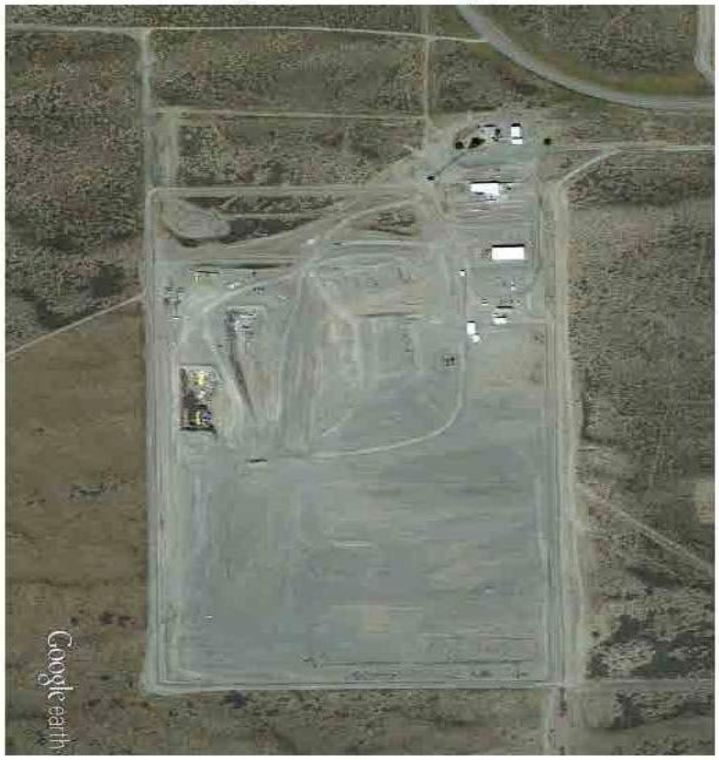

Report to Legislature on US Ecology Commercial Low-Level Radioactive Waste Site Closure

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Publication no. 15-05-013

DEPARTMENT OF ECOLOGY
State of Washington

Washington State Department of Health

Publication and Contact Information

This report is available on the Department of Ecology's website at
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Nuclear Waste Program
Washington State Department of Ecology
Richland, Washington

Office of Radiation Protection
Washington State Department of Health
Richland, Washington

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Executive Summary

The Washington State Legislature passed a budget proviso during the 2015 legislative session requiring the Washington State Departments of Ecology and Health (Agencies) to work with the Yakama Nation to engage a third party to evaluate the specific technical concerns of the Yakama Nation regarding the cleanup and closure of the US Ecology Commercial Low-Level Radioactive Waste (LLRW) Site (US Ecology site), specifically the timing of the Phase I cover. (The proviso language is attached as Appendix A to this report.)

The proviso prohibits expenditure of funds to place a cover over the trenches that have released, or are projected to release, contaminants until the third party review is completed and collaboratively resolved. The proviso requires a report to the legislature, which is to include the third party's review and the Agencies' recommendations and the means for addressing risk to human health.

In the past, two kinds of waste were disposed of at the US Ecology site, radioactive waste and chemical waste. These two categories of wastes are currently governed by two separate sets of regulations. The proposed decision that concerns the Yakama Nation is about whether placing a cover over the older parts of the disposal site that contain chemical waste is necessary prior to making final decisions about remediation of the historic chemical waste.

This report addresses the third party's review and the Agencies' path forward, which includes meeting our statutory obligations for cleanup of hazardous and radiological waste associated with the US Ecology site. The independent third-party hired to conduct the review, consultant Neptune/RIDOLFI, submitted their final report to the Agencies and the Yakama Nation for review on October 13, 2015.

The primary goal of Neptune/RIDOLFI's review was to evaluate Yakama Nation's specific technical concerns with respect to the timing of a Phase 1 cover. The contract included the following Statement of Work to analyze the concerns:

- Run the Yakama Nation risk model for comparison to results of existing models.
- Review variables in landfill cap life estimates that might impact scenarios and Phase 1 cover timing. Review modeling assumptions and inventory estimates.
- Assess impact of Phase 1 cover on the Model Toxic Control Act (MTCA) work and consequences of delaying installation.
- Evaluate engineering and safety issues in opening the cover.
- Compare US Ecology and Hanford closure and cleanup requirements.

The Agencies worked collaboratively with the Yakama Nation and Neptune/RIDOLFI to meet the budget proviso's requirements as follows[1]:

- August 2014 – February 2015: The Yakama Nation, Ecology, and Health (Parties) collaboratively developed a contract scope of work and hired a third party.
- February 23, 2015: Meeting was held with the Parties and Neptune/RIDOLFI to hear the concerns and interests of the Yakama Nation.

[1] Documentation supporting the collaborative process is identified in Appendices B, C, D, E, F

- August 6, 2015: Neptune/RIDOLFI presented the preliminary document to the Parties for review and comment.
- September 8, 2015: The Agencies submitted combined comments on the preliminary document.
- October 1, 2015: Yakama Nation submitted comments on the preliminary document. Examples of specific comments/questions and how they were addressed in the final Neptune report and tentatively resolved subject to funding are identified below:
  - Comment – “No characterization from about 80 ft. to groundwater; known data gap with no proposed further characterization.” Neptune/RIDOLFI identified this issue as an issue that “makes it difficult to determine the time course of future aquifer concentrations.”

    Response – Ecology and Health will hire an Ecology-approved technical consultant to design additional characterization work to fill in the soil vapor and groundwater data gaps.
  - Comment – “Is there a plan to update the models as additional environmental data are acquired, particularly groundwater monitoring and the modeled near-term rise in plutonium concentrations?” Neptune/RIDOLFI stated that “the basis for removing plutonium as a material of concern must address the time frame for risk-based groundwater pathways decisions, since plutonium inventory that is not “mobile” may still reach groundwater in the more distant future.”

    Response – Health will continue to evaluate and analyze radiological monitoring data against model forecasts using an integrated model.
  - Comment – “Why has no benefit-cost evaluation been done to evaluate the feasibility of characterizing and/or removing some wastes?” According to Neptune/RIDOLFI, the MTCA contractor did not provide sufficient alternatives.

    Response - Ecology and Health will hire an Ecology-approved technical consultant to design additional characterization work to more completely define and cost the soil vapor and groundwater remediation work alternatives.
  - Comment – “The groundwater pathway and the amount of contamination related to that pathway and how the 22mrem was correlated to the Hanford sites requirement of 4mrem per year and how a “donut hole” would not be created.” Neptune/RIDOLFE noted that the “US Ecology radionuclide assessment employs the NRC 25 mrem/yr threshold for all pathways including direct contact and groundwater.”

    Response – At the face to face meeting with the Yakama Nation and Agencies, Health agreed to perform a technical review of its calculations to assess each pathway individually; this would possibly decrease the likelihood of the creation of the “donut hole” effect.
- October 13, 2015: The independent consultant revised the report based on comments provided by the three Parties and submitted the Final Report to the Agencies and the Yakama Nation.

A detailed summary of the Neptune/RIDOLFI report is provided on page 9 of this report.

Figure 1.0 Aerial View of US Ecology Site

The US Ecology site sits in the middle of the U.S. Department of Energy's (USDOE) Hanford Site (200 Area). The land is leased to the state of Washington to be operated as a low-level radioactive waste disposal site serving the eight states of the Northwest Interstate Compact and the three states of the Rocky Mountain Compact.

The US Ecology site is operated for the purpose of disposing of low level radiological waste. However the older parts of facility also contain chemical waste that was intermingled with radioactive waste before such disposal practices were changed. In order to meet Nuclear Regulatory Commission (NRC) closure standards for radiological waste, the Washington State Department of Health completed a computer model that used conservative assumptions. Meanwhile, the MTCA cleanup has been pursuing resolution of concerns about the chemical waste. The proviso focused on reviewing the modeling performed by the Department of Health and the standards for the cleanup to be performed by the Department of Ecology. The substitution of Yakama Nation risk assumptions for the Health's assumptions was one of the key elements of the review.

Agencies' Key Decisions on US Ecology Site Resulting from the Independent Third Party Evaluation:

- The proposed Phase 1 cover placement originally required to be installed by 2016 (based on 2012 Final Environmental Impact Study [EIS] addendum) to meet federal radiological requirements can be delayed due to:
    - The Health model is overly conservative in assuming potential releases from the facility.
    - The potential for exposure while the site remains under federal control is minimal.
- Based on the independent consultant analysis the State Department of Health with concurrence from Department of Ecology will not proceed with installation of the Phase 1 cover until completion of the MTCA process.
- Additional characterization to fill data gaps regarding groundwater and chemical vapors in the soil is needed.
- Some additional modeling for exposure pathways previously not evaluated should be considered (e.g. radon transport through the cover) to provide a complete picture of the potential risks.

- Consolidate and make electronic data available for information that the Neptune/RIDOLFI did not evaluate including the Inventory and Quality Assurance audit for the EIS. Records on the data and assumptions used in the Final EIS will also be provided electronically.

The proposed Phase 1 cover material is high-density polyethylene (HDPE), a material commonly used in the waste management industry for both bottom liners and surface covers. Applications include landfills of all types, Superfund and MTCA sites, and extensive use in liquid waste lagoons. HDPE as a surface cover is frequently used to provide a water barrier that is repairable and resistant to chemicals and radiation. Although the absence of an imminent need for a surface cover is sufficient reason to defer this specific installation, the state questions the potential cover maintenance and repair difficulties identified in the Neptune/RIDOLFI report. A HDPE cover will still be considered for the MTCA remediation and/or a radiological closure solution and, if the preferred solution, will be subjected to a more extensive analysis of performance expectations.

Background

Site Information

The US Ecology Commercial Low Level Radioactive Waste Disposal Facility is located:

- In Benton County.
- In the 8th Legislative District.
- On 100 acres of USDOE land leased to the state of Washington and subleased to US Ecology. Forty acres are in use as the actual disposal trenches.
- 23 miles northwest of Richland.
- Located in the center of the Hanford Reservation.

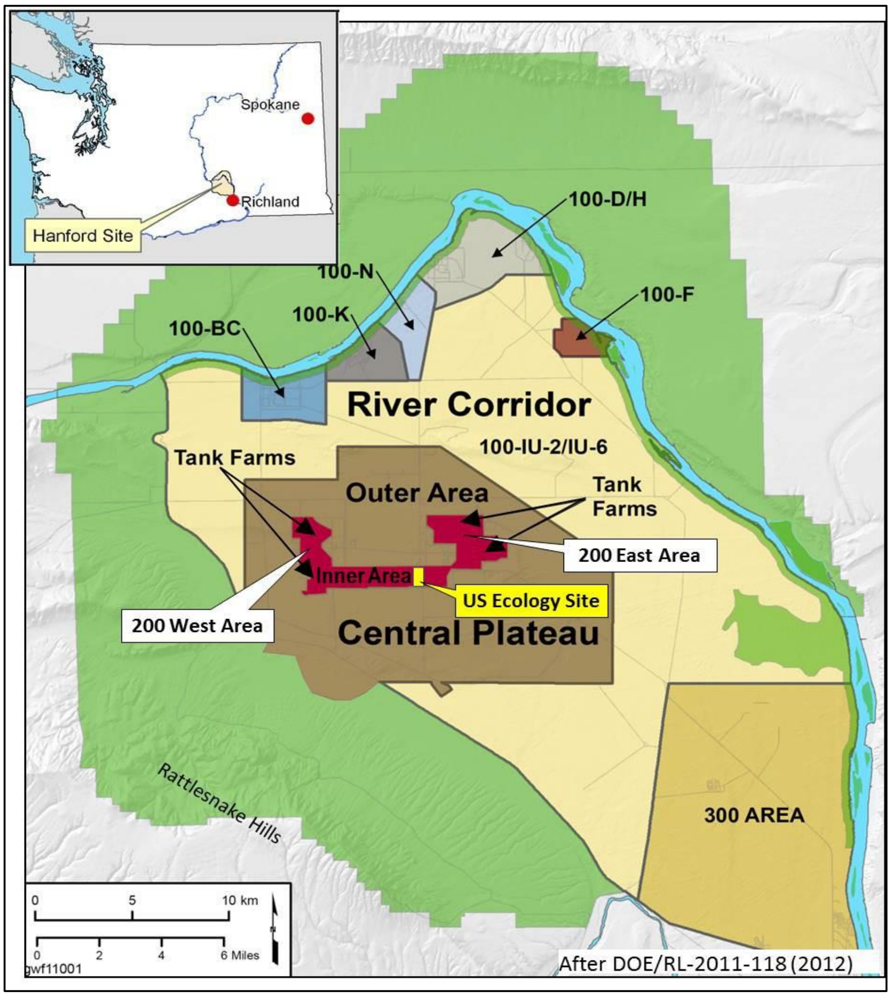


Figure 2.0 The Hanford Site Showing US Ecology Site

Site History and Users

The US Ecology landfill has disposed of low-level radioactive waste since 1965. Before 1993, the facility accepted waste from throughout the United States. The facility accepted 1.0 to 1.5 million cubic feet annually in the mid-1980s when waste was coming from throughout the United States. The volume of waste has decreased over time. After 1993, the facility has accepted waste only from the eight member-states of the Northwest Compact and three member states of the Rocky Mountain Compact. Since 2008, annual volumes average about 27,000 cubic feet a year.

US Ecology Operational History

- 1965: Site operations began; early disposals included both chemical and radioactive waste in separate locations.
- 1966: Washington became an Agreement State for implementing Nuclear Regulatory Commission regulations.
- 1970: Chemical trench closed.
- 1980: Cardboard packaging and non-medical waste generated out of state is banned; metal boxes and metal drums required.
- 1985: Hazardous scintillation fluids banned from disposal.
- 1985: Five resin tanks emptied; two tanks removed and three left in place.
- 1986: Oils and chelates (metals attached to anions) are required to be solidified.
- 1987: Wooden boxes are banned.
- 1993: Northwest Compact restricts disposal to member states.
- 1997: Absorbed liquid packages must be placed into engineered concrete barriers.
- 1999: Absorbed liquids banned from disposal; required to be solidified.
- 2001: Listed on Washington's Hazardous Site List (Model Toxics Control Act).
- 2004: The Environmental Impact Statement identifying closure requirements is completed.
- 2008: MTCA Investigation starts.
- 2010: Decision to install Phase 1 cover.

Timeline for MTCA activities:

- 1999: Phase 1 and 2 Comprehensive Facility Investigation Report.
- 2000: Draft EIS released with radiological risk.
- 2001: Listed on state's Hazardous Site List.
- 2004: Final Environmental Impact Statement released by the Washington State Departments of Health and Ecology.
- 2004: Memorandum of Agreement between the Department of Health, Department of Ecology, and US Ecology.
- 2006: Agreed Order DE 3834.
- 2008-2010: Period of conducting MTCA investigation.

- 2010: Remedial Investigation report completed.
- 2011 – Present: Focused Feasibility Study under preparation.

Who currently does what at the US Ecology facility?

There are two state Agencies and one private sector organization involved at this facility. Their roles are described below:

- US Ecology, a private company operates the commercial disposal facility.
- Department of Health regulates current operations and facility closure to meet Nuclear Regulatory Commission requirements.
- Department of Ecology:
  - Manages the lease of USDOE land for the state.
  - Oversees the Northwest Interstate Compact, whose states, along with the Rocky Mountain Compact, use the site for low-level radioactive waste disposal.
  - Manages the Site Closure Fund.
  - Investigates and regulates cleanup of chemical releases (under MTCA).

Who currently uses the US Ecology Disposal Site?

- Washington State users include:
  - Columbia Generating Station
  - Naval Shipyards
  - University and Research Institutions
  - Medical and Industrial Facilities
- The Northwest Compact States: Alaska, Hawaii, Idaho, Montana, Oregon, Utah, Washington, and Wyoming.
- The Rocky Mountain Compact States: Colorado, Nevada, and New Mexico.

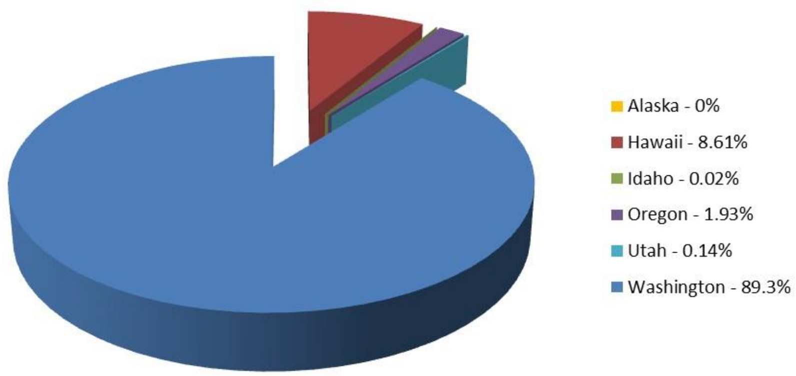


Figure 3.0 Disposal Percentages by Northwest Compact States in 2014

Three major issues for the future of the US Ecology Site

- Continued operation as a low level waste disposal facility in compliance with NRC requirements.
- Final closure and facility transition to the USDOE for integration into the Hanford 200 Area long term monitoring and maintenance plan.
- Use the MTCA process to remediate the chemicals disposed in the facility in the 1960s and 1970s.

Regulatory standards for closure/cleanup

The US Ecology Site is subject to two different sets of standards. The federal NRC sets operating and closure standards for low level radioactive waste disposal facilities. MTCA sets standards for cleanup of chemical wastes that were disposed of at the site under regulations which are no longer in place today.

- NRC standards for overall site closure
  - Criteria (federal regulations in 10 CFR Part 61):
    - Meet a public dose limit of 25 mrem per year from all pathways and sources, soil depths and from groundwater.
    - Meet the standards for cleanup immediately upon closure and for perpetuity.
    - Inadvertent intruder guideline (as low as reasonably achievable, but not greater than 500 mrem per year).
    - Long-term site stability.
- MTCA requirements for cleanup of hazardous substances
  - Selection of indicator hazardous substances.
  - Establishment of soil cleanup levels based on human exposure via direct contact to a depth of 15 feet.
  - Establishment of groundwater cleanup levels based on estimates of highest beneficial use and reasonable maximum exposure (e.g., drinking water) expected to occur under both current and potential future site use conditions.
  - Establishment of soil cleanup levels to protect groundwater.
  - Establishment of indoor air cleanup levels to protect against vapor intrusion.
  - Individual carcinogen limit of 10^{-6} risk and total site cancer risk of 10^{-5} (total risk across multiple carcinogens and multiple pathways).
  - Individual noncarcinogen limit of hazard quotient of 1 and total site hazard index of 1 (total hazard index across multiple noncarcinogens [with common target organ] and multiple pathways).
  - Establishment of soil cleanup levels to protect terrestrial ecological receptors (plants, soil biota, and wildlife).

In addition to NRC and MTCA standards, the Yakama Nation has requested that facility performance be compared to cleanup standards and processes established by the Comprehensive Environmental Response Compensation and liability Act (Superfund) at USDOE facilities located in the Hanford 200 area. Standards and processes established by Superfund for the Hanford 200 area are:

- Selection of indicator hazardous substances.
- Cleanup levels similar to those identified in Model Toxics Control Act.
- Federal drinking water standards for groundwater.
- $3x10^{-4}$ risk estimated at 12mrem.
- Risk for direct contact based on potential exposure to soils down to 15 feet.

Neptune/RIDOLFI Study

What Neptune/RIDOLFI Studied

A. Run the Yakama Nation risk model for comparison to results of existing models.
B. Review variables in cap life estimates that might impact scenarios and Phase 1 cover timing. Review modeling assumptions and inventory estimates.
C. Assess impact of Phase 1 cover on MTCA work and consequences of delaying installation.
D. Evaluate engineering and safety issues in opening the cover.
E. Compare US Ecology and Hanford closure and cleanup requirements.

Figure 4.0 Map of Trenches and Groundwater Monitoring Well Locations in 2012

Major Conclusions from Neptune/RIDOLFI Report[2]

- The timing of cover installation has little effect on groundwater doses for the period of time after assumed loss of institutional control.
- Detailed documentation of the waste inventory is not provided with the Final Environmental Impact Statement (EIS).
- Reliance solely on environmental data (soil, soil vapor, and groundwater) to drive MTCA decisions ignores the possibility that significant chemical sources remain in the trenches to be released in the future.
- There is a low probability that all institutional and societal knowledge of Hanford will be lost and that a drinking water well will be constructed on the Central Plateau in the next few centuries. The realization of a near-term groundwater exposure pathway is therefore unlikely.
- There are several potentially important assumptions invoked in the Final EIS contaminant transport and dose calculation that are not adequately explained and supported.
- The artificial separation of chemical and radiological assessments and actions, and the very different assumptions and models used, makes a holistic assessment of risks and uncertainties impossible.
- In order to be useful for benefit-cost informed decision making, a risk assessment model must be unbiased and complete in its consideration of transport pathways. Biased screening models are useful only for supporting decisions when they encompass all pathways and indicate no possibility of exceeding thresholds. Follow latest guidance from NRC (NUREG-2175) to build an adequate foundation for the model.
- The NRC has proposed revisions to 10 CFR 61.
- Recognize that groundwater transport was modeled with a protective screening model, and that dose results are mostly from a sweat lodge inhalation model that implausibly assumes nonvolatile radionuclides will be present as respirable particulates in equilibrium with saturated water vapor. Assess urgency of Phase 1 cover timing accordingly.

Summary of other issues raised by Neptune/RIDOLFI during their review

- *Limitations of Screening Methodology*
    - Each set of pathway calculations (contamination of groundwater, exhumation of drill cuttings, and ground surface flux of radon) was done independently using protective models and assumptions, rather than as an integrated analysis.
    - No realistic modeling of system performance was done, and therefore the degree of "conservative" bias is largely subjective.
- *Timing of Phase 1 Cover.* A persuasive technical rationale has not been made for the necessity of installing the Phase 1 cover for the purpose of interrupting near-future groundwater pathway dose.
- *Radiological Risk Assessment (RRA) Endpoints.* The Final EIS radiological risk assessment compared adult receptor doses to dose-based performance metrics.

[2] The report contains additional conclusions; these are the conclusions that impact the decision to spend closure funds on a Phase 1 Cover. The reader is referred to Appendix E for the full list of report conclusions.

- Parameter values and calculations were developed for children, but results were not provided or applied to conclusions and recommendations.
    - Cancer risk results were not provided, frustrating risk communication. Cancer risk is the ultimate concern for radionuclide exposure, for which effective dose is an imperfect proxy, although a regulatory target.
- *RRA Conceptual Model.* Dose results in the Final EIS may be underestimated because the modeling of nonvolatile radionuclide transport from disposed wastes did not assess all relevant pathways.
- *RRA Model Boundaries.* There are several potentially important assumptions invoked in the Final EIS transport and dose calculations that are not explained and supported.
- *RRA Inventory and Waste Concentrations*. Detailed waste inventories and uncertainties of the waste inventory were not well documented in the Final EIS.
- *Chemical MTCA Investigation*
    - The reliance solely on environmental data (soil, soil vapor, and groundwater) to drive MTCA decisions ignores the possibility that significant chemical sources remain in the trenches to be released in the future.
    - The limited vertical extent of the vapor monitoring wells (~100 ft with an aquifer depth ~300 feet) makes it difficult to determine the time course of future aquifer concentrations.
- *Impact of the Phase 1 Cover on Future Investigation or Remediation*
    - Any actions that involve excavation or other substantial disturbance of the Phase 1 cover will be disadvantaged from a benefit-cost perspective relative to a no-cover baseline due to the higher costs imposed by having to subsequently repair the liner and re-compact the earthen materials comprising the cover.
    - Engineered cover repair may not be completely successful and could potentially create areas of future weakness, differential settling, or preferential contaminant transport pathways.
- *Comparison of US Ecology and Hanford Closure and Cleanup Requirements*
    - Central Plateau Inner Area soil radionuclide remediation criteria for direct contact pathways are calculated based on EPA's 10^{-6} to 10^{-4} Superfund risk range rather than NRC 25 mrem/yr all pathways dose threshold.
    - The US Ecology RRA applies the 25 mrem/yr NRC all-pathways threshold whereas Hanford radionuclide groundwater cleanup criteria are based on Maximum Contamination Levels of 4 mrem/yr and 15 pico ci/l for beta/photon emitters and alpha emitters respectively.
- *Consequences of Future MTCA Efforts*
    - Additional MTCA investigatory or remedial actions may require the breach or removal of the cover system by drilling or trenching.
    - These investigatory and remedial activities would be substantially more difficult to logistically initiate once the Phase 1 cover is installed and would require potentially extensive work to repair the geomembrane barrier and the surrounding engineered soils.

- Any potential impacts to cover design and performance would be avoided if cover is installed following completion of MTCA investigation.

- *Liner Performance and Repair Limitations*
  - Impacted by: exposure to oxygen or deletion of antioxidants, temperature, UV exposure, and irradiation.
  - Aging of the geomembrane barrier due to landfill conditions may increase the likelihood that repairs to the Phase 1 Cover system would compromise the overall liner integrity.
  - Partial removal and replacement, piercing by drilling, repair work, and barrier manipulation could compromise the cover system integrity and could increase the difficulty of detecting breaches.
  - Repair could be more extensive (as a result of landfill or waste conditions) when potential future MTCA investigation work penetrates or disturbs the constructed cap/cover system.

- *Worker and Public Health and Safety*
  - Installation of a vapor control system will be necessary during installation of the geomembrane barrier.
  - Uncertainties related to the waste contents, package conditions, and disposal location make calculating worker exposures difficult whether or not the Phase 1 cover is installed.
  - Installation of the Phase 1 cover would likely restrict visual inspection of the waste and may result in physical confined space challenges should the cover need to be removed to investigate the waste.
  - Worker radiation dose related to MTCA investigations or remedial activities, could reasonably be anticipated to decrease over time as short-lived radionuclides decay.

- *MTCA cost*
  - MTCA cost estimates for waste excavation have been estimated to be in the range of $3.3 billion to $11.8 billion.
  - The costs to either selectively remove or excavate all waste could decrease over time if radiological material in the trenches decays to levels low enough to allow workers to safely handle the waste.
  - The costs for MTCA actions are estimated to increase as the cleanup remedies become more complex. The range of remedies that may be considered go from one or two new boreholes/wells for sampling to partial excavation to removal of all wastes in a trench.
  - Costs of the alternatives range from ~$59 million to several billion; the MTCA contractor did not provide alternatives between the two points.

The information below is from Table 2 of the Neptune report (Appendix E) and converted from international system of units to empirical units of measure. The Final EIS food assumptions reflect typical values for the U.S. consumption rates; the tribal numbers reflect Yakama Nation consumption values. The primary value that made the State risk conclusions more conservative than the Yakama Nation values is the sweat lodge inhalation rate.

Table 1.0 Comparison of Difference between Exposure Parameter Values

Exposure Parameter	Units	Yakama Nation	Ecology and Health Final EIS
Soil ingestion rate (adult/child)	oz./day	0.07 / 0.14	0.07 / 0.07
Exposure Frequency	day/year	365	365
Inhalation rate (adult/child)	$ft.^3$/day	34.01 / 20.93	39.24 / 19.62
Drinking water ingestion rate (adult/child)	gal/day	0.66 / 0.44	0.66 / 0.44
Fruit + vegetable ingestion rate[3] (adult/child)	lbs./day	3.1 / 0.7	1.3 / 0.7
Meat (beef) ingestion rate[4] (adult/child)	lbs./day	1.6 / 0.5	0.6 / 0.4
Milk ingestion rate [4] (adult/child)	quart/day	1.04 / 0.44	0.44 / 0.7
Sweat lodge exposure frequency	hr./year	365[5]	365
Sweat lodge water intake	gal/event	0.22	0.22
Sweat lodge water use; steam	gal/event	0.88	0.23
Sweat lodge inhalation rate	$ft.^3$/day	1.41	1.57

The projected costs for remediation of the site, as defined in Kurion 2015 *Focused Feasibility Study, US Ecology Low-Level Radioactive Disposal Draft B* site are shown in Figure 5.0.

[3] FEIS values pertain to locally grown produce (assumed to be 62.5% of total).

[4] FEIS evaluated these pathways only for well water, not drill cuttings. Uptake in a localized are of drill cuttings contamination may be of particular relevance for poultry and eggs.

[5] Maximum daily is 7hr/day; 1 hr/day applied for chronic exposure.

Cost Information – US Ecology MTCA Investigation		
Alternative	Description	Cost ($)
Total Excavation	Total excavation activities for up to 10 years, and natural attenuation of groundwater for up to 20 years.	$ 11,809,169,179
Targeted Excavation	Targeted activities for up to two years, conduct passive soil vapor extraction for 28 years, and with a geosynthetic cover for 30 years	$ 3,307,075,136
Active Soil Vapor Extraction and Cover	Active soil vapor extraction five years, and with a geosynthetic cover system for 30 years.	$ 58,986,962
PSVE and Cover	Passive soil vapor extraction 15 years and with a geosynthetic cover for 30 years.	$ 59,207,550
Cover and MNA	Geosynthetic cover system for up to 30 years and monitored natural attenuation for 15 years.	$ 58,774,704

Figure 5.0 MTCA Costs for Remediation

Agencies' Path Forward

In modeling work, conservative assumptions are used to compensate for incomplete data. This is a technique often used in evaluating possible impacts from buried waste where historic records do not meet current manifesting and placement record requirements.

The Neptune/RIDOLFI report noted poor documentation of the assumptions used in the prior modeling work and the writers lacked the time and scope to reproduce the file searches that generated those assumptions. The Neptune/RIDOLFI model also introduced some new assumptions and hypothetical risks that needed referencing. In order to avoid historical gaps for future work, Ecology and Health agreed to provide the background for the new assumptions and to place the prior investigatory work into an accessible electronic file.

Based on technical review of the current risk assessment, Health and Ecology will postpone cover construction until after the completion of the additional work noted below.

- Health and Ecology will hire a contractor to update the risk assessment and create a supplemental EIS per report recommendations. This will include:
  - Proposed revisions to NRC Part 61 rules pertaining to facility closure requirements.
  - Analysis of conformity with Hanford 200 area performance standards.
  - Evaluate likely long-term cover performance.
- With existing 2015-17 Capital appropriation, Ecology and Health will hire a technical consultant from Ecology's Toxic Cleanup Program's list of "prime" contractors to:
  - Design additional characterization work to fill in the soil vapor and groundwater data gaps.
  - More completely define and cost the soil vapor and groundwater remediation work alternatives.

- Ecology and Health will coordinate with the U.S. Environmental Protection Agency and USDOE to further characterize the nature and extent of the groundwater plume in the area around the US Ecology site.
- Ecology and Health will development a long-term integrated strategy for managing the radiological and chemical materials at the site during operation and closure of the US Ecology site.
- An HDPE cover will be considered for the MTCA remediation and/or a radiological closure solution and, if the preferred solution, will be subjected to a more extensive analysis of performance expectations.
- Ecology will collect additional soil vapor and groundwater samples every year to inform future remediation activities for chemical releases.
- Health will continue to evaluate and analyze radiological monitoring data and compare data against model forecasts.
- Ecology and Health will pursue cost effective resources (such as free soil or testing collaboration with USDOE) as necessary for investigatory, remedial or closure purposes.
- Ecology and Health will continue to consult with the Tribal Nations (Yakama, Nez Perce, and Confederated Tribes of the Umatilla Indian Reservation) and other interested stakeholders as the characterization strategy is developed and validated data is available.
- A future decision on placement of a Phase 1 cover will be driven by:
  - Updated Radiological Risk Assessment– if new data indicates radiological limits will be exceeded without installation of a Phase 1 cover.
  - Regulatory requirements from the NRC.
  - MTCA cleanup action plan – if MTCA Remedial Investigation/Feasibility Study determines that placement of a cover is an integral part of the remedial actions.
- Ecology and Health will develop a life of project outline, schedule, and budget estimate and develop a 2017-19 budget submittal.

Time line for turning the US Ecology Site over to USDOE

Continue receiving waste until 2056

- 2056: Disposal Operations Cease.
- 2056 – 2057: Final Facility Closure Period. US Ecology is responsible for final closure of the trenches and the facility.
- 2058 – 2062: Stabilization Period. US Ecology is responsible for post-closure maintenance at the commercial LLRW site for the first five years after closure.
- 2063: The prime lease between the state and USDOE for the land the commercial LLRW site occupies expires on September 9, 2063.
- 2063: Institutional Controls Period. The state returns the commercial LLRW site to USDOE under the terms of the 1965 Perpetual Care Agreement. At the same time, the state will transfer the Perpetual Care and Maintenance (PC&M) fund to USDOE. The PC&M fund was established to monitor and maintain the site for a minimum of 100 years after closure.
- 2063: PC&M Begins.

Available Financial Resources for Site Closure

The 2015 budget proviso limits spending on the cover construction. The funding will continue to be needed for further study on the risk and remedy alternatives on the radiological and hazardous chemical risks at the site. Funding will be needed in the future for further cleanup and closure work to protect the public and the environment. The following is a brief summary of the funds the state is currently projected to have available for all the work needed to cleanup and close the facility:

- The Site Closure Account (SCA) was authorized in RCW 43.200.080 which specifies that the SCA can only be used to reimburse the site operator (US Ecology) or state licensing agency (Health) for their costs in closing the site.
  - MTCA investigation and Phase 1 cover are elements of site closure.
  - The SCA was funded with fees charged to both out of region generators and in region generators with fees being higher for out of region users prior to the site solely serving Northwest Compact states. Currently no fees are charged for site closure.
  - Fund Balance as of October 1, 2015 is nearly $27.5 million. The fund also accrues:
    - $1 million per year payment into the fund from a payback on a 2004 transfer of $13.8 million to General Fund.
- The PC&M fund accumulated through user fees (for long-term maintenance of the closed facility by USDOE). The PC&M has a balance of $45.2 million

Appendices

Appendix A. Section 3002 Budget Proviso

NEW SECTION. **Sec. 3002. FOR THE DEPARTMENT OF ECOLOGY**

Low-Level Nuclear Waste Disposal Trench Closure (19972012)

The appropriations in this section are subject to the following conditions and limitations: The department of ecology and department of health shall work with the Yakama nation to engage a third party to evaluate the specific technical concerns the tribe has identified with respect to the timing of the phase 1 cover. Funds may not be expended to place a cover over the trenches which are releasing or are projected to release contaminants until the third party review is completed and collaboratively resolved. A report on the above referenced work, including recommendations and the means for meeting health and cancer risks, must be delivered to the appropriate committees of the legislature by December 1, 2015.

Appendix B. Neptune Contract

Washington State Department of Health

CONTRACT NUMBER: N20730	SUBRECIPIENT * ☐YES ☒NO
	FFATA FORM REQUIRED ☐YES ☒NO

* see Attachment 2

THIS AGREEMENT is made by and between the state of Washington Department of Health, hereinafter referred to as DOH, and the party whose name appears below, hereinafter referred to as Contractor.

CONTRACTOR NAME and ADDRESS:

Neptune and Company Inc.
1435 Garrison Street, Suite 110
Lakewood, CO 80215

UBI #: 602-269-444

IT IS MUTUALLY AGREED THAT:

PURPOSE: Evaluate the concerns the Yakama Tribe has identified with respect to the US Ecology closure, cleanup, timing and use of the Phase 1 cover. Evaluate if the cover would impede additional Model Toxics Control Act (MTCA) work and compare the US Ecology closure standards to the adjacent Hanford site.

STATEMENT OF WORK: The Contractor shall provide the all necessary personnel, equipment, materials, goods and services and otherwise do all things necessary for or incidental to the performance of the work as described in **Exhibit A**, attached hereto and incorporated herein.

PERIOD OF PERFORMANCE: Subject to its other provisions, the period of performance under this contract shall be **from Date of Execution through May 30, 2015** unless sooner terminated as provided herein. No billable activity may take place until this contract has been signed by both parties.

DEPARTMENT OF ENTERPRISE SERVICES APPROVAL: This agreement may be required to be filed with the Department of Enterprise Services (DES) for approval under the provisions of Chapter 39.26 RCW. No contract or amendment required to be so filed is effective and no work thereunder shall be commenced nor payment made therefore until ten (10) working days following the date of filing, and, if required, until approved by DES. In the event DES fails to approve the contract or amendment, the contract shall be null and void.

FEDERAL FUNDING ACCOUNTABILITY AND TRANSPARENCY ACT (FFATA): If checked above, this contract is supported by federal funds that require compliance with the Federal Funding Accountability and Transparency Act (FFATA or the Transparency Act). The purpose of the Transparency Act is to make information available online so the public can see how federal funds are spent.

To comply with the act and be eligible to enter into this contract, your organization must have a Data Universal Numbering System (DUNS®) number. A DUNS® number provides a method to verify data about your organization. If you do not already have one, you may receive a DUNS® number free of charge by contacting Dun and Bradstreet at www.dnb.com.

Information about your organization and this contract will be made available on www.USASpending.gov by DOH as required by P.L. 109-282. DOH's form, **Federal Funding Accountability and Transparency Act Data Collection Form,** is considered part of this contract and must be completed and returned along with the contract.

CONSIDERATION: The maximum consideration available under this contract shall not exceed **$60,000.00** without a properly executed written amendment signed by representatives of both parties authorized to do so.

Source of funds: Federal: $0 **State: $60,000** Other: $0 **Total: $60,000.00**

Contractor agrees to comply with all applicable rules and regulations associated with these funds.

Unless otherwise indicated in this contract, any state funds which are unexpended as of June 30th will not be available for carry over into the next state fiscal year (July – June).

INVOICES AND PAYMENT: Contractor will submit invoices to the DOH Project Manager for all amounts to be paid. Invoices must reference this contract number and provide detailed information as requested. All invoices must be approved by DOH prior to payment; approval will not be unreasonably withheld. DOH will authorize payment only upon satisfactory completion and acceptance of deliverables and for allowable costs as outlined in the statement of work and/or budget. DOH will return all incorrect or incomplete invoices and will not pay for services that occur outside the period of performance. The Contractor will not invoice for services if they are entitled to payment, have been, or will be paid by any other source for that service.

DOH will issue payment within 30 days of receiving a correct and complete invoice and approving the deliverable(s). DOH must receive correct and complete invoices within 60 days of the contract expiration date. Late invoices will be paid at the discretion of DOH and are contingent upon the availability of funds. Failure to submit a properly completed IRS form W-9 may result in delayed payments.

GOVERNANCE: In the event of an inconsistency in this contract, unless otherwise provided herein, the inconsistency shall be resolved by giving precedence in the following order:

- Applicable Federal and State statutes and regulations
- Special Terms and Conditions
- Attachment 1, General Terms and Conditions
- Exhibit A, Statement of Work
- Any other provision of the contract whether incorporated by reference or otherwise – including RFQQ N20730, amendments to RFQQ N20730 and the bidder's response.

UNDERSTANDING: This contract, including referenced exhibits, attachments & documents included herein by reference, contains all the terms and conditions agreed upon by the parties. No other understandings, oral or otherwise, regarding the subject matter of this contract shall exist or bind any of the parties hereto.

APPROVAL: This contract shall be subject to the written approval of DOH Contracting Officer and shall not be binding until so approved. Only the Contracting Officer or his/her designee, by written delegation made prior to action, shall have the expressed, implied, or apparent authority to alter, amend, modify, or waive any clause or condition of this contract. Furthermore, any alteration, amendment, modification, or waiver of any clause or condition of this contract is not effective or binding unless made in writing and signed by the Contracting Officer.

IN WITNESS WHEREOF: DOH and the Contractor have signed this agreement.

CONTRACTOR SIGNATURE Kelly Black	**DATE** 2/6/15
print or type name & title below: Kelly Black, President	
DOH CONTRACTING OFFICER SIGNATURE Frank L Webley **Frank Webley** Contract Specialist	**DATE** 02/09/15

This contract has been approved as to form by the attorney general.

Statement of Work for the US Ecology Facility Phase 1 Cover Evaluation

General Description:
The purpose of this contract is to evaluate the concerns the Tribe has identified with respect to the US Ecology closure, cleanup, timing and use of the Phase 1 cover. It is intended to enable the Department of Health (DOH), the Confederated Tribes and Bands of the Yakama Nation (Yakama Nation or Nation) and the Department of Ecology (Ecology) to achieve a common understanding of the State of Washington's work in this regard related to:

1) The closure, under U.S. Nuclear Regulatory Commission Agreement State standards, and
2) The US Ecology cleanup under the Model Toxics Control Act (MTCA).

The following tasks are anticipated in performing this work:

1. The contractor will review and obtain an understanding of the following:

   A. The relationship between the facility location and the Yakama Nation's history, treaty reserved rights, natural resource uses, and traditions.

   B. The specific modeling, engineering and other technical concerns that the Nation has identified with respect to the timing of the placement of the Phase 1 cover.

   C. The DOH –Ecology approved US Ecology closure plan for the site and the 2004 Final Environmental Impact Statement.

   D. The 2012 DOH radiological risk assessment including contaminant movement models, data used in forecasting models, exposure assumptions, and the outcomes produced.

   E. The MTCA work being conducted at the site.

   F. The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) cleanup imposed on the adjacent Hanford site including regulatory limits, points of compliance, schedules (time of compliance), risk levels and deed/access restrictions.

   G. The Conceptual Site Model (Vista, 2013); associated references and supporting documents, data, methods, etc. used to develop the CSM and resulting decisions and relevant supplemental information as provided

2. The contractor will then:

   A. Run the Yakama Nation risk model for comparison to the existing risk models. After evaluation of existing models, consult with the Yakama Nation, the DOH, and Ecology for concurrence of need for further evaluation.

B. Review variables in cap life estimates that might change exposure scenarios and the corresponding impact on Phase 1 cover timing. The contractor will review other pertinent modeling assumptions and explain how changes in those assumptions and uncertainties (such as cover design) could impact release of radiological materials. Contractor will review the method of calculating radiological inventory used in the models. Contractor will review the distribution of radiological risk as calculated for the pathways used in the models to date. After evaluation of the existing models, contractor will consult with Yakama Nation, the DOH, and Ecology for consideration of and concurrence for need for further evaluation of model parameters and assumptions.

C. Evaluate whether construction of the Phase 1 cover at US Ecology would impede additional MTCA investigatory or remedial action. Contractor will discuss and compare consequences of waiting to install Phase 1 cover until MTCA investigation is complete. The contractor will present the history of the use of radiological models for the US Ecology site.

D. Evaluate the engineering limitations, anticipated cover performance and public and worker safety issues associated with opening or disturbing phase 1 of the cover if necessary for MTCA actions.

E. Compare the site closure and cleanup requirements with closure and cleanup requirements imposed on the adjacent Hanford site, including regulatory limits, models, points of compliance, exposure pathways, schedules (time of compliance), risk levels and deed/access restrictions. Identify and discuss consequences of discrepancies.

Resources, Product, Work Location and Schedule:

A. The contractor will review and use existing investigations and models to obtain information and compile responses to the topics noted in the bullets under item #2 above. A partial list of references is attached in Appendix A.

B. State technical staff will make themselves available for questions/clarifications of the work to date.

C. The final product is expected to consist of a 20-40 page report. Present and explain the contractor's understandings to the DOH, Ecology, and the Yakama Nation. The contractor must generate a presentation explaining this work suitable for informing elected bodies.

Due Date: Final report and presentation are due by May 30, 2015.

D. The contractor will meet with the Yakama Nation and the state agencies to present a draft report and obtain feedback, and then meet to present the final report to the DOH, Ecology and the Yakama Nation by May 15, 2015. This date may change if needed to accommodate changes in scope.

E. Meetings will be held in the Central Washington area. Location, dates and times for the meetings to assist the contractor will be developed jointly. Two one-day meeting are anticipated at the start of the work and an additional two one-day meetings near the conclusion of the project.

Confidentiality:

The contractor shall recognize that some of the material provided by Yakama Nation will be culturally sensitive and therefore protected from disclosure under the Public Records Act. The Contractor shall agree in writing not to publicly disclose such information. Although state agencies will be able to review the information, they will not receive a hard copy for the files that may later be subject to public disclosure. Yakama Nation owns all rights to information provided in the Yakama Nation Risk Scenario and any other additional traditional information that may be provided to the contractor for the purpose of this review. If the DOH, Ecology, or any other state agency receives a request for disclosure of any such information under an applicable public records disclosure law, the agency shall notify the Yakama Nation in writing of the request (email notification is acceptable) and of the agency's conclusion as to whether disclosure is required in response to the request. Such notification shall be provided promptly so that the Yakama Nation will have a reasonable opportunity to seek to enjoin or otherwise object to disclosure of the subject information within the confines of any applicable deadlines.

Logistics:

The DOH will invite Ecology and the Yakama Nation to the contractor's discussions and presentations referred to in #2 above. Additionally, Ecology and the Yakama Nation will be invited to all contractor meetings. E-mail communications related to the contractor's discussions, presentations and meetings will be shared with the DOH, Ecology and the Yakama Nation.

Not included in the scope of this Work:
The contractor will not take new or additional samples or perform work at the US Ecology facility. The contractor will not develop new models but will interpret existing models.

Special Requirements:
All work performed in this contract is in response to RFQQ N20730 US Ecology Phase 1 Cover Study and its amendments. This RFQQ, the RFQQ amendments and the bidder's response are incorporated herein by reference.

Contract Total: $60,000

Exhibit A - Appendix A
Resources available to the contractor include but are not limited to the following:

A. The Conceptual Site Model (Vista, 2013); associated references and supporting documents, data, methods, etc. used to develop the CSM and resulting decisions and relevant supplemental information as provided.

B. The Final Report: Evaluation of Closure Time on All Pathways Doses (K-Spar, 2012)

C. The Final Report: Technical Evaluation Report (NRC, 2010)

D. The Final Remedial Investigation Report (Vista, 2010)

E. The Final Environmental Impact Statement (FEIS) (WDOH, 2004)

F. The FEIS Radiological Risk Assessment (WDOH, 2003)

G. The Final Report: Groundwater Concentrations/Doses (WDOH, 2003)

H. The Final Report: FOLAT (leaching model) (WDOH, 2003)

I. The 2012 Addendum to the Final Environmental Assessment Low-Level Radioactive Waste Disposal Site Richland Wa –June 2012

J. 2012 Addendum to the Final Environmental Impact Statement, Commercial Low-Level Radioactive Waste Disposal Site, Richland, Washington, June 2012.

ATTACHMENT 1

GENERAL TERMS AND CONDITIONS

I. GENERAL TERMS (DEFINITIONS)

As used throughout this contract, the following terms shall have the meanings set forth below:

a) "Allowable Cost" shall mean an expenditure which meets the test of the appropriate OMB Circular (see "III. Federal Compliance"). The most significant factors affecting allowability of cost are; 1) they must be necessary and reasonable, 2) they must be allocable, 3) they must be authorized or not prohibited under state or local laws and regulations, and 4) they must be adequately documented.

b) "Client" shall mean an agency, firm, organization, individual or other entity applying for or receiving services under this contract.

c) "Cognizant State Agency" shall mean the state agency from whom the sub-recipient receives federal financial assistance. If funds are received from more than one state agency, the cognizant state agency shall be the agency who contributes the largest portion of federal financial assistance to the sub-recipient, unless a cognizant state agency has been designated by OFM.

d) "Confidential Information " shall mean information that is exempt from disclosure under chapter 42.56 RCW, and other state or federal statutes and regulations

e) "Contractor" shall mean that agency, firm, provider, organization, individual or other entity performing services under this contract. It shall include any subcontractor retained by the prime contractor as permitted under the terms of this agreement.

f) "Contracting Officer" shall mean that individual(s) of the Office of Contract Services of DOH and his/her delegates within that office authorized to execute this agreement on behalf of the Department.

g) "Department" shall mean the Department of Health (DOH) of the State of Washington, any division, section, office, unit or other entity of the department, or any of the officers or other officials lawfully representing the department.

h) "Equipment" shall mean an article of non-expendable, tangible property having a useful life of more than one year and an acquisition cost of $5,000 or more.

i) "Personal Information" means information identifiable to any person, including, but not limited to, information that relates to a person's name, health, finances, education, business, use or receipt of governmental services or other activities, addresses, telephone numbers, social security numbers, driver license numbers, other identifying numbers, and any financial identifiers. Personal information includes "protected health information" as set forth in 45 CFR § 164.50 as currently drafted and subsequently amended or revised and any other information that may be exempt from disclosure to the public or other unauthorized persons under either chapter 42.56 RCW or other state and federal statutes.

j) "Reimbursement" shall mean that the Department of Health will repay the Contractor for allowable costs incurred under the terms of this contract.

k) "Sensitive Data" means data that is held confidentially, and if compromised may cause harm to individual citizens or create a liability for the State

l) "Subcontractor" shall mean a person, partnership, or company, not in the employ of or owned by the contractor, who is performing all or part of those services under a separate contract with or on behalf of the Contractor. The terms "subcontractor" and "subcontractors" mean subcontractor(s) in any tier. See OMB Circular A-133 for additional detail.

m) A "Subrecipient" is a contractor operating a federal or state assistance program receiving federal funds and having the authority to determine both the services rendered and disposition of program. See OMB Circular A-133 for additional detail.

n) "Successor" is defined as any entity which, through amalgamation, consolidation, or other legal succession becomes invested with rights and assumes burdens of the first contractor/ vendor.

o) A "Vendor" is an entity that agrees to provide the amount and kind of services requested by DOH; provides services under the contract only to those beneficiaries individually determined to be eligible by DOH; and, provides services on a fee-for-service or per-unit basis with contractual penalties if the entity fails to meet program performance standards. See OMB Circular A-133 for additional detail.

II. GENERAL CONDITIONS

1. **ACCESS TO DATA** – In compliance with chapter 39.26 RCW, the Contractor shall provide access to data generated under this contract to DOH, the Joint Legislative Audit and Review Committee, and the State Auditor at no additional cost. This includes access to all

information that supports the findings, conclusions, and recommendations of the Contractor's reports, including computer models and methodology for those models. The Contractor agrees to make personal information covered under this agreement available to DOH for inspection or to amend the personal information, as directed by DOH. Contractor shall, as directed by DOH, incorporate any amendments to the personal information into all copies of such personal information maintained by the Contractor or its subcontractors.

2. **ADVANCE PAYMENTS PROHIBITED** – No payment in advance or in anticipation of services or supplies to be provided under this agreement shall be made by DOH.

3. **AMENDMENTS** – This contract may be amended by mutual written agreement of the parties. Such amendments shall not be binding unless they are in writing and signed by personnel authorized to bind each of the parties.

4. **AMERICANS WITH DISABILITIES ACT (ADA) OF 1990, PUBLIC LAW 101-336, also referred to as the "ADA" 28 CFR Part 35** – The Contractor must comply with the ADA, which provides comprehensive civil rights protection to individuals with disabilities in the areas of employment, public accommodations, state and local government services, and telecommunications.

5. **ASSIGNABILITY** – Neither this contract nor any claim arising under this contract shall be transferred or assigned by the contractor without prior written consent of DOH.

6. **ATTORNEYS' FEES** – In the event of litigation or other action brought to enforce contract terms, each party agrees to bear its own attorney's fees and costs.

7. **CHANGE IN STATUS** - In the event of substantive change in the legal status, organizational structure, or fiscal reporting responsibility of the Contractor, Contractor agrees to notify DOH of the change. Contractor shall provide notice as soon as practicable, but no later than thirty days after such a change takes effect.

8. **CONFIDENTIALITY/SAFEGUARDING OF INFORMATION** – The use or disclosure by any party, either verbally or in writing, of any Confidential Information shall be subject to Chapter 42.56 RCW and Chapter 70.02 RCW, as well as other applicable federal and state laws and administrative rules governing confidentiality. Specifically, the Contractor agrees to limit access to Confidential Information to the minimum amount of information necessary, to the fewest number of people, for the least amount of time required to do the work. The

obligations set forth in this clause shall survive completion, cancellation, expiration, or termination of this Agreement.

A. Notification of Confidentiality Breach

Upon a breach or suspected breach of confidentiality, the Contractor shall immediately notify the DOH Privacy Officer at dohprivacyofficer@doh.wa.gov. For the purposes of this Agreement, "immediately" shall mean within two calendar days.

The contractor will take steps necessary to mitigate any known harmful effects of such unauthorized access including, but not limited to sanctioning employees, notifying subjects, and taking steps necessary to stop further unauthorized access. The Contractor agrees to indemnify and hold harmless Agency for any damages related to unauthorized use or disclosure by the Contractor, its officers, directors, employees, Subcontractors or agents.

Any breach of this clause may result in termination of the contract and the demand for return of all Information.

B. Subsequent Disclosure

The Contractor will not release, divulge, publish, transfer, sell, disclose, or otherwise make the Confidential Information known to any other entity or person without the express prior written consent of the Secretary of Health, or as required by law.

If responding to public record disclosure requests under RCW 42.56, the Contractor agrees to notify and discuss with the DOH Privacy Officer requests for all information that are part of this Agreement, prior to disclosing the information. The Contrctor further agrees to provide DOH a minimum of two calendar weeks to initiate legal action to secure a protective order under RCW 42.56.540.

9. **CONFLICT OF INTEREST** – Notwithstanding any determination by the Executive Ethics Board or other tribunal, DOH may, in it's sole discretion, by written notice to the Contractor, terminate this contract if it is found, after due notice and examination by DOH or it's agent that there is a violation of the ethics in public service act, chapter 42.52 RCW, or any similar statute involving the contractor in the procurement of, or performance of this contract.

   In the event this contract is terminated as provided above, DOH shall be entitled to pursue the same remedies against the Contractor as it could pursue in the event of a breach of the contract by the Contractor. The rights and remedies of DOH provided for in this section shall not be exclusive are in addition to any other rights and remedies provided by law. The existence of facts upon which DOH makes a determination under this section shall be an issue and may be reviewed as provided in the "disputes" section of this contract.

10. **COVENANT AGAINST CONTINGENT FEES** – The Contractor warrants that no person or selling agent has been employed or retained to solicit or secure this contract upon an agreement or understanding for a commission, percentage, brokerage or contingent fee, excepting bona fide employees or bona fide established agents maintained by the

Contractor for the purpose of securing business. DOH shall have the right, in the event of breach of this clause by the Contractor, to annul this contract without liability, or in its discretion, to deduct from the contract price or consideration or recover by other means the full amount of such commission, percentage, brokerage or contingent fee.

11. **DEBARMENT** – The Contractor, by signature to this contract, certifies that the Contractor is not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded in any Federal department or agency from participating in transactions. The Contractor agrees to include the above requirement in all subcontracts into which it enters to complete this contract.

12. **DISPUTES** – The parties shall use their best, good faith efforts to cooperatively resolve disputes and problems that arise in connection with this contract. Both parties will continue without delay to carry out their respective responsibilities under this contract while attempting to resolve the dispute under this section. When a genuine dispute arises between DOH and the Contractor regarding the terms of this agreement or the responsibilities imposed herein which cannot be resolved at the project management level, either party may submit a request for a dispute resolution to the DOH Contracts Unit which shall oversee the following dispute resolution process: DOH shall appoint a representative to a dispute panel; the Contractor shall appoint a representative to the dispute panel; DOH's and Contractor's representatives shall mutually agree on a third person to chair the dispute panel. The dispute panel shall thereafter decide the dispute with the majority prevailing.

    A party's request for a dispute resolution must:

    - be in writing,
    - state the disputed issues,
    - state the relative positions of the parties,
    - state the Contractor's name, address, and his/her department contract number,
    - be mailed to ATTN: Contracts and Procurement Manager, DOH Contracts Unit, PO Box 47905, Olympia, WA 98504-7905 within thirty (30) calendar days after the party could reasonably be expected to have knowledge of the issue which he/she now disputes.

    This dispute resolution process constitutes the sole administrative remedy available under this contract. The parties agree that this resolution process shall precede any action in a judicial and quasi-judicial tribunal.

13. **EFFECTIVE DATE** – Unless otherwise specified under period of performance, the effective date of this agreement and subsequent amendments, if any, is the date of execution. The date of execution is the last date of signature of the parties to the agreement. No billable activity may take place prior to the date of execution. Contractor assumes all liability for any

expenses incurred prior to the date of execution or in the event the agreement/amendment is not executed.

14. **GOVERNING LAW** – This contract shall be governed by the laws of the state of Washington and applicable federal laws and regulations. The venue of any legal action or suit concerning this agreement shall be the Thurston County Superior Court and all actions or suits thereon shall be brought therein.

15. **INDEMNIFICATION** – To the fullest extent permitted by law, Contractor shall indemnify, defend and hold harmless the state of Washington, DOH, agencies of the State and all officials, agents and employees of the State, from and against all claims arising out of or resulting from the performance of the contract. "Claim" as used in this agreement means any financial loss, claim, suit, action, damage, or expense, including but not limited to attorney's fees, attributable for bodily injury, sickness, disease or death, or injury to or destruction of tangible property including loss of use resulting therefrom. Contractor's obligation to indemnify, defend, and hold harmless includes any claim by Contractors' agents, employees, representatives, or any subcontractor or its employees.

    Contractor expressly agrees to indemnify, defend, and hold harmless the State for any claim arising out of or incident to Contractor's or any subcontractor's performance or failure to perform the contract. Contractor's obligation to indemnify, defend, and hold harmless the State shall not be eliminated or reduced by any actual or alleged concurrent negligence of State or its agents, agencies, employees and officials.

    Contractor waives its immunity under Title 51 RCW to the extent it is required to indemnify, defend and hold harmless State and its agencies, officials, agents or employees.

16. **INDEPENDENT CAPACITY OF THE CONTRACTOR** – The parties intend that an independent contractor relationship will be created BY this contract. The Contractor and his or her employees or agents performing under the contract are not employees or agents of DOH. The contractor shall not hold himself/herself out as nor claim to be an officer or employee of DOH or of the state of Washington by reason hereof, nor will the Contractor make any claim of right, privilege or benefit which would accrue to such employee under law. Conduct and control of the work will be solely with the Contractor.

17. **INDUSTRIAL INSURANCE COVERAGE** – The Contractor shall comply with the provisions of Title 51 RCW, Industrial Insurance. Prior to performing work under this contract, the Contractor shall provide or purchase industrial insurance coverage for the Contractor's employees, as may be required of an "employer" as defined in Title 51 RCW, and shall maintain full compliance with Title 51RCW during the course of this contract. If the Contractor fails to provide industrial insurance coverage or fails to pay premiums or penalties on behalf of its employees as may be required by law, DOH may collect from the Contractor the full amount payable to the Industrial Insurance accident fund. DOH may

deduct the amount owed by the Contractor to the accident fund from the amount payable to the Contractor by DOH under this contract, and transmit the deducted amount to the Department of Labor and Industries, Division of Insurance Services. This provision does not waive any of the Department of Labor and Industries rights to collect from the Contractor.

Industrial insurance coverage through the Department of Labor & Industries is optional for sole proprietors, partners, corporate officers and others, per RCW 51.12.020.

18. **INSURANCE** – The Contractor shall provide insurance coverage as set out in this section. The intent of the required insurance is to protect the State should there be any claims, suits, actions, costs, damages or expenses arising from any negligent or intentional act or omission of the Contractor or subcontractor, or agents of either, while performing under the terms of this contract.

The Contractor shall provide insurance coverage which shall be maintained in full force and effect during the term of this Contract, as follows:

A. Commercial General Liability Insurance Policy - Provide a commercial general liability insurance policy, including contractual liability, in adequate quantity to protect against legal liability arising out of contract activity but no less than $1,000,000 per occurrence. Additionally, the Contractor is responsible for ensuring that any subcontractors provide adequate insurance coverage for the activities arising out of subcontracts.

B. Automobile Liability. In the event that services delivered pursuant to this contract involve the use of vehicles, either owned or unowned by the Contractor, automobile liability insurance shall be required. The minimum limit for automobile liability is:

   1. $1,000,000 per occurrence, using a combined single limit for bodily injury and property damage

C. The insurance required shall be issued by an insurance company/ies authorized to do business within the state of Washington, and shall name the state of Washington, its agents and employees as additional insureds under the insurance policy/ies. All policies shall be primary to any other valid and collectable insurance. Contractor shall instruct the insurers to give DOH 30 days advance notice of any insurance cancellation.

Upon request, Contractor shall submit to DOH, a certificate of insurance which outlines the coverage and limits defined in the *Insurance* section. If a certificate of insurance is requested, Contractor shall submit renewal certificates as appropriate during the term of the contract.

19. **LICENSING, ACCREDITATION AND REGISTRATION** – The Contractor shall comply with all applicable local, state, and federal licensing, accreditation and registration requirements/standards, necessary for the performance of this contract.

20. **LIMITATION OF AUTHORITY** – Only the Contracting Officer or his/her delegate by writing (delegation to be made prior to action) shall have the express, implied, or apparent authority to alter, amend, modify, or waive any clause or condition of this contract on behalf of DOH. No alteration, modification, or waiver of any clause or condition of this contract is effective or binding unless made in writing and signed by the Contracting Officer.

21. **NONDISCRIMINATION** – During the performance of this contract, the Contractor shall comply with all federal and state nondiscrimination laws, regulations and policies.

22. **NONDISCRIMINATION LAWS NONCOMPLIANCE** – In the event of the Contractor's noncompliance or refusal to comply with any nondiscrimination law, regulation, or policy, this contract may be rescinded, canceled or terminated in whole or in part, and the Contractor may be declared ineligible for further contracts with DOH. The Contractor shall, however, be given a reasonable time in which to cure this noncompliance. Any dispute may be resolved in accordance with the disputes procedure set forth herein.

23. **OVERPAYMENTS AND ASSERTION OF LIEN** – In the event that DOH establishes overpayments or erroneous payments made to the Contractor under this contract, DOH may secure repayment, plus interest, if any, through the filing of a lien against the Contractor's real property, or by requiring the posting of a bond, assignment or deposit, or some other form of security acceptable to DOH, or by doing both.

24. **PRIVACY** – Personal information including, but not limited to "protected health information" collected, used or acquired in connection with this contract shall be used solely for the purposes of this contract. Contractor and its subcontractors agree not to release, divulge, publish, transfer, sell or otherwise make known to unauthorized persons personal information without the express written consent of DOH or as provided by law. Contractor agrees to implement physical, electronic and managerial safeguards to prevent unauthorized access to personal information.

    The DOH reserves the right to monitor, audit, or investigate the use of personal information collected, used or acquired by the contractor through this contract. The monitoring, auditing, or investigating may include but is not limited to "salting" by DOH. Contractor shall certify the return or destruction of all personal information upon expiration of this contract. Salting is the act of placing a record containing unique but false information in a database that can be used later to identify inappropriate disclosure of data contained in the database.

    Any breach of this provision may result in termination of the contract and the demand for return of all personal information. The contractor agrees to indemnify and hold harmless DOH for any damages related to the contractor's unauthorized use of personal information.

For the purposes of this provision, personal information includes but is not limited to information identifiable to an individual that relates to a natural person's health, finances, education, business, use or receipt of governmental services, or other activities, names, addresses, telephone numbers, social security numbers, driver license numbers, financial profiles, credit card numbers, financial identifiers and other identifying numbers.

25. **PUBLICITY** – The Contractor agrees to submit to DOH all advertising and publicity matters relating to this Contract wherein DOH's name is mentioned or language used from which the connection of DOH's name may, in DOH's judgment, be inferred or implied. The Contractor agrees not to publish or use such advertising and publicity matters without the prior written consent of DOH.

26. **RECORDS, DOCUMENTS, AND REPORTS** –The Contractor shall maintain books, records, documents, data and other evidence relating to this contract and performance of the services described herein, including but not limited to accounting procedures and practices which sufficiently and properly reflect all direct and indirect costs of any nature expended in the performance of this contract. Contractor shall retain such records for a period of six (6) years following the date of final payment. At no additional cost, these records, including materials generated under the contract, shall be subject at all reasonable times to inspection, review or audit by DOH, personnel duly authorized by DOH, the office of the state auditor, and federal and state officials so authorized by law, regulation or agreement.

    If the contract reimburses the Contractor for costs incurred in performance, the Contractor shall in addition maintain books, records, documents and other evidence of procedures and practices which sufficiently and properly reflect all direct and indirect costs of any nature expended in the performance of this agreement.

    If any litigation, claim or audit is started before the expiration of the six (6) year period, the records shall be retained until all litigation, claims, or audit findings involving the records have been resolved.

27. **REGISTRATION WITH DEPARTMENT OF REVENUE** – The Contractor shall complete registration with the Washington State Department of Revenue, if applicable, and be responsible for payment of all taxes due on payments made under this contract.

28. **RIGHT OF INSPECTION** – The Contractor shall provide right of access to its facilities to DOH, or any of its officers, or to any other authorized agent or official of the state of Washington or the federal government, at all reasonable times, in order to monitor and evaluate performance, compliance, and/or quality assurance under this contract. The Contractor shall make available information necessary for DOH to comply with the client's right to access, amend, and receive an accounting of disclosures of their Personal

Information according to the Health Insurance Portability and Accountability Act of 1996 (HIPAA) or any regulations enacted or revised pursuant to the HIPAA provisions and applicable provisions of Washington State law. The Contractor's internal policies and procedures, books, and records relating to the safeguarding, use, and disclosure of personal information obtained or used as a result of this contract shall be made available to DOH and the U.S. Secretary of the Department of Health & Human Services, upon request.

29. **RIGHTS IN DATA/COPYRIGHT** – Unless otherwise provided, all materials produced exclusively under this contract shall be considered "works for hire" as defined by the U.S. Copyright Act and shall be owned by DOH. DOH shall be considered the author of such Materials. In the event the Materials are not considered "works for hire" under the U.S. Copyright laws, Contractor hereby irrevocably assigns all right, title, and interest in Materials, including all intellectual property rights, to DOH effective from the moment of creation of such materials.

    Materials means all items in any format and includes, but is not limited to, data, reports, documents, pamphlets, advertisements, books, magazines, surveys, studies, computer programs, films, tapes, and/or sound reproductions that derive exclusively from the Contractor's work under this contract. Ownership includes the right to copyright, patent, register and the ability to transfer these rights.

    For materials that are delivered under the contract, but that incorporate pre-existing materials not produced under the contract, Contractor hereby grants to DOH a nonexclusive, royalty-free, irrevocable license (with rights to sublicense others) in such materials to translate, reproduce, distribute, prepare derivative works, publicly perform, and publicly display. The Contractor warrants and represents that Contractor has all rights and permissions, including intellectual property rights, moral rights and rights of publicity, necessary to grant such a license to DOH.

    The Contractor shall exert all reasonable effort to advise DOH, at the time of delivery of materials furnished under this contract, of all known or potential invasions of privacy contained therein and of any portion of such document which was not produced in the performance of this contract. DOH shall receive prompt written notice of each notice or claim of copyright infringement received by the Contractor with respect to any data delivered under this contract. DOH shall have the right to modify or remove any restrictive markings placed upon the data by the Contractor.

30. **SECURITY OF INFORMATION** – Unless otherwise specifically authorized by the DOH IT Security Officer, Contractor receiving confidential information under this contract assures that:

- It is compliant with the applicable provisions of the Washington State Office of the Chief Information Officer's policy, Securing Information Technology Assets, available at http://ofm.wa.gov/ocio.

- It will provide DOH copies of its IT security policies, practices and procedures upon the request of the DOH IT Security Officer.
- DOH may at any time conduct an audit of the Contractor's security practices and/or infrastructure to assure compliance with the security requirements of this Agreement.
- It has implemented physical, electronic and administrative safeguards that are consistent with ISB IT security standards and guidelines to prevent unauthorized access, use, modification or disclosure of DOH Confidential Information in any form. This includes, but is not limited to, restricting access to specifically authorized individuals and services through the use of:
- Documented access authorization and change control procedures;
- Card key systems that restrict, monitor and log access;
- Locked racks for the storage of servers that contain Confidential Information or AES encryption (128bit or stronger) to protect confidential data at rest;
- Documented patch management practices that assure all network systems are running critical security updates within 6 days of release when the exploit is in the wild, and within 30 days of release for all others;
- Documented anti-virus strategies that assure all systems are running the most current anti-virus signatures within 1 day of release;
- Complex passwords that are systematically enforced and expire at least every 180 days;
- Strong (Two Factor) authentication mechanisms that assure the identity of individuals who access Confidential Information;
- Account lock-out after 5 failed authentication attempts for a minimum of 20 minutes, or for Confidential Information, until administrator reset;
- AES encrypted (128bit or stronger) sessions for all data transmissions.
- Firewall rules and network address translation that isolate database servers from web servers and public networks;
- Regular review of firewall rules and configurations to assure compliance with authorization and change control procedures;
- Log management and intrusion detection/prevention systems;
- A documented and tested incident response plan

Any breach of this clause may result in termination of the contract and the demand for return of all personal information.

31. **SEVERABILITY** – If any provision of this agreement or any provision of any document incorporated by reference shall be held invalid, such invalidity shall not affect the other provisions of this agreement which can be given effect without the invalid provision, and to this end the provisions of this agreement are declared to be severable.

32. **SITE SECURITY** – While on DOH premises, Contractor, its agents, employees, or subcontractors shall conform in all respects with physical, fire or other security policies or regulations. Failure to comply with these regulations may be grounds for revoking or suspending security access to these facilities. DOH reserves the right and authority to immediately revoke security access to Contractor staff for any real or threatened breach of this provision. Upon reassignment or termination of any Contractor staff, Contractor agrees to promptly notify DOH.

33. **SUBCONTRACTING** – Neither the Contractor, nor any subcontractors, shall enter into subcontracts for any of the work contemplated under this agreement without prior written approval of DOH. In no event shall the existence of the subcontract operate to release or reduce the liability of the contractor to DOH for any breach in the performance of the contractor's duties. This clause does not apply to Hospitals and/or Medical Clinics that must contract with specialty physicians (e.g. anesthesiologists, radiologists, physicians groups, independent practitioners, etc) nor does it include contracts of employment between the contractor and personnel assigned to work under this contract.

    Additionally, the Contractor is responsible for ensuring that all terms, conditions, assurances and certifications set forth in this agreement are carried forward to any subcontracts. Contractor and its subcontractors agree not to release, divulge, publish, transfer, sell or otherwise make known to unauthorized persons personal information without the express written consent of DOH or as provided by law.

    If, at any time during the progress of the work, DOH determines in its sole judgment that any subcontractor is incompetent or undesirable, DOH shall notify the Contractor, and the Contractor shall take immediate steps to terminate the subcontractor's involvement in the work.

    The rejection or approval by DOH of any subcontractor or the termination of a subcontractor shall not relieve the Contractor of any of its responsibilities under the contract, nor be the basis for additional charges to DOH.

    DOH has no contractual obligations to any subcontractor or vendor under contract to the Contractor. The Contractor is fully responsible for all contractual obligations, financial or otherwise, to their subcontractors.

34. **SURVIVABILITY** – The terms and conditions contained in this contract which by their sense and context, are intended to survive the completion, cancellation, termination, or expiration of the contract shall survive, including but not limited to clauses I, 8, 13, 14, 23, 24 and 29.

35. **SUSPENSION OF PERFORMANCE AND RESUMPTION OF PERFORMANCE** – In the event contract funding from state, federal, or other sources is withdrawn, reduced, or limited in any way after the effective date of this contract and prior to normal completion, DOH may give notice to Contractor to suspend performance as an alternative to termination. DOH may elect to give written notice to Contractor to suspend performance when DOH determines that there is a reasonable likelihood that the funding insufficiency may be resolved in a timeframe that would allow performance to be resumed prior to the end date of this contract. Notice may include notice by facsimile or email to Contractor's representative. Contractor shall suspend performance on the date stated in the written notice to suspend. During the period of suspension of performance each party may inform the other of any conditions that may reasonably affect the potential for resumption of performance.

    When DOH determines that the funding insufficiency is resolved, DOH may give Contractor written notice to resume performance and a proposed date to resume performance. Upon receipt of written notice to resume performance, Contractor will give written notice to DOH as to whether it can resume performance, and, if so, the date upon which it agrees to resume performance. If Contractor gives notice to DOH that it cannot resume performance, the parties agree that the Contract will be terminated retroactive to the original date of termination. If the date Contractor gives notice it can resume performance is not acceptable to DOH, the parties agree to discuss an alternative acceptable date. If an alternative date is not acceptable to DOH, the parties agree that the Contract will be terminated retroactive to the original date of termination.

36. **TAXES** – All payments accrued on account of payroll taxes, unemployment contributions, any other taxes, insurance or other expenses for the Contractor or its staff shall be the sole responsibility of the Contractor.

37. **TERMINATION FOR CONVENIENCE** – Except as otherwise provided in this contract, the Contracting Officer may, by TEN (10) calendar days written notice, beginning on the second day after the mailing, terminate this contract in whole or in part when it is in the best interests of DOH.

    If this contract is so terminated, DOH shall be liable only for payment in accordance with the terms of this contract for services rendered prior to the effective date of termination.

38. **TERMINATION FOR DEFAULT** – In the event DOH determines the contractor has failed to comply with the conditions of this contract in a timely manner, DOH has the right to suspend or terminate this contract. Further, DOH may terminate this contract for default, in whole or in part, if DOH has a reasonable basis to believe that the contractor has:

    A. Failed to meet or maintain any requirement for contracting with DOH;

    B. Failed to ensure the health or safety of any client for whom services are being provided under this contract;

C. Failed to perform under, or otherwise breached, any term or condition of this contract; and/or

D. Violated any applicable law or regulation.

Before suspending or terminating the contract, DOH shall notify the contractor in writing of the need to take corrective action. If corrective action is not taken within fourteen (14) days, the contract may be terminated or suspended. In the event of termination or suspension, the contractor shall be liable for damages as authorized by law including, but not limited to, any cost difference between the original contract and the replacement or cover contract and all administrative costs directly related to the replacement contract, e.g., cost of the competitive bidding, mailing, advertising and staff time. DOH reserves the right to suspend all or part of the contract, withhold further payments, or prohibit the contractor from incurring additional obligations of funds during investigation of the alleged compliance breach and pending corrective action by the contractor or a decision by DOH to terminate the contract. A termination shall be deemed to be a "termination for convenience" if it is determined that the contractor: (1) was not in default; or (2) failure to perform was outside of his or her control, fault or negligence. The rights and remedies of DOH provided in this contract are not exclusive and are in addition to any other rights and remedies provided by law.

39. TERMINATION PROCEDURE – Upon termination of this agreement DOH may require the Contractor to deliver to DOH any property specifically produced or acquired for the performance of such part of this agreement as has been terminated. The provisions of the *Treatment of Assets* clause shall apply in such property transfer.

DOH shall pay to the Contractor the agreed upon price, if separately stated, for completed work and services accepted by DOH. In addition DOH shall pay the amount agreed upon by the Contractor and the Contracting Officer for (a) completed work and services for which no separate price is stated, (b) partially completed work and services, (c) other property or services which are accepted by DOH, and (d) the protection and preservation of the property. If the termination is for default, the Contracting Officer shall determine the extent of the liability of DOH. Failure to agree with such determination shall be a dispute within the meaning of the *Disputes* clause of this contract.

DOH may withhold from any amounts due the Contractor for such completed work or services such sum as the Contracting Officer determines to be necessary to protect DOH against potential loss or liability.

The rights and remedies of DOH provided in this section shall not be exclusive and are in addition to any other rights and remedies provided by law or under this agreement.

After receipt of a notice of termination, and except as otherwise directed by the Contracting Officer, the Contractor shall:

- Stop work under the agreement on the date and to the extent specified in the notice;
- Place no further orders or subcontracts for materials, services, facilities except as necessary to complete such portion of the work not terminated;

CERTIFICATIONS AND ASSURANCES

I/we make the following certifications and assurances as a required element of the bid to which it is attached, understanding that the truthfulness of the facts affirmed here and the continuing compliance with these requirements are conditions precedent to the award or continuation of the related contract(s):

1. I/we declare that all answers and statements made in the bid are true and correct.
2. The prices and/or cost data have been determined independently, without consultation, communication, or agreement with others for the purpose of restricting competition. However, I/we may freely join with other persons or organizations for the purpose of presenting a single bid.
3. The attached bid is a firm offer for a period of 60 days following receipt, and it may be accepted by the DOH without further negotiation (except where obviously required by lack of certainty in key terms) at any time within the 60-day period.
4. In preparing this bid, I/we have not been assisted by any current or former employee of the state of Washington whose duties relate (or did relate) to this bid or prospective contract, and who was assisting in other than his or her official, public capacity. (Any exceptions to these assurances are described in full detail on a separate page and attached to this document.)
5. I/we understand that the DOH will not reimburse me/us for any costs incurred in the preparation of this bid. All bids become the property of the DOH, and I/we claim no proprietary right to the ideas, writings, items, or samples, unless so stated in this proposal.
6. Unless otherwise required by law, the prices and/or cost data that have been submitted have not been knowingly disclosed by the Bidder and will not knowingly be disclosed by him/her prior to opening, directly or indirectly to any other Bidder or to any competitor.
7. I/we agree that submission of the attached proposal constitutes acceptance of the solicitation contents and the attached sample contract and general terms and conditions. If there are any exceptions to these terms, I/we have described those exceptions in detail on a page attached to this document.
8. No attempt has been made or will be made by the Bidder to induce any other person or firm to submit or not to submit a proposal for the purpose of restricting competition.
9. Information that has been determined to be proprietary or confidential has been clearly marked and included in this bid as a separate document.
10. If any staff member(s) who will perform work on this contract has retired from the State of Washington under the provisions of the 2008 Early Retirement Factors legislation, his/her name(s) is noted on a separately attached page.
11. I/we declare that we are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded in any Federal department or agency from participating in transactions.
12. I/we declare that we have clearly identified any present or past financial (or other) affiliation with any of the parties to the current litigation between Heart of America NW, the Yakama Nation and the state of Washington including work on the resources identified in Exhibit A – Appendix A.

Kelly Black

Signature of Bidder

President | 2/6/15

Title | Date

Appendix C. Neptune Initial Report on U.S. Ecology August 6, 2015

Review of US Ecology Modeling and Assessment, and Implications for the Phase I Cover

Ralph Perona
Callie Ridolfi
John Tauxe

NEPTUNE AND COMPANY
RIDOLFI Environmental

RFQQ N20730 Statement of Work

A. Run the Yakama Nation risk model for comparison to results of existing models.
B. Review variables in cap life estimates that might impact scenarios and Phase I cover timing. Review modeling assumptions and inventory estimates.
C. Assess impact of Phase I cover on MTCA work and consequences of delaying installation.
D. Evaluate engineering and safety issues in opening the cover.
E. Compare US Ecology and Hanford closure and cleanup requirements.

US Ecology Hanford Site

Began accepting waste in 1965. Chemical waste trench was closed 1970. Mixed low-level waste was accepted in other trenches.

Inventory: Solid materials, solidified liquids, stabilized liquids (liquid-containing vials suspended in absorbent media), contaminated equipment, cleaning wastes, tools, protective clothing, gloves, laboratory wastes, and naturally occurring or accelerator produced radioactive material (NARM), including radium.

Structures: 20 trenches, 4 caissons, 3 underground tanks

Trenches and GW Well Locations

Image from Vista Engineering presentation; Carly Arendt

Presentation Outline

1. Summary of key issues discovered during review (7)
2. Results related to Tasks A and B (23 slides)
   – Application of Yakama scenario; summary of FEIS conceptual model, pathways, and dose assessment results; comparison of FEIS and Yakama scenario exposure parameters and doses
   – Chemical risk assessment
   – Focused review of radiological groundwater transport model
3. Results related to Tasks C, D, and E (8 slides)
   – Impact of Phase I cover on MTCA work; engineering and safety issues in opening cover; US Ecology *vs.* Hanford requirements.
4. Recommendations (1) and Supplemental Slides (6)
   – Proposed 10 CFR Part 61 changes; additional Yakama Nation questions

Key Results (1)

Limitations of Screening Methodology

- Each set of pathway calculations (groundwater, drill cuttings, and radon) was done independently using protective models and assumptions, rather than as an integrated analysis.
- No realistic modeling of system performance was done, and therefore the degree of “conservative” bias is largely subjective.
- Such results cannot be used for benefit-cost types of decisions, such as whether the benefit (potentially lower future doses) of putting on the Phase I cover now outweighs the increased costs of sampling or remedial actions with it in place.
- If screening results show no potential for adverse effects, you are done. When such potential is shown, as is the case here, more realistic models and assumptions should be developed.

Key Results (2)

Timing of Phase I Cover. There is likely to be little practical value in reducing future peak doses by installing the Phase I cover in order to interrupt near-term groundwater pathway doses.

1. Final EIS (WDOH 2004) Table 5.1.2 indicates groundwater pathways dose before 250 yr is attributable primarily to plutonium isotopes. The modeled Pu-239 groundwater concentrations at year 2015 were approximately 0.1 pCi/L, but actual average Pu-239 concentrations in 2013 were reportedly between 0 and 0.0025 pCi/L in wells at the disposal facility.
2. The degree of protective bias in the mobile fractions of uranium and plutonium isotopes, transport model equations, and input parameter values for leaching and transport is large and poorly understood.
3. There is a very low probability that all institutional and societal knowledge of Hanford will be lost and a drinking water well will be constructed on the Central Plateau in the next few centuries. Near-term groundwater pathway doses are therefore highly unlikely.

Key Results (3)

Endpoints. The FEIS radiological risk assessment compared adult receptor doses to dose-based performance metrics.

1. Parameter values and calculations were developed for children, but results were not provided or applied to conclusions and recommendations.
2. Cancer risk results were not provided, frustrating risk communication. Cancer risk is the ultimate concern for radionuclide exposure, for which effective dose is an imperfect proxy, although a regulatory target.

Key Results (4)

Conceptual Model. Dose results in the Final EIS may be underestimated because the modeling of nonvolatile radionuclide transport from disposed wastes did not assess all relevant pathways. Other relevant pathways include

1. upward diffusion in pore water,
2. gully erosion from the sides of the embankment,
3. deposition of Pb-210 in the cover by radon decay along the diffusion gradient, or
4. plant root uptake and animal burrowing into subsurface cover material integrated with all of the above.

Key Results (5)

<u>Model Boundaries</u>. There are several potentially important assumptions invoked in the Final EIS transport and dose calculations that are not explained and supported:

1. "Infiltrating water is the primary mechanism of radionuclide transport." (Rood 2012, p. 10)
2. No basis/rationale is provided for the Phase 1 and 2 screenings that limit the radionuclides evaluated in the leaching and groundwater transport models.
3. The cover is assumed to naturalize at 500 yr after closure.
4. Radon inventory present in sealed sources and will fail at 500 yr after closure.
5. Aquifer porosity is assumed to be extremely small (0.1), decreasing radionuclide travel time.

Key Results (6)

Inventory and Waste Concentrations. Detailed documentation of the waste inventory is not provided with the Final EIS. Section 6.1 of the 2012 FEIS Addendum states: "The estimated uranium 235 and 238 activities are now believed to be accurately reported. Uncertainties are not included for any source term input as it would be difficult to quantify and validate any isotope uncertainty generated."

1. How is the uranium inventory 'believed to be accurate' if there's inadequate information to assess uncertainty in the estimates?
2. The importance of variability in inventory among trenches was ignored in the drill cuttings and radon dose calculations by using only an average across the entire disposal site.
3. Inventory documentation is primarily in the form of tables and accompanying notes. The argument that inventory uncertainty is addressed by use of protective modeling assumptions is subjective and difficult to verify.

Key Results (7)

RI Report and CSM.

1. The reliance solely on environmental data (soil, soil vapor, and groundwater) to drive MTCA decisions ignores the possibility that significant chemical sources remain in the trenches to be released in the future.
2. The limited vertical extent of the vapor monitoring wells (~100 ft, with an aquifer depth ~300 ft) makes it difficult to determine the time course of future aquifer concentrations.
3. The artificial separation of chemical and radiological assessments and actions, and the very different assumptions and models used, makes a holistic assessment of risks and uncertainties impossible.

RFQQ N20730 Tasks A and B

A. Run the Yakama Nation risk model for comparison to results of existing models.

B. Review variables in cap life estimates that might impact scenarios and Phase I cover timing. Review modeling assumptions and inventory estimates.
   - Application of Yakama scenario
   - Summary of FEIS conceptual model, pathways, and dose assessment results
   - Comparison of FEIS and Yakama scenario exposure parameter values and doses
   - Chemical risk assessment
   - Focused review of groundwater transport model

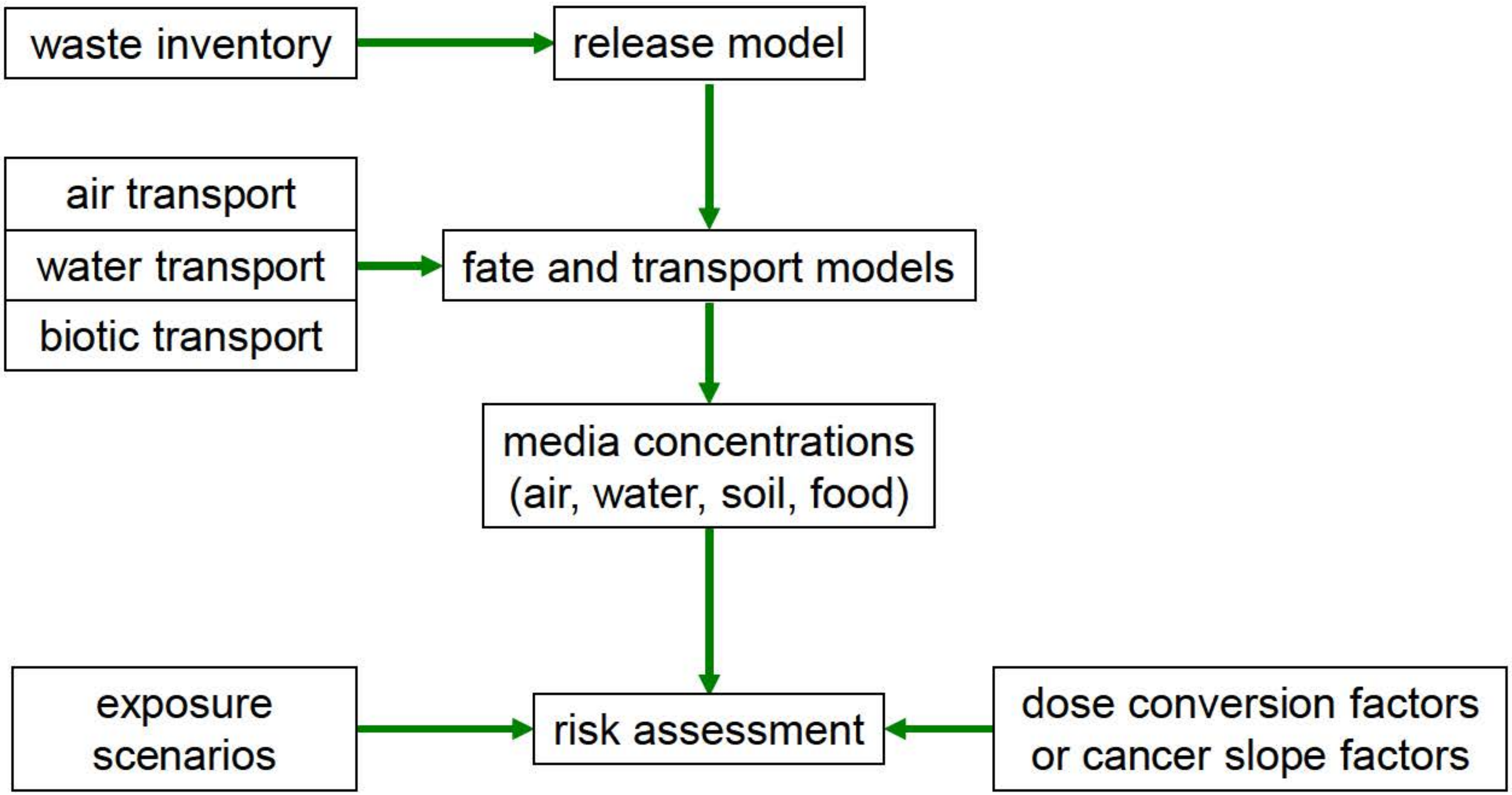
Radiological Risk Assessment

Potential future radiation dose attributed to a (very) long-term disposal facility is estimated by the modeling of

- aging of the waste,
- performance of engineered barriers,
- natural fate and transport processes, and
- future human activities and behaviors.

This analysis is performed in order to inform decision making, with imperfect knowledge and under public scrutiny.

RRA Logic Diagram

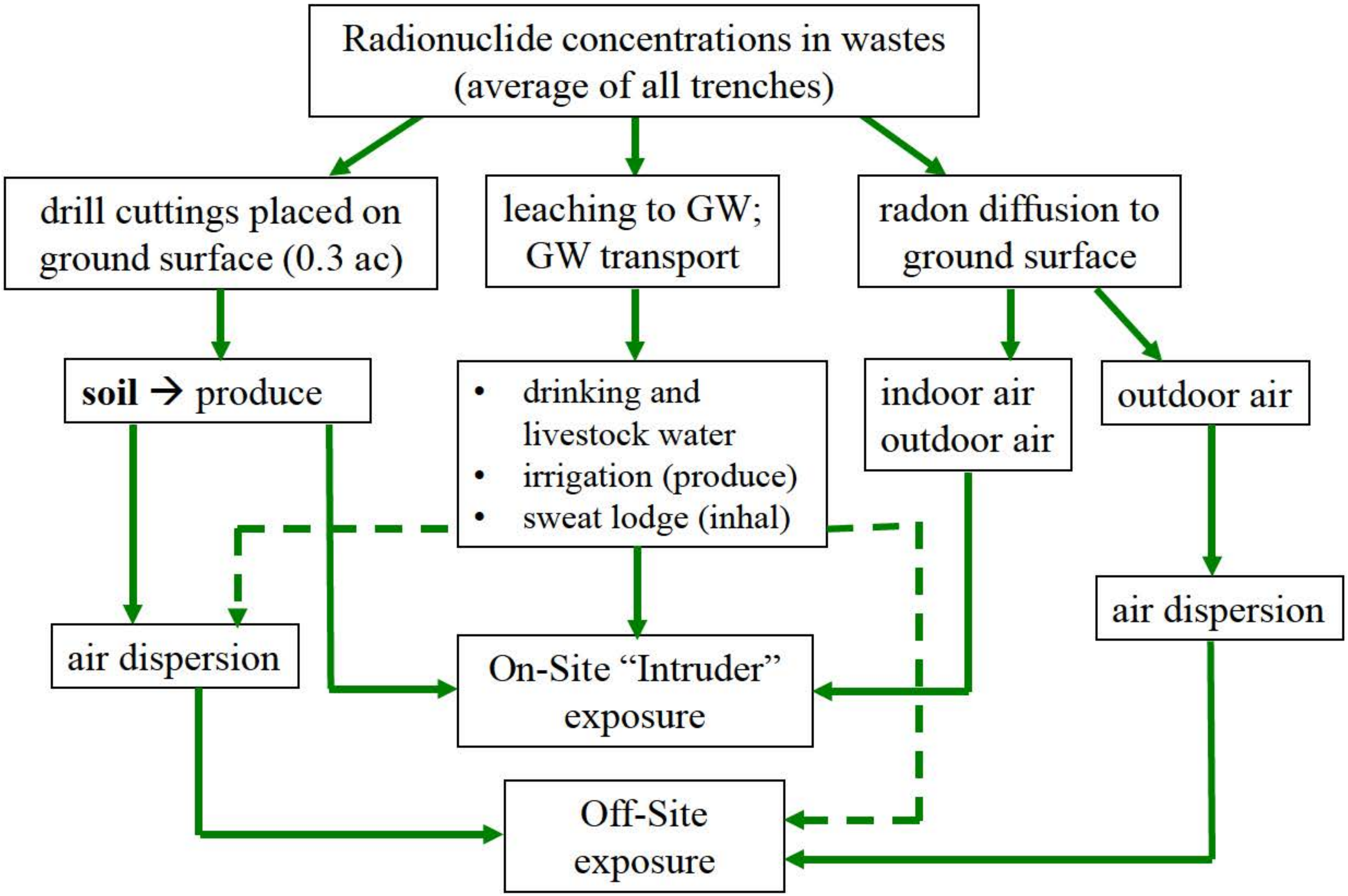


Yakama Scenario Application to USE Site

Exposure Media	Exposure Routes
Soil (irrigation and drill cuttings)	Inadvertent ingestion, external radiation, dust inhalation
Groundwater	Ingestion, watering livestock, inhalation in sweat lodge
Garden produce (irrigation, drill cuttings)	Ingestion
Domestic beef and milk (watering)	Ingestion
Poultry (soil; drill cuttings)	Ingestion
Game meat	Not assessed
Columbia River fish	Not assessed
Wild plants	Not assessed
River water, seeps, sediment	Not assessed

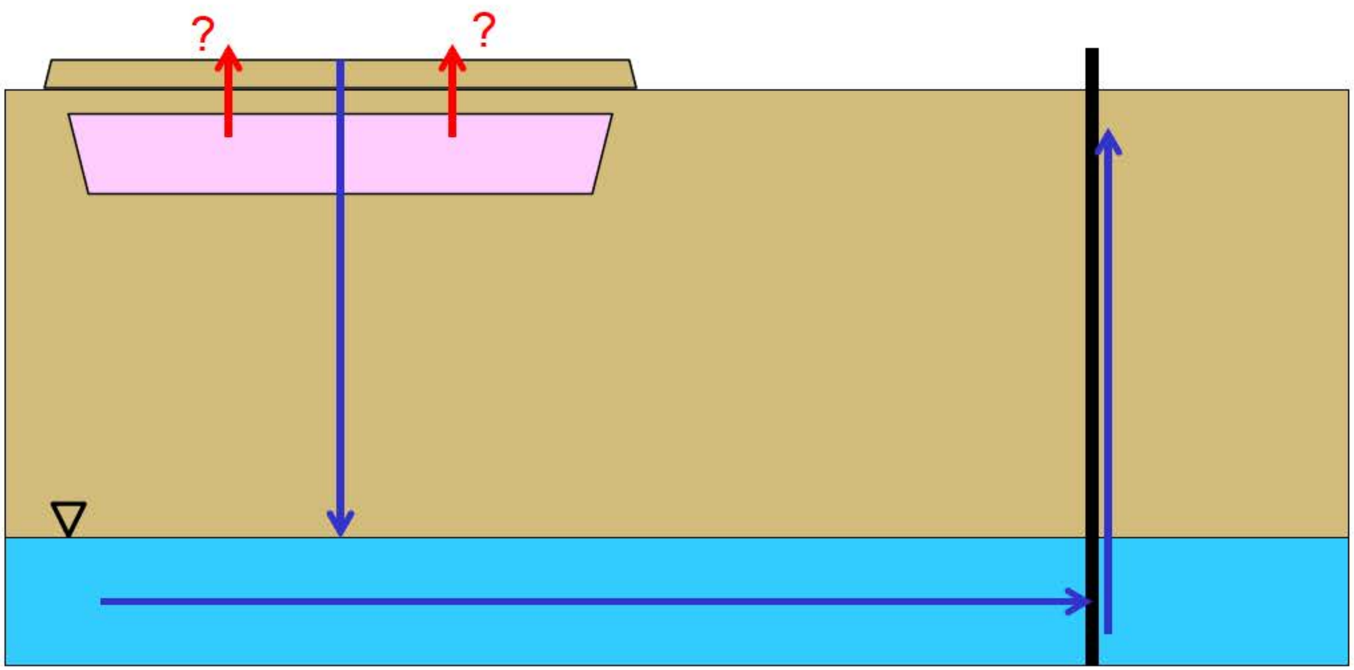
The application follows the FEIS dose assessment model, with the addition of ingestion of meat from domestic poultry. Exposure from pathways not assessed would result in lower doses than application of the scenario to a rural residential setting.

FEIS Conceptual Model



Incomplete Conceptual CT Model

The conceptual model for contaminant transport considers only downward pathways, ignoring potentially significant upward migration.



The Incomplete CT Model

The incomplete contaminant transport model

- considers only the groundwater pathway,
- ignores upward CT pathways, which are known to be significant at other arid sites (e.g. Nevada National Security Site, Los Alamos National Laboratory, Clive Utah), and
- may mislead the risk assessment since all potentially significant features, events, processes, and scenarios (FEPSs) are not considered. (See NUREG-2175 guidance.)

Biotic Transport Pathways

Section 4.4.2 of the Final EIS (2004) states, "The deepest burrowing animal was the harvest ant at 8.9 ft … The plant species with the greatest average maximum rooting depth is antelope bitterbrush at 9.7 feet." Because cover thickness is anticipated to exceed 15 ft, plant root and animal burrow pathways were eliminated.

- The highest *average* rooting depth alone is not a basis for eliminating this pathway because individual deep-rooting plants will have roots penetrating the waste.
- Upwards diffusion in the water phase, and lead-210 from radon diffusion, will distribute radionuclides in the cap above the waste.
- Depth to waste will be less from within erosion gullies that will develop along the sides of the embankment.

2012 FEIS Addendum Results: Native American Adult (Table 5.1.1)

	On-Site Exposure (mrem/year)				Off-Site Exposure (mrem/year)			
Model Time (years)	100 - 500	500-1,000	1,000-5,000	5,000-10,000	100 - 500	500-1,000	1,000-5,000	5,000-10,000
Groundwater Pathways	21	6.8	8.3	3.9	21	6.8	8.3	3.9
Drill Cuttings Pathways	40	26	26	26	0.1	0.1	0.0	0.0
Radon Pathways	17	71	57	10	0.2	1.0	0.8	0.14
TOTAL	78	104	91	40	22	7.9	9.1	4.0

For off-site exposures, groundwater pathways and near-term dose dominates.

For on-site exposures, drill cuttings and radon pathways dominate and doses are “high” for 1,000s of years.

Comparison of 2012 FEIS Addendum and Re-Modeled Groundwater Doses

	On-Site Exposure (mrem/year)					
Model Time (years)	Near term max (year 67; 2032)	100 -500 (year 100)	500-1,000 (year 990)	1,000-5,000 (year 1100)	5,000-10,000 (year 9900)	Long term max (~76,000)
FEIS Addendum Table 5.1.1	na	21	6.8	8.3	3.9	na
Re-Modeled	31	18	9.5	12	3.6	122

Some groundwater pathway results in Table 5.1.1 were biased high because the highest doses for each radionuclide within a time period were summed.

Comparison of FEIS and YN Exposure Parameter Values

Exposure Parameter	units	YN	FEIS
Soil ingestion rate (adult / child)	mg/day	200 / 400	200 / 200
Exposure frequency	day/year	365	365
Inhalation rate (adult / child)	m^3/day	26 / 16	30 / 15
Drinking water ingestion rate (adult / child)	L/day	3 / 2	3 / 2
Fruit + vegetable ingestion rate[1] (adult / child)	g/day	1,417 / 314	574 / 314
Meat (beef) ingestion rate[2] (adult / child)	g/day	704 / 212	275 / 169
Milk ingestion rate[2] (adult / child)	L/day	1.2 / 0.5	0.49 / 0.85
Sweat lodge exposure frequency	hr/year	365 [3]	365
Sweat lodge water intake	L/event	1	1
Sweat lodge water use; steam	L/event	4	1.05
Sweat lodge inhalation rate	m^3/hr	1.08	1.2

[1] FEIS values pertain to locally-grown produce (assumed to be 62.5% of total).
[2] FEIS evaluated these pathways only for well water, not drill cuttings. Uptake in a localized area of drill cuttings contamination may be of particular relevance for poultry and eggs.
[3] Maximum daily is 7 hr/d; 1 hr/d applied for chronic exposure.

Comparison of FEIS Native American and Yakama Scenario Adult Doses

	On-Site Exposure (mrem/year)					
	<100	100 -500	500-1,000	1,000-5,000	5,000-10,000	>10,000
GROUNDWATER PATHWAYS[1]						
FEIS Native	31	21	9.5	12	3.6	120
Yakama	33	19	10	12	8.0	120
DRILL CUTTINGS PATHWAYS[2]						
FEIS Native	na	37	(26)	(26)	(26)	na
Yakama	na	46 [4]	na	na	na	na
RADON PATHWAYS[3]						
FEIS Native	na	17	71	57	10	na
Yakama	na	17	71	57	10	na

[1]Exact groundwater times are years 67, 100, 990, 1100, 9900 and 76000.
[2]Year 2056 inventory. Groundwater and drill cuttings doses are not fully additive.
[3]Both scenarios assume full-time exposure, 50% indoor/50% outdoor. 309.1 Ci Ra-226.
[4]Approximately 51mrem/yr with the addition of a home-raised poultry pathway.

Groundwater Pathways: FEIS Native American and Yakama On-Site Adult Scenarios

	<100	100 -500	500-1,000	1,000-5,000
FEIS NATIVE AMERICAN				
Drinking water	2.0	1.3	0.97	1.2
Produce	1.4	0.83	0.44	0.60
Livestock (beef)	0.098	0.084	0.11	0.15
Soil (ing, dust)	0.21	0.11	0.026	0.028
Sweat lodge, inh	27	16	8.0	9.6
YAKAMA SCENARIO				
Drinking water	2.0	1.3	0.97	1.2
Produce	7.1	4.1	2.2	2.9
Livestock (beef)	0.24	0.21	0.26	0.38
Soil (ing, dust)	0.20	0.10	0.023	0.026
Sweat lodge, inh	23	14	6.9	8.3

Doses in mrem/yr

- Sweat lodge inhalation dominates dose, particularly for the FEIS model, for all exposure periods (and 25% of drinking water is related to sweat lodge consumption).
- 100% of meat and produce raised On-Site (except FEIS produce; 62.5%)

Drill Cuttings Pathways: FEIS Native American and Yakama On-Site Adult Scenarios

	Year 2056
FEIS NATIVE AMERICAN	
Soil, external	22
Produce	0.061
Livestock	not assessed
Soil ingestion	1.9
Dust inhalation	13
YAKAMA SCENARIO	
Soil, external	32
Produce	0.49
Livestock (poultry meat)	(5)
Soil ingestion	3.2
Dust inhalation	11

Doses in mrem/yr

Year 2056 inventory used for drill cuttings calculations.

Vista Remedial Investigation Summary

1. No soil analytes (0 to 4.6 m [15 ft] bgs) failed direct-contact screening to MTCA Method B levels.
2. No soil analytes (0 to 4.6 m [15 ft] bgs) failed screening to ecological levels.
3. Nitrate was the only surface soil analyte (0 to 4.6 m [15 ft] bgs) that failed the MTCA groundwater protection screening.
4. Hexavalent chromium, methylene chloride, nitrate, and nitrite failed the deep soil (>4.6 m [15 ft] bgs) groundwater protection screen.
5. Groundwater screening: 1,2-dichloroethane-d4, antimony, arsenic, bromofluorobenzene, fluoride, hexavalent chromium, molybdenum, nitrate, toluene-d8, trichloroethene, uranium, and vanadium failed.
6. Soil vapor screening: 1,1- dichloroethane, 1,3-butadiene, benzene, carbon tetrachloride, chloroform, cis-1,2-dichloroethene, Freon 12, tetrachloroethene, and trichloroethene failed.

Vista Conceptual Site Model Summary

Identification of Indicator Hazardous Substances (IHSs) based on WAC 173-340-703:

1. Soil IHSs (groundwater protection): hexavalent chromium, 1,1-dichloroethane, benzene, carbon tetrachloride, chloroform, cis-1,2-dichloroethene, Freon 12, tetrachloroethene, and trichloroethene.

(All but Cr+6 pertain to soil vapor and were added for this reason.)

2. Soil Vapor IHSs: 1,1,1-trichloroethane, 1,1- dichloroethane, 1,1-dichloroethene, benzene, carbon disulfide, carbon tetrachloride, chloroform, cis-1,2-dichloroethene, methylene chloride, phenol, Freon 11, Freon 13, tetrachloroethene, and trichloroethene.
3. Groundwater IHSs: hexavalent chromium, chloroform, trichloroethene, and vanadium.

(The relationship between soil vapor and groundwater IHSs is tentative because vapor monitoring wells extend to only ~100 ft but the aquifer is at approximately 300 ft.)

On Screening Models

Screening Models such as that employed in the groundwater pathway analysis (Rood 2012) are used for estimating worst case impacts from groundwater use and,

- are intended to conservatively overpredict risk,
- are not reflective of realistic modeling,
- are generally deterministic,
- are not useful for decision making, and
- should lead to more realistic modeling if the screening results show anything of concern.

Focused Review of GW Screening Model (1)

The groundwater screening model developed by Rood (2012)

- seems to be mathematically correct, given the assumptions it makes (see next slide),
- makes some unfounded assumptions, and
- is focused completely on groundwater, ignoring other contaminant transport pathways.

Focused Review of GW Screening Model (2)

Example problems with the screening model:

- "A model calibration was performed where two rate constants, waste-to-backfilled-soil partition coefficient, and the removal rate constant from disposal trenches to the vadose zone, were derived and used with the existing model to predict tritium release and transport (Rood 2008)." (Rood 2012, p. 1) *Calibrating an incomplete model is pointless.*
- "Not all radionuclides or decay chains were considered in the all-pathways dose assessment. Only those radionuclides that had a significant contribution to the total overall dose were provided by WDOH." (Rood 2012, p. 32) *How could this be known in advance?*
- "In Phase I screening, radionuclides with half-lives less than 4.987 years were eliminated. The 4.987 years was selected based on a conservative estimate of the vadose zone transport time divided by 10." (Rood 2012, p. 9) *Why not simply 5 years? And why divide by 10?*

Focused Review of GW Screening Model (3)

Example Quality Assurance (QA) issues with the screening model:

- "...in the original FOLAT calculations the wrong [plutonium] K_d value was used." (Rood 2012, p. 32) *How did this happen? How do we know that this is an isolated error?*

- Referring to sources of information for the radioactive inventory:

"a. From "sourceterm.xls" spreadsheet. Values for U-238, U-235, and U-234 were later revised in the spreadsheet "Recommended uranium values for USE.xls".
b. From the document, "Potential additional isotopes for gw modeling.doc"
c. From the spreadsheet 2003 to 2011 Disposal Activity for Selected Radionuclides.xls provided by Kristin Felix, WDOH
d. From the spreadsheet "Source term projections for Art 101302.xls". Value for U-234 and U-235 were modified as discussed in text." (Rood 2012, footnote to Table 2) *This draws QA pedigree and consistency into question.*

Dose *vs.* Cover Installation Time

This graph shows that the timing of cover installation has no effect on groundwater doses after loss of institutional control.

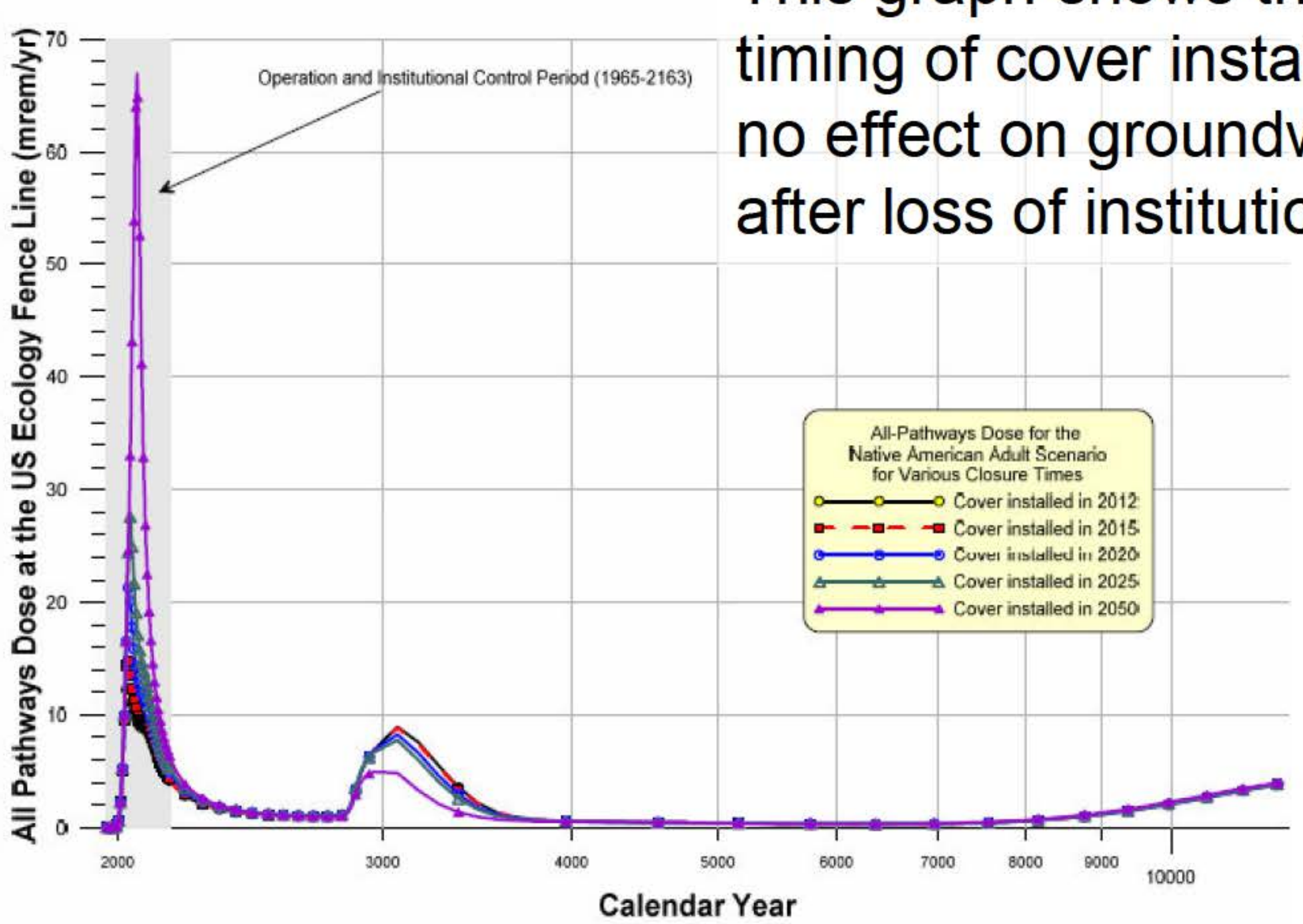


Figure 13
(Rood 2012)

GW Dose *vs.* Time for 2020 Cover

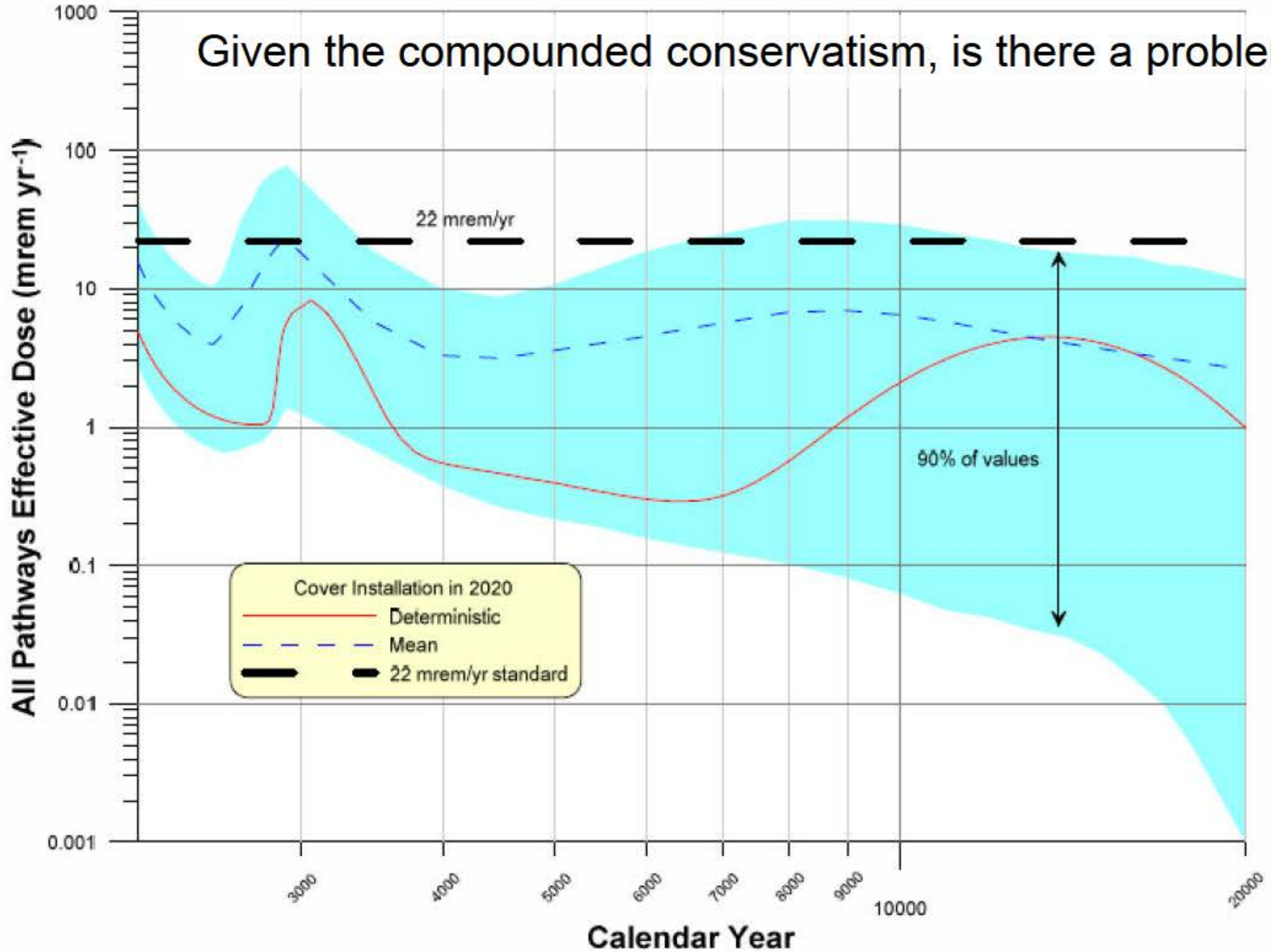


Figure 18
(Rood 2012)

RFQQ N20730 Tasks C, D and E

C. Assess impact of Phase I cover on MTCA work and consequences of delaying installation.
D. Evaluate engineering and safety issues in opening cover.
E. Compare US Ecology and Hanford closure and cleanup requirements.

Phase I Impermeable Barrier Cover System

- Construction of new soil layer (up to 12 feet in thickness) over existing cover
  - Requires select earthen material meeting suitability requirements
  - Top 6 inches of soil free of organics and particles larger than ½ inch
  - Tested during construction to ensure 95% compaction
- Geomembrane barrier of HDPE meeting sourcing and performance specifications
  - Nondestructive, destructive, and seam testing requirements during construction
- Top layer of soil (min. 2.5 feet) amended with 25% gravel rooted with native vegetation
- Assumes no vapor extraction piping within the impermeable barrier cover

Impacts to Cover Integrity from Future MTCA Actions

- Will be compromised by borings to investigate underlying wastes
- Will be compromised by partial removal to sample contained wastes
- Repair procedures for HDPE layer would require patching and welding according to manufacturer's specifications and guidelines
- If boreholes and/or excavated areas are filled, cover performance will be degraded
- Potential for increased infiltration through the cover and differential settling within the cover
- Liability considerations related to breaching the cover after construction is certified

Increased Expense of Future MTCA Actions

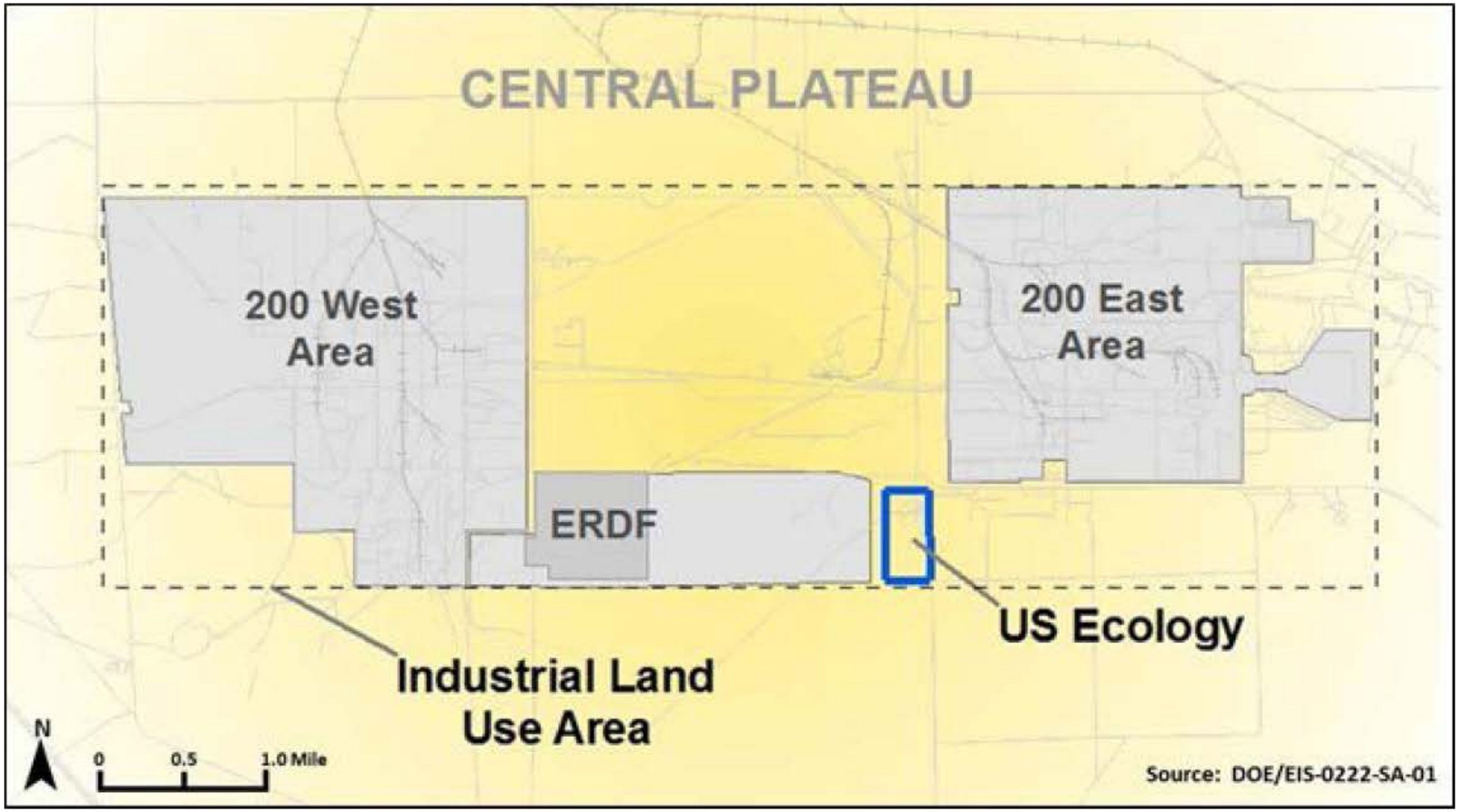
- Investment in Phase 1 Cover System Alternative for Pre-1985 Trench Areas is $59M (*check: may be total cost, not Phase 1*)
- Alternative of future actions, given MTCA screening criteria, would be biased against removal toward more cost effective approaches, i.e. leaving the Phase 1 cover in place
- Cost of characterizing wastes will increase significantly once Phase 1 Cover is installed
- Cost to remove and replace the cover to manage underlying wastes could be nearly $100M (*estimated from Phase 1 cost*)

(Cost of retrieval and characterization of waste was determined to be prohibitive in the Focused Feasibility Study.)

Health and Safety Issues

- Drilling or trenching to characterize wastes once the cover is installed could adversely affect worker health and safety.
- Challenges and limitations exist for visual inspection of wastes and confined space requirements.
- Even without the cover, uncertainties related to waste contents, package conditions, and disposal locations make calculating worker doses difficult.

US Ecology *vs.* Hanford Requirements



The US Ecology Site is within the Central Plateau Inner Area, which has been designated for continuing industrial land use into the "foreseeable future" by the Tri-Parties.

What does this mean for potential exposures centuries or millennia in the future?

US Ecology *vs.* Hanford: GW Standards

Table 14. Selected Cleanup Levels for 200-UP-1 OU

200-UP-1 Groundwater OU ROD (2012)

COCs	Units	90th Percentile Groundwater Concentrations	Federal Drinking Water Standard[a]	Model Toxics Control Act Method B Cleanup Levels: Non-Carcinogens at HQ = 1	Model Toxics Control Act Method B Cleanup Levels: Carcinogens at 1×10^{-6} Risk Level	Cleanup Level
I-129	pCi/L	3.5	1	–	–	1[d]
Tc-99	pCi/L	4,150	900	–	–	900
Tritium	pCi/L	51,150	20,000	–	–	20,000
Uranium	µg/L	206	30	–	–	30
Nitrate[b] (as NO3)	mg/L	133	45	113.6	–	45
Nitrate[b] (as N)	mg/L	30.1	10	25.6	–	10
Total Chromium	µg/L	99	100	24,000	–	100
Hexavalent Chromium	µg/L	52	-[c]	48	–	48
Carbon Tetrachloride	µg/L	189	5	5.6	0.34[e]	3.4[f]

a. Federal DWS from 40 C.F.R. Part 141, "National Primary Drinking Water Regulations," with I-129 and Tc-99 values from **EPA 816-F-00-002,** ***Implementation Guide for Radionuclides***.

b. Nitrate (NO3) may be expressed as the ion NO3 (NO3- NO_3) or as nitrogen (NO_3-N). The federal DWS for nitrate is 10 mg/L expressed as N and 45 mg/L expressed as NO_3^-. The state cleanup level is 25.6 mg/L, as nitrogen.

c. There is no federal DWS for hexavalent chromium.

d. Currently identified groundwater treatment technology is insufficient to reach the 1 pCi/L DWS.

e. This value is represents estimated risk from an individual contaminant, at $1\text{x}10^{-6}$ risk level.

f. This cleanup level is a risk-based calculation for carbon tetrachloride. This value represents a cumulative $1\text{x}10^{-5}$ risk in accordance with WAC 173-340-720(7)(a).

- Values for radionuclides other than uranium and radium-226/228 are calculated based on generic MCLs of 4 mrem/yr (beta/photon emitters) and 15 pCi/L (alpha emitters).
- US Ecology groundwater doses for all radionuclides compared to 25 mrem/yr NRC threshold.

US Ecology *vs*. Hanford: Soil Standards

Central Plateau / Hanford

- Central Plateau Inner Area soil radionuclide remediation criteria for direct contact pathways calculated based on EPA's 10^{-6} to 10^{-4} Superfund risk range rather than an annual dose threshold.
- Central Plateau Inner Area soil chemical remediation criteria for direct contact pathways calculated based using MTCA methods (direct contact).
- Groundwater protection evaluation for both chemicals and radionuclides at the Hanford Site guided by the 'Graded Approach' document (DOE/RL-2011-50, Rev 1) and use of the Subsurface Transport Over Multiple Phases (STOMP) computer code.

US Ecology

- US Ecology radionuclide assessment employs the NRC 25 mrem/yr threshold for all pathways, including direct contact and groundwater.
- MTCA groundwater protection for US Ecology evaluated using the MTCA three-phase partition model.

Recommendations

1. In order to be useful for benefit-cost informed decision making, a risk assessment model must be unbiased and complete in its consideration of transport pathways. Biased, screening models are useful only for supporting decisions when they encompass all pathways and indicate no possibility of exceeding thresholds. Follow latest guidance from NRC (NUREG-2175) to build an adequate foundation for the model.
2. Recognize that groundwater transport was modeled with a protective screening model, and that dose results are mostly from a sweat lodge inhalation model that implausibly assumes nonvolatile radionuclides will be present as respirable particulates in equilibrium with saturated water vapor. Assess urgency of Phase I cover timing accordingly.

Supplemental Slides

1. Proposed revisions to Nuclear Regulatory Commission 10 CFR Part 61 regulations.
2. Additional specific Yakama Nation questions.

Proposed 10 CFR 61 Revisions

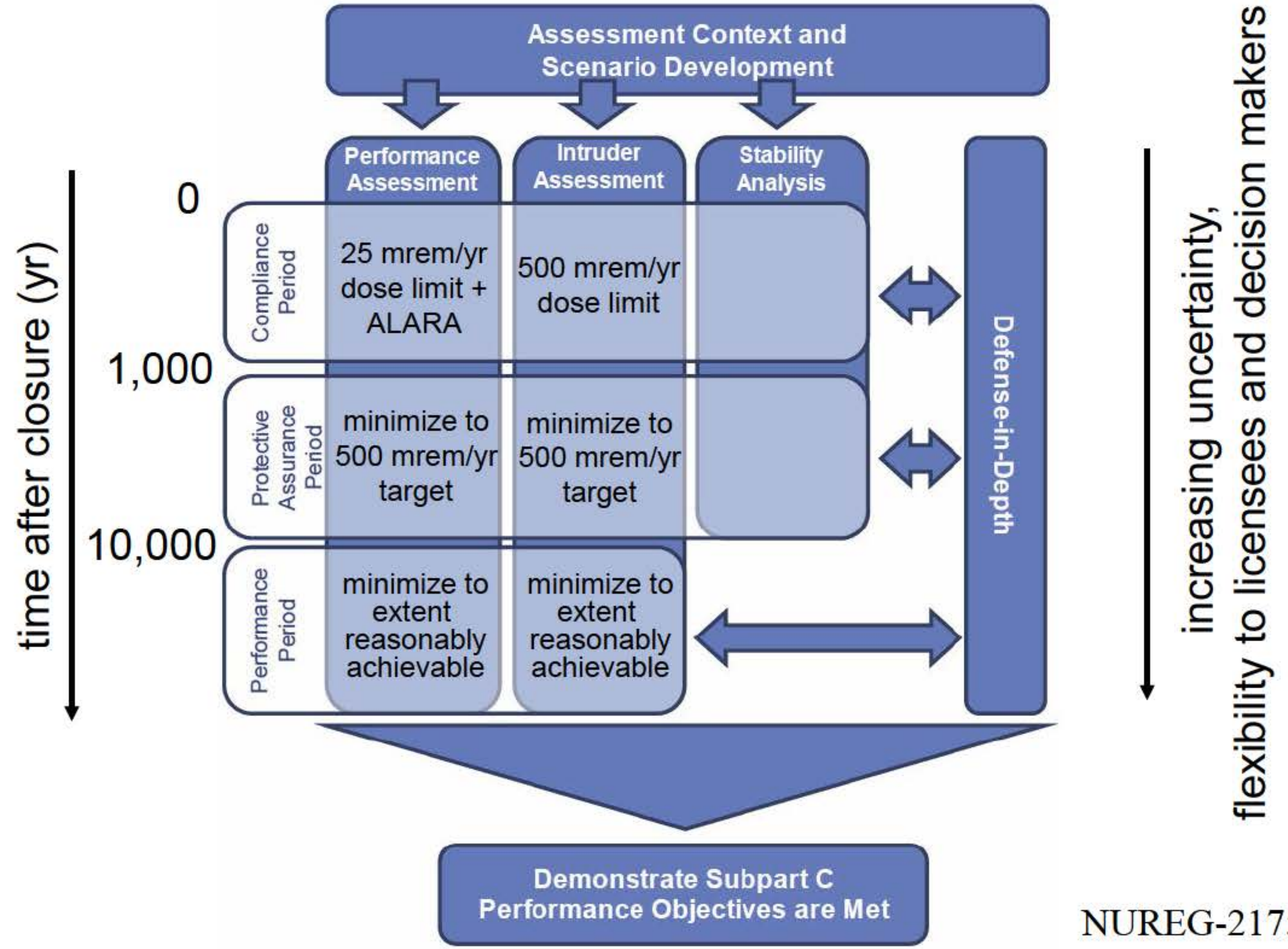
The NRC has proposed revisions to 10 CFR 61:

- Performance Assessment + Intruder Assessment
- new analysis timeframes
- revised dose limits
- new focus on FEPs (or FEPSs)
- site-specific PA and IA required
- site-specific Waste Acceptance Criteria allowed
- new terms: Safety Case, Defense-in-Depth
- new guidance: NUREG-2175

Applicability of Proposed 10 CFR 61 Revisions

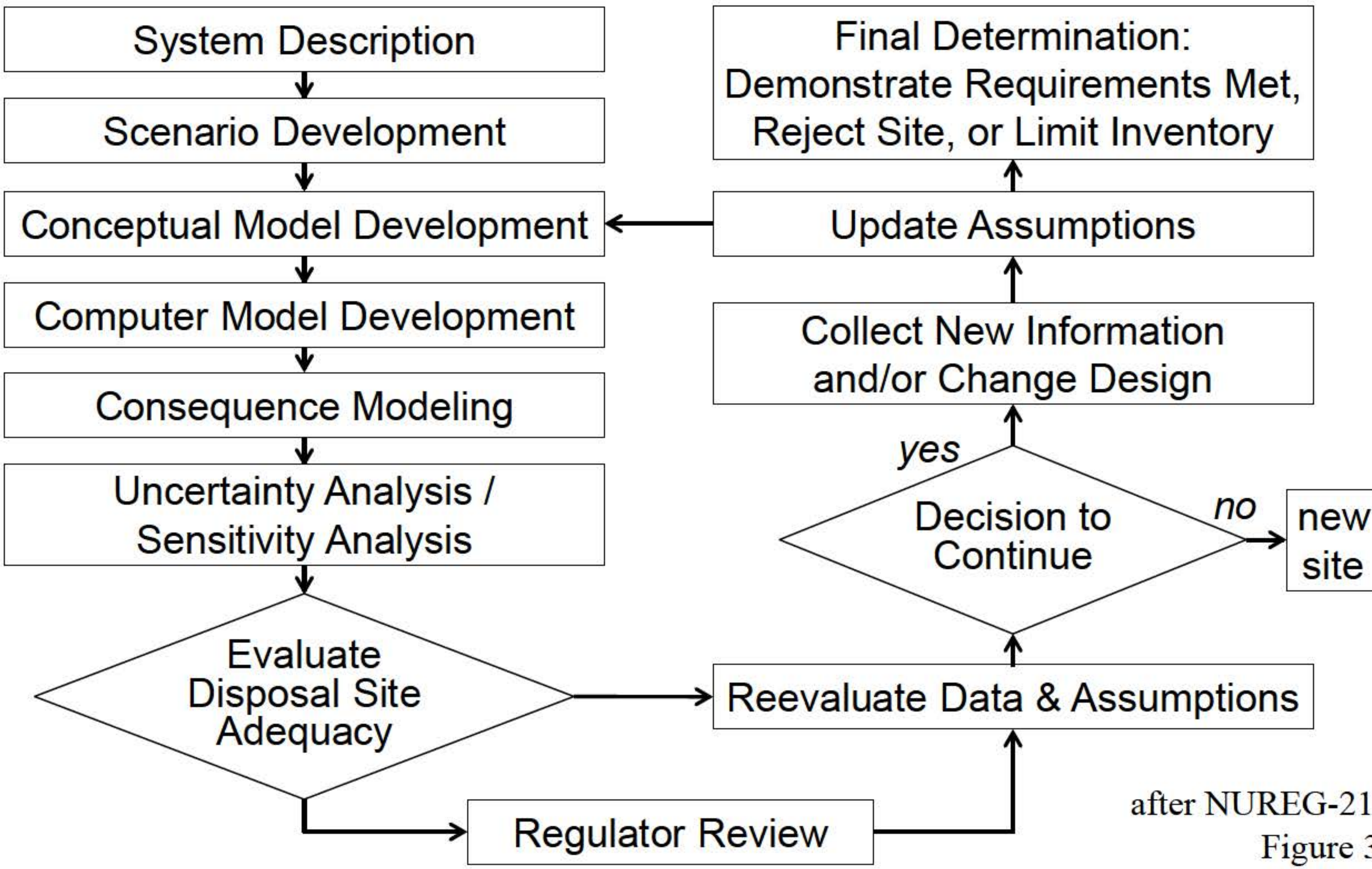
- Agreement State Compatibility revisions will require modification of state regulations
- Technical Analyses (§ 61.13) required for all licensees within 5 years of the date of the revision

Context of Proposed 10 CFR 61 Technical Analyses



NUREG-2175 Figure 1-1

Proposed 10 CFR Part 61 Performance Assessment Process



after NUREG-2175
Figure 3-1

Additional Yakama Nation Questions / Concerns

1. What is the design life of the cover, how is it likely to fail, were the failure modes assessed and incorporated in the modeling? (*How will Ecology and the Department of Health be able to ensure and maintain the integrity of the barrier over a 20,000 year time period?*)
2. Is there a plan to update the models as additional environmental data are acquired, particularly groundwater monitoring and the modeled near-term rise in plutonium concentrations?
3. What is the rationale for ignoring ecological risk?
4. Why has no benefit-cost evaluation been done to evaluate the feasibility of characterizing and/or removing some wastes?

Appendix D. Ecology and Health Comments on Interim Neptune Report

Comments on Neptune Presentation (8/6/2015)
US Ecology Modeling and Assessment, and Implication for the Phase 1 Cover

The numbers are keyed to the slides of August 6

3 – Currently this slide lists 4 caissons. We only document 2 caissons in the Final EIS.

4 – The current slide only shows older GW wells. Three newer wells have been installed. The locations will be provided to you.

6 – Last bullet - What are the adverse effects you are identifying? If additional modeling is required, can you provide some specific recommendations?

7 – As we understand this slide, the actual monitoring data is substantially below the model forecasts for Pu. That seems to reinforce the conclusion that a Phase 1 cover may not be necessary. In addition, it appears that the mobility of the other radiological components has been over estimated.

Based upon this slide, please confirm that Neptune concludes the Phase 1 cover is unnecessary to meet regulatory standards.

Although this was not part of your tasks, we are now wondering if the Phase 1 cover would enable the site to achieve a closure performance that would be significantly better that the regulatory standard currently required and what that value might be. Is that a question where modeling might provide a reasonable answer?

10 – Point #2: If we understand the concern correctly, the basis/rationale for the two screenings is provided in Final EIS Appendix IV, starting on page 7. Does that address the identified concern?

Point #3: Similarly, the basis/rationale for the 500 year cover failure number is also documented in Appendix II (pages 36 and 57) and Appendix IV of the Final EIS (page 22 and footnote).

Point #5 is a bit confusing as phrased. If we understood it correctly, "Aquifer porosity is assumed to be extremely small (0.10). This assumption means that radionuclides would travel faster in the hypothetical model than reasonably likely to occur in the real aquifer."

So the consequence of this is that with more realistic assumptions, the radiological constituents would not leave the site location and have a longer opportunity to accomplish in situ decay?

11 - Were you able to establish a level of uncertainty associated with what is currently determined to be in the trenches? If so please explain.

12 – This slide noted that chemical and radiological assessments are separated; that approach, as we've understood it, is consistent with the approach used for the surrounding 200 area.

14 – Second bullet uses the word aging of the waste; is decay a better word?

16 – So is the conclusion of this slide that a farm adjacent to the site poses a greater risk than a hunter/gatherer scenario adjacent to the site?

18 –19 notes that upward contaminant transport has been documented at other arid locations. Were covers installed at those locations and would a Phase 1 cover truncate those routes? Is there other information that establishes that these sites are comparable and what percent of contribution might be missing if the upward pathways is added in?

20 – Can you substantiate the penetrating roots, water phase waste, and gully initiation on a rip-rap cover? Also, is this possible penetration in reference to the Phase 1 cover or the final cover?

21 – 26 – Is it possible to draw an overall conclusion or summary with regards to the comparison of FEIS and YN Scenario?

26 – This seems to imply that a well is drilled and cutting exposure is possible in the year that the facility stops accepting waste. Is that a realistic scenario given that the site will conducting closure work after 2056 and then turned over to the Department of Energy for maintenance?

30 – Unfounded or poorly documented?

31 – 2nd & 3rd bullets: Much of Rood's original work was documented in FEIS, Appendix IV and carried forward in subsequent updating work.

36 – 3rd bullet –The final cover design has not been completed, but it will meet RCRA performance standards and be consistent with the performance expectations of the 200 industrial area. The first and third bullet on this slide are elements of the final cover that will be placed in 2056. The second and fourth bullet pertain to the design of the Phase 1 cover.

37 – It is our understanding that post-cover penetration or other work involving cover modification for HDPE/FML covers such as proposed for the Phase 1 cover is not uncommon. The contract documents for a contractor performing these borings stipulate that the repair must meet or exceed the specifications of the original cover and can also include protection against differential settling through the use of amendments like bentonite clay or soil cement. With liner repair commonly performed, what references indicate concerns that a repaired HDPE liner will not operate per specs?

38 –The $59M cost is the total cover cost including both the Phase 1 FML cover and the final cover to be placed in 2056. The costs also include pertinent maintenance for the period between Phase 1 placement and closure in 2056, with a separate fund providing for perpetual maintenance after turnover to Department of Energy. The anticipated investment in the Phase 1 cover is $15 million and that would be for all trenches that are currently closed.

We need estimates for a comparison between waste characterization before and after placing a cover. Given the worker safety and environmental risks involved in a direct trench penetration, characterization would likely be through lateral drilling.

Could you provide an example of what type of waste management might be anticipated? We understand the $100 million estimate was premised on a higher cost for original installation; a revised estimate would be better defined for us if it included an estimated date of application and some scope of anticipated waste management work.

39 – It is our understanding that penetrating the waste prior to allowing radiological decay time could pose a significant worker safety risk. Please provide additional rationale as to how opening a trench through a HDPE cover to perform work increases worker safety issues.

Because a HDPE cover and accompanying soil layers would protect workers through additional shielding, we have also wondered about whether the Phase one cover would potentially reduce worker risk from adjacent trenches.

40 – The location within the Hanford 200 Industrial area means the US Ecology facility will be integrated in to the Department of Energy maintenance programs in perpetuity. Does that answer the question embedded in the figure?

41 – The title for this slide implies a comparison between US Ecology and Hanford limits. With the 200-UP-1 clean-up level table so prominent, the comparison between Hanford and US Ecology is diminished. With the pertinent information in the bullets, this material should be the focus along with a concluding statement about comparing these two styles of limits.

43 – The second point appears to argue again that the EIS model is overly conservative and the risk is low enough that a Phase 1 cover is not warranted for radiological protection purposes. Is that correct?

46 – 2nd bullet is valid assuming this proposed regulation is included in the final regulation without change.

49 – These would be the answers we would offer to some of the questions raised on slide 49:

1 – The Phase 1 cover is assumed to function only through the operational life of the US Ecology facility. The final cover scheduled for 2056 is expected to confine and protect allow in-situ decay processes for 500 years. Per the EIS, after the site closes in 2056, the property will be turned back over to the Federal Department of Energy and the final cover and boundaries will be maintained as part of the 200 area industrial site perpetual care and exclusion commitment by the US Government.

2 – As noted in the presentation, the modeled/forecasted increase in Plutonium has not been supported by results from ongoing monitoring. This reinforces the question about the legitimacy of the sample that supposedly detected Pu. Model updating could be used to justify removing Pu as a material of concern.

3 – The final cover design and maintenance will be consistent with the other 200 area covers and the ecology will be protected to the same standard as anticipated for the 200 area.

4 – The MTCA cost estimates for waste excavation have been estimated to be in the range of $3.3 Billion to $11.8 Billion for targeted to complete removal. Determining the benefits of a removal investment would require additional modeling linked to each increment of cost; specifically how much one would choose to excavate or inversely what benefit could be achieved at each level of cost. Because of worker safety concerns, costs could also decrease over time as the radiological materials in the trenches decay.

Appendix E. Yakama Nation Comments on Interim Neptune Report

Ralph,
The following are my overall concerns:

Foremost: Neptune's time was wasted; delays by DoH resulting in some requests undone. Neptune was asked to consider the data gaps and propose different parameters but had no time to do so. Yet by DoH comments, they are asking Neptune to do additional workscope and cost estimates. I request our comments be fully answered and consultation with the WA Dept of Ecology and DoH before any additional workscope be performed by Neptune.

Secondly, I was assured by Jane Hedges, David Jansen, and others, that the groundwater pathway would be examined and a comparison to the Hanford site requirements. I know that you mentioned that the two were separate authorities, but this was discussed at our first meeting when the contract was being drawn up. It's not your fault but it leaves me very dissatisfied and it is not resolved to my satisfaction.

In all instances I would like to request additional workscope be planned to resolve the issues. Thank you,
Jean Vanni

1. The groundwater pathway and the amount of contamination related to that pathway and how the 22 mrem was correlated to the Hanford sites requirement of 4mrem per year and how a "donut hole" would not be created.
2. Children were not modeled, target receptor was only an adult. I recommended and request that for public health awareness, the risk assessment warrants a comprehensive assessment of both chemical and rad risk with an integrated model developed (e.g. biotic transport pathways overtime was eliminated prematurely).
3. Risk assessment kept directly on site as thought to be the area of most exposure; no larger pathways considered which does not represent the YN life-style or account for all the exposure risks. (Note: YN risks identified as not significantly higher than what was used in the initial analysis due to differences in inhalation factors)
4. *Model's as chosen were done appropriately if you accept the assumptions used, but only at a screening level/one dimensional. Radon pathway modeled independently and sometimes, especially in arid climates this can be important*. How Radon should be modeled is an issue. This issue was left unresolved as well as the true picture of the vertical and lateral spread of contamination.
5. No characterization from about 80ft to groundwater; known data gap with no proposed further characterization.
6. Ecology's letter of okaying the removal of vapor extraction systems is predicated on the belief that these contaminants cannot be removed effectively as they will migrate to groundwater. I believe this to indicate a DNAPL is present on site and Ecology is doing nothing to remediate it. Can you clarify what is happening in the vadose zone given this explanation for removal of the VES and what can be done?
7. Data Quality: overall: QA train had to support; not necessarily wrong but it should be able to be followed and reproduced (I think this is an uncertainty which remains). Some of the assumptions had weak or no support provided to Neptune; model seemingly bias towards conservatism but no basis for knowing what was the most significant Rad contribution (could suggest re-running of all Rad cals; even if by 10 half lives , a rad is considered gone by DoH, that could still leave a significant mass for a long period of time). It remains unclear to me whether Rood assumed no or some cover to block infiltration during the HDPE cover lifespan. (I still don't know what infiltration rate was used)
8. Questions remaining about the inventory re-calculations. No double check made on types of casks actually used to transport materials. What is suggested was use of those reserved for military use. If incorrect, the inventory for Ur is much higher.
9. Uncertainty in trenches: UR inventory is unquantifiable; Chemical inventory pre 1985 not accounted for in entirety=data gap remains. No proposed characterization.

10. No comparisons to adjacent Hanford site Facility standards for both soils and groundwater. No addressing of concerns with Greater than Class C wastes buried on site.
11. No clear understanding of the types and amounts of contaminants of concern in the pre-1985 trenches and no in-trench characterization proposed in the RI/FS.
12. Questions about the remaking of data by Drew Thatcher who is DoH employee. Who will continue to check and verify these against what was provided to Ecology by Vista?

Neptune's last slide: All valid concerns and questions which I want answered.

13. What is the design life of the cover, how is it likely to fail, were the failure modes assessed and incorporated in the modeling? *How will Ecology and the Department of Health be able to ensure and maintain the integrity of the barrier over a 20,000 year time period?*
    1. I note that DoH believes it won't need to be concerned because of potential changes in the NRC regulations. However, are these not long lived rads which will continue to pose groundwater concerns? This question remains fundamental and I don't think it's Neptune's responsibility to make any decisions on closure status.
14. Is there a plan to update the models as additional environmental data are acquired, particularly groundwater monitoring and the modeled near-term rise in plutonium concentrations?
15. What is the rationale for ignoring ecological risk?
16. Why has no benefit-cost evaluation been done to evaluate the feasibility of characterizing and/or removing some wastes?

Appendix F. Final Neptune Report

US Ecology Phase 1 Cover Study

Final Report

October 13, 2015

Prepared by

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and

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Contents

Figures and Tables

Executive Summary: Key Findings and Recommendations

The Washington Department of Health (WDOH) proposes to construct the lower layer of an engineered soil cover (the Phase I cover) over filled radioactive waste disposal trenches at the U.S. Ecology waste disposal site on the Hanford Reservation. The purpose of installing the Phase I cover is to reduce infiltration of water, a process that could result in leaching and transport of radionuclides to groundwater. In particular, installation of the Phase 1 cover is intended to mitigate potential near-future groundwater exposure and radiation doses from relatively soluble radionuclides.

WDOH has requested that Neptune and Company, Inc. (Neptune) and RIDOLFI Inc. (RIDOLFI) evaluate the technical basis for the proposed timing of the Phase 1 cover emplacement, and this report documents that evaluation. This includes questions of whether the cover could impede additional site investigations or remediation work as well as the implications of using the Yakama Nation risk model (RIDOLFI 2007) to assess the impacts of potential future exposures. The approach employed to achieve these objectives includes focused review and analysis of key technical reports, and application of the Yakama Nation risk model to radionuclide exposure concentrations developed in WDOH's Radiological Risk Assessment (RRA) (Thatcher 2003). The results of these reviews and analyses were then combined with an evaluation of engineering and safety concerns to develop recommendations pertaining to the necessity and timing of Phase 1 cover emplacement.

Key findings and recommendations include:

<u>1. Conclusions on the Timing of Phase I Cover</u>.

a) A persuasive technical rationale has not been made for the necessity of installing the Phase I cover for the purpose of interrupting near-future groundwater pathway doses.

b) The Final EIS (WDOH 2004) Table 5.1.2 indicates that the groundwater pathways dose before 250 yr following site closure is attributable primarily to plutonium isotopes. The modeled Pu-239 groundwater concentrations at year 2015 were approximately 0.1 pCi/L (3.7 mBq/L), but actual average Pu-239 concentrations in 2013 and 2014 were reportedly between 0 and 0.008 pCi/L (3 mBq/L) in wells at the disposal facility and indistinguishable from zero.

c) The degree of protective bias in the mobile fractions of uranium and plutonium isotopes, transport model equations, and input parameter values for leaching and transport is potentially large and poorly described.

d) There is a low probability that all institutional and societal knowledge of Hanford will be lost and that a drinking water well will be constructed on the Central Plateau in the next few centuries. The realization of a near-term groundwater exposure pathway is therefore unlikely.

2. RRA: Limitations of Screening Methodology.

a) Each set of transport pathway calculations (contamination of groundwater, exhumation of drill cuttings, and ground surface flux of radon) was done independently using protective models and assumptions, rather than as an integrated analysis.

b) No realistic modeling of system performance was done, and therefore the degree of "conservative" bias is largely subjective.

c) These results cannot be used to support benefit-cost types of decisions, such as whether the benefit (potentially lower future doses) of putting on the Phase I cover now outweighs the increased costs of sampling or remedial actions with it in place.

d) Because screening results show all-pathways doses up to approximately 100 mrem (1 mSv) in a year within 1,000 yr, consideration should be given to developing more realistic models that integrate all relevant transport pathways and quantitatively manage uncertainties without bias.

RRA Endpoints. The Final Environmental Impact Statement (EIS) RRA compared adult receptor doses to dose-based performance metrics.

a) Parameter values and calculations were developed for children, but results were not provided or applied to conclusions and recommendations.

b) Cancer risk results were not provided, frustrating risk communication. Cancer risk is the ultimate concern for radionuclide exposure, for which effective dose equivalent is an imperfect proxy, albeit a regulatory target.

RRA Conceptual Model. Dose results in the Final EIS may be underestimated because the modeling of nonvolatile radionuclide transport from disposed wastes did not assess all relevant pathways. Additional relevant contaminant transport pathways include:

a) upward diffusion in pore water,

b) gully erosion from the sides of the embankment,

c) deposition of lead-210 (Pb-210) and other progeny of radon-222 (Rn-222) in the cover by radon decay along the diffusion gradient, and

d) plant root uptake and animal burrowing into subsurface cover material integrated with all of the above.

RRA Model Boundaries. There are several potentially important assumptions invoked in the Final EIS contaminant transport and dose calculations that are not adequately explained and supported:

a) No basis/rationale is provided for the Phase 1 and 2 screenings that limit the radionuclides evaluated in the leaching and groundwater transport models.

b) The cover is assumed to naturalize at 500 yr after closure.

c) All radium inventory is present in sealed sources and will fail at 500 yr after closure.

d) Aquifer porosity is assumed to be extremely small (0.1), decreasing radionuclide travel time.

RRA Inventory and Waste Concentrations. Detailed documentation of the waste inventory is not provided with the Final EIS.

a) The importance of variability in inventory among trenches was ignored in the drill cuttings and radon dose calculations by using only an average across the entire disposal site. This could underestimate the consequences of specific intrusion events.
b) Inventory documentation is primarily in the form of tables and accompanying notes. The argument that inventory uncertainty is addressed by use of protective modeling assumptions is subjective and difficult to verify.

Chemical Model Toxics Control Act (MTCA) Investigation.

a) The reliance solely on environmental data (soil, soil vapor, and groundwater) to drive MTCA decisions ignores the possibility that significant chemical sources remain in the trenches to be released in the future.
b) The limited vertical extent of the vapor monitoring wells (~100 ft [~30 m], with an aquifer depth ~300 ft [~100 m]) makes it difficult to determine the time course of future aquifer concentrations.
c) The artificial separation of chemical and radiological assessments and actions, and the very different assumptions and models used, makes a holistic assessment of risks and uncertainties impossible.

Impact of the Phase I Cover on Future Investigation or Remediation.

a) Any actions that involve excavation or other substantial disturbance of the Phase I cover will be disadvantaged from a benefit-cost perspective relative to a no-cover baseline due to the higher costs imposed by having to subsequently repair the liner and re-compact the earthen materials comprising the cover.
b) Engineered cover repair may not be completely successful and could potentially create areas of future weakness, differential settling, or preferential contaminant transport pathways.

Comparison of US Ecology and Hanford Closure and Cleanup Requirements.

a) Central Plateau Inner Area soil radionuclide remediation criteria for direct contact pathways are calculated based on EPA's 10^{-6} to 10^{-4} Superfund risk range rather than NRC's 25 mrem/yr (0.25 mSv/yr) all pathways dose threshold. An approximate equivalence is $3 \times 10^{-4} \approx 12$ mrem/yr (0.12 mSv/yr), but adjusting this for the Yakama Scenario 70-year exposure duration 25 mrem/yr (0.25 mSv/yr) equates to about a 1×10^{-3} lifetime cancer risk.
b) The US Ecology RRA applies the 25 mrem/yr (0.25 mSv/yr) NRC all-pathways threshold whereas at Hanford radionuclide groundwater cleanup criteria are based on MCLs (4 mrem/yr [40 µSv/yr] for beta/photon emitters and 15 pCi/L [0.56 Bq/L] for alpha emitters).

1 Introduction

1.1 Site Description

The US Ecology Site is located within the 200 Area at the Hanford Reservation (Figure 1) and consists of 20 land disposal trenches that vary dimensionally from 100 to 300 m (300 to 1,000 ft) long, 6 to 45 m (25 to 150 ft) wide, and 6 to 14 m (20 to 45 ft) deep. The trenches occupy approximately 13 ha (32 acres) in the southeastern and east-central portion of the Site. The US Ecology Site also hosts four 10-m (30-ft) deep caissons located between Trenches 3 and 4, and three underground steel tanks ranging in nominal capacity from 4 to 75 m^3 (1,000 to 20,000 gallons) (Vista 2013). Once filled to capacity with waste, each trench is covered with at least an 2.6-m (8-ft) thick layer of soil and topped with 15 cm (6 in) of rock (Vista 2013). Older trenches were covered with 1 m (3 ft) of soil before cap placement (DOE/LLW-241 – cited in Vista, 2013).

The US Ecology Site is bounded to the east and west by two DOE radioactive waste disposal areas. The Environmental Restoration Disposal Facility (ERDF) is located to the west of the US Ecology Site, and the BC Cribs area is located to the east. Built in 1996, ERDF accepts low-level radioactive waste (LLW), and hazardous and mixed wastes that are generated only during Hanford cleanup activities (Vista 2013). In the 1950s, the BC Cribs and trenches were used to bury liquid effluent primarily from the 221/224-U Plant waste (PNNL-14948 – cited in Vista, 2013).

The US Ecology Site is leased from the DOE by the Washington State Department of Ecology (Ecology), which in turn subleases the Site to US Ecology (Vista 2013). The US Ecology Site has been accepting LLW for burial since 1965. The accepted waste contained solid materials, solidified liquids, stabilized liquids (liquid-containing vials suspended in absorbent media), contaminated equipment, cleaning wastes, tools, protective clothing, gloves, laboratory wastes, and naturally occurring or accelerator produced radioactive material (NARM), including radium.

1.2 Problem Statement, Scope of Work, and Objectives and Technical Approach

The WDOH proposes to construct the lower layer of a Resource Conservation and Recovery Act (RCRA)-equivalent cover (the Phase I cover) over filled trenches at the US Ecology site. These include all disposal trenches at the US Ecology site with the exceptions of Trenches 18 and 19 (Vista 2013; Section 3.4). The Phase I cover will consist of a 2-mm (80-mil) high-density polyethylene (HDPE) barrier sandwiched between two soil layers, the lower of which varies in thickness to allow for contouring of the cover and the upper of which provides protection for the liner. Originally, horizontal HDPE piping for a soil vapor extraction system was proposed for installation below the Phase I cover at trenches where volatile organic compounds (VOCs) are of concern, but more recently this has been supplanted by a plan to employ horizontal boreholes for vadose zone vapor extraction. The purpose of installing the Phase I cover is to reduce infiltration of meteoric water (precipitation) that may result in leaching and transport of radionuclides to groundwater in the relatively near future, thereby ensuring that modeled offsite human exposures over time remain at levels that result in dose rates below threshold values. In particular, installation of the Phase 1 cover is intended to mitigate potential future groundwater exposure and radiation doses from relatively soluble and mobile constituents that have been previously modeled to impact groundwater relatively early in the compliance period.

Figure 1-2. Vicinity Hanford Projects.

Figure 1: Google Earth photo of Hanford's Central Plateau, from Vista (2013)

The objective of this report is to evaluate specific technical concerns of the Yakama Nation related to the timing of the Phase 1 cover emplacement, specifically with regard to whether the cover would impede additional Model Toxics Control Act (MTCA) investigations or remediation work and the implications of using the Yakama Nation risk model to assess the impacts of potential future exposures (WDOH 2014). The tasks specified in WDOH (2014) include:

A. Run the Yakama Nation risk model for comparison to results of existing models.
B. Review variables in cap life estimates that might impact scenarios and Phase I cover timing. Review modeling assumptions and inventory estimates.
C. Assess impact of Phase I cover on MTCA work and consequences of delaying installation.
D. Evaluate engineering and safety issues in opening the cover.
E. Compare US Ecology and Hanford closure and cleanup requirements.

General concerns raised by Yakama Nation Environmental Restoration/Waste Management (ERWM) representatives during the scoping meeting of 23 February 2015 are to ensure protection of Yakama Nation members pursuing Treaty-reserved rights, including use of cultural and natural resources in a traditional way. More specifically, ERWM representatives maintained that radioactive and hazardous waste disposals on the Hanford Reservation impact the health of the Yakama people through their occupation of ancestral lands (including all of what is now the Hanford Reservation) and continuation of traditional lifeways, including utilization of natural foods and medicines. They stated their wish to regain access to these lands as is guaranteed them by the Treaty of 1855 and dismissed an "iron fence" approach to preventing exposures which is interpreted as exclusion rather than protection. They want to understand how the US Ecology site fits into the broader context of all of the Hanford Reservation residual contamination with regard to long-term exposures to radionuclides and related effects.

The technical approach employed to achieve the objectives was to focus review and analysis into two complementary parts. The results of these reviews and analyses were then combined with an evaluation of engineering and safety concerns to develop recommendations pertaining to the necessity and timing of Phase 1 cover emplacement.

> Part 1. Key technical reports relating to the Remedial Investigation (RI) and Feasibility Study (FS) for nonradiological constituents under MTCA, groundwater modeling supporting the Environmental Impact Statement (EIS) and associated radiological risk assessment (RRA), and other reports and analyses were reviewed to identify and critique key assumptions and methods.
>
> Part 2. The RRA was reviewed in parallel with these technical reports, again with the goal of identifying and critiquing key assumptions and methods. Information on radionuclide concentrations over time in different exposure media and radiation dose coefficients from the RRA were used in conjunction with exposure assumptions from the Yakama Nation risk model to compare risk results for the Yakama Nation and RRA Native American exposure scenarios.

2 Summary of Reports Reviewed

2.1 Review of Reports Addressing Impacts of Non-Radiological Contaminants

The reviewed reports that address the impacts of non-radiological contaminants include the Remedial Investigation (RI) Report (Vista, 2010) and Conceptual Site Model (CSM) (Vista 2013) as well as the Final Chemical Risk Assessment (Kirner 1999). The conclusions of the Kirner report with respect to little potential for groundwater contamination based on modeling from assumed trench inventories is inconsistent with Vista screening results indicating numerous chemicals present in groundwater at concentrations above screening criteria. A number of soil gas analytes were identified as being of potential concern in the Vista reports based on a screening of possible migration into buildings that may be constructed on the disposal site in the future.

2.1.1 Conceptual Site Model and Final Remedial Investigation Report

Environmental data for nonradiological contaminants were evaluated from seven groundwater monitoring wells (MW-3, MW-5, MW-8, MW-9, MW-9A, MW-10, and MW-13) installed at the US Ecology Site. In addition, data from 17 vapor monitoring points (CT-1/CT-2 and CT-3/CT-4; T-51/T-52 and T-53/T-54; VW-1 through VW-10; and VW-102 through VW-103) located around the trenches area to monitor for subsurface, volatile vapors were evaluated (Vista 2013). Soil data from 30 borings were reviewed to support the RI.

Soil, groundwater, and soil vapor data were evaluated in the RI Report by comparison of 95% upper confidence limits on the mean (95UCLs, methods adapted from EPA's ProUCL software) to MTCA screening criteria (Vista, 2010). Soil 95UCLs were compared to MTCA Method B (unrestricted use) screening levels computed using Equations 740-1 and 740-2 of Washington Administrative Code (WAC) 173-140-740. Soil 95UCLs were also screened against groundwater protection levels calculated with the three-phase partition model (Equation 747-1 of WAC 173-140-747). Groundwater 95UCLs were compared to EPA or Washington (WAC 246-290-310) maximum contaminant levels (MCLs), or risk-based values if an MCL was unavailable or insufficiently protective (MCL value results in a cancer risk $>10^{-5}$ or <1.0 [WAC 173-340-720(7)(b)]). Soil vapor 95UCLs were used as the basis for estimating indoor air concentrations using the EPA's Johnson and Ettinger soil gas screening model (SG-Screen v3.1) and these modeled concentrations were compared to unrestricted use levels computed based on WAC 173-340-750. An ecological screening was conducted by comparing 95UCLs to screening levels from WAC 173-340-900 Tables 749-3 and 749-5, EPA ecological soil screening levels , or values from Los Alamos National Laboratory's ECORISK database (in that hierarchy).

The following screening conclusions were provided in the RI (Vista 2010):

1. No soil analytes (0 to 4.6 m [15 ft] bgs) failed direct-contact screening to Method B levels.
2. No soil analytes (0 to 4.6 m [15 ft] bgs) failed screening to ecological levels.
3. Nitrate was the only soil analyte (0 to 4.6 m [15 ft] bgs) that failed the groundwater protection screen.
4. Hexavalent chromium, methylene chloride, nitrate, and nitrite (>4.6 m [15 ft] bgs) failed the groundwater protection screen.
5. 1,2-dichloroethane-d4, antimony, arsenic, bromofluorobenzene, fluoride, hexavalent chromium, molybdenum, nitrate, toluene-d8, trichloroethene, uranium, and vanadium failed the groundwater screening.
6. 1,1- dichloroethane, 1,3-butadiene, benzene, carbon tetrachloride, chloroform, cis-1,2-dichloroethene, dichlorofluoromethane, tetrachloroethene, and trichloroethene failed the soil vapor screening.

Section 5 of the CSM (Vista 2013) focuses on identifying key indicator hazardous substances (IHSs), defined in accordance with WAC 173-340-703 as excluding those that have a negligible contribution to human health or ecological risks. The following is a summary of these IHSs.

Trichloroethene. Trichloroethene is the most prevalent dense non-aqueous phase liquid (DNAPL) present at the US Ecology Site. TCE DNAPL potentially exists somewhere in the vadose zone near vapor monitoring well VW-1, but vapor monitoring wells do not penetrate deeper than 34 m (110 ft) bgs and the unconfined aquifer is approximately 90 m (300 ft) bgs. TCE concentrations in groundwater are greatest in groundwater monitoring well MW-3, nearest to vapor monitoring well VW-1, and groundwater monitoring well MW-5, nearest to groundwater monitoring well VW-2.

VOCs in Soil Vapor. Additional vapor intrusion modeling subsequent to the RI expanded the list of soil vapor target analytes exceeding MTCA B levels from 9 to 23. Following the process to identify IHSs, the following 15 VOCs were retained as soil vapor IHSs:

1,1,1-Trichloroethane	Dichlorodifluoromethane (Freon 12)
1,1-Dichloroethane	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)
1,1-Dichloroethene	Methylene chloride
Benzene	Phenol
Carbon disulfide	Tetrachloroethene
Carbon tetrachloride	Trichloroethene
Chloroform	Trichlorofluoromethane (Freon 11)
Cis-1,2-dichloroethene	

Soil IHSs. Among the four analytes identified as present at levels exceeding screening criteria related to groundwater protection, all but hexavalent chromium were eliminated based on detection frequency and (for nitrate) background considerations. However, a number of soil vapor IHSs were added as potential threats to groundwater, for this final list of soil IHSs:

1,1-Dichloroethane	Dichlorodifluoromethane (Freon 12)
Benzene	Hexavalent chromium
Carbon tetrachloride	Tetrachloroethene
Chloroform	Trichloroethene
Cis-1,2-dichloroethene	

Groundwater IHSs. Among the 12 identified as present at levels exceeding groundwater screening criteria, all but hexavalent chromium, chloroform, trichloroethene and vanadium were eliminated for reasons including potential hazard potential, detection frequency, or background considerations.

A schematic of the WDOH-preferred cover system is referenced to the Final EIS and shown as Figure 4-7 of the Draft B Focused Feasibility Study (FFS) (Kurion 2015). This figure indicates a minimal cover thickness of 4.8 m (15.75 ft), which presumably means that direct contact MTCA pathways for trench constituents did not need to be considered. This cover system with active soil vapor extraction was identified in the FFS as the preferred alternative for the Pre-1985 Trench Area Decision Unit (Kurion, 2015; Table 7-1).

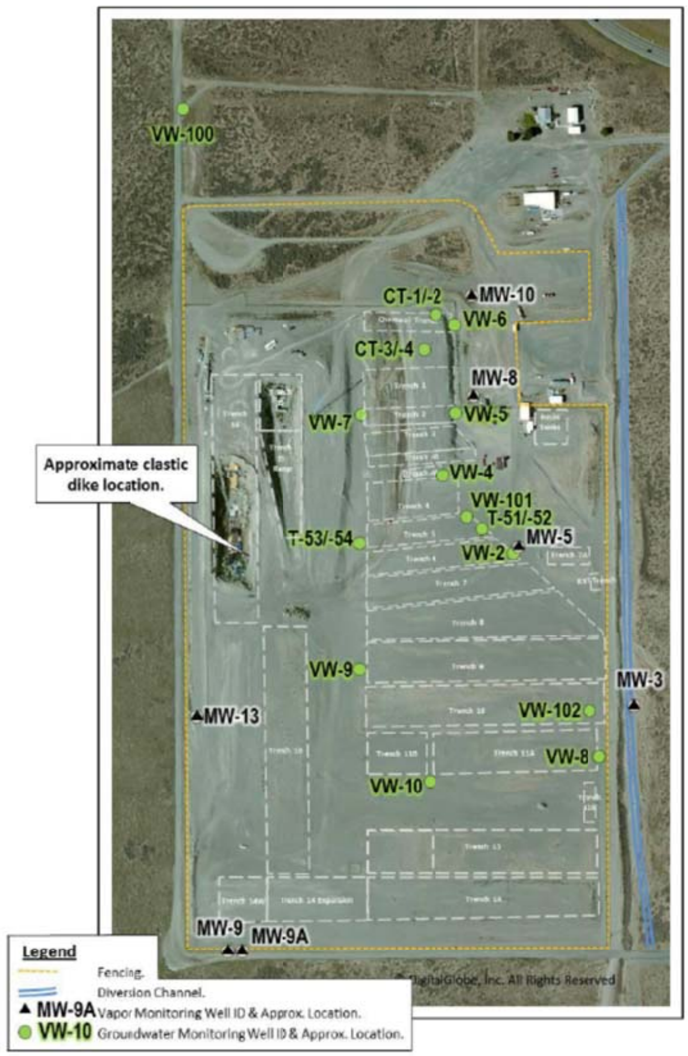

Figure 1-4. Vapor Monitoring Well and Groundwater Monitoring Well Site Plan.

Figure . Groundwater and vapor monitoring wells location figure from Vista CSM (2013)

2.1.2 Final Chemical Risk Assessment

Table A-5 of the *Final Chemical Risk Assessment* (Kirner 1999) summarizes the landfill trench concentrations that were used in this report to calculate risks subsequent to disposal of drill cuttings onto the ground surface. Groundwater pathway risks were calculated only for organic chemicals, not metals. Modeling of onsite groundwater well concentrations of organic chemicals is discussed in Appendix B. Groundwater exposure concentrations are shown in Table B-4. Kirner (1999) concludes the results of the modeling indicated that maximum organic chemical concentrations were below levels of concern.

Although Kirner (1999) states that the groundwater pathways pose negligible risks, this modeling result is apparently contradicted by the findings of the RI (Vista 2010) and CMS (Vista 2013). There are several organic and inorganic chemical groundwater COPCs identified by risk-based screening in the RI and CMS.

2.2 Nuclear Regulatory Commission Technical Evaluation Report

The NRC (2010) report focuses on two questions for which WDOH requested assistance from the NRC:

1. Did waste disposed during the period 1965 to 1980 meet Code of Federal Regulations Title 10 Part 61 (10 CFR 61) (and WAC 246-250) performance objectives even though it may have contained TRU in excess of 3.7 Bq/kg (100 nCi/g)?
2. What are the radiological worker health and safety risks if the waste is exhumed? This pertains to approximately 37,000 m^3 (1.3 million ft^3) of waste in the seven pre-Part 61 trenches (NRC notes in fact there are only six: Trenches 1 through 6).

NRC (12-10-2010 transmittal letter) concluded that there is reasonable assurance that the 10 CFR 61, Subpart C performance objectives can be met "for special nuclear material disposals authorized by the NRC between the years 1965 and 1980." Regarding the second question, NRC concluded that lack of information regarding waste content, packaging, and location in the trenches limits the ability to calculate worker risks. NRC further concluded that constructing an interim cover "is expected to significantly reduce future risks associated with radioactive releases from the disposal site." However, in the Executive Summary of the Technical Evaluation Report (NRC 2010), this conclusion is caveated as "Based on WDOH's risk assessment calculations…" so it does not appear to be an independent evaluation. In the ES of NRC (2010) NRC concludes that the benefits of waste exhumation are limited because WDOH's assessment indicates risk is primarily due to mobile (soluble) radionuclides that may already have migrated from the trenches.

Sections 2.2.18 and 2.2.19 (Site Stability) of NRC (2010) evaluated subsidence and differential settlement, and erosion and mass wasting. NRC notes that erosion was evaluated in Attachment M of the Closure Report. Water erosion was evaluated using the Universal Soil Loss Equation over a design life of 1,000 years, leading to a conclusion that "calculated average soil thickness loss … was less than 2 inches [5 cm]." Wind erosion was examined using the Wind Erosion Equation, leading to a conclusion that "calculated average soil thickness loss for the design life of 1,000 years was approximately 11 inches [28 cm].” However, both of these calculations are related to sheet erosion – there appears to be no evaluation of the possibility and consequences of gully erosion along the sides of the embankment.

The NRC report evaluated the modeling performed for the US Ecology site, but did not question the conceptual model implied by the modeling. For example, they did not question the assumption that all fate and transport is accounted for in the downward water advection transport pathway. To the contrary, NRC stated that “the methodology used in WDOH’s groundwater modeling and risk assessment are technically sound.” This conclusion appears to be focused on review of the specific hydrogeological modeling and associated risk models, but does not encompass certain key uncertainties. Specifically, NRC identified several key assumptions that bound the validity of the work, including:

- the inventory of key radionuclides is not greater than that assumed,
- the mobility of key radionuclides is not greater than that assumed,
- early (pre 10 CFR 61) waste disposals with less stringent controls on waste inventory, stability, and segregation, do not lead to greater potential for greater infiltration, leaching, or waste concentrations, and
- the engineered cover assumed for the modeling maintains its design performance.

If the modeling of the inventory is indeed sufficiently conservative (see comments in Section 2.3) then the first two of these may not be a problem. But the third issue, pertaining to the early waste disposals, could very well be a problem, as little is known about these wastes. The fourth issue about the cover performance is potentially of concern since naturalization of engineered covers is a known phenomenon and seems not to have been accounted for.

WDOH responded in an October 2012 letter to questions raised by the NRC. How uncertainty in the source term was addressed was the focus of the majority of NRC’s comments. A subset of the inventory comments relate to radium inventory and radon doses, but the majority were more general or focused on estimation of uranium and plutonium inventory. The gist of WDOH’s responses to general and uranium/plutonium inventory comments is that protective assumptions introduced in the groundwater pathway modeling assure that dose results are protective even in light of source term uncertainties. But as shown in Table 5.1.1 of the 2012 FEIS Addendum (Thatcher 2012), the groundwater pathway is dominant only for offsite receptors. For onsite receptors, either the drill cuttings or radon ground surface flux pathways dominate depending on the time frame. The proportions of total onsite dose contributed by the groundwater pathway over time (Thatcher, 2012) are:

100 – 500 y	27%
500 – 1K y	6.5%
1K – 5K y	14%
5K – 10K y	9.7%

The NRC reviewers evaluated the dose methodology used in the RRA and found it to be acceptable. They note that uncertainties in key exposure and dosimetry assumptions was evaluated, that various exposure scenarios were considered, and that probabilistic techniques were employed to support the analysis. NRC also notes that while differences between the rural resident and Native American dose results can largely be attributed to differences in exposure parameter values, that some pathways (such as fish ingestion) were not evaluated and should be considered in updates to the RRA.

NRC's two technical recommendations were: 1) that better transparency in the documentation of assumptions and inputs is needed, and, 2) that better conceptual and quantitative support for key modeling assumptions is needed. These recommendations are consistent with aspects of this review.

With respect to Recommendation 1, neither the 2003 RRA (Thatcher 2003) nor the 2012 FEIS Amendment (Thatcher 2012) provided tables for the specific radionuclide concentration inputs to the risk calculations (a matrix of radionuclide concentrations and model time for groundwater, drill cuttings waste inventory, and radium inventory) or a dose results matrix of pathways, radionuclides, and model time. Without the concentration inputs it is impossible to independently calculate or verify the risk assessment results. And without detailed outputs as described it is exceedingly difficult to determine the basis for any discrepancy between reported dose results and independent results. As discussed further in Section 3, organization and archiving of supporting technical materials for the RRA inputs, calculations, and results was discovered to be incomplete and attempts to recreate exposure concentration inputs and results matching summary tables in Thatcher (2012) were only partially successful.

Institute for Energy and Environmental Research (IEER) Comments on NRC Analysis

IEER's review of the NRC analysis raises several appropriate concerns, several of which are discussed elsewhere in this review. Specific points raised by IEER (2011) that should be considered in any future transport modeling and risk assessment, with notes reflecting these reviewers opinions, include:

- A rejection of the notion that the responsibility for environmental and health protection can be pushed onto future generations for the indefinite future by maintenance of institutional controls.
- "…no final conclusion is tenable without a definitive and reliable inventory estimate."
- NRC noted that the cover modeling reflects "intact conditions" only and that "[t]he same vegetative density and growth pattern was assumed for all covers and all time periods." An assumption that covers will remain functionally intact, other than a change in the rate of infiltration, for an indefinite period is unrealistic and is contrary to relevant research performed at the Hanford Reservation and elsewhere.

- The variation of moisture, porosity, and diffusion coefficients was not considered as part of the uncertainty analysis; further, the values used "may not be appropriate or conservative for all cover designs." (IEER quoting NRC). We note that this observation is consistent with the need for a comprehensive probabilistic analysis.
- The performance assessment did not consider the cumulative impacts due to existing contaminant plumes at Hanford, such as technetium and uranium plumes. Consideration of exposures related to fish consumption is especially important for the Yakama Nation in this context.

2.3 FOLAT Leaching and Transport Model Final Report and Evaluation of Closure Time on All-Pathways Doses for the US Ecology LLW Site

Rood (2003) documents a very basic screening-level model for first-order leaching of radionuclides into water, and limited contaminant transport. The leaching is standard, using the common basic linear instantaneous K_d–based leach model. The transport is limited to downward advection in the water phase in unsaturated media. For the purposes employed – a simple modeling of one-dimensional vadose zone flow – the model is appropriate and should function well. FOLAT has recently been superseded by MCM, which is a fresh implementation of the same underlying contaminant transport mathematics.

Rood (2012) documents calculations of groundwater concentrations resulting from radionuclides disposed at the US Ecology Site. The model addresses the downward flow of water in the unsaturated zone, and later flow in the saturated zone. As noted in Section 2.2 and discussed in more detail in Section 3, this is an inadequate conceptual model for supporting human exposures. Nonetheless, there are several issues that raise concerns to the point that the groundwater concentrations (and thence any human exposure or dose calculations based on groundwater concentrations) are questionable. The major concerns are presented here in bullet form:

- The inventory supplied to Rood by WDOH (pp. 7,8) was in the form of a few spreadsheets, then more to follow. There is no indication regarding the QA behind these spreadsheet inventories, and the revisions and additional spreadsheets appear indicative of a data management process in disarray. For example, "...in the original FOLAT calculations the wrong [plutonium] K_d value was used" (Rood 2012, p. 32). As another example, Section 6.1 of the 2012 FEIS Addendum (Thatcher 2012) states: "The estimated uranium 235 and 238 activities are now believed to be accurately reported. Uncertainties are not included for any source term input as it would be difficult to quantify and validate any isotope uncertainty generated." The modeling has to work with the information supplied, but there is no indication that the inventory information has undergone proper and traceable QA. The QA of the entire process, from data acquisition to modeling, should be documented and accessible to reviewers in a transparent manner rather than as a collection of spreadsheets, email logs, etc.

- The Phase I radionuclide screening (p. 9) using a half-life of 4.987 years is overly precise and appears arbitrary. The basis stated was to use 1/10 of the travel time of water from the waste to the water table, but the associated rationale was not explained or referenced.
- The conceptual model states clearly (p. 10) that “infiltrating water is the primary mechanism of radionuclide transport.” While that is understood in the use of this simple screening model, there is no basis for this statement. This again reflects the incomplete conceptual model for radionuclide fate and transport.
- The infiltration rate assumed for this modeling is a simple area-weighted average of the infiltration rates estimated for the covered part of the waste, and the uncovered part (p. 11). A better approach would have been to add the contributions from two distinct parts of the site, allowing the areas to change in a dynamic manner in time.
- The cover is assumed to naturalize at 500 yr (p. 13) but no basis or reference for this is provided.
- The calculations surrounding transport in groundwater from the US Ecology Site to the Columbia River (p. 15) appears inconsistent in that even though path lines for plume migration are provided, the distance to the river is assumed to be a straight line path.
- The porosity for the aquifer is assumed to be 0.1 (Table 3). This is an extremely small value for porosity in natural materials, especially for sediments underlying the Hanford Reservation. A more typical value for porosity of such materials would be 0.3, which would increase the travel time of a given volume of water by a factor of 3.
- The reported values for plutonium in groundwater (pp. 39,40) are possibly spurious. These values are close to the detection limit, and a proper statistical analysis should be performed in order to determine the likelihood that any plutonium exists in groundwater.
- The all-pathway dose conversion factor (DCF) distributions presented in Table 11 are extremely broad, and there is no information provided as to how they were derived. The distribution for thorium-230 (Th-230) is clearly in error, casting an unfavorable light on whatever quality assurance (QA) process may have been implemented in producing this analysis.

A significant conclusion of the groundwater modeling and risk evaluation, highlighted in Figure 3, is that that the timing of cover installation has little effect on groundwater doses for the period of time after assumed loss of institutional control.

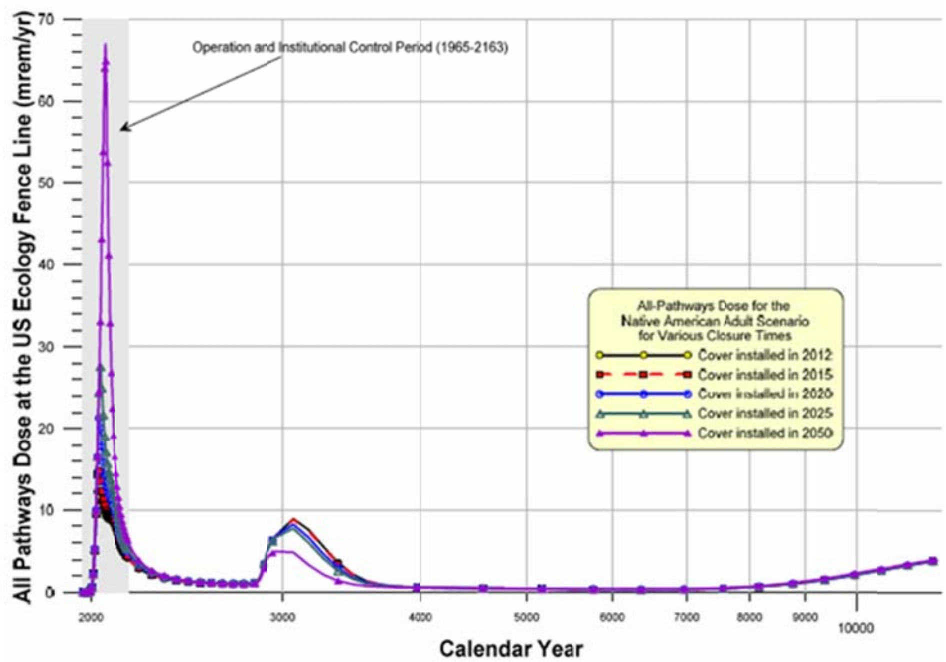

Figure 3. Impact of Phase 1 cover timing on groundwater dose (Rood 2012, Figure 13)

2.4 Construction Documents: Phase 1 Final Cover Design, Low-Level Radioactive Waste Facility

The construction drawings of DB Stephens and Assoc. and Dwyer Engineering (2010) were reviewed in order to evaluate 1) the implications of how installation of such a cover would impede MTCA remedial actions, or rather how the repair of such a cover would be problematic, and 2) the long-term fate of the cover. The latter is significant in that it is assumed in the modeling that the cover remains intact and retains as-built performance indefinitely.

On the first point, any cover can be dug up for the purposes of getting to waste below, but this cover design would be difficult to reconstruct, or “patched” in a discrete area. The challenge is in preserving continuity of material properties over the area of the cover. This is discussed in Section 5 of this review.

On the second point, it is possible that this cover design is over-engineered and that in an arid climate such as that found at the Hanford Reservation, the most effective cover for reducing infiltration may be a simple monofill cover that can support vegetation: an evapotranspirative (ET) cover. This type of cover will not inhibit the upward migration of moisture, as is found with covers containing HDPE layers. Layers that are impermeable to moisture tend to collect water below them, similar to a vapor barrier. Further, an ET cover made of native materials will not introduce uncertainty related to the change in its performance in time, since it is already in a naturalized state when constructed.

3 Review of Radiological Risk Assessment Modeling Assumptions, Methods, and Results

The task of comparing Yakama Nation risk model results with risk assessment results described in the *2012 Addendum to the Final EIS* (Thatcher 2012) rests on a critical review of the assumptions and methods employed in the radiological risk assessment (RRA) described in Thatcher (2012). The conceptual site model (CSM) that forms the basis of the RRA transport and dose calculations is shown in Figure 4.

The FEIS RRA was based on a source term that was calculated from disposal manifests, beginning in 1965 through 1996. It assumes that the disposal site inventory contains about 622 separate radionuclides. Radionuclides that were excluded from the source term for the groundwater pathways risk calculations include short-lived (≤ 5.5 year half-life) radionuclides and those of low activity (≤ 37 GBq, or 1 Ci, in 1996). Radionuclides included in the source term were not decayed prior to 1996, but considered decayed as of 1996 for all future projections of risk.

In Neptune's experience with performance assessment modeling of radiological waste disposal sites in the arid west, the groundwater transport pathway is commonly a minor contributor to all-pathways dose. And yet, in the current CSM, transport to groundwater and radon diffusion are the only natural processes evaluated. A fundamental flaw in the RRA is that the CSM is not based on an assessment of all possible features, events, and processes that could reasonably affect future exposure media concentrations.

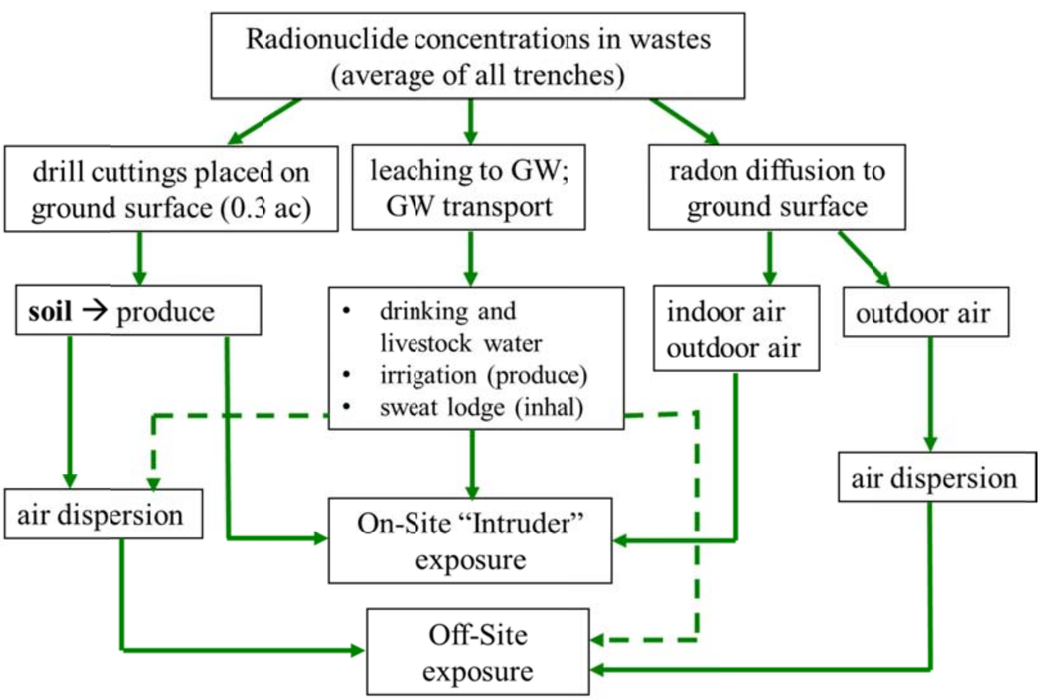

Figure 4: Final EIS conceptual site model

The following fate and transport pathways that were not evaluated in the RRA could potentially be significant in moving radionuclides in disposed wastes upward to the ground surface:

- Upwards diffusion in the water phase (more important the less the rate of advection).
- Deposition of Pb-210 and its progeny in the cover by radon decay along the air-phase diffusion gradient from disposed wastes to the ground surface.
- Plant uptake and translocation of radionuclides to the ground surface.
    - Section 4.4.2 of the Final EIS (2004) states, "The deepest burrowing animal was the harvest ant at 8.9 ft … The plant species with the greatest average maximum rooting depth is antelope bitterbrush at 9.7 feet." Because cover thickness is anticipated to exceed 15 ft, plant root and animal burrow pathways were eliminated. The highest *average* rooting depth alone is not an adequate basis for eliminating this pathway because individual deep-rooting plants may have roots penetrating the waste and even if plant roots do not get into the actual waste, they still occupy the cover layers above the waste, and these cover layers get contaminated from the abovementioned diffusive processes.
- animal burrowing, which brings contaminated cover materials (contaminated by upward diffusive processes) to the ground surface, and in general mixes the cover via bioturbation).
- The effects of gully erosion, which may impact both upwards pathways as well as localized infiltration rates. WDOH noted during the 23 Feb 2015 scoping meeting that the side slopes of the final cover could potentially be built at slope angles of 3:1 or 5:1, depending on location.

Given the processes bulleted above, contamination of the cover surface by natural processes may take place, so that ground surface soils become an exposure medium themselves (for external irradiation, as well as a source for contamination for crops and native plants, and a source of dust for atmospheric dispersion. None of this is captured in the current CSM.

Because only screening models were applied for the RRA the degree of "conservative" bias for each separate pathway is largely subjective and the performance of the disposal system as a whole is largely unexplored. All-pathways Native American adult doses described in Thatcher (2012) within 1,000 years reach approximately 100 mrem/yr (1 mSv/yr). This suggests that more accurate and defensible models should be developed to better understand disposal system behavior and exposures. Screening results cannot be used for benefit-cost types of decisions, such as whether the benefit (potentially lower future doses) of putting on the Phase I cover now outweighs the increased costs of sampling or remedial actions with it in place. In addition to incorporation of the neglected pathways itemized above, a system-level integrated model can be used to couple modeling of radon diffusion in the air phase with the hydrogeology modeling such that assumptions related to air-filled and water-filled porosity, tortuosity, and similar model attributes are consistent. Similarly, review of the radionuclide source term in *Source Term Documentation for Radiological Risk Analysis* (Thatcher and Elsen 1999) and updates in Thatcher and Elsen (2002) indicates that the evolution of the disposed wastes was not holistically modeled. The modelers evaluated the decay and ingrowth of individual radionuclides, but not how concentrations in the disposed wastes and cover will evolve due to transport pathways such as advection and diffusion.

The following list provides some discrete comments from review of the RRA.

- Thatcher (2003). Table 5.1.2: Lifetime cancer risk results are presented, but separate values are shown for children and adults, which makes no sense for this endpoint. The lack of summed values of lifetime cancer risk suggests a methodological error.

- Thatcher (2003). The radionuclides shown in Table 4.2.1 have concentrations that match draft EIS values rather than Final EIS (WDOH 2004) values (compare to Table 21 of Appendix IV).

- Thatcher (2003) Section 4.1. There is insufficient documentation of inventory to calculate waste source term concentrations for the drill cuttings and radon pathways. A time series of modeled exposure concentrations related to irrigation with groundwater (soil, garden produce, forage plants, animal products), and radon in air, is needed to calculate Yakama Nation scenario risks in a time-efficient manner. An analogous time series of concentrations related to mixing drill cuttings into soil is necessary to document the calculations narratively described in Section 4.3.3.

- Thatcher (2003). Since radon, groundwater and drill cuttings pathway risks are summed in the results tables, the waste source term in principle should be evolved with ingrowth and decay in an analogous manner for all of them. There is no detail beyond footnote 35 in Section 4.0 that addresses this. It does not appear that leaching of radionuclides from wastes for the groundwater pathway was accounted for in the source term used for modeling radon and drill cuttings pathway doses over time.

- Section 4.4.1.2 of the 2004 RRA indicates that outdoor radon concentrations are calculated from two sources: surface flux from buried waste and drill cuttings on the ground surface. It does not appear the modelers evaluated the possibility that subsequent receptors might build upon ground contaminated with cuttings from a prior inhabitation.

- Section 5.0.1 of the 2003 RRA Thatcher (2003) discusses assumptions regarding the depth of disposed radium-226 (Ra-226) in existing wastes and future wastes. The Draft EIS assumed homogenization of Ra-226activity in the entire waste volume, whereas the Final EIS (WDOH 2004) assigns Ra-226activity to discrete depth horizons and calculates separate radon dose for pre-2005 and post-2005 wastes. This is a step in the right direction, but it's also necessary to look at individual trenches when the endpoint is indoor radon dose if there is significant variation in depth and inventory among the different trenches. Variability among trenches may be very important source in understanding the range of potential future radon doses. This concern is extendable to dose calculations for the drill cuttings source term, which likewise uses an inventory averaged across all trenches.

- Section 5.0.1 of the 2012 FEIS Addendum (Thatcher 2012), 2nd paragraph, states that the solubility limit for the mobile fraction of Pu-239 was adjusted from the 2003 RRA groundwater modeling "due to the divergence of the predicted Pu-239 concentration as compared with the actual Pu-239 concentrations found in groundwater." Figure 5.1 of the Addendum (copied from Fig 17 of Rood, 2012), which plots predicted *vs.* measured Pu-239 groundwater concentrations, shows that measured Pu-239 concentrations between 1989 and 2011: 1) are below detection limits, and, 2) appear to vary at random around a value of 0 pCi/L with no indication of increase with time. As summarized below, the groundwater data after 2011 show increasing divergence from the modeled case as groundwater monitoring well measurements do not indicate the presence of plutonium.

For year 2013, the predicted Pu-239 groundwater concentration from Figure 5.1 (Thatcher 2012) is approximately 0.07 pCi/L. But Pu-239 groundwater measurements for calendar year 2013, described in the addendum to the 2013 Environmental Monitoring Report (US Ecology 2013; Tables 10-2, 10-5, 10-6; page 60 of 72 of the pdf), are: 1) clearly well below 0.07 pCi/L, 2) well below the current method detection limit of 0.01 pCi/L, and 3) indistinguishable from zero (units are pCi/L):

Well 3 avg: 0.0025	max error: 0.012
Well 5 avg: 0.00225	max error: 0.006
Well 8 avg: 0.0005	max error: 0.008
Well 9 avg: 0.001	max error: 0.005
Well 10 avg: 0.0	max error: 0.005
Well 13 avg: 0.0015	max error: 0.006

2014 groundwater monitoring data from Table 9.4 of the *2014 Environmental Monitoring Report* (US Ecology 2015) were reviewed after this report was forwarded by Earl Fordham (WDOH) following the August 6, 2015 second stakeholder meeting. Plutonium-238 and Pu-239/240 groundwater concentrations were not tabulated in this report; there is simply a statement that all measurements were below investigation levels, which is specified as 0.03 pCi/L for both Pu-238 and Pu-239/240 in Table 6.3. Figures 16 and 17 of Rood (2012) indicate that modeled groundwater concentrations of Pu-238 and Pu-239/240 in 2014 are approximately 0.14 pCi/L and 0.08 pCi/L, respectively.

Plutonium-239 groundwater measurements for 2015, evaluated from data provided in Excel file ‘USE CY 2014 GW Data.xlsx’ received via email from Earl Fordham, WDOH, on August 18, 2015 are indistinguishable from zero.

Exposure Assumptions

The general framework for the scenario used in the 2012 RRA (Thatcher 2012) was borrowed from the *Final Environmental Impact Statement for the Hanford Tank Waste Remediation System* (DOE/EIS-0189). The Native American is assumed to live offsite while using the surrounding area for a variety of the activities or live off-site and act as an intruder. The Native American scenario represents exposures received by an individual who engages in both traditional lifestyle activities (e.g., hunting, gathering plants, and using a sweat lodge) and contemporary lifestyle activities (e.g., using groundwater for drinking, showering, and irrigated farming). The individual is assumed to spend 365 days per year on the LLRW disposal site over a 70-year lifetime, although some activities are assumed to continue year-round, while others are limited by climate (e.g., frost-free days). The Native American adult is assumed to spend 1 hour/day in a sweat lodge, and an additional liter of water is consumed accordingly.

Exposure is not expected to begin until after the 107 years of institutional controls. Related to the assumption of effective controls is the assumption that short-lived radionuclides (with a half-life ≤ 5.5 years) do not contribute to exposure. As all waste depths are expected to be greater than 4.6 m (15 ft), the site (proposed trench cover depth of 5 m, or 16’4”) is deemed in compliance with the Department of Ecology regulations and no biotic intrusion (roots or burrowing animals) was assumed.

Exposure pathways (Thatcher 2012) include:

- ingestion of (drinking) groundwater (4 L/d),
- ingestion of vegetables and animal products,
- ingestion of soil (200 mg/d),
- external exposure to soil ,
- inhalation of re-suspended soil (i.e., fugitive dust),
- inhalation of water vapors in the sweat lodge, and
- ingestion and direct contact with buried waste by plants/animals.

Missing exposure pathways include:

- exposure to chemical substances,
- dermal contact (absorption) with groundwater and soil (other than tritium),
- ingestion of locally caught fish (a pathway of concern to the Yakama Nation),
- exposure to other off-site (Hanford) contamination (cumulative exposures), and
- exposure to Native American children.

4 Comparison of Yakama Nation and Final EIS Native American Scenarios

As shown in Figure 4, there are three exposure pathways evaluated in the Final EIS (2004) as well as the 2012 FEIS Addendum (Thatcher 2012):

1. leaching of radionuclides from waste and transport to a groundwater supply well, where the water has both domestic and agricultural (produce and livestock) uses,
2. contamination of surface soil with water well drill cuttings from a well drilled through the wastes, where the soil may form part of a home garden, and
3. radon diffusion from buried radium-containing wastes into indoor and outdoor air.

The Yakama Nation scenario was applied to the US Ecology Site following a similar CSM. However, the application of the Yakama Nation scenario included the addition of ingestion of meat from domestic poultry. A complete set of exposure pathways for the Yakama Nation scenario (RIDOLFI 2007) is shown in Table 1. Exposure from pathways not assessed would result in lower doses than application of the scenario to the rural residential setting described in the Final EIS CSM because radionuclide concentrations in these exposure media would be lower than those calculated in foods raised on soils affected by contaminated drill cuttings and grown using irrigation water from an adjacent groundwater well.

Table 1: Yakama Scenario application to the US Ecology Site

Exposure Media	Exposure Routes
Soil (irrigation and drill cuttings)	Inadvertent ingestion, external radiation, dust inhalation
Groundwater	Ingestion, watering livestock, inhalation in sweat lodge
Garden produce (irrigation, drill cuttings)	Ingestion
Domestic beef and milk (watering)	Ingestion
Poultry (soil; drill cuttings)	Ingestion
Game meat	Not assessed
Columbia River fish	Not assessed
Wild plants	Not assessed
River water, seeps, sediment	Not assessed

A comparison of the exposure parameter values employed in the Final EIS Native American scenario and the Yakama Nation scenario is shown in Table 2.

Table 2: Comparison of Final EIS and Yakama Nation scenario exposure parameter values

Exposure Parameter	units	YN	FEIS
Soil ingestion rate (adult / child)	mg/day	200 / 400	200 / 200
Exposure frequency	day/year	365	365
Inhalation rate (adult / child)	m^3/day	26 / 16	30 / 15
Drinking water ingestion rate (adult / child)	L/day	3 / 2	3 / 2
Fruit + vegetable ingestion rate[1] (adult / child)	g/day	1,417 / 314	574 / 314
Meat (beef) ingestion rate[2] (adult / child)	g/day	704 / 212	275 / 169
Milk ingestion rate[2] (adult / child)	L/day	1.2 / 0.5	0.49 / 0.85
Sweat lodge exposure frequency	hr/year	365 [3]	365
Sweat lodge water intake	L/event	1	1
Sweat lodge water use; steam	L/event	4	1.05
Sweat lodge inhalation rate	m^3/hr	1.08	1.2

[1] FEIS values pertain to locally-grown produce (assumed to be 62.5% of total).
[2] FEIS evaluated these pathways only for well water, not drill cuttings. Uptake in a localized area of drill cuttings contamination may be of particular relevance for poultry and eggs.
[3] Maximum daily is 7 hr/d; 1 hr/d applied for chronic exposure.

In order to calculate doses for the Yakama Nation scenario that are comparable to those described in Thatcher (2012) it is necessary to employ the same radionuclide concentrations in exposure media over time as well the same radiation dose coefficients for converting radiation exposure to effective dose. Although the dose coefficients are published and accessible, the radionuclide concentrations are specific to the inventory and models of the FEIS RRA. When a review of the FEIS reports and appendices revealed that the radionuclide exposure concentration information was not tabulated it was requested from WDOH. In March 2015, the following specific supporting information was requested:

- the time-series of modeled radionuclide groundwater concentrations supporting the dose results shown in Table 9 of Rood (2012),
- the time series of calculated radionuclide concentrations in each additional RRA exposure medium (garden soil, foods, air) calculated from these groundwater concentrations,
- the time series of radionuclide concentrations in the hypothetical well volume used for the drill cuttings pathways and the related concentrations in each additional exposure medium (garden soil, foods, air) calculated from these drill cuttings concentrations, and
- the time series of indoor and ambient air radon concentrations modeled from the disposed radium wastes.

This information was not documented and archived by WDOH in a manner that rendered it retrievable, and WDOH therefore engaged the author of the 2003 and 2012 RRAs (Andrew Thatcher) to provide this information. Again, the time series of radionuclide concentrations that were used to calculate the risk assessment results tabulated in Thatcher (2012) were not archived and retrievable. Over the course of approximately 8 to 10 weeks from May through early August 2015 dose calculation workbooks provided by Andrew Thatcher were reviewed and the inputs and result summaries for the Native American scenario compared to those documented in Thatcher (2012) for the groundwater, drill cuttings, and radon exposure pathways. The objective of this process was to recreate the specific inputs employed to calculate these results so that FEIS Native American and Yakama Nation risk results could be directly compared for specific exposure pathways as shown in Tables 4 and 5.

Ultimately, an exact match between the dose calculation workbook results and the results tabulated in Thatcher (2012) could only be achieved for the radon exposure pathway. The drill cuttings pathway dose results for the FEIS Native American scenario were slightly lower than the values provided in Table 5.1.1 of Thatcher (2012). As described in footnote 5 to Table 3, for model years other than 100 to 500 these differences between calculated drill cuttings pathway dose and doses shown in Thatcher (2012) were accommodated by adjusting the calculated doses so that parity between FEIS and Yakama Nation results was maintained.

The FEIS Native American groundwater pathway doses shown in Table 3 are overestimated by a factor of approximately 40% in comparison to the values presented in Thatcher (2012, Table 5.1.1). Based on personal communication with Andrew Thatcher, the reason for this is that the highest groundwater concentration for each individual radionuclide in each year range category was entered in the dose calculation workbook instead of the concentrations at the specific year when modeled doses were highest. Time and funding constraints did not allow for revision of the groundwater concentrations, but this error does not greatly affect a comparison of the relative risks between the FEIS Native American and Yakama Nation scenarios.

The reasons for differences between the Final EIS and Yakama Nation scenario adult dose results shown in Table 3 can be determined by more detailed evaluation of the groundwater pathway and drill cuttings pathway doses. The sweat lodge inhalation pathway dominates the groundwater-related doses (Table 4), and here the slightly higher inhalation rate values used in the Final EIS calculations (see Table 2) results in the slightly higher Final EIS groundwater doses. The Yakama Nation scenario doses for the drill cuttings pathways are generally higher than those calculated using the Final EIS Native American scenario (Table 5).

The differences in the dose results shown in Table 3 are insignificant relative to the FEIS conceptual model biases and uncertainties described in Section 3. Both the Final EIS Native American scenario and the Yakama Nation scenario represent a worst-case exposure condition where an individual resides above the disposed wastes and consumes foods grown with contaminated groundwater and soil. The more significant uncertainties are related to inventory estimates, and the modeling of radionuclide transport in the environment.

Table 3: Comparison of Final EIS and Yakama Nation scenario adult doses

	On-Site Exposure (mrem in a year)					
	<100	100-500	500-1,000	1,000-5,000	5,000-10,000	>10,000
GROUNDWATER PATHWAYS[1]						
FEIS Native	31	21	9.5	12	3.6	120
Yakama	33	19	10	12	8.0	120
DRILL CUTTINGS PATHWAYS[2]						
FEIS Native	na	37	(24) [5]	(24) [5]	(24) [5]	na
Yakama	na	51 [4]	(33) [5]	(33) [5]	(33) [5]	na
RADON PATHWAYS[3]						
FEIS Native	na	17	71	57	10	na
Yakama	na	17	71	57	10	na
ALL PATHWAYS COMBINED						
FEIS Native	na	75	105	93	38	na
Yakama	na	87	114	102	43	na

[1]Exact groundwater times are years 67, 100, 990, 1100, 9900 and 76000.
[2]Year 2056 inventory. Groundwater and drill cuttings doses are not fully additive.
[3]Both scenarios assume full-time exposure, 50% indoor/50% outdoor. 309.1 Ci Ra-226.
[4]Includes 5 mrem/yr from the home-raised poultry pathway.
[5]The value of 24 mrem/yr is adjusted from the value of 26 mrem/yr in Table 5.1.1 of the 2012 FEIS based on the ratio of the recalculated dose at 100-500 yr (37 mrem/yr) and the value shown in Table 5.1.1 (40 mrem/yr). The value of 33 mrem/yr is then estimated as: (24 mrem/yr / 37 mrem/yr) × 51 mrem/yr.

Table 4: Comparison of Final EIS and Yakama Nation scenario groundwater pathways doses

	<100	**100 -500**	**500-1,000**	**1,000-5,000**
FEIS NATIVE AMERICAN (mrem/yr)				
Drinking water	2.0	1.3	0.97	1.2
Produce	1.4	0.83	0.44	0.60
Livestock (beef)	0.098	0.084	0.11	0.15
Soil (ing, dust)	0.21	0.11	0.026	0.028
Sweat lodge, inh	27	16	8.0	9.6

YAKAMA SCENARIO (mrem/yr)				
Drinking water	2.0	1.3	0.97	1.2
Produce	7.1	4.1	2.2	2.9
Livestock (beef)	0.24	0.21	0.26	0.38
Soil (ing, dust)	0.20	0.10	0.023	0.026
Sweat lodge, inh	23	14	6.9	8.3

Table 5: Comparison of Final EIS and Yakama Nation scenario drill cuttings pathways doses

FEIS NATIVE AMERICAN (mrem/yr)	
Soil, external	22
Produce	0.061
Livestock	not assessed
Soil ingestion	1.9
Dust inhalation	13
YAKAMA SCENARIO (mrem/yr)	
Soil, external	32
Produce	0.49
Livestock (poultry meat)	(5)
Soil ingestion	3.2
Dust inhalation	11

Drill cuttings dose calculations employ an estimate of radionuclide concentrations averaged across all disposed wastes, with ingrowth and decay to year 2056.

5 Impact of the Phase 1 Cover on Conducting Future MTCA Work

This section describes our evaluation of the impact of the Phase I cover at the US Ecology commercial low-level radioactive waste disposal site on future MTCA investigations or remedial action work at the site.

5.1 Description of the Cover

The addition of the planned interim remedial action Phase I cover at the US Ecology site, although designed to reduce general exposure to wastes interred at the landfill, could impede additional MTCA investigatory or remedial actions at the site. Yakama Nation representatives have expressed the concern that "once more soil is placed on the site it isn't coming off," and that proper characterization of the trench inventory will be adversely affected by the additional costs imposed by disturbing the Phase I cover. This sentiment may reflect a benefit-cost consideration: When evaluating potential actions in the FS, any actions that involve excavation or other substantial disturbance of the Phase I cover will be disadvantaged due to the higher costs imposed by having to remove the cover and subsequently repair the liner and re-compact the earthen materials. Costs for MTCA actions would be expected to increase as you go from one or two new boreholes/wells to excavation to sample or remove some or all wastes in a trench.

The Phase I cover is intended to be a physical and chemical barrier isolating wastes buried in the landfill from the environment and surrounding area. The Phase I cover is designed to require compacted earthen materials that meet suitability requirements, a HDPE geomembrane barrier meeting sourcing and performance specifications, and a top layer of 2.5 feet or more of compacted soil above the geomembrane barrier. Recent modifications do not require vapor extraction piping within the cover system.

The isolation process proposed uses a geomembrane barrier to keep many volatile vapors, gases, and small particles inside the landfill and meteoric water from entering the waste-filled trenches and creating additional leachate that may enter the subsurface environment through the unlined landfill base. The geomembrane barrier is armored on the top and bottom by compacted engineered soils that protect the integrity of the barrier.

5.2 Consequences of Future MTCA Efforts

Additional MTCA investigatory or remedial actions may require the breach or removal of the cover system by drilling or trenching. These investigatory and remedial activities would be substantially more difficult to logistically initiate once the Phase I cover is installed and would require potentially extensive work to repair the geomembrane barrier and the surrounding engineered soils. Once the cover is breached, the earthen soils underlying the geotextile barrier would need to be replaced in the affected zones and re-compacted, and meeting the specifications required by the design in doing so would be challenging. HDPE geotextile repair procedures would require patching, welding, and testing according to manufacturers' guidelines and design specifications. Even so, repair work may not be completely successful and could potentially create areas of future weakness, differential settling, or preferential pathways for contaminants to migrate within and out of the landfill. Although HDPE membranes are repairable by sealing, depending on the age of the barrier when penetration occurs, the membrane could be more brittle than when initially installed. In addition, compaction of the underlying earthen materials to the same specification as when originally placed would be challenging if not infeasible since they would be implemented under different field construction conditions. Integration of such repairs within the boundaries of the opening or excavation may compromise the landfill integrity. As future MTCA actions become more intrusive or penetrate a larger area, relative costs of re-covering the landfill, compacting the soils, and repairing the geotextile liner will increase.

If the Phase I cover is initiated after completion of potential future MTCA investigations or remedial activities, it is likely that the cover system would create a longer-lasting and more stable environment for isolating the wastes. In addition, expenses related to repeated repair work, construction quality assurance, and integrity testing would be limited to construction and monitoring over the lifespan of the cover.

5.3 Liner Performance and Repair Limitations

Parameters that impact HDPE geomembrane performance include: exposure to oxygen or deletion of antioxidants, temperature, UV exposure, and irradiation. Overall, increased exposure to elevated temperatures (greater than 20 to 30 degrees C), oxygenated environments, and gamma/UV radiation generally cause increased aging and increased brittleness of the HDPE material used in landfill environments.

Aging of the geomembrane barrier due to landfill conditions may increase the likelihood that repairs to the Phase I cover system would compromise the overall liner integrity as the HDPE component of the cover system ages and becomes more brittle over time and with exposure to temperature changes, oxygen, and radiation. Partial removal and replacement, piercing by drilling, repair work (involving heavy equipment and welding), and barrier manipulation could compromise the cover system integrity and could increase the difficulty of detecting breaches. Repairs could be more extensive (as a result of landfill or waste conditions) when potential future MTCA investigation work penetrates or disturbs the constructed cap/cover system. Post-investigation work zones, and areas where the cap would be repaired, would require construction quality assurance oversight, inspection, and liner integrity testing to assure performance design specifications are met. These areas may have compromised integrity due to weakness caused by differential settlement of the landfill over time, and this could result in breaches or preferential pathways in the liner.

5.4 Worker and Public Health and Safety

Installation of a geomembrane barrier without the installation of a vapor control system could trap volatile organic compounds in the landfill trenches and allow these compounds to concentrate and migrate to lower concentration areas or zones of lower pressure. (It is uncertain when Washington Department of Ecology plans to construct vertical/angled extraction wells and if it will influence volatile organics within each trench.) Benzene, toluene, and xylenes have been detected in soil gas in and around the landfill and are probably components of wastes at the landfill. The potential for these gases and other volatile organic compounds to migrate along the geomembrane barrier could expose and introduce an increased health and safety risks to site workers as they access areas under the HDPE layer and those located along the travel path of migrating chemicals. Liner breaches during future potential MTCA investigations or remedial activities would also need to account for these exposures during work performed under the Phase I cover system.

Uncertainties related to the waste contents, package conditions, and disposal locations make calculating potential worker exposures difficult whether or not the Phase I cover is installed. However, the Phase I cover emplacement would likely restrict visual inspections of the waste and may result in physical confined space challenges should the cover need to be removed to investigate the waste. With respect to worker radiation dose related to MTCA investigations or remedial activities, such potential doses could reasonably be anticipated to decrease over time as short-lived radionuclides decay. Although the aforementioned uncertainties in radionuclide inventories, package conditions, and disposal locations will inevitably render estimation of worker dose reduction as a function of time highly uncertain as well, this largely affects worker doses in the near future. That is, while near-future worker doses from short-lived radionuclides are uncertain any such potential doses are reliably known to decrease with time as a function of the radionuclide half-life.

6 Comparison of US Ecology and Hanford Requirements

Central Plateau / Hanford

- Central Plateau Inner Area soil radionuclide remediation criteria for direct contact pathways calculated based on EPA's 10^{-6} to 10^{-4} Superfund risk range rather than an annual dose threshold.
- Central Plateau Inner Area soil chemical remediation criteria for direct contact pathways calculated based using MTCA methods (direct contact).
- Groundwater protection evaluation for both chemicals and radionuclides at the Hanford Site guided by the 'Graded Approach' document (DOE/RL-2011-50, Rev 1) and use of the Subsurface Transport Over Multiple Phases (STOMP) computer code.

US Ecology Site

- US Ecology radionuclide assessment employs the NRC 25-mrem/yr (0.25-mSv) threshold for all pathways, including direct contact and groundwater. An approximate equivalence for a 30-year exposure duration is 3E-04 ≈ 12 mrem/yr (EPA 2014), indicating that the NRC dose limit exceeds EPA's risk management range.
- MTCA groundwater protection for US Ecology evaluated using the MTCA three-phase partition model.

For radionuclides in groundwater, the US Ecology RRA applies the 25-mrem/yr (0.25-mSv) NRC all-pathways threshold whereas at Hanford radionuclide groundwater cleanup criteria for radionuclides other than uranium and radium-226/228 are calculated based on generic MCLs of 4 mrem/yr (beta/photon emitters) and 15 pCi/L (alpha emitters). These differences equate to an approximately 2- to 6-fold higher threshold of allowable groundwater concentrations for the US Ecology site. There is also an approximately 6-fold higher threshold for soil radionuclide concentrations for US Ecology using the upper end of EPA's risk management range as a target (25 mrem/yr ≈ 6×10^{-4} risk). Target risk-based soil radionuclide concentrations would be proportionally lower if applying a risk threshold lower than the 1×10^{-4}. Additionally, using an exposure duration equivalent to 70 years (RIDOLFI 2007) instead of 30 years would change the risk : dose equivalence to approximately 7×10^{-4} ≈ 12 mrem/yr, so that 25 mrem/yr equates to approximately 1×10^{-3} lifetime cancer risk. For these reasons, there is potentially significantly greater disparity between soil risk assessment targets than groundwater targets when comparing US Ecology RRA and Hanford values.

7 Discussion of Specific Additional Yakama Nation Concerns

Additional concerns have been raised by the Yakama Nation in a series of written comments forwarded to Neptune and RIDOLFI. Four concerns in particular were identified as particularly germane to the contract scope of work and objectives and included in a slide presentation presented at the August 6, 2015 second stakeholder meeting. In their comments related to these same slides, WDOH provided some response to these concerns, which are reproduced here with our additional comment.

1. What is the design life of the cover, how is it likely to fail, were the failure modes assessed and incorporated in the modeling? (*How will Ecology and the Department of Health be able to ensure and maintain the integrity of the barrier over a 20,000 year time period?*)

WDOH-Ecology comment: The Phase 1 cover is assumed to function only through the operational life of the US Ecology facility. The final cover scheduled for 2056 is expected to confine and protect allow in-situ decay processes for 500 years. Per the EIS, after the site closes in 2056, the property will be turned back over to the Federal Department of Energy and the final cover and boundaries will be maintained as part of the 200 area industrial site perpetual care and exclusion commitment by the US Government.

Reviewer comment: There are two issues at play here. First, the Yakama Nation position as understood by these reviewers and described in Section 1.2 is that exclusion from the 200 Area including the US Ecology site is an unacceptable mechanism of preventing exposures. Second, the ability of the US Government to ensure perpetual care on the order of millennia cannot be known.

2. Is there a plan to update the models as additional environmental data are acquired, particularly groundwater monitoring and the modeled near-term rise in plutonium concentrations?

WDOH-Ecology comment: As noted in the presentation, the modeled/forecasted increase in plutonium has not been supported by results from ongoing monitoring. This reinforces the question about the legitimacy of the sample that supposedly detected plutonium. Model updating could be used to justify removing plutonium as a material of concern.

Reviewer comment: The basis for removing plutonium as a material of concern must address the time frame for risk-based groundwater pathways decisions, since plutonium inventory that is not "mobile" may still reach groundwater in the more distant future. Additionally, per discussion in Section 3, the current risk assessment has not adequately addressed exposure pathways related to upwards migration of contaminants in the disposed wastes.

3. What is the rationale for ignoring ecological risk?

WDOH-Ecology comment: The final cover design and maintenance will be consistent with the other 200 area covers and the ecology will be protected to the same standard as anticipated for the 200 area.

Reviewer comment: This assurance appears to require at a minimum a comparative evaluation of the inventory, waste forms, and disposal depths of the US Ecology Site and the disposal systems alluded to in the WDOH-Ecology comment.

4. Why has no benefit-cost evaluation been done to evaluate the feasibility of characterizing and/or removing some wastes?

WDOH-Ecology comment: The MTCA cost estimates for waste excavation have been estimated to be in the range of $3.3 Billion to $11.8 Billion for targeted to complete removal. Determining the benefits of a removal investment would require additional modeling linked to each increment of cost; specifically how much one would choose to excavate or inversely what benefit could be achieved at each level of cost. Because of worker safety concerns, costs could also decrease over time as the radiological materials in the trenches decay.

Reviewer comment: Any such benefit-cost analysis would require a more accurate and defensible model of radionuclide inventory, release, and environmental transport over time than the screening models and associated assumptions that were the subject of this review.

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Appendix G. Links to Other Key Documents

1. *Final Environmental Impact Statement – Commercial Low-level Radioactive Waste Disposal Site (FEIS) –* http://www.doh.wa.gov/Portals/1/Documents/Pubs/320-031_vol1_w.pdf

2. *US Ecology Low-Level Radioactive Waste Disposal Site Remedial Investigation -* http://www.ecy.wa.gov/programs/nwp/llrw/llrw.htm