in this case occurs as a result of bringing up the drill cuttings, spreading them around and farming on the land as well as drinking the water, irrigating with the water and consuming the crops. This intrusion scenario is calculated for both category 1 and 3 waste and it is considered to occur 500 years after closure. The basis of this time-frame is not clearly established in the PA.

It is not understood how the drilling intrusion calculation utilized the groundwater contamination data generated from the natural release scenario; the primary point of uncertainty being the location of the uptake well. With the dilution of contamination as it reaches the groundwater being a highly significant dose reduction factor, the drilling intrusion groundwater dose should be higher than the natural groundwater scenario dose because of differences in the groundwater uptake well location. This is not explained in the PA.

For both intrusion scenarios, the dose-to-man is linearly proportional to the radionuclide concentrations (curies/volume) at the time of intrusion. The dose is dominated by ingestion of contamination in both cases.

Radionuclide concentration limits were established for category 1 waste based on the excavation intrusion scenario (primarily Sr-90 and Cs-137) . Likewise, limitations were established for category 3 waste based on the drilling intrusion scenario.

Dose estimations in the PA were applied by limiting the concentrations of specific radionuclides that have a half-life greater than 5 years. Also, criteria were established for total activity of long-lived and environmentally mobile radionuclides (C-14, Tc-99, I-129 and Uranium). The PA also demonstrated the need for an infiltration limiting cover for the facilities containing category 3 waste. The PA leaves open for future consideration, the possibility of requirements for waste form enhancement such as grouting of the waste or some form of stabilization.

Finally, the PA acknowledges the limitations of groundwater monitoring as an effective means of monitoring performance. Because of the slow releases, if a contaminant plume were to reach groundwater, the PA shows the concentrations would be so low that it is doubtful that it would be detected especially considering the current contamination in the groundwater beneath the sites. Monitoring of the infiltration through the future covers is recommended as a more effective site monitoring scheme.

5.6 Environmental Monitoring

There is minimal environmental monitoring at the LLBGs that is related to the geotechnical aspects of the sites. The environmental monitoring is reported in Hanford site-wide environmental monitoring reports such as DOE/RL (2001) or WMFS (1998). Current environmental monitoring includes groundwater monitoring, air (radiation) monitoring, surface radiation monitoring and other, special studies that are related to the LLBGs.

Groundwater monitoring is accomplished with a minimum number of monitoring wells. The current number of monitoring wells installed around the burial grounds is not adequate from a regulatory basis as indicated by comments the solid waste EIS from the State Dept of Ecology. The general monitoring well placement guideline of one upstream and three downstream wells is not satisfied at some burial grounds. In addition, many wells are going dry due to the decline in groundwater levels and changes in the groundwater flow direction are dictating changes in well locations to comply with the basic guideline. On top of this, the existing contamination in the groundwater makes it difficult to determine the source(s) of contamination.

As indicated in the performance assessments, the concept of monitoring the actual LLBGs by sampling the groundwater is basically a bad idea. If contamination from the landfills were to reach groundwater before the end of the institutional control period, it would be in such low concentration that it would not be detectable especially considering the multitude of groundwater contamination sources. Besides that, by the time contamination is detected in the groundwater, a loss of containment would have occurred long ago and it would be too late to take any corrective action. Essentially the damage would already have been done by contaminating the vadose zones sediment column.

The results of the current groundwater contamination monitoring program do not provide any useful information related to operational monitoring aspects of the LLBGs.

Other studies performed at Hanford are worth noting because they are related to operational monitoring aspects of the LLBGs. These studies include meteorological monitoring (precipitation), lysimeters studies, and other special tests and studies that support either the performance assessments or burial ground design concerns.

other studies including, B-57 crib, lysimeters, meteorological, others

6.0 Summary of the US Ecology, Inc. Low-Level Waste Disposal Facility

6.1 General

The US Ecology, Inc. facility is a commercial low level waste disposal facility located about in the middle of the Hanford Site, adjacent to and just south of the 200 East Area (Figure 6.1). This location is directly east of the ERDF site discussed in section 5 of this report so that much of the previous discussion of the geology, hydrology and groundwater contamination is applicable to this site.

The 100 acres of land on which the facility sits, is owned by the Department of Energy, leased to the State of Washington and in-turn subleased to US Ecology, Inc. US Ecology is under contract to Washington State to operate the site for the State. It is not clear to this reviewer who is considered the owner of the facility, who is the regulator and who reporting to the NRC.

The facility first began receiving waste materials in 1965 and is the oldest commercial disposal facility operating in the US. The basic waste disposal practice at this facility is shallow land burial in unlined trenches. Typical trench dimensions are 800 ft long by 150 ft wide by 45 ft deep and there are about 20 such trenches at the facility as shown in Figure 6.2. The current total waste volume is about 13.5 million cubic feet.

In 1966, Washington State took over licensing responsibility for the site from the Atomic Energy Commission. US Ecology, Inc. has a Radioactive Materials License (WN-1019-2) from Washington State to operate the facility. The current license from the State is required to be renewed every five years. The last approved license was issued in 1992 and an application for license renewal was submitted in 1997. A renewal was not granted in 1997 due to a determination that an Environmental Impact Statement (EIS) was needed. A draft EIS was prepared by WA Department of Health (WDOH) and the WA Department of Ecology (WDOE) in 2000 (WDOH, 2000) which included a pending action for approval of the license renewal application. That draft EIS was not finalized and its current status is not known. The facility currently operates under the 1995 license per WA State regulations.

The license renewal application was not reviewed for the preparation of this report and it is not known what material differences exist between requirements of the State radioactive material license and the NRC requirements for disposal of low level nuclear waste (10 CFR 61, see Section 2 of this report).

Because this is an old disposal facility, there are a variety of waste types in the landfill including radioactive waste, hazardous chemical waste and a combination of mixed hazardous and radioactive waste. Information on the waste type and composition is very general in nature and a quantitative assessment of what has been placed in the landfill trenches cannot be made, especially for the trenches filled prior to about 1985. The breakdown of waste quantity with waste type is not well known.

The radioactive waste placed in the trenches includes primarily low-level radioactive waste designated as class A, B and C. The class A waste is the lowest radioactivity of the low level waste and accounts for about 98% of the total volume of material in the landfill. However, the class B and C waste, which is considerably higher in activity and comprises less than 2% of the volume, contains about 80% of the total radioactivity.

NARM waste was and continues to be disposed at the US Ecology site. NARM waste is material from naturally occurring sources such as mine or mill tailings or it originates from accelerator created materials. The site is currently permitted to receive up to 100,000 ft^3 of NARM waste but the actual volume received is much less.

Transuranic (TRU) waste was also accepted at the site until about 1979. Currently the site holds an estimate of about 80 lbs of known TRU waste. Additional TRU waste may have been placed in the landfill either intentionally or inadvertently in the early years but there is no way to confirm or disprove this (A.T.Kearney, 1987).

Chemical wastes disposed in the landfill include organic and inorganic liquids, solids and adsorbed liquids including resins, acids, chelating agents, basic solutions, decontamination agents, ammonia solutions and much more. Much of the chemical waste was mixed waste that also contained a variety of radionuclides. It included everything from decontamination cleaning solutions to laboratory testing vials to chemical process waste.

One trench is called the “chemical trench” (see Figure 6.2) because it was primarily used to dispose of non-radioactive chemical waste. Very little information is available on the waste type and characteristics in this trench. The waste was generally put into 55 gal. drums for disposal in the chemical trench but the trench may also have been used to dispose of bulk liquid or chemical sludge waste (A.T.Kearney, 1987). Past operations did not prohibit disposal of free liquid in the drums. “… inspectors at the site have indicated that leakers are occasionally observed during routine disposal operations” and “67 leakers were noted as violations from 1979 -84” (A.T. Kearny, 1987). Regardless of whether or not free liquids were dumped, it is clear that uncontained liquids were released. The chemical trench was closed in 1970 with a total of 17,000 ft^3 of waste.

Limited RCRA phase I and phase II subsurface characterization programs were conducted at the US Ecology site by the WDOE and WDOH prior to and in support of preparation of the draft EIS. The characterization included drilling and sampling beneath two trenches to assay the subsurface contamination. The characterization also included assay of groundwater samples from six groundwater monitoring wells at the site.

The vadose zone sediment samples taken from beneath the two trenches detected hazardous constituents: arsenic, beryllium, cadmium, chromium, acetone, benzene, tetrachloroethane, toluene and xylene. In addition, the following radionuclides were found in the sediment samples: Am-241, Ni-63, Pu-238, Pu-239/240, Sr-90, and Tc-99. Soil gas samples taken from some of the boreholes identified C-14 and Kr-85 in the soil vapor phase.

Contaminants in the groundwater beneath the site include I-129, Tc-99, tritium, Co-60, Pu-239/240, trichloroethylene (TCE) and chloroform. The plutonium may be a non-detect but there is no explanation or assessment of this data in the draft EIS. Subsequent sampling of the groundwater shows no detection of Pu in the groundwater (US Ecology, 2001) but again, there is no discussion of the change in the Pu data or an appropriate assessment of the data.

The historical trends and previous mapping of the groundwater contamination by DOE (PNNL 1999) as well as recent data (US Ecology, 2001) show that the tritium, and chloroform originated from upgradient contamination sources on the Hanford site. This is also in a region where the groundwater has been subjected to reversals in the groundwater flow direction resulting from releases of large volumes of water at the 200 East and 200 West Areas. This site is also a few thousand feet southeast of radioactive liquid releases at the BY cribs.

However, there remains the question as to the source of some of the contaminants in the groundwater as well as the question of what and how far contaminants have moved through the sediment in the vadose zone. An understanding of the current groundwater contamination is required before they can present a model showing compliance with groundwater contamination standards in the future.

A phase III characterization of the site is in the planning. However, the WDOE will not include characterization of radionuclide contamination in the phase III characterization.

Since 1985, only Class A, B and C low-level radioactive waste and NARM waste has been disposed of at the US Ecology Site and free liquids are no longer allowed. The post 1985 waste disposal practices and facility engineering are the primary focus of this review as it is intended to look at the current operational practices and performance. Dealing with past chemical and radiological contaminants from past practices involves an entirely different set of review criteria.

6.2 Site Geology and Hydrology

A general discussion of the geology and hydrology of the Hanford Site is provided in Section 5.2 of this report. Additional information is provided in the references Delaney (et. al. 1991 and Lindsey (et. al. 1992).

The US Ecology Site geology and hydrology are basically the same as that of the east side of the ERDF site. The geologic section from the top down starts with a few feet of eolian sand before we get into the upper part of the Hanford formation.

The walls and base of the trenches at the site are composed of predominantly fine sand with fluvial structures such as cross bedding and ripple marks. There are lenticular silt beds, layers of volcanic ash and regions of sharp horizontal bedding changes from fine sand to coarse sand and layers of elevated gravel content. Clastic dikes cutting vertically across the sedimentary bedding structures are common. This is typical of the Hanford formation which extends down to an elevation of about 420 ft which is about 200 ft below ground surface (bgs). The sand facies is the dominant sediment type with poorly graded fine sand and silty sand with layers of silt and fine sand.

Beneath the Hanford formation is the Ringold formation. This is a well graded, coarse grained sub-rounded to well rounded fluvial gravel with sand and minor silt and clay. The base of the Ringold formation is at 405 ft bgs at the top of the Miocene flood basalts.

Groundwater (unconfined aquifer) at the site is about 315 ft bgs in the middle Ringold formation. The base of the aquifer is the top of basalt at 405 ft, making the unconfined aquifer about 90 ft thick. The current groundwater flow direction is to the north-northeast direction with a very slight gradient (XXX ft/ft). This shallow gradient can make it difficult to determine which way is 'up' within the groundwater. Additionally, over the past 50 years, this area has been subjected to changes and reversals in groundwater flow direction due to release of water from cribs and ponds in the 200 Areas of Hanford.

6.3 Waste Disposal and Isolation Engineered Approach

The US Ecology Site has undergone a minimal amount of actual configuration design or engineering for performing its primary function of isolating the waste. No documentation was found in the WDOE library files on site engineering. This site basically evolved over time, starting simply as a trench that was dug in a convenient location on the Hanford site for disposing of the waste.

There has been some evolution of site practices and operations engineering plans with time, primarily as new regulations and requirements were imposed. A good example of this is the discontinuance of accepting hazardous or liquid waste materials.

Current applicable requirements and performance standards are listed in the draft EIS including the NRC regulations (10 CFR 61) listed in Section 2. However, the draft EIS indicates the NRC regulations are only applicable as guidance standards rather than mandatory.

The basic approach used to provide isolation of the radioactive waste material is to use the sandy soils as the containment media and take consideration of the arid climate, the great depth to groundwater at the site and the considerable travel time through the thick vadose zone. In addition, an engineered cover provides assurance of low moisture flux through the waste over the long term. The draft EIS states that the trench soils are the primary method of containing the radioactive waste.

With these considerations, the WDOE and WDOH believe the contaminant transport model detailed in the draft EIS, appropriately demonstrates the performance of the site.

6.4 US Ecology Facility Design, Construction and Operation Summary

The trenches at the US Ecology landfill are excavated in the existing sandy soil to a depth of about 45 ft and are generally 150 ft wide by 1000 ft long. The trench soil side slopes are set at an angle that is less than the angle of repose to decrease the potential for slope failures although some small local failures of the side slopes have occurred.

Some standard soil tests are run during construction on the “major stratigraphic units” including in-situ density, grain size and moisture content (US Ecology, 1987). Bearing capacity tests and direct shear tests are obtained on soil from the surface and from the trench bottom.

Wastes are packaged in steel boxes or 55 gallon metal drums. It is assumed that some soil waste such as NARM waste is accepted in bulk form as well but this is not indicated in the draft EIS. Wastes are segregated according to class (A, B, or C), to prevent excessive surface radiation and to segregate potentially reactive wastes. Class C waste is placed in high integrity concrete containers or concrete vaults and must be placed at least 16.5 ft below ground surface.

The steel boxes containing class A waste are carefully stacked but the steel drums are placed randomly. The draft EIS indicates that drum waste is emplaced in such a way that void spaces are minimized while permitting void spaces around waste containers to be filled with soil. With the random placement of drums it is not known how either of these is accomplished. The 1987 preliminary closure plan indicates that “ … no attempt is made to minimize void spaces between drums”. This may be the difference between past operations and current operations but, no specific void filling or lift construction engineering plans were identified in the review.

Backfilling is accomplished by pushing the granular soil backfill material over the top of the waste with a large dozer. No backfill compaction methodology is indicated in the facility standards manual (US Ecology, 1987). However, the manual does indicate that the backfill shall be placed so that the relative density is greater than or equal to 85% of the average in-situ density of the excavated materials. It is assumed that some sort of backfill density measurement is obtained. However, no moisture conditioning or compaction testing is specified and no compaction verification requirements were found in site documentation.

After the waste is emplaced the trenches are covered with up to 5 ft of soil as an interim cover before the final cover is installed and the landfill is closed. Backfilling is also done if required to maintain the radiation level at the trench edge at a value below 5mrem/hr.

The occurrence of a sinkhole was documented in Trench 13 and Trench 10 had tension and subsidence cracks in the surface. These were “remediated” by placing additional fill and compacting on top of the fill.

Subsidence measurements are not specified in the site operation plans and engineered subsidence criteria have not been prepared.

Details of the final cover design have not been finalized as a closure plan has not been approved. One holding point is a requirement to assess different cover designs in an EIS. The current draft EIS includes an analysis of six cover alternatives. An analysis of potential intrusion scenarios is also included in the draft EIS. Intrusion prevention is accomplished by providing a cover that is at least 16 ft thick and, for some of the proposed covers, with the addition of an asphaltic layer or some other physical barrier that primarily prevents animal intrusion.

Since the beginning of the US Ecology site operations in 1965, the trenches have been maintained with a temporary or interim cover of on-site sand. They are kept free of vegetation by herbicide spraying to prevent intrusion by deep rooting plants. This also prevents evapotranspiration. A modeling study or analysis of the potential enhanced infiltration resulting from the current interim configuration similar to the Envirocare open cell modeling report has not been done and no criteria exist for an allowable length of time before a cover must be placed.

The WDOH is the primary regulating agency at the site and they have an on-site presence, providing inspections, audits and reviews of site construction and operations. The site characterization work and preparation of the draft EIS was all done by WDOH and WDOE.

6.5 Infiltration and Contaminant Transport Model

Discussions of the infiltration and contaminant transport model and the risk assessment evaluation for the groundwater pathway are provided in the draft EIS (WDOE, WDOH 2000). Only radionuclides were modeled for the preparation of the draft EIS. This work was completed to support selection of operation and closure alternatives and to demonstrate compliance with basic radiation exposure requirements.

The groundwater pathway modeling analysis first utilized the UNSAT-H program to quantify the net infiltration through several proposed covers. Multiple cover designs were analyzed as part of the draft EIS cover alternative selection process. Calculated infiltration rates through the cover varied from 0.001 mm/yr for several composite covers to 20 mm/yr (2 cm/yr) for a simple cover composed of site soils which is essentially equivalent to not having an infiltration inhibiting cover.

With the cover infiltration data determined, a model of the vadose zone and groundwater was prepared using the program GWSCREEN. This is a finite element program which simulates the vadose zone contaminant migration process as a steady state, one dimensional advection and dispersion process where the pore water velocity is controlled by the recharge flux. The vadose zone beneath and surrounding the landfill was modeled with a background moisture flux of 0.5 mm/yr while the waste material zone beneath the cover had an infiltration shadow caused by the cover. Infiltration rates through the waste zone were modeled with varying infiltration or moisture flux through the cover, depending on the type of cover being modeled.

The source term used in the model is specified in terms of total quantity only and those values are assumed to be highly uncertain. The draft EIS does not provide an estimation or discussion of the uncertainty of the source term. Multipliers of 2 and 10 were applied to the U-235 and U-238 quantities respectively because of the uncertainty of the total uranium in the landfill, largely from the early years of operation.

In order to simplify the analysis, the number of radionuclides modeled was reduced by an initial screening analysis. The screening analysis used a simplified model with a 5 cm/yr infiltration rate or about on third of the annual precipitation. Tritium was not modeled as it was estimated to enter the groundwater within decades at that infiltration rate and it was determined that tritium would be investigated under the active site monitoring program. The screening analysis identified five radionuclides that could potentially impact the groundwater and create a measurable dose. They include Cl-36, Tc-99, I-129, U-235 and U-238.

These five radionuclides were then modeled with the different covers to determine the impact on groundwater and eventually the dose to man and the impacts to the environment.   The source material is assumed to be available for transport at closure time, thus not taking credit for any packaging or waste form enhancement. The distribution coefficients used in the groundwater pathway analysis assumes waste of low salt composition, neutral pH and no organics in the waste that could enhance migration. When the contaminant reaches groundwater the model assumes mixing with the groundwater that is dependent on the area of the trench footprint.   The receptor well is assumed at a point that is 900 ft from the center of the trench.

Results from the groundwater pathway analyses predicted concentrations of these nuclides in the groundwater that do not cause an exposure exceeding the WA State regulatory limit of 4 mrem/yr for ingestion of groundwater.

One area of uncertainty besides the source term uncertainty, is the current depth of migration of contaminants. The infiltration umbrella effect that is gained from installation of a cover is only effective if the waste is close beneath the cover, thus removing the waste from any substantial downward flow of moisture.   The current depth of migration of contaminants at the US Ecology site is not known and it could be significant considering that the landfill has been uncovered and subjected to up to 5 cm/yr infiltration for up to forty years so far.

Also, the characterization and modeling effort does not include an attempt to understand the environmental impacts and the potential future dose from radionuclides found in the vadose zone beneath the chemical trenches. The presence in particular of americium, plutonium and strontium beneath the trenches does not conform to and is not explained by the contaminant transport model. It is possible that the chemical co-contaminants may be enhancing the mobility of these radionuclides.

6.6 Environmental Monitoring

Environmental monitoring at the US Ecology site includes ambient air radiation monitoring, vegetation monitoring, surface radiation monitoring (beta & gamma), groundwater monitoring and some limited vadose zone gas monitoring. Groundwater and vadose zone monitoring data provided in US Ecology (2001) were review for this report.

Groundwater monitoring data are obtained quarterly from seven groundwater monitoring wells located as shown in Figure 6.2. Four of the wells are downgradient and three are upgradient although two wells (9 and 9a) are adjacent to each other so that there are two upgradient groundwater monitoring locations.   Samples of the groundwater are obtained for chemical and radiological analysis and the groundwater depth and pertinent field measurements are taken with each sampling event.

Principal radionuclide contamination in the groundwater that is monitored or tracked includes gross alpha and beta, tritium, C-14, Tc-99, uranium and plutonium. Of these, tritium is the only one that shows an increasing trend. That contamination likely originates from contamination releases in the 200 West Area or possibly from the nearby BY cribs, considering past changes in the groundwater flow direction.

Plutonium is monitored but all laboratory measurements consistently show no plutonium detected above the minimum detectable activity of 0.01 pCi/L. The established action level used to indicate a clear positive detection is 0.03 pCi/L. Pu was detected in well XXX at a level of 0.247 pCi/L when this well was first installed and sampled. No discussion of the initial positive detection or the apparent changes in the Pu monitoring results is provided in the monitoring report.

A suite of non-radiological and hazardous constituents are also monitored including chloride, nitrate, pH, total dissolved solids, conductivity, sulfate, various metals and various cations and anions. Results of this monitoring do not provide evidence that the burial ground is a contributing source of these constituents to the groundwater. However, the conclusion that the site is not contributing to the groundwater contamination does not necessarily follow.

A comparison of the site groundwater data with data from the larger Hanford site-wide groundwater monitoring provides reasonably conclusive evidence that many of the contaminants or chemical anomalies originated from other sources. For a conclusive determination of the source of all of the constituents in the groundwater, monitoring will be required for several years with a stable hydrologic regime and, again considering the reversals of the groundwater flow direction and the current steady decline in groundwater elevation, it may never be possible to provide that type of conclusion about some of the contaminants in the groundwater at the US Ecology site.

Two contaminants (TCE and chloroform) in the groundwater that were reported in the draft EIS were not found in the annual groundwater monitoring report. The source of these contaminants was a significant concern in the draft EIS and appears to remain so.

Vadose zone monitoring at the US Ecology site involves vapor sampling from four vadose zone sampling boreholes and from solar stills located at various strategic positions around the surface of the facility.

Carbon dioxide levels are elevated in two of the boreholes, possibly from the breakdown of organics in the trenches. Tritium is also elevated and an upward trend in tritium vapor in the boreholes close to the trenches indicates the trenches as the source. The solar still data also show an increasing trend in tritium near a trench. These data are not surprising and they are undoubtedly the result of vapor phase tritium migration. These results do not indicate anything unexpected in terms of contaminant migration through the vadose zone. They do warrant continued monitoring.

7.0 Facility Review Criteria Assessments

7.1 Envirocare, Inc. Facility Assessment

<u>Site Suitability</u>

10 CFR 61.50 (a)(2)
The Envirocare facility is capable of being characterized, modeled, analyzed and monitored. This is largely due to the homogeneous nature of the geology and hydrology. Characterization is accomplished with numerous characterization boreholes. Monitoring of the LARW is largely accomplished with groundwater, and lysimeter monitoring systems and by intensive monitoring of an analogous test cell. Monitoring of the mixed waste embankment is accomplished by leachate collection and monitoring, groundwater monitoring and lysimeter monitoring.

10 CFR 61.50 (a)(3)
The location of the Envirocare facility, the climate in the immediate area and the lack of potable water all make it an extremely unlikely location for future population growth and development. This region is zoned for hazardous industrial operations such as the landfill operation.

10 CFR 61.50 (a)(4)
The region of the Envirocare facility has no known current or potential future natural resources for exploitation.

10 CFR 61.50 (a)(5)
The Envirocare facility is in a region where there are no surface waters. This is a region where evaporation greatly exceeds precipitation creating a saline groundwater system. Precipitation infiltrates into the upper portion of the vadose zone and is evaporated away.

10 CFR 61.50 (a)(6)
Upstream drainage onto the site or within several miles of the site does not occur in the arid environment of the Envirocare site.

10 CFR 61.50 (a)(7)
The saline groundwater at the Envirocare site is about 30 ft below ground surface. The last time the groundwater reached the base elevation of the landfill was about 13,000 years before present, during the Pleistocene. It is not plausible that groundwater would intrude into the waste zone within a time frame of concern for the low level waste or the mixed waste embankments.

10 CFR 61.50 (a)(8)
There is no discharge of groundwater to the surface at or near the site.

10 CFR 61.50 (a)(9)
The Envirocare facility is located on the western portion of the Intermountain Seismic Zone. The liner systems, waste placement methodology, and cover systems are designed for the maximum credible seismic event and earthquake intensity with a maximum spectral acceleration of 0.37 g at this site.

10 CFR 61.50 (a)(10)
The Envirocare facility is located in a geologically stable area where temporally significant dynamic geologic processes are limited to wind deposition and erosion and fluvial erosion of the distant uplift regions. Wind erosion does not effect the stability of the embankments as the cover systems are designed to prevent wind erosion.

10 CFR 61.50 (a)(11)
The Envirocare facility is located immediately adjacent to other landfill cells of similar function. The environmental and facility monitoring systems are such that each has an independent monitoring system that does not interfere with the others and each is capable of exclusive detection of a potential release of contamination.

Site Design

10 CFR 61.51 (a)(1)
A primary goal of the LARW and mixed waste embankment designs is to provide long-term isolation. No post closure maintenance requirements are expected other than those related to maintaining the post closure monitoring systems.

10 CFR 61.51 (a)(2)
The Envirocare site design and operations support and enhance facility closure plans. The site closure plans provide reasonable assurance that the performance objectives will be met. No conflicting conditions are found between the design and operations and the facility closure objectives.

10 CFR 61.51 (a)(3)
The Envirocare facility is designed to complement and improve the natural characteristics of the disposal site to assure compliance with the performance objectives. Examples of improvements include installation of engineered liner systems and engineered cover systems. Additional assurance of meeting the performance objectives is provided by consideration in the facility designs of all of the various components and the role of each in satisfying the requirements.

10 CFR 61.51 (a)(4)
The cover systems at the Envirocare facility are designed to minimize infiltration to the greatest extent possible. It is contoured to direct percolating water away from the waste and it allows drainage of water that could collect in the upper region of the covers. The cover systems at the LARW and mixed waste embankments are designed to deter intrusion using a combination of gravel and rip-rap rock cover. The rock covers are also designed to prevent surface wind erosion.

10 CFR 61.51 (a)(5)
There is no surface water at the facility. In the extremely unlikely possibility of a surface runoff due to a local flood or extreme rainfall event, the cover systems are contoured and covered with rip rap to prevent erosion by surface water.

10 CFR 61.51 (a)(6)
The Envirocare facility has an open cell modeling study upon which operation requirements are based, establishing the maximum time allowed before the working open cell must be covered with a permanent cover. This study provides the basis for preventing significant waste contact with meteoric water that could infiltrate while the cell is being filled. Once the cover is installed, contact with potential percolating water is prevented.

Site Operations and Closure

10 CFR 61.52 (a)(1)
Class A wastes are segregated from potentially reactive or other wastes at the LARW because it only receives Class A wastes. Wastes at the mixed waste embankment are segregated according to the various types, waste form, size or dimension, and potential reactivity. Waste emplacement and cell filling plans are developed for each cell to assure compliance with requirements of this section.

10 CFR 61.52 (a)(2)
Class C wastes are not accepted at the Envirocare facility.

10 CFR 61.52 (a)(4)
Waste emplacement and cell filling plans are prepared for each waste cell at the Envirocare facility to help assure the waste package integrity is maintained and to minimize the void spaces between packages. These plans are reviewed and approved by the regulator (State of Utah). Where void spaces are unavoidable, the facility has and utilizes capabilities for grout filling and large scale and smaller scale waste encapsulation.

10 CFR 61.52 (a)(5)
Void spaces are filled with earth if compaction capabilities permit meeting the compaction requirements. Otherwise, they are filled with grout (CLSM) or void filling encapsulation foam. All are part of a waste cell fill plan along with testing and verification requirements.

10 CFR 61.52 (a)(6)
The projected dose at the surface of the waste cells (before the final cover is emplaced) is maintained in compliance with the listed exposure requirements by consideration in the waste cell filling plan and confirmed by monitoring of radiation levels.

10 CFR 61.52 (a)(7)
Boundaries and coordinates of the waste cells as well as individual waste packages are located and mapped as required.

10 CFR 61.52 (a)(8)
A buffer zone is established around and beneath the waste. The buffer zone beneath the waste includes the vadose zone and groundwater region. The moisture in the vadose zone beneath and around the waste zone is monitored with lysimeter installations. Groundwater monitoring occurs close enough to the waste zone in both depth and horizontal dimensions that mitigative measures can be taken before extensive migration of contaminants could occur. The mixed waste

embankment includes a leachate collection system that is used to identify excessive moisture migration through the waste material.

10 CFR 61.52 (a)(9)
The Envirocare facilities have approved closure plans that are implemented as each disposal cell is filled. An open cell modeling report specifies the time allowed before a working cell must be filled (4 years).

10 CFR 61.52 (a)(10)
A condition where active disposal operations could adversely impact stabilization and closure wasn't found at the Envirocare facility.

10 CFR 61.52 (a)(11)
The Envirocare facility in total maintains separate facilities for disposal of radioactive materials, for mixed waste materials and for 11e.(2) waste materials allowing segregation of each different type.

<u>Environmental Monitoring</u>

10 CFR 61.53 (a)
A comprehensive hydrogeologic report provides the required environmental background information on the site. Additional data and information are provided in annual environmental monitoring reports.

10 CFR 61.53 (b)
The reviewed Envirocare facility reports do not include plans for corrective measures as the closure plans do not anticipate a specific need for potential corrective measures. The environmental monitoring plans do have criteria for detection of anomalous conditions that could create either additional investigation or the development of corrective measures in the future.

10 CFR 61.53 (c)
Envirocare maintains an environmental monitoring program that is judged to be effective at evaluating potential impacts during construction and operation of the facility. Monitoring includes leachate monitoring (mixed waste embankment), vadose zone monitoring and groundwater monitoring among others. Additional monitoring and special studies include the development of an embankment cover infiltration test cell and the installation of lysimeters to enable prediction of long-term environmental effects and to identify inconsonant conditions and the potential need for mitigative measures. The monitoring systems appear to be capable of providing early warning of releases of radionuclides before they leave the site boundary. The definition of early warning is taken to imply that there is ample time to apply viable corrective measures before an actual release at a site boundary could occur.

10 CFR 61.53 (d)
The Envirocare facility closure plans include the continuation of the current environmental monitoring activities with minor changes. The monitoring systems are capable of providing

early warning of releases of radionuclides before they reach the site boundaries. Again, early warning is taken to imply that there is ample time to apply viable corrective measures before an actual release at a site boundary could occur.

Performance Demonstration

10 CFR 61.40 General Requirement
The Envirocare facility appears to be sited, designed, operated and closed with plans for monitoring and control after closure so that reasonable assurance exists that exposure is within the performance objectives.

10 CFR 61.41 Protection of the general population from releases of radioactivity
Envirocare has done the appropriate engineering and has developed a reasonable exposure model to demonstrate that concentrations of radioactivity released to the environment are and will be within the limits specified in this section. An engineering analysis was performed, the facility was appropriately designed, constructed, operated and closed to show that Envirocare has made a reasonable effort to maintain releases of radioactive effluent that are as low as reasonably achievable and will remain so.

10 CFR 61.42 Protection of individuals from inadvertent intrusion
The designs of the cover systems for the mixed waste and LARW facilities have considered the requirement to prevent intrusion into the waste by man and animals. The current designs would still not prevent intrusion into the waste by a determined intruder. However, it is probably not possible to truly prevent intrusion with any certainty, by a determined intruder at a near-surface facility. A reasonable effort was made and reasonable consideration is provided in the cover design and elsewhere to preventing intrusion as an inadvertent action.

10 CFR 61.43 Protection of individuals during operations
Operations appear to be conducted in compliance with exposure standards although this review does not specifically cover this topic. Effluent releases from the facility are clearly minimized to maintain radiation exposures that are as low as reasonably achievable presently and in the future.

10 CFR 61.44 Stability of the disposal site after closure
The long-term stability of the site is achieved and assured through site design, construction, operation and closure processes as outlined in the design reports. No ongoing active maintenance is required after closure that is not related to site surveillance and monitoring.

Defense-in-Depth System Design

The methodology and approach to the design of the embankment landfills at the Envirocare facility is provided in Envirocare (2001b) and in Envirocare (2002). The design approach adopted by Envirocare is that which is recommended by the NRC and EPA in their joint guidance document (NRC/EPA 1987).

The Envirocare design documents list the design criteria and requirements and they show what specific components or functions of the landfill are used to satisfy each criteria or requirement.

Multiple components are used to satisfy each objective and likewise, multiple objectives are satisfied with each component. This design matrix is used to demonstrate a defense-in-depth design approach thereby assuring that failure of one component will not cause a failure of the principal design criteria.

ALARA

Reference was not made to ALARA in the Envirocare mixed waste embankment engineering justification report (Envirocare 2001b) or in the LARW embankment construction plan (Envirocare 2002).

ALARA listed in the performance criteria quoted in the NRC regulations.

It isn't known if a specific ALARA review of the Envirocare facility has been conducted. At the same time, there is no reason to believe that an intensive ALARA review would not be entirely favorable.

No apparent violations of the ALARA concept were identified in this review.

RCRA Compliant Liner and Cover

RCRA requirements are applicable to the mixed waste embankment at the Envirocare facility. The mixed waste embankment is constructed with liner and cover systems that are in compliance with RCRA requirements. That compliance is determined or verified by independent review and oversight by the State of Utah.

7.2 DOE ERDF Facility Assessment

Site Suitability

10 CFR 61.50 (a)(2)
Generally speaking, the ERDF site is capable of being characterized, modeled, analyzed and monitored. However, there is some exception.

The characterization and understanding of the older groundwater contamination plumes may not be adequate for the ERDF facility to utilize groundwater monitoring to asses or monitor site performance. The primary concern is the detection of contamination in the groundwater that could falsely implicate the ERDF as the source.

In addition, the characterization of heterogeneities in the vadose zone sediments may not be adequate to accurately model them. At the same time, there may be no way to accurately model these heterogeneous sediments so additional characterization may be a moot point. Sensitivity analysis of simulated heterogeneities suggests they do not significantly affect site performance. However, that sensitivity analysis uses a model to confirm a model and the accuracy of the representation as well as the sensitivity assessment is not determined.

The accuracy of models of contaminant transport in the Hanford vadose zone remains an important unanswered question because the models don't produce good representations of observed contamination distributions and characteristics. If the site design relies on the vadose zone sediments to provide isolation of the waste and meet the performance objectives, a good argument can be made that the site cannot be accurately and appropriately modeled and analyzed.

10 CFR 61.50 (a)(3)
Population growth and future development are not likely to affect the ability of the ERDF facility to meet the performance objectives. This region is established for management of hazardous and radioactive materials and will be subjected to an extensive period of institutional control.

10 CFR 61.50 (a)(4)
The region of the ERDF facility has no known current or potential future natural resources for exploitation.

10 CFR 61.50 (a)(5)
The ERDF facility is in an area with no surface waters and is not within a hazard area.

10 CFR 61.50 (a)(6)
Upstream drainage onto the site or within several miles of the site does not occur in the arid environment of the ERDF site.

10 CFR 61.50 (a)(7)
The groundwater at the ERDF site is about 200 ft below ground surface. Inundation by groundwater is virtually impossible.

10 CFR 61.50 (a)(8)
There is no discharge of groundwater to the surface at or near the site.

10 CFR 61.50 (a)(9)
The ERDF facility is located in a region of relatively low seismic activity.
The application of seismic design criteria in the design of the liner systems, waste placement methodology, and cover systems could not be determined in the review.

10 CFR 61.50 (a)(10)
The ERDF facility is located in a geologically stable area where temporally significant dynamic geologic processes are limited to wind deposition and erosion. It is assumed that the final cover design for the ERDF will consider mitigation of wind erosion.

10 CFR 61.50 (a)(11)
DOE facilities adjacent to the ERDF could impact the ability of the ERDF to meet the performance objectives or vice versa. Assessment and consideration of the potential impacts has begun at Hanford with an initial composite analysis of the impacts of all 200 Area plateau operations (PNNL 1998). This work is just beginning at Hanford and the level and adequacy of our understanding of this issue will undoubtedly be debated for some time especially until extensive site characterizations are completed.

There is no doubt that the DOE facilities surrounding the ERDF can significantly mask environmental monitoring programs at the ERDF. The best example of this is the existing groundwater contamination and limitations in our knowledge of the current contamination distribution and behavior. However, from a design perspective, we need to consider the role of groundwater monitoring at the ERDF in demonstrating or monitoring site performance. Other monitoring methods, namely leachate monitoring, are much better at monitoring the ERDF site performance. So, concerns about masking of groundwater monitoring at the ERDF become less significant for the ERDF. From a performance monitoring system design standpoint, additional monitoring methods such as vadose zone moisture monitoring beneath or within the lower admixture liner may be useful.

Other environmental monitoring programs such as surface contamination monitoring could also be affected by adjacent DOE operations. However, actual impacts on the ability to demonstrate ERDF facility performance are probably not significant if proper care is taken in implementation of these monitoring programs.

<u>Site Design</u>

10 CFR 61.51 (a)(1)
The design of the ERDF facility is clearly directed toward providing long-term isolation. No post closure maintenance requirements are expected other than those related to maintaining the post closure monitoring systems as long as those systems are needed.

10 CFR 61.51 (a)(2)
The ERDF site design and operations are compatible with the facility closure plans. The site closure plans provide reasonable assurance that the performance objectives will be met.

10 CFR 61.51 (a)(3)
The ERDF facility is designed to complement and improve the natural characteristics of the disposal site to assure compliance with the performance objectives. The best examples of this are installing an engineered liner system and developing waste acceptance criteria. Additional assurance of meeting the performance objectives is provided by consideration in the key design documents of the role and function of the various components of the facility in satisfying the performance objectives.

10 CFR 61.51 (a)(4)
The cover system for the ERDF facility is not yet designed. However, minimum requirements for the cover and the level of regulatory oversight of the facility appear to be adequate to assure that the cover design minimizes the moisture flux through the waste and resists degradation. Resisting degradation of the cover from biotic activity, including biotic intrusion from humans and animals is not mentioned specifically in the brief discussion of cover systems in the RIFS. It is assumed that minimizing infiltration and preventing intrusion will both be key design objectives in the cover design.

10 CFR 61.51 (a)(5)
There is no surface water flow at the facility other than what could potentially be caused by a water line break. The final cover will be sloped to direct surface water away from the landfill.

10 CFR 61.51 (a)(6)
The ERDF facility is designed so that waste material will be covered with an interim cover as the waste cells are filled. The interim cover is appropriate to minimize contact of the waste with meteoric water. Timely installation of the final cover will minimize to the extent practicable, the contact of the waste with percolating water. The definition of "timely installation" has not been determined but, with the consideration of the leachate collection system, the in-depth design of the facility decreases the significance of a timely installation of the cover.

<u>Site Operations and Closure</u>

10 CFR 61.52 (a)(1)
Class A wastes are segregated from potentially reactive or other wastes at the ERDF to the extent the waste characterization allows or the site characterization knowledge. Segregation occurs during waste material disposal or during waste excavation/demolition. Waste emplacement segregation considerations appear to be adequate to prevent potential reactivity. However, because the ERDF is a radioactive and mixed waste site, there exists a potential that a combination of specific radionuclides or other hazardous constituents with a mobilization agent in the waste material could cause increased mobility of contaminants in the vadose zone. However, consideration of other facility design elements, namely the liner system, provides a level of protection from that. A comprehensive characterization of the sites being remediated would help eliminate any potential waste interaction problem.

10 CFR 61.52 (a)(2)
Higher activity waste and Class C waste is placed at least 16 ft below the planned top surface of the cover. It isn't known if another intrusion barrier will be included in the final design as an additional level of protection from a determined intruder.

10 CFR 61.52 (a)(4)
Waste emplacement and cell filling requirements at the ERDF assure package integrity and specify void space filling within and around irregular shaped packages. Grouting is used when needed to fill void spaces and soil backfilling requirements include soil compaction specifications as well as compaction verification requirements.

10 CFR 61.52 (a)(5)
Void spaces are filled with soil material if compaction capabilities permit meeting the compaction requirements. Otherwise, the packages are covered with free flowing grout.

10 CFR 61.52 (a)(6)
The dose at the surface of the waste cells is maintained in compliance with the exposure requirements during waste placement by covering the waste with a daily cover of soil. Monitoring of radiation levels assures compliance with these requirements.

10 CFR 61.52 (a)(7)
Boundaries and coordinates of the waste cells are located and mapped as required. Additional information is also obtained on the location of specific waste packages or waste types.

10 CFR 61.52 (a)(8)
A buffer zone exists around and beneath the waste. It couldn't be determined if the buffer zone beneath the waste is considered to include the vadose zone and groundwater region. Environmental monitoring beneath the waste includes leachate collection as well as groundwater monitoring although the role of groundwater monitoring in assessing the site performance or determining the potential need for mitigative measures is not clear.

10 CFR 61.52 (a)(9)
The ERDF facility operations are conducted so that each disposal cell is covered with an interim cover as it is filled. Excavation of subsequent disposal cells occurs as the previous cells become filled. The time allowed between interim cover placement and final cover placement is not established and the potential impact of the interim moisture flux into the waste zone is not known. However, the liner and leachate collection system provide additional assurance that the interim moisture flux through the waste will not affect site performance.

10 CFR 61.52 (a)(10)
The site operations are designed to complement site closure and stabilization measures. Such things as waste material and interim cover compaction and waste placement criteria support the closure goal of assuring long term stability.

10 CFR 61.52 (a)(11)

This criteria is not applicable to the ERDF as the ERDF is designed for disposal of both low-level waste and mixed waste.

Environmental Monitoring

10 CFR 61.53 (a)
A comprehensive hydrogeologic report and a baseline environmental monitoring report provide the required environmental background information on the ERDF site. Additional data and information are provided in annual environmental monitoring reports. Additional characterization and investigation of existing groundwater contamination at the site is recommended if the groundwater monitoring is to be used to monitor site performance.

10 CFR 61.53 (b)
No specific plans for corrective measures were found in the review of the ERDF documents. However, the CERCLA process has built in procedures for development of corrective measures if required. The environmental monitoring plans include criteria for detection of anomalous conditions that could create either additional investigation or the development of corrective measures if they are needed at some time in the future.

10 CFR 61.53 (c)
The ERDF site is monitored with a site specific monitoring program and a Hanford site-wide monitoring program. Monitoring methods include surface radiation measurements, airborne contamination monitoring, groundwater monitoring, leachate monitoring and personnel monitoring, and monitoring of environmental media (soil, vegetation, animals, etc.). The groundwater pathway is monitored by groundwater monitoring and by leachate collection and monitoring.

The existing monitoring programs probably provide a reasonable capability to evaluate site performance and assess any long-term effects. They should provide the capacity to identify a need for mitigative measures. The monitoring programs are capable of providing early warning of releases as excessive releases in the leachate collection would warn of an impending problem.

10 CFR 61.53 (d)
Specific post operational surveillance and monitoring plans have not yet been developed for the ERDF. It is assumed that the current environmental monitoring will continue with minor changes. The current monitoring systems appear to be capable of providing early warning of releases of radionuclides before they reach the site boundaries.

Performance Demonstration

10 CFR 61.40 General Requirement
The ERDF facility appears to be sited, designed, operated and closed with plans for monitoring and control after closure so that reasonable assurance exists that potential exposure surely complies with performance objectives.

10 CFR 61.41 Protection of the general population from releases of radioactivity

The ERDF facility design, operation and closure are such that they minimize releases of radioactivity to the general environment. The ERDF performance assessment analysis and the associated waste acceptance criteria indicate compliance with the listed exposure limits. Environmental monitoring is appropriately used to demonstrate or assure compliance. With the facility design and assessment it is clear that a reasonable effort has been made to maintain effluent releases to the environment that are as low as reasonably achievable.

10 CFR 61.42 Protection of individuals from inadvertent intrusion
The ERDF waste placement operations put the higher activity waste in the deeper portions of the landfill and thereby limit exposure. However, this does not prevent intrusion into the Class A or other radioactive waste. If an intrusion barrier is not designed and installed with the final cover, a good argument could be made that a reasonable effort is not made to prevent intrusion into the ERDF facility. Cover design details are not known at this time.

10 CFR 61.43 Protection of individuals during operations
ERDF operations appear to be conducted in compliance with exposure standards although this review does not specifically address this topic. The leachate collection system provides assurance that effluent releases from the facility are minimized to maintain radiation exposures that are as low as reasonably achievable.

10 CFR 61.44 Stability of the disposal site after closure
The long-term stability of the site is achieved and assured through site design, construction, operation and closure process. Active maintenance is not required after closure except for maintenance related to site surveillance and monitoring. Additional levels of protection from intrusion and infiltration will be provided in the cover depending upon cover design requirements.

<u>Defense-in-Depth System Design</u>

The ERDF design process is largely shown by the conceptual design report (USACE 1994), the RIFS document (DOE/RL, 1993a) and the Record of Decision (EPA, 1995). No other design documents were reviewed. The requirements for the ERDF design, operation and other aspects of the facility came from the RIFS process which is an alternatives selection process and a really good way to determine just exactly what the facility is required to do.

However, a detailed functional analysis was not found that lists the requirements and identifies components or design elements used to satisfy the requirements. This type of assessment was completed for portions of the facility like the liner system and much of the operations. A facility wide detailed functional analysis would be most useful in evaluating the extent of the defense-in-depth design.

This limited review of the ERDF design, operations and monitoring found a comprehensive design process, with clear consideration given to providing a layered defense to isolation of the waste material. Performance assessment modeling of the site is extensive and useful for identifying potential sensitivities and for helping to establish conservative waste acceptance criteria. The liner and cover systems provide added defense and assurance for minimal infiltration and migration of contaminants. Site operations are controlled by facility design requirements and verification and regulatory oversight appear to be extensive.

No apparent violations of the defense-in-depth design principle are identified.

ALARA

The requirement for implementation of the ALARA concept for minimization of exposure to radiation is a basic DOE requirement. It is not known if the ALARA concept was directly applied in the design of the ERDF.

It is also not known if a specific ALARA review of the Envirocare facility has been conducted. At the same time, there is no reason to believe that an intensive ALARA review would not be entirely favorable.

If you apply the ALARA concept to consider minimizing the potential for future contamination to a reasonably achievable level, no apparent violations of that concept can be found in the ERDF facility. If some leeway is given on the conservative side to the question of what is reasonable, still no apparent violations are found.

RCRA Compliant Liner and Cover

RCRA requirements are applicable to the ERDF because it is a mixed waste facility. The liner and cover systems comply with RCRA requirements. That compliance is determined or verified by independent review and oversight by the EPA.

7.3 DOE Low-Level Waste Facility Assessment

Site Suitability

10 CFR 61.50 (a)(2)
Generally speaking, the DOE LLBGs are capable of being characterized, modeled, analyzed and monitored. However, and in a manner similar to the ERDF facility, the characterization may not be adequate, the accuracy of the modeling may not be good enough for the level of reliance placed upon it and the current monitoring scheme does not satisfy performance demonstration needs.

As with the ERDF, the characterization of heterogeneities in the vadose zone sediments beneath the DOE LLBGs may not be adequate to accurately model them. At the same time, there may be no way to accurately model these heterogeneous sediments so additional characterization may be a moot point. Sensitivity analysis of simulated heterogeneities suggests they do not significantly affect the rate of contamination movement through the vadose zone. However, that sensitivity analysis uses a model to confirm a model and the accuracy of the representation as well as the sensitivity assessment, is not determined. An appropriate balance between characterization and contaminant transport model demonstration has not been achieved at Hanford to permit total reliance on the models to assure waste isolation.

The accuracy of models of contaminant transport in the Hanford vadose zone remains an important unanswered concern because the models do not produce a good representation of observed contamination distributions and transport characteristics. The accuracy of the long-term predictions is not well established.

Performance of the LLBGs relies on the vadose zone sediments to provide isolation of the waste and therefore, site suitability is a critical issue. This basic method of performance can be monitored and performance can be verified but, under the existing monitoring scheme at the LLBGs, it is not.

So, the DOE LLBGs do not appear to satisfy the key intent of this requirement.

10 CFR 61.50 (a)(3)
Population growth and future development are not likely to affect the ability of the DOE LLBG facilities to meet the performance objectives. This regions where the LLBGs are located (200 East and 200 West Areas) are established for management of hazardous and radioactive materials and will be subjected to an extensive period of institutional control.

10 CFR 61.50 (a)(4)
The regions of the LLBG facilities have no known current or potential future natural resources for exploitation.

10 CFR 61.50 (a)(5)
The DOE LLBG facilities are in an area with no surface waters and are not within a hazard area.

10 CFR 61.50 (a)(6)
Upstream drainage onto the sites or within several miles of the sites does not occur in the arid environment of the LLBG sites.

10 CFR 61.50 (a)(7)
The unconfined groundwater table beneath the LLBGs is at least 200 ft below ground surface. Inundation by groundwater is virtually impossible.

10 CFR 61.50 (a)(8)
There is no discharge of groundwater to the surface at or near the LLBGs.

10 CFR 61.50 (a)(9)
Seismic design data and design considerations were not found for the DOE LLBG facilities. Information on the seismicity of the Hanford site is provided in the DOE solid waste EIS. It is assumed that seismic design considerations have been assessed and do not appreciably affect the site design. It is also assumed that the cover system will be designed for the appropriate acceleration and seismic activity.

10 CFR 61.50 (a)(10)
The LLBG facilities are located in geologically stable areas where temporally significant dynamic geologic processes are limited to wind deposition and erosion. It is assumed that the final cover design for the LLBGs will consider mitigation of potential wind erosion.

10 CFR 61.50 (a)(11)
DOE facilities adjacent to the DOE LLBGs could impact the ability of the facilities to meet the performance objectives or vice versa. Assessment and consideration of individual and combined potential impacts has begun at Hanford with an initial composite analysis of 200 Area plateau operations (PNNL 1998). This work is just beginning at Hanford and the level and adequacy of our understanding of this issue will undoubtedly be debated for some time, especially until comprehensive site characterizations are completed.

There is no doubt that the DOE facilities surrounding the DOE LLBGs currently hinder or mask the ability to utilize groundwater monitoring of the LLBGs as a performance monitoring method. Other performance monitoring methods and schemes would be much better at providing appropriate facility performance monitoring data.

<u>Site Design</u>

10 CFR 61.51 (a)(1)
A detailed functional design of the DOE LLBGs was not found. The primary focus of the facility design features in the waste disposal plan focused on trench dimensions, waste cell filling and other aspects. A facility design directed toward providing long-term isolation was not identified.

There is concern that settlement of the waste material or the interim cover material over and around the waste, could cause the potential failure of the cover system. A closure plan has not yet been prepared for the DOE LLBGs. Unless the potential settlement issue is mitigated in the cover design, there is potential for the need for continued active maintenance after site closure.

10 CFR 61.51 (a)(2)
A site stabilization and closure plan has not been developed yet for the DOE LLBGs. Current site operations could be incompatible with site closure if the closure plan does not consider and design or mitigate for waste material and cover settlement.

10 CFR 61.51 (a)(3)
The DOE LLBGs do not really complement or improve the ability of the site's natural characteristics to meet the performance objectives unless one considers the construction of an infiltration limiting cover. Some of the proposed covers do not improve site characteristics but they are likely to complement them. Since the cover has not yet been finalized, the influence of the cover on site design is not known.

Other aspects of the facility design and operation do not really complement or improve the site performance. Some characteristics and operational aspects of the site actually degrade the site's ability to meet performance objectives. One is the removal of vegetation over the landfills to prevent weed growth. This actually increases infiltration. The other is the loosening of the soil during excavation and the resultant increase in permeability.

10 CFR 61.51 (a)(4)
The cover system for the DOE LLBGs is not yet designed. One cover design proposed and modeled in the performance assessment does not minimize the infiltration to the extent practicable. Also, some proposed cover systems do not include an intrusion barrier to resist degradation by biotic activity.

Conclusions about the cover system cannot be made until final design is completed. Compliance with this requirement cannot be demonstrated at this time.

10 CFR 61.51 (a)(5)
Surface water is appropriately directed away from the disposal facilities. Proposed cover designs are also sloped to direct surface water away from the landfill.

10 CFR 61.51 (a)(6)
The DOE LLBGs are designed and operated so that waste material is covered in a timely manner with an interim cover as the waste cells are filled. The interim cover is appropriate to minimize contact of the waste with meteoric water. Timely installation of the final cover will minimize to the extent practicable, contact of the waste with percolating water. However, it has been forty years since portions of the landfill have been filled. If you consider that the requirements for a cover and the requirement to minimize infiltration did not exist until the late 1980's, then there has been a twenty year time delay in complying with this requirement.

Because the LLBGs do not yet have a cover limiting percolation of water into the waste zone of the landfill and they do not have an assessment of this potential impact, they do not comply with this criteria.

Site Operations and Closure

10 CFR 61.52 (a)(1)
Class A or category 1 wastes are segregated from other wastes at the DOE LLBGs and appropriate concern appears to be given to waste placement and filling operations so that potential interaction of wastes will not cause a failure to meet the basic performance objectives. However, the adequacy of the waste material characterization and verification as it relates to this issue was not evaluated.

10 CFR 61.52 (a)(2)
Class C or category 3 waste is placed at least 16 ft below the planned top surface of the cover. It is not known if an intrusion barrier is also planned for the cover as the cover system is not designed yet. Addition of an intrusion barrier to the cover system would provide another level of protection from a determined intruder.

10 CFR 61.52 (a)(4)
The waste placement is done at the DOE LLBGs using different methods. Some waste packages are carefully stacked while others are randomly placed and sometimes simply dumped into the pit. Waste placement criteria do not exist and procedures are not followed in all cases so that package integrity is maintained and void spaces are filled.

10 CFR 61.52 (a)(5)
Because of random waste placement and other waste placement concerns, void spaces are not always filled at the DOE LLBGs. In addition, waste and soil compaction requirements are minimal making it impossible to assure that future subsidence will not occur at these facilities.

Mitigative measures could be applied at these facilities before a final cover is emplaced.

10 CFR 61.52 (a)(6)
The dose at the surface of the waste cells is maintained in compliance with the exposure requirements during waste placement by covering the high activity wastes and by other means. Monitoring of radiation levels around the facilities assures compliance with these requirements.

10 CFR 61.52 (a)(7)
Boundaries and coordinates of the waste cells are located and mapped as required.

10 CFR 61.52 (a)(8)
A buffer zone is maintained around and beneath the disposal site. If you consider that the buffer zone includes the vadose zone all the way down to the groundwater, this region is not of adequate dimension to carry out environmental monitoring activities as it is too large to permit taking mitigative measures. The point is that once the contamination reaches the groundwater, it is economically and practically impossible to mitigate. The buffer zone is therefore not of adequate dimensions to carry out environmental monitoring activities and permit timely detection of problems to permit taking mitigative measures.

10 CFR 61.52 (a)(9)
Closure and stabilization of the DOE LLBGs is not carried out as each trench is filled. Also, an approved site closure plan does not exist.

10 CFR 61.52 (a)(10)
The site operations could have an adverse impact on closure and stabilization measures if site closure plans do not mitigate potential subsidence problems at the DOE LLBGs.

10 CFR 61.52 (a)(11)
The DOE LLBGs only accept low level waste.

Environmental Monitoring

10 CFR 61.53 (a)
A comprehensive hydrogeologic report and a baseline environmental monitoring report provide the required environmental background information on the DOE LLBGs. Additional data and information are provided in annual environmental monitoring reports.

10 CFR 61.53 (b)
Plans for developing corrective measures are built into the RCRA process that regulates the DOE LLBGs. However, relative to the vadose zone and groundwater migration pathway, the DOE has no way to determine if radionuclide migration is occurring that would be out of compliance with performance objectives.

10 CFR 61.53 (c)
The DOE LLBGs are monitored with site specific monitoring programs and a Hanford site-wide monitoring program. Monitoring methods include surface radiation measurements, airborne contamination monitoring, groundwater monitoring, personnel monitoring, and monitoring of environmental media (soil, vegetation, animals, etc.).

Unfortunately, the groundwater pathway is not monitored in such a manner that long-term effects and the need for mitigative measures can be determined. For this pathway, the monitoring system is not capable of providing early warning of releases before they leave the site boundary. Conditions could easily exist where undetected releases can occur both now and in the future, and long-term effects cannot be evaluated.

10 CFR 61.53 (d)
Specific post operational surveillance and monitoring plans have not yet been developed for the DOE LLBGs. Unless changes are made to the facility monitoring plans, the monitoring system will not be capable of providing early warning of releases of radionuclides before they reach the site boundaries.

Performance Demonstration

10 CFR 61.40 General Requirement

The siting of the DOE LLBGs was one of convenience and not specifically for providing reasonable assurance of limiting exposure.

The design of these facilities was primarily an evolution of disposal practices and is also not specifically focused on providing reasonable assurance of meeting exposure requirements.

Operations could be improved, specifically in waste placement and compaction, as the current operations fail in several areas to provide reasonable assurance of meeting exposure requirements.

Closure of the DOE LLBGs is still not determined. There is potential that the closure of these facilities could provide reasonable assurance of meeting exposure requirements if appropriate site engineering is completed and a design-in-depth closure plan is developed.

10 CFR 61.41 Protection of the general population from releases of radioactivity
The performance assessment models show that concentrations of contaminants released from the DOE LLBGs will not result in exceedance of the dose standards. However, the question of what constitutes a “reasonable effort” to minimize releases warrants consideration.

The protection from an exceeding dose now and in the future is based entirely on demonstration in the performance assessment. There are no multiple layers of protection afforded by such things as an engineered liner and the performance monitoring is not adequate to demonstrate and thus assure site performance. This is not reasonable considering the cost and effort required to improve the design and impose multiple layers of protection. The economics of improving the landfill must be viewed in light of the economy of scale provided by the burial of the large quantities of waste.

The DOE LLBGs fail this requirement for protection of the general population from releases of radioactivity for a reasonable effort has not been made to provide protection.

10 CFR 61.42 Protection of individuals from inadvertent intrusion
The waste placement operations at the DOE LLBGs places the higher activity waste in the deeper portions of the landfill thereby providing protection from intrusion into category 3 waste. However, this does not prevent intrusion into the lower activity waste near the surface. It is probably not possible to prevent intrusion into a near surface facility by a determined intruder. But, that does not mean that a reasonable effort does not need to be made to prevent intrusion.

The DOE has modeled an intrusion scenario and used that model to help develop waste acceptance criteria to limit the future exposure. However, the modeled intrusion exposure scenario may not be realistic, it may not be accurate, and it may not be conservative.

That brings us back to considering multiple levels of protection from intrusion. Currently, reliance is placed on the waste acceptance criteria in combination with a complex contaminant exposure model. The final cover design for the DOE LLBGs should consider the option of providing an additional level of protection from intrusion.

Because some of the proposed cover designs do not include intrusion barriers, the DOE LLBGs only partially satisfy this requirement.

10 CFR 61.43 Protection of individuals during operations
The operations at the DOE LLBGs appear to be conducted in compliance with exposure standards although this review did not specifically investigate this topic. The facility operations standards are developed, procedures are in place and operations monitoring information is available.

10 CFR 61.44 Stability of the disposal site after closure
The DOE LLBGs do not yet have a closure plan so this criteria can only be evaluated based on inferred plans for closure.

The only active maintenance that should be required at the facilities is correction of any potential subsidence due to settlement after closure. Appropriate waste and soil compaction criteria and verification requirements are not applied at the landfills so it is not possible to discount the potential for subsidence to occur. Possibilities exist for correction of this problem before closure.

The other area of concern relative to achieving long-term stability is the potential for leaching of contaminants through the sediment. The stability of the LLBGs in this regard has not been demonstrated and assured to a reasonable degree.

Defense-in-Depth System Design

The DOE LLBGs were never really subjected to an intensive design process with a detailed functional analysis. Instead, these facilities were placed in a convenient location, built to size and depth specifications that aided disposal operations and the waste was in most cases, simply dumped into the pits and covered over with available soil. This simply does not constitute a defense-in-depth system design.

For some aspects of the facility, the only defense to contaminant migration and potential future exposure, is the existing site soil column with all of its heterogeneities and difficulties for predicting contaminant migration. For the groundwater pathway in particular, there is no effective means of monitoring site performance.

This limited review has determined that the DOE LLBGs do not have a defense-in-depth to the control or release of contaminants.

ALARA

The requirement for implementation of the ALARA concept for minimization of exposure to radiation is a basic DOE requirement. It is not known if a specific ALARA review of the DOE LLBG facilities has been conducted.

Applying the ALARA concept to assess the potential for future contamination exposure, it is determined in previous discussion that there are several violations to the ALARA concept. Primary violations relate to the potential leaching of contaminants through the groundwater pathway, minimization of infiltration, and the potential for intrusion.

The only defense the DOE LLBGs have to some of these potential problems is provided in the risk assessment models which show that if the waste acceptance criteria are applied there will not be an exposure in excess of requirements. This is not what is reasonably achievable.

To achieve a reasonable level of assurance from excessive exposure, a detailed functional design would be required, and multiple levels of protection would have to be built into the isolation systems. This reasonable level of protection is largely the application of existing technology at an economical level just as the DOE did at the ERDF.

RCRA Compliant Liner and Cover

The DOE LLBGs are regulated as RCRA facilities. However, liner and cover systems for mixed waste facilities are not a requirement for the low level radioactive waste sites.

7.4 US Ecology, Inc. Facility Assessment

Site Suitability

10 CFR 61.50 (a)(2)
The US Ecology facility is not currently capable of being characterized, modeled, analyzed and monitored. The facility is surrounded by an uncontrolled surface radiation release site, called the "BC Cribs Control Area". Animals spread contamination extensively from the USDOE's BC cribs, creating an area of extensive surface contamination and biota contamination. As one drives into the US Ecology site, the most striking observation is the fencing and surface contamination signs to either side of the road. This contamination area surrounds the US Ecology site,a nd is acknowledged to preclude effective monitoring. Releases and uptake in vegetation and wildlife may be masked, or will be masked, by the surrounding contamination. The facility has an inadequate groundwater monitoring system – e.g., there are no wells in place to monitor the likely releases from the chemical resin tanks.

As with the DOE LLBGs, there is some question about the level of characterization that has been done relative to the modeling and specifically relative to the heterogeneities in the natural geologic systems.

Because the US Ecology site relies upon the existing site soils to provide long-term isolation of the waste, the levels of site characterization and modeling are not adequate to accurately demonstrate compliance with exposure requirements. Unless this changes and the modeling and site characterization improve considerably, the conclusion is maintained that the site is not capable of being characterized, modeled and analyzed.

The current configuration of utilizing groundwater monitoring as the primary method of monitoring the groundwater exposure pathway at the site, does not provide the appropriate long-term performance monitoring capability. Other methods, notably vadose zone monitoring or leachate monitoring, need to be employed at the site to demonstrate that the site is capable of being monitored.

10 CFR 61.50 (a)(3)
Population growth and future development are likely to affect the ability of the US Ecology facility to meet the performance objectives. The region just south of the 200 East Area at Hanford is currently utilized for management of hazardous and radioactive materials and will be subjected to an extensive period of institutional control. However, the Hanford Future Site Uses Working Group Report noted that it is reasonably foreseeable that the areas outside the boundaries of the 200 Areas will be open and desired for unrestricted use, and require cleanup to the unrestricted use level. This was also reported in 2003 by the Exposure Scenarios Task Force, comprised of a wide range of stakeholders brought together by Ecology, ePA and USDOE.

The Draft EIS issued in 2000 by the Washington Departments of Ecology and Health established that reasonably foreseeable exposure will occur due to the exercise of Native American Treaty rights in and around the site, after the radioactive waste management zone is shrunk to be within the core area of the 200 East and 200 West areas.

In fact, if the soil closure cover proposed by the site operator were to be utilized, the Draft EIS forecast exposures to Native American children exercising Treaty rights to utilize the vicinity of the site and the Columbia River shorelines which would result in a 3% cancer risk (3E-2). This exceeds the maximum allowable carcinogen risk from releases by 3000 times. [7]

10 CFR 61.50 (a)(4)
The groundwater under and around the US Ecology site is a valuable natural resource. The Treaties of 1855 grant the Yakama and Umatilla Nations rights to gather plants, and other rights at the site and around it, and to utilize the area for cultural and religious purposes.

10 CFR 61.50 (a)(5)
The US Ecology facility is in an area with no surface waters and is not within a hazard area.

10 CFR 61.50 (a)(6)
Upstream drainage onto the US Ecology facility or within several miles of it does not occur in this arid environment.

10 CFR 61.50 (a)(7)
The unconfined groundwater table beneath the US Ecology site is at least 200 ft below ground surface. Inundation by groundwater is virtually impossible.

10 CFR 61.50 (a)(8)
There is no discharge of groundwater to the surface at or near the US Ecology site.

10 CFR 61.50 (a)(9)
The US Ecology site is located in an area of relatively low seismic activity. No seismic design considerations were found for the design and construction of the US Ecology facility.

Because this is standard procedure, it is assumed that seismic design considerations will be built into the cover system design.

10 CFR 61.50 (a)(10)
The US Ecology facilities are located in geologically stable areas where temporally significant dynamic geologic processes are limited to wind deposition and erosion. The site closure plan considers wind erosion in the proposed cover designs.

10 CFR 61.50 (a)(11)
DOE facilities adjacent to the US Ecology site can impact the ability of the facility to meet the performance objectives or vice versa. Assessment and consideration of individual and combined potential impacts has begun at Hanford with an initial composite analysis of 200 Area plateau

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[7] **Comments of Heart of America Northwest, Heart of America Northwest Research Center, Legal Advocates for Washington: Commercial Low-Level Radioactive Waste Disposal Site Draft Environmental Impact Statement** on: Relicensing Site, Radioactive NARM Waste Disposal Quantities Allowed, Closure Plan; November, 2000. Available at www.heartofamericanorthwest.org

operations (PNNL 1998). This work is just beginning at Hanford and the level and adequacy of our understanding of this issue will undoubtedly be debated for some time, especially until comprehensive site characterizations are completed.

The ability to monitor the performance of the US Ecology site is currently significantly masked by past releases of contamination from the adjacent DOE operations. Since groundwater monitoring is currently the only means of monitoring the groundwater pathway, this facility is deemed to be out of compliance with this requirement.

Site Design

10 CFR 61.51 (a)(1)
A detailed functional design of the US Ecology facility was not found to exist. So, facility design features cannot be shown to be directed at long-term isolation.

Slumping and settlement collapse failures of the waste and fill materials is known to have occurred in the past and mitigative changes to the site operations do not appear to have been taken. It is assumed that such failures will continue to occur in the future. Therefore, the site is not designed for avoidance of the need for continued active maintenance.

10 CFR 61.51 (a)(2)
A draft site stabilization and closure plan has been developed for the US Ecology facility but it is not approved due primarily to environmental impacts that have not been determined in an EIS. The current draft EIS is not approved and additional characterization work is planned.

There are several areas where current site design and operations can be shown to be non-compatible with a site closure that provides reasonable assurance of site performance. An example of this is the potential for collapse settlement and thus failure of the cover system.

10 CFR 61.51 (a)(3)
The US Ecology facility does not really complement or improve the ability of the site's natural characteristics to meet the performance objectives unless one considers the construction of an infiltration limiting cover. Instead, the facility utilizes the existing conditions at the site to provide isolation of the waste material and demonstrates compliance with the performance objectives with a contaminant transport and exposure model.

Other aspects of the facility design and operation actually degrades the site's ability to meet performance objectives such as the removal of vegetation over the landfills.

10 CFR 61.51 (a)(4)
The proposed cover systems for the US Ecology site include infiltration limiting layers in the design. As far as whether or not these designs qualify as minimizing infiltration "to the extent practicable" depends largely on whether or not other layered or backup infiltration limiting schemes are employed or other steps are taken to minimize the impact of potential cover failure. It could be considered practicable to install a man-made infiltration barrier or a secondary infiltration barrier if no other deterrent is designed into the landfill system.

The US Ecology facility appears to be in compliance with this requirement although an engineering assessment of this could not be made because the closure plan is not finalized.

10 CFR 61.51 (a)(5)
Surface water is appropriately directed away from the disposal facilities. Proposed cover designs are also sloped to direct surface water away from the landfill.

10 CFR 61.51 (a)(6)
The US Ecology facility is designed and operated to minimize contact with standing water during and after disposal. Waste material should be covered in a timely manner with an interim cover as the waste cells are filled. However, we observed and photographed barrels that had been exposed or re-exposed for many years, including highly radioactive Class C wastes.

Installation of a final cover will minimize contact of the waste with percolating water. However, the closure plan is not yet approved and it has been at least 30 years since interim covers have been placed over portions of the US Ecology burial grounds. An assessment has not been made of the impacts of not having a cover for the past 30 years.

Because the US Ecology site does not have a cover limiting percolation of water into the waste zone of the landfill and they do not have a timetable for installation of a cover, they do not comply with this requirement.

<u>Site Operations and Closure</u>

10 CFR 61.52 (a)(1)
Class A wastes are segregated from other wastes at the US Ecology site and appropriate concern appears to be given to waste placement and filling operations so that interaction of wastes is minimized.

The adequacy of the waste characterization as it relates to this issue was not evaluated.

10 CFR 61.52 (a)(2)
Class C waste is placed at least 16 ft below the planned top surface of the cover. An intrusion barrier is not planned as a part of any of the proposed cover systems.

An intrusion barrier designed into the cover system would provide another level of protection from a determined intruder.

10 CFR 61.52 (a)(4)
As near as can be determined from the documents, waste placement at the US Ecology facility occurs either by carefully stacking some packages or by randomly placing other packages such as barrels. Backfilling, compaction and waste filling criteria in the facility operation procedures and the verification of backfilling and compaction do not appear to be commensurate with standard geotechnical practice nor are they adequate to assure compliance with this requirement.

10 CFR 61.52 (a)(5)
Void spaces between randomly placed waste packages are filled by pushing sandy soil over the top of the waste trench. This filling method, the absence of void filling requirements in the operating procedures and the absence of a compaction and filling criteria have led to the occurrence of sinkholes or settlement slumps in the interim cover at the US Ecology site.

Therefore, the US Ecology site does not meet this requirement.

10 CFR 61.52 (a)(6)
The dose at the surface of the waste cells is maintained in compliance with the exposure requirements during waste placement by covering the high activity wastes and by other means. However, as noted above, we observed Class C wastes that were not covered, and had not been for many years. Monitoring of radiation levels around the facilities assures compliance with these requirements.

10 CFR 61.52 (a)(7)
Boundaries and coordinates of the waste cells are located and mapped as required. Permanent markers are placed on the surface at each trench corner.

10 CFR 61.52 (a)(8)
A buffer zone is maintained around and beneath the disposal site. However, that buffer zone is not of adequate dimension to allow taking mitigative measures. Once contamination reaches the groundwater, it is economically and practically impossible to mitigate the problem. Therefore, the US Ecology site does not satisfy this requirement.

10 CFR 61.52 (a)(9)
Closure and stabilization at the US Ecology site is not carried out as each trench is filled. However, each trench is covered with an interim cover as each trench is filled. A plan for site stabilization and closure not approved.

10 CFR 61.52 (a)(10)
The site operations could have an adverse impact on closure and stabilization measures if site closure plans do not mitigate potential subsidence problems at the US Ecology facility.

10 CFR 61.52 (a)(11)
The US Ecology site only accepts low level waste at their facility.

<u>Environmental Monitoring</u>

10 CFR 61.53 (a)
A site characterization and hydrogeology report and baseline environmental monitoring data provide the required baseline information to a degree. Information on migration and distribution of previously radioactive and hazardous contaminants is not complete and a phase III site characterization has been in the planning for about two years. However, the baseline characterization will not include an assessment of the radionuclide contamination distribution.

That contamination could critically affect the ability of the site to satisfy the performance objectives.

The current baseline information on the US Ecology site is not complete so this requirement is not satisfied.

10 CFR 61.53 (b)
Plans for developing corrective measures are built into the RCRA and MOTCA processes which will govern the investigation and cleanup of the US Ecology facility. However, the procedures leading to the imposition of corrective measures will likely not be applied for the groundwater contaminant migration pathway because the monitoring scheme does not allow detection of radionuclides to a level that permits a determination of whether or not performance objectives will be met.

Essentially, the US Ecology facility fails this criteria because it does not have the capability to determine if performance objectives will be met.

10 CFR 61.53 (c)
The US Ecology site is monitored with a monitoring program that can effectively evaluate the potential health and environmental impacts during construction and operation. However, the environmental monitoring program does not enable evaluation of long-term effects and the need for mitigative measures relative to the groundwater pathway.

Monitoring of the groundwater cannot provide early warning of releases of radionuclides from the disposal site before they leave the site boundary if the "early warning" is considered to be a sufficient time to allow the taking of mitigative measures.

10 CFR 61.53 (d)
Specific post operational surveillance and monitoring plans have not yet been developed for the US Ecology site. Unless changes are made in the closure plan to the facility monitoring plan, the monitoring system will not be capable of providing early warning of releases of radionuclides.

Performance Demonstration

10 CFR 61.40 General Requirement
The siting of the US Ecology facility was mainly one of convenience, familiarity, experience and a lack of regulatory requirements. The site was not selected based on its ability to provide reasonable assurance of meeting the exposure limits.

The design of the US Ecology facility was primarily an evolution of disposal practices and is also not specifically focused on providing reasonable assurance of meeting exposure requirements. A minimal functional design process does not appear to have been taken. Instead, it appears that the facility was reverse engineered by showing, via modeling, that the existing operation is in compliance with requirements.

In 1992, the U.S. Environmental Protection Agency (EPA) found that hazardous liquid wastes had probably been released from the site and an investigation under EPA's RCRA authority was begun. This investigation is still far from complete, and a decision has been made to ignore radionuclide contaminants. Thus, a complete characterization of releases and the potential for additional releases to contaminate the groundwater resource may never be available.

Operations appear to be designed and developed for the purpose of stabilizing and assuring isolation of the waste and it is evident that operations were also an evolving process. As Improvements could be made in the waste placement and compaction processes or in the verification and oversight of those processes or both, whichever is required. It makes no sense to build a landfill with potential for excessive cover settlement and it makes no sense to not be able to verify compaction.

Closure plans are not determined yet. Questions remain about principal components of closure including the cover selection, monitoring requirements and other things that directly affect the ability to meet the performance objectives. The 1996 closure plan does not include a detailed functional analysis and this short review is not adequate to properly assess the closure plan.

For this general performance assessment requirement, the US Ecology facility only partially satisfies the letter and intent of the requirement.

10 CFR 61.41 Protection of the general population from releases of radioactivity
While the performance assessment models show that concentrations of contaminants released from the US Ecology facility will not result in exceedance of the dose standards, the assessment of releases and reasonably foreseeable exposure scenarios conducted for the Draft Washington State EIS on Closure of the facility (2000) revealed that releases may greatly exceed applicable standards. If the proposed soil cover caps were utilized, exposure to Native American children was predicted to reach a fatal cancer risk of 3%. [8]

The Washington State Health and Ecology Departments' Draft EIS stated, at P.94, : "All cover designs, except the Site Soils Cover, are below the 500 mrem/year onsite intruder guidance. However, only the Enhanced asphalt cover is below the 100 mrem/year level of the 100/500 mrem/year consideration value recently adopted in the Radiation Cleanup Standards (Chapter 246-246, WAC)." The decision on which cover to use, or which covers to use for different portions of the site, awaits the outcome of the MOTCA investigation into the releases from the site. Thus, the Draft EIS asserted – without considering the monitoring data that showed relaeses had occurred nd reached groundwater, in contradiction of the model utilized for the performance assessment and for the EIS, - that the standards adopted by the Health department to mirror NRC standards would be met. *However, the standards applicable to protect public health from releases are not projected to be met at the US Ecology Site*: the standards in Washington's Model Toxics Control Act (MOTCA, RCW Chapter 70.105D and implementing regulations in Chapter 173-340 WAC), RCRA and Superfund (CERCLA, 42 USC 9601 et seq). A release that results in a radiation dose of 3E-2 is 330 times the allowable maximum risk from the

[8] Id.

applicableState standard – without even beginning to calculate the cumulative risk from exposure to the released nonradioactive hazardous carcinogenic wastes.

The question of what constitutes a "reasonable effort" to minimize releases warrants consideration.

At the US Ecology site, assurance of protection from an exceeding dose now and in the future is based entirely on the performance assessment model. This is at a facility that relies entirely upon the natural system to provide that isolation. The problem with this is that there are no multiple layers of protection afforded by such things as an engineered liner and there is no way to monitor site performance when it comes to the groundwater exposure pathway. Monitoring the groundwater 200 ft down is not a reasonable monitoring method to use to evaluate or assure site performance. The main reason these are not reasonable considers the cost and effort required to improve the design, impose multiple layers of protection and validate or verify those improvements.

For this review, the US Ecology site fails this requirement for protection of the general population from releases of radioactivity because a reasonable effort does not appear to have been made to minimize the potential for a release.

10 CFR 61.42 Protection of individuals from inadvertent intrusion
US Ecology's waste placement operations puts the higher activity waste in the deeper portions of the landfill and places most of it in intrusion deterring concrete vaults or caissons thereby providing at least two levels of protection from intrusion to the Class C waste.

The rest of the waste materials are disposed of near surface. A scenario of intrusion into this waste was modeled to help develop waste acceptance criteria, thereby limiting future exposure. However, the modeled intrusion exposure scenario may not be realistic for there are many possible exposure scenarios that could occur but were not assessed. The intrusion scenario is probably non-conservative and as it was modeled, the intrusion scenario is one of the limiting scenarios for the US Ecology facility.

The US Ecology site does not have multiple levels of protection from intrusion for the landfill in general and it may not have a single level of protection from intrusion for much of the waste. An intrusion barrier is not included in the cover described in the 1996 closure plan. This does not ensure protection from inadvertent intrusion. As noted above, the State Draft EIS (2000) found intrusion with resultant exposures exceeding applicable standards to be reasonably foreseeable.

10 CFR 61.43 Protection of individuals during operations
The operations at the US Ecology site appear to be conducted in compliance with exposure standards although this review did not specifically investigate this topic.

10 CFR 61.44 Stability of the disposal site after closure

The US Ecology site is not necessarily sited to achieve long-term stability. If that were the case, it would be located in a salt dome or underground structure. However, the site can be designed or engineered to work.

Unfortunately, the US Ecology facility was not necessarily designed to provide long-term stability. If it had been, a nice functional analysis would be found and layers of protection would be shown for the various exposure pathways. In some cases there exists only one layer of protection for achieving long-term stability, and our knowledge of and about that single layer of protection may not be adequate to rely upon it.

A closure plan for the US Ecology site was prepared in 1996 but has not been approved by WA State pending additional site characterization work and a determination by the State of just exactly what the closure requirements will be.

There is a moderate possibility for the occurrence of additional sinkholes at the US Ecology site, especially in the older trenches. If this is not remediated prior to closure or considered in the closure cover, it will require active maintenance, probably on the order of every few decades. Active maintenance is chosen in the closure plan as the method of mitigation. The only other possible active maintenance may be related to wind erosion or to monitoring.

The other area of concern relative to achieving long-term stability is the potential for leaching of contaminants through the sediment. The stability of the US Ecology site in this regard has not been demonstrated to a reasonable degree. Too many possibilities exist for failures in the disposal system. This could be anything from a failure in accepting out of compliance waste to a failure of the cover system 100 years from now because of partial intrusion. The engineering, design, characterization and planning that is necessary to achieve and demonstrate long-term stability of the disposal site has simply not been done.

So the US Ecology site is judged not to have been designed, sited, and closed to achieve long-term stability. And, the current closure plans do not avoid active maintenance after closure.

<u>Defense-in-Depth System Design</u>

The documentation indicates the US Ecology facility was never subjected to an intensive design process that included a detailed functional analysis. The engineering of this facility evolved over time along with the disposal practices and demonstration of compliance with contaminant transport models. Changes to the facility design or operations were caused mainly by the imposition of new regulations. It appears that as new regulations were imposed, instead of determine how best to satisfy the regulations, the engineering design was based on the minimum design or operation changes required to satisfy the regulations. In many cases that minimum is based on a tenuous interpretation of a specific regulatory requirement or it is entirely based upon demonstrating compliance with a contaminant exposure model. This does not constitute a defense-in-depth system design.

For several aspects of the facility, the only defense to contaminant migration and potential future exposure, is the existing site soil column with all of its heterogeneities and difficulties for predicting contaminant migration. Like the DOE LLBGs, the US Ecology facility EIS, does not appropriately acknowledge the uncertainties and inaccuracies in the contaminant transport models. Yet, the engineering basis of the facility relative to isolation of the waste and exposure prevention, is often entirely dependent upon the models.

For the groundwater pathway, there is no effective means of monitoring site performance at the US Ecology facility. Effective performance monitoring is another means of providing a defense-in-depth, but it is not utilized at the facility.

On top of this, there is serious concern that the regulation and oversight of the US Ecology facility is not adequate. This largely arises over the fact that the facility is owned by the State who contracts US Ecology, Inc. to operate the facility for the State. The State prepared the EIS and the State is conducting the site characterization work, not US Ecology. In this case the State is regulating the State. Considering the facility's failure to meet some of the NRC regulatory requirements listed above causes one to ask who is regulating the facility and why did the State issue a license to operate the facility. This apparent deficiency in effective oversight and regulation indicates that yet another layer of an in-depth defense could be eliminated for certain contaminant pathways.

This limited review has determined that the US Ecology facility does not have a defense-in-depth to the control or release of contaminants.

ALARA

It is not known if a specific ALARA review of the DOE LLBG facilities has been conducted.

Potential ALARA violations were identified that relate to potential leaching of contaminants through the groundwater pathway and the potential for intrusion.

The only defense for the groundwater pathway exposure is the unsaturated zone soil column. That defense is only effective if the contaminant transport and exposure models are accurate. It is not a reasonably achievable defense to potential exposure when reliance is placed entirely upon an exposure model.

Potential intrusion into the waste is always a problem for near-surface facilities. Because no intrusion barriers are guaranteed to be effective, design consideration should be give to multiple layers of protection. Having no intrusion barrier does not comply with the ALARA concept as the potential for failure is high. A detailed functional design of the facility would identify a reasonable level of appropriate safeguards to limit the potential of intrusion to a reasonable level.

RCRA Compliant Liner and Cover

RCRA compliant cover and liner systems are not required at the US Ecology facility.

8.0 Facility Comparison

The following is a comparison of the four landfills based on how well they satisfy the review criteria. Table 8-1 provides the results of the review. Unfortunately, this table only shows compliance or not as a yes or no statement and does not allow a discussion of how well the facility did or did not satisfy the review criteria. Also, reference to the review criteria is only made by the CFR number which unfortunately makes it necessary for the reviewer to consult the language of the criteria in Section 2.

Site Suitability

All of the requirements for site suitability are satisfied at the Envirocare and ERDF facilities. The appropriate implication applies that both the Great Salt Lake Dessert site in Tooele County Utah and the Hanford Site in arid southeast Washington are suitable for disposal of low-level radioactive wastes from the perspectives of these NRC regulations.

Both the DOE LLBGs and the US Ecology facilities fail the site suitability requirements even though they are also located on the Hanford site. There are two reasons for this. The first is that with the current configurations, the sites are not capable of being characterized, modeled, analyzed, and monitored.

Remember that the primary emphasis in site suitability is given to long term isolation of the wastes and to satisfying the long-term performance objectives. Under the current scheme where the reliance is placed entirely on the vadose zone sediment to assure isolation, the characterization is probably beyond what we can do or certainly would want to do.

Next, the models developed for the facilities are useful and can help in the facility design. But so far, the modeling of the heterogeneous sediments with any accuracy or assurance appears to be beyond current capabilities.

That leaves monitoring. That is, monitoring to assure long-term isolation. Several schemes are envisioned to do this at the two unlined facilities, most involve vadose zone monitoring. But, the level of assurance of these monitoring schemes is difficult to evaluate. The ability to monitor site performance may also be beyond our current capabilities.

The other reason the DOE LLBGs and the US Ecology site fail site suitability is that the existing groundwater contamination masks the effectiveness of the groundwater monitoring which is an exceedingly important component of the environmental monitoring program. Again, emphasis of site suitability is placed on ensuring that long-term performance objectives are met. There is no assurance if you can't effectively monitor the groundwater pathway.

At the ERDF site, groundwater monitoring becomes less important because of leachate collection and monitoring. That is why the ERDF site is capable of being monitored while the others are not.

As far as comparing the Hanford site in general to the Envirocare site and ignoring potential design features of the different facilities, the Envirocare site has a relatively homogeneous, low permeability lacustrine soil over a saline aquifer system in an area of negative recharge. The Hanford soil is a high permeability, complex glaciofluvial and fluvial sandy soil over a very deep, contaminated aquifer in a region of slightly positive recharge. Both appear to be suitable sites for designing and building a low-level radioactive waste disposal facility from an NRC regulatory requirements point of view.

Site Design

All site design requirements are satisfied at the Envirocare and the ERDF facilities. The DOE LLBGs and the US Ecology facility fail most of the requirements under the design review criteria. The main reason for this is that neither facility appears to have been subjected to an extensive design process similar to those at the Envirocare or the ERDF facilities.

The site designs at the DOE LLBGs and the US Ecology facility are not directed toward long-term isolation, they are not necessarily compatible with closure and stabilization objectives, they are not necessarily designed to complement and improve the sites, and they do not minimize water percolating through the wastes with the timely installation of a cover.

The covers of these facilities are not designed yet so it is difficult to evaluate whether or not the cover design will help resolve other site design issues.

Site Operations and Closure

Again, the Envirocare and ERDF sites satisfy the requirements under the operations and closure criteria while the DOE LLBGs and the US Ecology site do not. The criteria failure is due to a lack of waste material and backfill compaction or at least inadequate compaction requirements and verification in the operations plans, inadequate void space minimization during waste placement operations, an inadequate buffer zone beneath the waste zone to allow performance monitoring or detection of inconsonant conditions, and the lack of an approved closure plan or absence of a close-as-you-go closure process.

The DOE LLBGs and the US Ecology site are both weak in their waste placement and backfilling operations. A relatively easy remedy to this would be to change or improve operations and verification.

Neither facility has an appropriate buffer zone for monitoring. This requires changing the facility design to accommodate appropriate performance monitoring such as leachate monitoring or some form of effective vadose zone monitoring.

Finally, neither site has an approved closure plans. This could be good or bad. Good in that opportunity exists to improve the closure plan and bad in that the facility is not being closed. The potential exists that deficiencies in the operations, if unmitigated before closure or not considered in the cover design, will cause a requirement for continued active maintenance, which is contrary to the requirement. Until a closure plan is prepared compliance with the closure requirements can’t be confirmed.

The Envirocare and ERDF facilities have appropriately considered closure requirements primarily in their facility designs and both appear to have sound, verifiable operations that are consistent with closure and stabilization goals.

Environmental Monitoring

The Envirocare and ERDF facilities satisfy the language and intent of the environmental monitoring criteria.

As far as a pre-operational environmental characterization requirement, the US Ecology site is judged to fail this requirement because the existing contamination distribution is not known and the State is in the process of preparing a phase III characterization plan.

Relative to groundwater pathway monitoring, the DOE LLBG and US Ecology facilities simply do not have the environmental monitoring capability to evaluate long-term effects and the health and environmental impacts or the need for mitigative measures. Once the contamination reaches the groundwater, it is too late for mitigative measures and the environment will already have been seriously impacted

Finally, the environmental monitoring at the DOE LLBGs and the US Ecology site are not capable of providing early warning of releases. An argument of compliance based on the location of the site boundary simply does not work for this requirement (10 CFR 61.53(d)) because the monitoring programs do not satisfy the concept of providing an early warning. If there is a problem, timely detection of the problem is critical to the basic tenet of the environmental monitoring objectives. At these facilities, groundwater monitoring is not a viable method of early warning to prevent migration of contaminants beyond the site boundaries for once it gets into the groundwater, it is too late and your warning is not early.

A primary purpose of environmental monitoring is to obtain monitoring data in support of and to demonstrate compliance with performance requirements. The monitoring schemes designed for the Envirocare and ERDF facilities appear to be adequate to do this. However, the DOE LLBGs and the US Ecology facility are not adequate to demonstrate or assure compliance, particularly with the long-term performance objectives.

Performance Demonstration

The Envirocare facility and the ERDF facility both demonstrate compliance with the performance requirements by the use of facility design, siting operations and closure. In addition, both have demonstrated that they provide reasonable assurance of meeting performance objectives by implemention an environmental monitoring program designed to monitor site performance.

However, a reasonable effort has not been made at the DOE LLBGs or the US Ecology site to maintain releases in effluents that are as low as reasonably achievable. Relying upon highly permeable vadose zone sediments to provide isolation and using a relatively simple contaminant transport model as a demonstrate of compliance is not reasonable.

Both facilities do not provide any protection from intrusion into the bulk of the waste (Class A) other than a simple cover. The DOE LLBGs use a tenuous contaminant exposure scenario at an inappropriate exposure time (500 years), to show that the dose received from intrusion will be below standards. Again, we come to the question of whether or not this is reasonable. From the perspective of this review, it is not. Until the closure plans are finalized and an appropriate design provides due consideration to the intrusion problem, they cannot be considered to satisfy intrusion prevention requirements.

The closure plans for both facilities must also deal with the soil and waste compaction problem and mitigate with something other than active maintenance. Waste placement and filling operations are not compatible with closure criteria.

Finally, a reasonable effort to assure performance includes monitoring that performance. Neither the DOE LLBGs or the US Ecology site have an environmental monitoring program that is capable of monitoring site performance and demonstrating compliance with the performance criteria.

Defense-in-Depth System Design

The Envirocare and the DOE ERDF facilities both have what is considered to be a defense-in-depth design. The Envirocare design is a purposeful design that lists requirements, identifies methods of performance and shows multiple layers of protection from potential exposure.

The ERDF facility arrives at a defense-in-depth design using the RCRA RIFS process in combination with design processes for the major landfill components. Multiple levels of protection are also provided at the ERDF facility.

The DOE LLBGs and the US Ecology site do not have a defense-in-depth design. The main reason they do not satisfy many of the NRC regulations may be because neither facility has been subjected to an intensive design process. Multiple layers of protection are not provided by what appears to be an as-built design process.

ALARA

It could not be determine if any of the facilities reviewed have undergone a formal ALARA review. Additional investigation would be required to make that determination.

ALARA violations were found at the DOE LLBGs and the US Ecology site relating to the potential for long-term exposure. Those violations center on the assessment that reasonable effort has not been made at either facility to assure exposure is minimized as discussed above.

RCRA Compliant Liner and Cover

The ERDF facility and the Envirocare mixed-waste facility have RCRA compliant liners and covers as required. They are not required for the DOE LLBGs and the US Ecology facility.

9.0 Conclusions

To be prepared after review and consultation with client.

10.0 References

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Appendix:

Analysis of USDOE's "Performance Assessments" for Low-Level Radioactive Waste Burial Grounds At Hanford

Gerald Pollet, JD; Executive Director, Heart of America Northwest

Analysis of USDOE's "Performance Assessments" for Low-Level Radioactive Waste Burial Grounds

Gerald Pollet, JD; Executive Director, Heart of America Northwest

USDOE relies upon two "Performance Assessments" for its analysis of the proposal to expand Hanford's Low-Level Burial Grounds to accommodate disposal of an additional 350,000 cubic meters of Low-Level Radioactive Waste in the unlined trenches that comprise the burial grounds.[vi] The Performance Assessments are the critical documents underlying conclusory statements in the Hanford Site Solid Waste Environmental Impact Statement (HSWEIS), that the burial of additional waste would not have unacceptable impacts on human health and the environment. The Performance Assessments were published for the burial grounds in 200 West in June, 1995 and for 200 East Area in August, 1996. The documents were provided to Heart of America Northwest by Michael Collins, USDOE Program Manager for the Hanford Site Solid Waste Environmental Impact Statement (HSWEIS), because – while relied upon for analysis in the EIS – the documents are not available on the internet.

- It is necessary to review the Performance Assessments in order to independently assess the basis for USDOE's claims of low health risks from the proposal to more than double the total amount of radioactive waste buried in unlined soil trenches at Hanford. The unlined soil trenches have no leachate collection and inadequate groundwater monitoring.
- Claims related to health risks rely upon <u>exposure scenarios</u> for future users of the Hanford Site and Columbia River, that are found in the Performance Assessments.

<u>Waste Quantity</u>:

- More than double the total amount of radioactive waste buried in unlined soil trenches at Hanford:
  - Documentation: EIS Table 3.2 for LLW: "Previously buried waste" = 283,067 cubic meters

    "Upper Bound" proposed = 631,427

    Added Waste = 348,360

    However: cf: WMPEIS[vii] summary at 53 shows Hanford total "current inventory plus 20 years generation" = 89,000 cubic meters.
- 350,000 cubic meters LLW x 35.3 to get cubic feet = 12,355,000 cubic feet

USDOE's Performance Assessments Use Criteria for Acceptable Health Impacts Which Exceed Legal Limits for Radiation Exposure and Health Risk to the Public:

- Washington State's Model Toxics Control Act (Chapter 70.95D, R.C.W.; and implementing regulations at Chapter 173-303 WAC) set applicable health based standards for public exposure to "hazardous substances" and carcinogens released from disposal sites. Included in hazardous substances are radionuclides.
- The State limits exposure, and requires cleanup, if exposure would result in a total carcinogen risk (from all sources at the site) greater than **one in one hundred thousand**. Thus, if more than one exposed person in one hundred thousand would get cancer, additional cleanup is required. (This is often expressed in scientific notation as 1E-5). The State limit applies at federal Superfund sites in Washington.
    - This is one additional cancer in the most sensitive exposed population, per 100,000 exposed; i.e., children or Native American children who consume large quantities of water and food from the site.
- United States Environmental Protection Agency (EPA) sets a more relaxed standard utilizing a risk range allowing between one additional fatal cancer per ten thousand and one in one hundred thousand. (1E-4 to 1E-5).[viii]
- USEPA has issued a formal opinion that exposure to 25 millirem per year of radiation from pollution at a federal Superfund site is not protective of human health or the environment, calling that level of exposure "unacceptably high" because it would result in 5 additional fatal cancers per ten thousand exposed adults (5E-4).[ix]
    - EPA has formally found that a proposal to allow 100 millirem exposure annually "could create unacceptable health risks to the public… and potentially result in the creation of new Superfund sites."[x]
    - The EPA and Washington State standards are applicable to the Hanford Low-Level Waste Burial Grounds because:
        3) The burial grounds have released wastes to the environment, and have illegally been used to dispose of hazardous wastes – subjecting them to RCRA and Washington Hazardous Waste Management Act requirements for permitting and remediation. Washington State utilizes the MTCA standard for RCRA permit actions – consistent

with the philosophy that we should not create new Superfund sites requiring cleanup.

4) The burial grounds are in the midst of the federal designated Superfund National Priority List site and MTCA designated site.

The USDOE's Performance Assessment – and Hanford Site Solid Waste EIS – are Based on Performance Objectives that "create unacceptable health risks to the public… and potentially result in the creation of new Superfund sites":

USDOE's Performance Assessment is based on the burial grounds meeting "Performance Objectives" that allow radiation doses of 25 mrem per year to the public and continuous exposure to 100 mrem per year of radiation following reasonably foreseeable intrusions into the waste sites. Doses of 500 mrem per year are considered acceptable by USDOE for a single exposure following intrusion.

Rather than designing the burial grounds to meet the applicable EPA and Washington State standards, USDOE sets "performance objectives" (which are not regulatory rules) in DOE Order 5820.2A for general public exposure from all pathways and post-intrusion exposures.[xi]

EPA has specifically called the 25 mrem per year annual exposure an "unacceptable health risk".[xii] This radiation dose is fifty times the allowable carcinogen risk under Washington's Model Toxics Control Act.

USDOE's performance objective for reasonably foreseeable continuous annual exposure after intrusion into the burial grounds results in 2 fatal cancers for every 1,000 adults exposed. It is now generally accepted that children are 5 to 8 times more susceptible to cancer from ionizing radiation exposure than adults. For children, post intrusion risk deemed acceptable under USDOE's performance objective could be as high as 1 in 100. (Washington State law sets the standard as 1 additional cancer in 100,000 from all carcinogens remaining on the site).

USDOE's Performance Assessment Ignores the Disposal of Hazardous Wastes in the Low-Level Burial Grounds:

Extensive documentation exists of hazardous wastes disposed in the burial grounds.[xiii]

The presence of non-radioactive hazardous wastes is highly significant because:

- Hazardous wastes migrating from the burial grounds create significant health and environmental risks – for the commercial Low-Level Waste Burial Grounds, Washington Ecology has documented releases of nonradioactive hazardous wastes other than radionuclides (there is also evidence of radionuclides reaching groundwater) have reached groundwater in less than forty years of operation, in concentrations exceeding Washington State cleanup standards and Safe Drinking Water Standards.
    - Some of the hazardous wastes disposed included liquids that will mobilize other wastes; or were wastes that would increase the corrosion of waste containers.
    - Some hazardous wastes disposed in the LLBG were explosive or flammable.
- Hazardous wastes disposed in the burial grounds were often solvents and wastes that will serve to mobilize radionuclide contaminants, and dramatically increase the speed at which they travel to groundwater.
- Hazardous wastes change the ability of radionuclides to "sorb" to the soil, destroying the basis for USDOE's models that show limited radionuclide migration through soil to groundwater.

Incredibly, USDOE's Performance Assessment – relied upon for the HSWEIS – totally ignores the presence of hazardous wastes in the Low-Level Burial Grounds.

The discovery in 2002 of Carbon Tetrachloride (CCL4) at 1,760 parts per million at a vent in Waste Management Area 4 of the Hanford Low-Level Burial Grounds shows the danger of relying upon a performance assessment that ignores the presence of non-radioactive hazardous wastes.

USDOE's Performance Assessment does not even reference standards for the burial grounds to meet for non-radioactive hazardous wastes.

Cumulative impacts, which the National Environmental Policy Act and State Environmental Policy Act require to be considered in an EIS, from the burial grounds already appear to exceed applicable standards from the Carbon Tetra-Chloride release – before considering additional releases from adding more waste to the LLBGs.

It must be noted that, even without considering the impact of hazardous wastes on the models used to predict contaminant transport and perform the risks assessments, the HSWEIS admits that radioactive Iodine 129 and Tritium contamination from the burial grounds will greatly exceed standards at a well one kilometer away from the burial grounds, and require restricting access to a large area (which two Native America Nations have treaty rights to utilize) for "thousands of years".

For the HSEWEIS, USDOE inexplicably only presents groundwater contamination data for a single well one kilometer away from the burial grounds – which is further than one kilometer from many of the burial grounds. No explanation is proffered for why or how this single point was chosen.

In discussing "parameters that could influence radionuclide groundwater concentrations", USDOE never mentions the potential for non-radioactive hazardous wastes to increase contaminant mobility.[xiv]

<u>Groundwater Standards for Radionuclides Are Shown to be Exceeded in the Performance Assessment</u>:

Despite the Solid Waste EIS depicting groundwater results only for a single well in the 200 West Area (one kilometer away from the edge of the nearest burial ground), the Performance Assessment for 200 West clearly shows that for a well 100 meters from the burial grounds, the radiation doses from use of groundwater would exceed standards.

As noted earlier, the Maximum Concentration Limit (MCL) under the Safe Drinking Water Standard, utilized by EPA and Washington State for Superfund and MTCA standards, is based on a maximum dose of 4 mrem per year. At Table 4-22, USDOE provides "Radionuclide Dose Estimates for Groundwater Pathways"[xv]. Doses exceeding 4 millirem per year are shown for:

C^{14}; Cl^{36}; Tc^{99}; I^{129}; Se^{79}; Np^{137}; Pa^{231}; U

The total cumulative dose – not shown in the Performance Assessment – from the groundwater pathways would equal >9E+4 mrem/year. The MCL standard would be 4E+1. In plain language, the MCL will be exceeded by three magnitudes.

The HSWEIS, however, presents results solely for one well a full kilometer away from the burial grounds. The EIS shows MCLs violated for that well for only Iodine 129 and Tritium (H3). The reason for USDOE choosing to only present data for a well 1 kilometer away from the burial grounds appears to be to prevent disclosure of the excessive groundwater contamination that will occur from these burial grounds.

A final groundwater note: The majority of groundwater monitoring wells at the edge of the LLBGs are dry or out of compliance with RCRA requirements. A dry well can not find contamination in the aquifer. The Performance Assessment relies upon models, rather than actual data. The significance of this is shown by the investigation into the nearby Hanford commercial Low-Level Waste site run by US Ecology Corp.. For the EIS for relicensing that site, US Ecology relied upon the same model as USDOE used in the Performance Assessments for 200 East and West. As with the HSWEIS, little migration through soil was predicted and groundwater was not expected to be impacted. However, actual data from monitoring wells (starting in late 2000) conclusively revealed that hazardous substances had reached groundwater from the US Ecology burial grounds.

Foot Notes:

[i] "This guidance clarifies that cleanups of radionuclides are governed by the risk range for all carcinogens established in the NCP (National Contingency Plan) when ARARs are not available or are not sufficiently protective. That is to say, such cleanups should generally achieve risk levels in the 10^{-4} to 10^{-6} range." OSWER No. 9200.4-18; USEPA; August 22, 1997, at P.3.
[ii] "Analysis of what Radiation Dose Limit is Protective of Human Health at CERCLA Sites"; USEPA; August 20, 1997 at Page 7. EPA's limit is 10 millirem from a single source of airborne radionuclides for NESHAP; 4 millirem per year from groundwater and no more than 10 to 15 millirem from all sources would meet NCP requirements.
[iii] U.S. Environmental Protection Agency; April 19, 1999; letter to Conference of Radiation Control Program Directors commenting on proposal to allow residual contamination levels resulting in 100 millirem per year of potential public exposure. The EPA cited the same concern for NRC's license termination rule. July 7, 2000.
[iv] USDOE Performance Assessment for 200 West Burial Grounds, Table S-1 at Page vi; see also same table in 200 East Assessment.
[v] Id and EPA August 20, 1997, Op.Cit..

<u>Foot Notes for Performance Assessment Review:</u>
[vi]"Performance Assessment for the Disposal of Low-Level Waste in the 200 West Burial Grounds", WHC-EP-0645, prepared for the U.S. Department of Energy by Westinghouse Hanford Company, June 1995; and, "Performance Assessment for the Disposal of Low-Level Waste in the 200 East Burial Grounds", WHC-SD-WM-TI-730, prepared for the U.S. Department of Energy by Westinghouse Hanford Company, August, 1996.
[vii] Waste Management Programmatic Environmental Impact Statement, USDOE, 1997.
[viii] "This guidance clarifies that cleanups of radionuclides are governed by the risk range for all carcinogens established in the NCP (National Contingency Plan) when ARARs are not available or are not sufficiently protective. That is to say, such cleanups should generally achieve risk levels in the 10^{-4} to 10^{-6} range." OSWER No. 9200.4-18; USEPA; August 22, 1997, at P.3.

[ix] "Analysis of what Radiation Dose Limit is Protective of Human Health at CERCLA Sites"; USEPA; August 20, 1997 at Page 7. EPA's limit is 10 millirem from a single source of airborne radionuclides for NESHAP; 4 millirem per year from groundwater and no more than 10 to 15 millirem from all sources would meet NCP requirements.

[x] U.S. Environmental Protection Agency; April 19, 1999; letter to Conference of Radiation Control Program Directors commenting on proposal to allow residual contamination levels resulting in 100 millirem per year of potential public exposure. The EPA cited the same concern for NRC's license termination rule. July 7, 2000.

[xi] USDOE Performance Assessment for 200 West Burial Grounds, Table S-1 at Page vi; see also same table in 200 East Assessment.

[xii] Id and EPA August 20, 1997, Op.Cit..

[xiii] See Heart of America Northwest Reports available on our website:www.heartofamericanorthwest.org: "Washington Beware". USDOE has acknowledged prior disposal of hazardous wastes in a Part B RCRA application to Washington State. The Heart of America Northwest report conclusively shows that illegal disposal of hazardous wastes continued in the trenches after 1989.

[xiv] SEE Performance Assessment for 200 West at 4.2.5

[xv] Page 4-48; Assessment for 200 West.