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The results of an ecological risk assessment screening at the Idaho National Engineering's waste area group 2

The Idaho National Engineering Laboratory (INEL) is a Department of Energy (DOE) facility located in southeastern Idaho (Figure 1) . The site occupies 2,300 km^2 (890 mi^2) on the northwestern portion of the eastern Snake River Plain in southeastern Idaho. It is nearly 63 km (39 mi) long from north to south and about 58 km (36 mi) wide in its broadest southern portion. Mountain ranges bordering the INEL on the north and west are the Lost River Range, the Lemhi Range, and the Bitterroot Range (see Figure 1). The INEL is surrounded by agricultural lands, U.S. Forest Service lands, and Bureau of Land Management lands managed as rangeland. Irrigated farmlands exist adjacent to approximately 25% of the INEL boundary. These areas also provide food and water resources for some INEL wildlife.

Intermittently flowing waters from the Big Lost River, the Little Lost River, and Birch Creek drainages flow onto the INEL. Water evaporates and infiltrates into the Snake River Plain Aquifer at the Big Lost Rivers Sinks. Much of the water is diverted for irrigation and power production before reaching the INEL and the rivers only flow onto the site when there is sufficient snowpack runoff. Nineteen ninety-three and now 1995 were the first years since 1986 that sufficient runoff existed for the Big Lost River to flow onto the INEL and this occurred for only a few weeks. Typically, waters from major drainages do not flow off the INEL.

The INEL and has been devoted to nuclear energy research and related activities since it's establishment in 1949. In the process of fulfilling this mission, wastes were generated, including radioactive and hazardous materials. Most materials were effectively treated, stored, or otherwise disposed of; however, some release of contaminants to the environment has occurred (DOE-ID 1994). For this reason, the INEL was listed was listed by U.S. Environmental Protection Agency (EPA) on the National Priorities List (NPL), November 21, 1989.

INEL hazardous waste sites have been systematically divided into smaller, more manageable waste areas groups (WAGs) to facilitate environmental remediation efforts. WAGs 1 through 9 generally correspond to INEL operational facilities. WAG 10 corresponds to overall concerns associated with the Snake River Plain Aquifer and those surface and subsurface areas are not included in the bounds of the facility-specific WAGs.

WAG 2, referred to as the Test Reactor Area (TRA), was established in the early 1950s. TRA is located in the southern central portion of the INEL as shown in Figure 1, and

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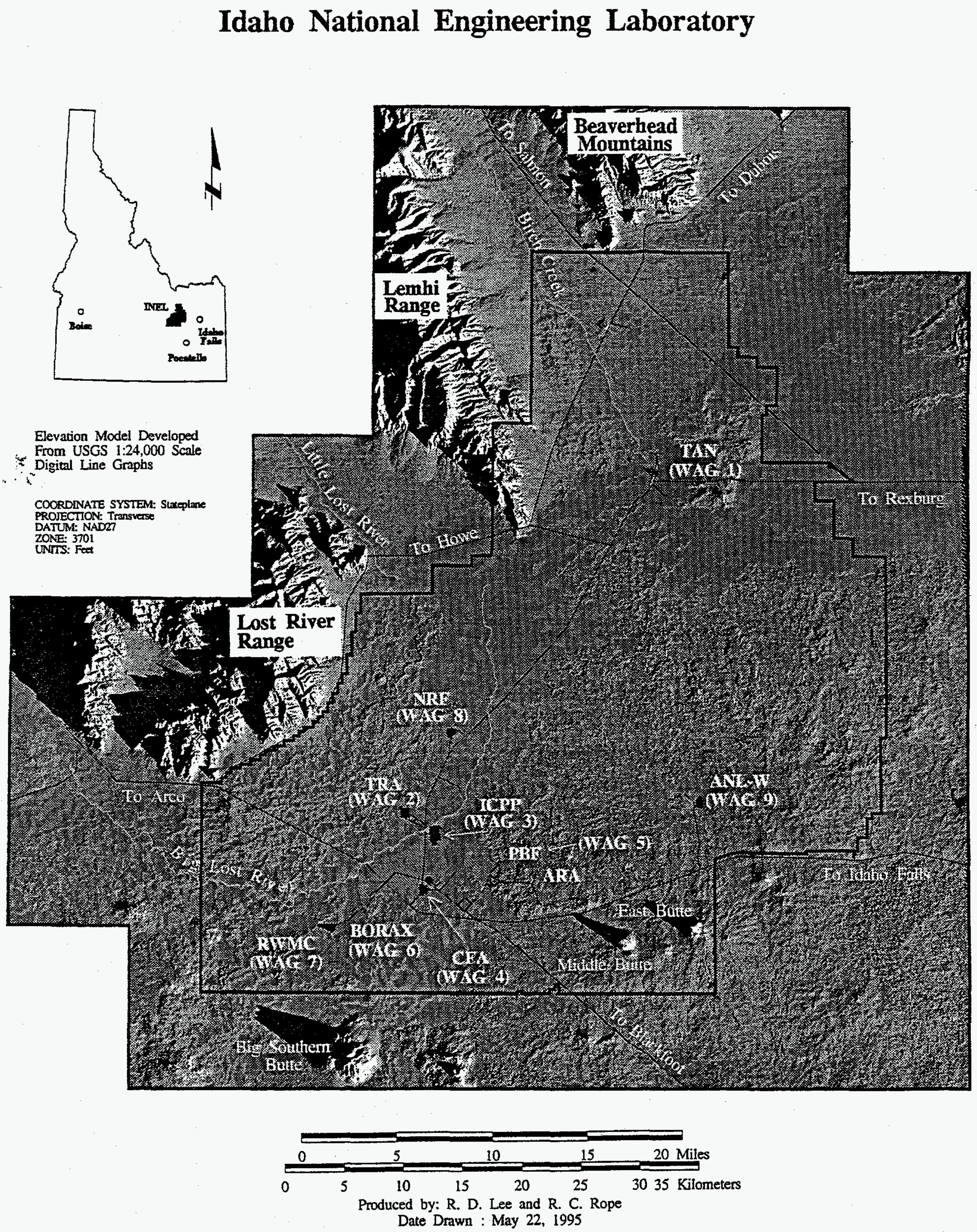

Figure 1-1. Waste area groups (WAGs) at the INEL.

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houses extensive facilities for studying the effects of radiation on materials, fuels, and equipment. Three major reactors have been built at TRA: the Materials Test Reactor (MTR), the Engineering Test Reactor (ETR), and the Advanced Test Reactor (ATR). The ATR is currently the only large operational reactor within TRA and is designed to produce a neutron flux that allows simulation of long-duration radiation effects on materials and fuels.

Ecological risk assessment (ERA) is "the evaluation of the likelihood that undesirable ecological effects may occur or are occurring as a result of exposure to one or more stressors (where "stressor" refers to any physical, chemical, or biological entity that can induce an adverse effect)" (EPA 1992). ERAs are often performed because human health risk assessments are not always adequately protective of ecological receptors (Hegner, 1994). As a first step in providing a consistent approach to ecological risk assessment at the INEL, the *Guidance Manual for Conducting Screening Level Ecological Risk Assessments at the INEL* (VanHorn et al. 1995), subsequently referred to as the Guidance Manual, was produced. The Guidance Manual approach emphasizes limiting the number of contaminants to be addressed in a baseline assessment, identifying those sites contributing to ecological risk, and producing comparable results for multiple assessments. This guidance was developed specifically for use at INEL for the performance of screening level ecological risk assessments (SLERAs), and may not be appropriate to other sites. This paper will summary the SLERA process and discuss the results for WAG 2.

SLERA Objectives

The objectives of the WAG 2 SLERA were to:

- Identify those contaminants of potential concern (COPCs) that may contribute to a potential ecological risk
- Identify those sites that contain levels of contamination contributing to this possible risk
- Indicate those sites for which additional data or monitoring is needed for performance of a more detailed ecological risk assessment (ERA) or finalization of the SLERA, if found to be a potential contributor to ecological risk through this initial screening process.

The SLERA methodology applied for this analysis involves a three step approach that parallels the EPA *Framework for Ecological Risk Assessment* (EPA 1992): problem

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formulation, screening analysis, and screening level evaluation. Each of these steps is discussed in this paper.

Problem Formulation

In the problem formulation step of this analysis, all potential contaminant stressors were characterized, the facility and ecosystem at risk were described, and previous investigations were reviewed and summarized. Descriptions for those sites identified in the FFA/CO (DOE-ID 1991), including all the operable units (OUs) and individual contaminated sites within each OU are presented. Those sites for which no contaminant source remains (e.g. remediated sites) and those for which no pathway to the terrestrial environment exists were eliminated in this step of the assessment. Only data from sites of potential concern were carried through the screening analysis and evaluation. The final list of 20 sites (out of 57) that were included in the analysis are discussed. Only 14 of these 20 sites of concern had data available for analysis.

The ecosystem characterization, began with the delineation of the WAG 2 assessment area. An area of potential contaminant influence, or assessment area, was defined using available contaminant sampling data and ecological rationale. Faunal species potentially occurring within this assessment area are representative of avian, mammalian, and reptilian species found across the INEL.

Threatened and endangered (T/E) species are of particular concern for the SLERA and are discussed in detail (INEL 1995). Those addressed in the WAG 2 SLERA include seven terrestrial species; the peregrine falcon (*Falco peregrinus*), bald eagle (*Haliaeetus leucocephalus*), ferruginous hawk (*Buteo regalis*), loggerhead shrike (*Lanius ludovicianus*), northern goshawk (*Accipiter gentilis*), pygmy rabbit (*Brachylagus idahoensis*), and Townsend's Western big-eared bat (*Plecotus townsendii*), and two aquatic species: the black tern (*Childonias niger*), and white-faced ibis (*Plegadis chihi*). No T/E plant species have been recorded inside the assessment area. These species were specifically analyzed as part of the SLERA.

WAG 2 contaminated media include subsurface and surface soil, surface water, and sediments. Contaminants were summarized using data collected for INEL human health risk assessments for sites of concern. At WAG 2, available data currently include only surface and subsurface soil, and surface water sampling. Contaminants sampled for these media include nonradiological (organics and inorganics) and radionuclides. A five step screening process was performed to identify contaminants in surface and subsurface soils. This process reduced the number of nonradiological contaminants that were assessed from 239 to 25 for surface soil and 194 to 27 for subsurface soil pathways. None of the 16 radionuclides identified as present in surface or subsurface soil at WAG 2 were eliminated. These are summarized in Table 1. The arithmetic mean of each contaminant retained in the assessment was used calculated across the WAG for used in the screening analysis (VanHorn et al 1995). All of the available surface water data was screened against existing ambient water quality criteria or sediment quality benchmarks as necessary.

The contaminated media have potential for posing risk to WAG 2 ecological components through various direct and indirect pathways. A pathway analysis, was performed for the sites of concern. An analysis for each medium was used to determine those functional groups and T/E species that were directly and indirectly exposed to potential contamination (receptors). Contaminated surface and subsurface soil represent the major sources of possible contaminant exposure for WAG 2 ecological components. Seven sites of concern contain surface soil contamination, and 10 contain subsurface soil contamination. Three sites that may contain standing water were evaluated in the assessment. Of these three sites, only the Cold Waste Disposal Pond has standing water of a duration that represents a potential for receptor exposure to contaminants. The other two sites were assessed as sources of soil contamination.

Based on this information, assessment and measurement endpoints were developed. The endpoints were developed around the protection of the INEL biota represented by grouped ecological components (functional groups) (VanHorn et al. 1995) and individual T/E and sensitive species known to exist at WAG 2 and identified as having potential for exposure to contaminants. Assessment endpoints include no indication of possible effects to WAG 2 T/E individuals and populations, native vegetation, and wildlife populations (represented by functional groups) as a result of contaminant exposure (i.e, the SLQs are less than 1 for nonradionuclides and 0.1 for radionuclides).

Screening Analysis

The screening analysis phase of the WAG 2 SLERA evaluated exposure of receptors to contaminants and potential effects of that exposure. The evaluations were conducted interactively to ensure that the methods were compatible.

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Table 1. WAG 2 soil contaminants and screening level quotients (SLQs).

	Surface Soil			Subsurface Soil		
Nonradionuclides	FOD	Mean concentration[a] (mg/kg)	SLQ	FOD	Mean concentration[a] (mg/kg)	SLQ
1,1,2,2-Tetrachloroethane	Eliminated[b]			2/35 (6%)	1.5	>1
2,4,6-Tribromophenol	1/1 (100%)	1,700	na[c]	Eliminated		
3-Hexene-2,5-dione	2/2 (100%)	900	na	Eliminated		
4-Chloroaniline	2/13 (15%)	77	>1	Eliminated		
4-(2,2,3,3-tetramethphenol)	1/1 (100%)	1,100	na	Eliminated		
Acetone	Eliminated			6/35 (17%)	5.5	<1
Antimony	7/37 (15%)	5.1	>1	3/15 (20%)	2.3	>1
Arsenic	20/46 (43%)	5.4	>1	12/15 (80%)	7.1	>1
Barium	46/46 (100%)	1,000	>1	15/15 (100%)	220	>1
Benzo(b)fluoranthene	Eliminated			3/44 (7%)	19	>1
Bis(2-Ethylhexyl)phthalate	11/16 (69%)	730	>1	23/42 (55%)	120	<1
Butylbenzylphthalate	11/13 (85%)	110	>1	4/44 (9%)	19	>1
Chromium	55/55 (100%)	100	>1	23/31 (74%)	90	>1
Chromium (+6)	8/9 (89%)	0.27	>1	5/15 (33%)	0.37	>1
Chyrene	Eliminated			3/44 (7%)	18	>1
Di-n-butylphthalate	9/13 (69%)	44	>1	8/44 (18%)	14	<1
Di-n-octylphthate	1/13 (8%)	54	>1	Eliminated		
Fluoranthene	2/13 (15%)	54	>1	5/44 (11%)	15	>1
Hexadecanoic acid	7/7 (100%)	1,500	na	5/5 (100%)	1,800	na
Isocyanomethane	Eliminated			2/2 (100%)	13	na
Lead	72/72 (100%)	430	>1	14/14 (100%)	29	>1
Mercury	40/45 (89%)	25	>1	10/16 (63%)	2.2	>1
Methylene chloride	5/32 (16%)	0.01	>1	Eliminated		
Octodecanoic acid	1/1 (100%)	17	na	Eliminated		
Nonylphenol	1/1 (100%)	2,300	>1	Eliminated		
PCBs	Eliminated			3/3 (100%)	21	>1
Pyrene	2/13 (15%)	54	>1	5/44 (11%)	15	<1
Selenium	14/46 (30%)	4.4	>1	1/15 (7%)	1.9	>1
Silver	38/46 (83%)	4.1	>1	8/16 (50%)	3.3	>1
Strontium	30/30 (100%)	130	>1	3/3 (100%)	53	>1
Sulfor Mol (58)	Eliminated			26/26 (100%)	590	>1
Thallium	Eliminated			2/16 (13%)	2.3	>1
Tin	5/30 (17%)	3.3	>1	Eliminated		>1
Toluene	Eliminated			8/34 (24%)	1.8	<1
Vanadium	Eliminated			16/16 (100%)	23	>1
Zinc	Eliminated			10/16 (63%)	87	>1

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Table 1. Continued.

	Surface Soil				Subsurface Soil			
			SLQ				SLQ	
Radionuclides	FOD	pCi/g	Internal	External	FOD	pCi/g	Internal	External
Am-241	7/37 (19%)	110	>1	<1	27/49 (55%)	7.8	<1	<1
Cm-244	Not detected				26/40 (65%)	4.9	<1	>1
Co-60	16/16 (100%)	66	<1	>1	6/6 (100%)	2.7	<1	<1
Cs-134	2/2 (100%)	1,700	>1	>1	2/2 (100%)	1,700	>1	>1
Cs-137	34/34 (100%)	970	>1	>1	8/8 (100%)	2,400	>1	>1
Eu-152	29/29 (100%)	980	>1	>1	2/2 (100%)	23	<1	<1
Eu-154	9/9 (100%)	150	<1	>1	2/2 (100%)	0.83	<1	<1
Eu-155	3/3 (100%)	19	<1	<1	1/1 (100%)	0.37	<1	<1
Pu-238	1/3 (33%)	0.58	<1	<1	28/42 (67%)	4.7	<1	<1
Pu-239	8/34 (24%)	0.31	<1	<1	29/48 (60%)	12	<1	<1
Sr-90	10/10 (100%)	7,800	>1	<1	35/45 (78%)	220	>1	<1
Th-228	33/33 (100%)	1.7	<1	<1	6/6 (100%)	1.4	<1	<1
Th-232	33/33 (100%)	1.6	<1	<1	6/6 (100%)	1.4	<1	<1
Th-230/U-234	32/32 (100%)	2.7	<1	<1	5/5 (100%)	2.3	<1	<1
U-234	3/3 (100%)	5.6	<1	<1	44/44 (100%)	2.1	<1	<1
U-238	35/36 (97%)	1.2	<1	<1	Not detected			

a. Nondetect values were assumed to be equal to one-half the detection limit. Samples with "X" flag were not included in calculation of mean values.
b. Contaminant was eliminated based on screening from this medium
c. na- not assessed, generally because the contaminant did not have a toxicity reference value developed

A hazard evaluation was performed that involved a comprehensive review of toxicity data for nonradiological contaminants to identify the nature and severity of toxic properties, especially with respect to members of functional groups. Dose-response assessment was used to estimate the amount of chemical exposure that may result in adverse ecological effects. Because no dose-based toxicological criteria exist for ecological receptors, appropriate toxicity reference values (TRVs) for the contaminant/functional group combinations at the INEL. TRVs values, determined to be protective of ecosystem populations by the IAEA (IAEA 1992), were used to assess the potential impact from radiological contaminants (VanHorn et al. 1995). T/E species, due to their sensitivity, were assessed using half the TRV developed for their associated functional group.

Basic exposure factors were developed for each of the functional groups and T/E species. Species-specific numerical exposure factors including body weight, ingestion rate,

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and fraction of diet composed of vegetation or prey, and soil consumed were determined for each species within the functional group. For each functional group, the most conservative parameters were used in the assessment; including the maximum percent soil ingested, exposure duration, site use factor, and ingestion rate, and the minimum home range and body weight.

Ecologically based screening levels (EBSLs) for contaminants in surface and subsurface soils at the INEL were developed using the TRVs and basic functional group exposure factors (VanHorn et al. 1995). EBSLs are ecologically-based target concentrations of contaminants in soil (or other media) derived from site-specific exposure scenarios for relevant ecological receptors. EBSLs were then used to interpret analysis results as discussed in the screening level evaluation.

Screening Level Evaluation

The screening level evaluation determines whether there is any indication of risk due to the contaminant concentrations. Exposure parameters and TRVs were used to calculate EBSLs for each functional group as described previously. Screening Level Quotients (SLQs) were then calculated by dividing the average concentration of contaminant in the contaminated media by the EBSL.

The results of the SLQ assessment for WAG 2 contaminants are summarized in Table 1. If the average concentration of a contaminant in the medium of interest did not exceed its minimum EBSL (i.e., SLQs are less than 1 for nonradionuclides and 0.1 for radionuclides), adverse effects from receptor exposure to that chemical are not expected, and no further evaluation of that contaminant is required. Hence, the SLQ is an indicator of risk.

Of the nonradionuclide contaminants identified in the problem formulation, methylene chloride for surface soil and 1,1,2,2-tetrachloroethane, di-n-butylphthalate, fluoranthene, pyrene, and toluene for subsurface soil are **not** likely to cause adverse effects to the exposed individuals. Chromium III appears to pose potential risk to plants due to both surface and subsurface soil exposure. Subsurface and surface concentrations of antimony and butylbenzylphthalate also exceed the SLQ target value (1).

Several radionuclides assessed appear likely to cause adverse effects to the populations of exposed functional groups and T/E species for both internal and external doses (i.e., SLQs

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are greater than 0.1). These include Co-60, Cs-134, Cs-137, Eu-152, and Eu-155 due to external dose and Am-241, Cs-134, Cs-137, Eu-152, and Sr-90 for internal dose. Since there is some evidence that radionuclides may have unusual bioconcentration mechanisms (e.g. carnivory, or consumption of certain plants) (IAEA 1992) for cesium this will need to be looked at in greater detail. See Table 1 for a summary of these results.

The screening of the sediment and surface water contamination indicates that cadmium, mercury and silver exceed the sediment quality benchmarks and should be assessed in the ERA. There is also some sampling that indicate the presence of radionuclides in the sediment sampling and this contamination will also be assessed in the ERA.

SLERA Summary and Conclusion

The screening process identified the number of sites of concern (20 out of 57). The contaminants sampling from these sites were then initially screened to eliminate nondetects, low frequency detects, and essential elements. This process reduced the number of contaminants in the SLERA from 239 to 25 for surface soil and from 194 to 27 for subsurface soil nonradionuclides.

TRVs could be developed for only 28 out of 36 nonradiological contaminants. Very conservative assumptions were applied in assessing these contaminants and those ecological receptors having highest potential for being adversely affected as a result of exposure to the contaminants. Using this methodology, SLERA endpoints were not attained for nonradionuclide contaminants. For the nonradionuclide soil contaminants, at least 1 functional group or T/E species had an SLQ greater than 1.0 for all of the 19 assessed for surface soils and 20 out of the 25 assessed for subsurface soil.

All radiological contaminant were assessed based on the values, determined to be protective of ecosystem populations by the IAEA (IAEA 1992). Very conservative assumptions concerning exposure were also used in the assessment of the radiological contaminants. Using this methodology, SLERA endpoints were not attained for all radiological contaminants. For the radionuclide soil contaminants, at least 1 functional group or T/E species had an SLQ greater than 0.1 for 7 out of the 16 contaminants assessed.

Subsequent ERA efforts will be focused on those WAG 2 contaminants and sites that have been shown to be potential contributors to ecological risk. Additional site contaminant

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data for previously uncharacterized WAG 2 sites must be incorporated as data collection is finalized.

The SLERA process overall provides a detail and comphrensive discussion of the ecosystem at risk during the problem formulation. It complies and summarizes available ecological data. It also complies, summarizes and adapts the sampling done during the human health risk assessment activities for use in the assessment process. As a result of this process data gaps are identified and discussed, focusing resultant ecological efforts.

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