A GUIDE TO SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

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This paper has been technically reviewed and endorsed by the Tri-Service Environmental Risk Assessment Working Group for use by Army, Navy, and Air Force Personnel

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A Note to readers:

Consensus following a peer review of risk assessments at several U.S. military installations revealed significant inconsistencies in approach to ecological risk assessments. Therefore, a need was identified to provide more specific information for the scoping and development of screening level ecological risk assessments. This document is intended to serve as guidance to those involved in scoping, planning and conducting ecological risk assessments at U.S. military installations. This document was written, developed, and reviewed consistent with applicable military regulations (e.g. AR 200-1), policy (e.g. US Navy 1999), and U.S. Environmental Protection Agency guidance.

This document was initially developed through the U.S. Army Biological Technical Assistance Group (BTAG). This document was subsequently reviewed and found consistent with the risk assessment procedures and guidance of the Navy and Air Force through the Tri-Services Environmental Risk Assessment Work Group (TSERAWG). The authors of this document are Mr. Andrew Rak, USACE Baltimore District, Ms. Mary Ellen Maly, USAEC, and Dr. Greg Tracey, SAIC. Technical reviewers are Mr. Terry Walker, USACE HTRW-CX, Dr. Brandolyn Thran, USACHPPM, Ms. Laurie Haines, USAEC, and Dr. Mark S. Johnson (USACHPPM).

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A GUIDE TO SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

1.0 Introduction.

This document was prepared to aid remedial project managers (RPMs) in understanding and executing screening-level ecological risk assessments (SLERAs) at hazardous waste sites. The SLERA process described here is consistent with the USEPA's *Ecological Risk Assessment Guidance for Superfund* (ERAGS)*: Process for Designing and Conducting Ecological Risk Assessments* (USEPA 1997), written for application within the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program. ERAGS is appropriate for Installation Restoration Program (IRP) sites, Base Realignment and Closure (BRAC) sites, and Formerly Used Defense Sites (FUDS), and may also be applied to corrective action sites investigated under the Resource Conservation and Recovery Act (RCRA); hereafter referred to as "sites".

While there is guidance available regarding the general ecological risk assessment (ERA) process (Wentsel et al. 1994, USEPA 1997, 1998), little specific guidance for preparation of a SLERA is available. Therefore, the purpose of this document is to present an overview as to how to prepare a SLERA in a manner that is both understandable to the DoD RPM and useful for facilitating risk communication between the Services, the regulatory community, and the public.

1.1 Overview of Screening-Level Ecological Risk Assessment.

The ERA process is used to evaluate potential hazards to the environment that are attributable to chemical releases from site-related activities. The process is generally divided into two tiers, the SLERA and the Baseline ERA (BERA).

The USEPA (1997) defines the SLERA process as follows:
"A simplified risk assessment that can be conducted with limited data; where site-specific information is lacking, assumed values should consistently be biased in the direction of overestimating risk… The need for conservatism is to provide a defensible conclusion that negligible ecological risk exists or that certain contaminants and exposure pathways can be eliminated from consideration".

The SLERA is generally meant to be a simple desktop analysis to eliminate substances or even sites from further consideration. This occurs through a relatively cost/time efficient effort that requires very limited data from the site and relies heavily on other (e.g., literature) information. Since by definition the SLERA is designed to be cost and time efficient, using limited site data, assumptions and parameters used in the exposure models are heavily biased to reduce the probability of incorrectly eliminating substances from further consideration.

Often the only site data that are used in the SLERA are media-specific chemical concentrations. The amount of data available for the SLERA depends on the degree of site characterization and the type of data that has been collected. The SLERA is designed for implementation at the initial stages of investigation, typically during the Site Inspection (SI).

The SLERA may help eliminate pathways of exposure (e.g., soil ingestion), foraging guilds (e.g. small mammalian herbivores), and even entire sites (yet in practice this is rare given the biased approach that is used). Since organisms of concern (i.e., Assessment Endpoints) have not yet been defined, and since a biased screening-level approach is used to estimate exposure, remedial decisions should ***not*** be made based upon the outcome of the SLERA. The SLERA's most valuable function is to refine the larger list of substances into a more defined list of Chemicals of Potential Ecological Concern (COPECs). The SLERA can also help define which receptors and pathways to those receptors that will be evaluated in the BERA, and function to rank the relative importance of specific substances.

1.2 Available Background Documents.

The foundation for the present ERA approach was presented in the *Framework for Ecological Risk Assessment* (USEPA 1992a), which was superseded by the *Guidelines for Ecological Risk Assessment* (USEPA 1998). The most recent procedural guidance is contained in ERAGS (USEPA 1997). ERAGS prescribes an 8-step process, the first two steps constituting the SLERA. The reader is also directed to *The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments* (USEPA 2001b) for additional discussion on how the SLERA is applied in the CERCLA process.

The Department of Defense (DoD) Tri-Services Ecological Risk Assessment Work Group has also produced ERA guidance generally following ERAGS protocols. The *Tri-Service Procedural Guidelines for Ecological Risk Assessments* (Wentsel et al. 1996) preceded ERAGS but advocated the same 8-step process. The *Tri-Service Remedial Project Manager's Technical Handbook for Ecological Risk Assessment* (Simini et al. 2000) provides the RPM with information to ensure the ERA stays focused while being timely and cost-effective.

The guidance documents cited above generally focus on the preparation and implementation of the BERA while qualified detailed guidance for conduct of the SLERA is generally lacking.

2.0 Planning for the SLERA.

The Army BTAG has prepared a technical document specifically for planning an ERA (USA BTAG 2002a). This document applies the U.S. Army Corps of Engineers (USACE) Technical Project Planning (TPP) guidance (USACE 1998). The TPP process assists in establishing the focus of the risk assessment and in determining data needs. The process also stresses early engagement of all stakeholders. Additional information relative to planning and stakeholder involvement throughout the entire ERA process is discussed in the Presidential/Congressional Commission's report on risk assessment and risk management (PCRARM 1997).

Site-specific technical assistance with planning for a SLERA can be obtained through the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM)(http://chppm-www.apgea.army.mil/), the USACE Environmental and Munitions Center of Expertise (EM CX) (http://www.environmental.usace.army.mil/) and/or the Army BTAG (http://aec.army.mil/usaec/cleanup/btag00.html).

2.1 Managing the Ecological Risk Assessment

At most military sites, the ERA will be performed by a contractor either directly for the installation or through an executing agency. In this case, the role of the RPM at the installation will be to provide direction to and oversight of the contractor, usually with the assistance of a technical support staff. This section of the report provides details on the items that an installation-level or service center RPM may need to complete or review to ensure that the SLERA will meet the needs of the installation's environmental restoration program.

2.1.1 Statements of Work

There are two existing guidance documents for writing a statement of work (SOW) for an ERA (USEPA 1992d, USACE 2002). Both documents emphasize a phased approach to the implementation of the ERA.

For most sites, a phased approach with expert review at each phase results in the most efficient use of resources. With the phased data approach, evaluation of data from one phase determines whether further information is needed to meet the assessment's objectives. At some sites, the phased approach might result in a low level of effort adequately characterizing ecological risks. At others, the phased approach might indicate that the assessment should be expanded to include studies of specific habitats or contaminants in order to evaluate the risks. At still other sites, the phased approach could identify areas originally not considered at risk. In this case, the DoD RPM would want to expand the work scope to include an assessment of the newly identified area. Review of interim products, such as a report on the levels of contaminants of concern or a field survey of resident species, can contribute to the phased approach. Careful review of interim products can help to ensure that the assessment remains focused on those projects most important for evaluating the site's ecological effects.

Additionally other mechanisms that are performance-based may be applicable particularly in this application (e.g. performance-based contracting). However, scopes of work must be specific in regards to end product.

2.1.2 Independent Government Cost Estimates

An independent government estimate (IGE) of the cost of the SLERA is required as part of the contracting process, if the total cost of the SLERA is expected to exceed $25K. Most SLERAs

will cost more than this threshold and therefore an IGE is almost always necessary. The level of detail for the IGE is dependent on the type of the contract vehicle and the requirements of the contracting officer. The total cost for the SLERA is directly proportional to the amount of data available for review and assimilation. The tasks in the IGE should be based on those listed in the SOW. A SLERA for a simple to moderately complex site should require between 200 to 500 hours depending on the data collection needs and the amount of available data, plus project management and any sampling/analysis requirements. More information can be found at the Federal Acquisition Regulation, Part 37, Subpart 37.6 (http://farsite.hill.af.mil/reghtml/regs/far2afmcfars/fardfars/far/37.htm).

2.1.3 Contract Vehicles

There are three main types of contract vehicles that seem appropriate for the SLERA, time and materials, firm-fixed price, and cost plus. The SLERA may be one of many deliver orders issued under a given particular contract vehicle. The type of the contract vehicle may be selected by the installation, USACE District, or other contracting center.

Because of the defined nature of the SLERA, the firm-fixed price type of contract is the most appropriate for simple to moderately complex sites. For sites that are very complex due to the nature of the contamination, number of receptors, or because of the presence of multiple threatened and endangered species, a time and materials or cost-plus contract vehicle may be more appropriate.

2.1.4 Timelines and Schedules

From start to finish the SLERA should require 12-18 months, including time for internal and external review, meetings, site visits, and reporting writing. From the date of award of the contract or delivery order, a SLERA draft work plan should be available in 30-60 days depending on the amount of existing data that has to be reviewed and assimilated. Site-specific climatic conditions (e.g., extensive snow cover) would likely limit data collection efforts and should be considered when building the SLERA schedule.

During the SLERA it may be necessary to collect additional samples to better characterize locations and media not fully addressed in existing reports (e.g., PA or SI reports). Timelines and schedules should be extended if additional data are required to complete the SLERA. Schedule and deliverables should be adjusted to accommodate field mobilization, sample collection, and sample analysis. Additional data would usually include collection and analysis of water, soil or sediment samples. Additional data would not typically include toxicity tests, tissue/organ collection, biomonitoring, or similar intensive ecological field studies.

2.2 Screening-Level Problem Formulation and Ecological Effects Evaluation.

In the SLERA, it is important to recognize the following relationship:

Risk = Exposure/Toxicity

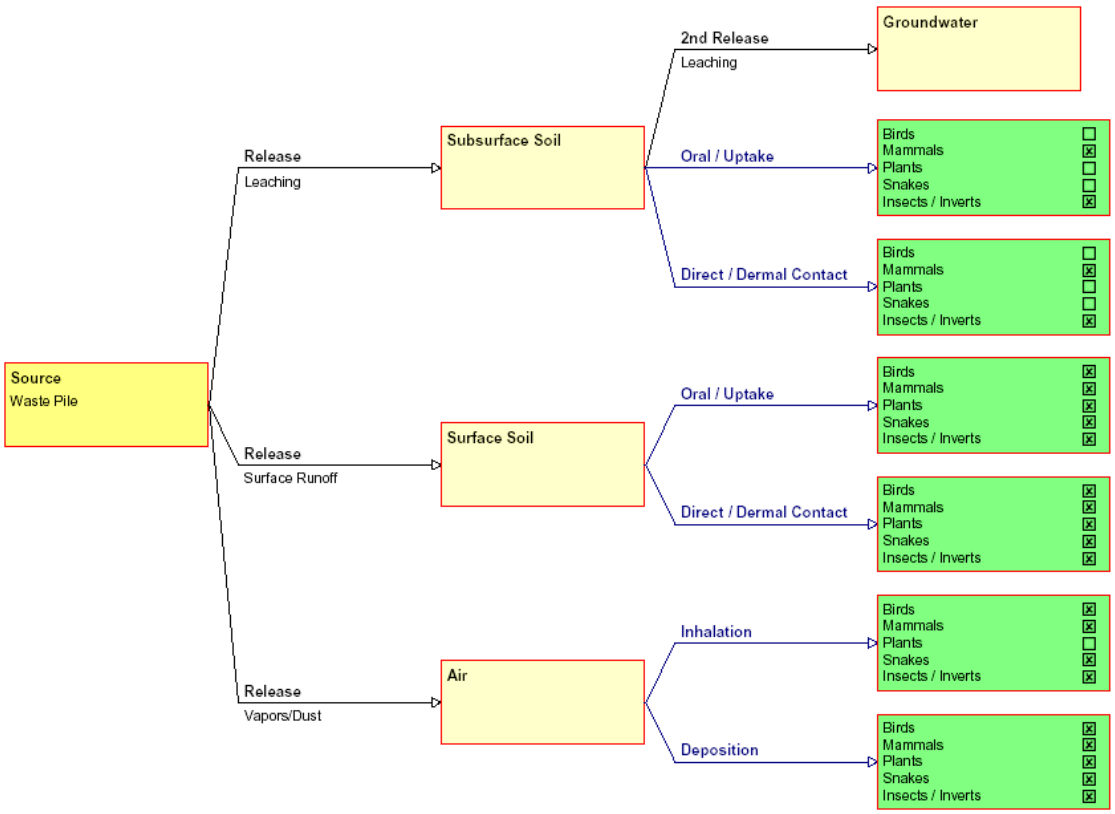
Here an estimate of exposure is compared with a toxicity benchmark that represents the upper level of what is considered acceptable. Both can be either chemical-specific media concentrations (e.g., mg substance/kg soil) or oral dose estimates (in mg substance/kg body/day). Both must be in the same units, however. Where there is no exposure, there is no risk.

Problem formulation and ecological effects evaluation for the SLERA is Step 1 of the ERAGS process (USEPA 1997). The purpose of this step is to gather existing data about the site and associated chemicals to identify how those chemicals might impact organisms within the ecosystem. USEPA guidance recommends establishing a "picture" of the site to assist in problem formulation. This picture becomes the conceptual site model (CSM). The CSM can have multiple forms. Figure 1 is an example CSM based on ASTM Standard E1689-95 (ASTM 1995). In the screening-level problem formulation, a CSM is developed to address the environmental setting and contaminants characterization, fate and transport, routes of exposure and categories of receptors, complete exposure pathways, and endpoints to evaluate for the potential for adverse effects. In development of the CSM, the following questions are addressed:

- Do transport pathways exist at the site that could result in toxic exposures to terrestrial or aquatic receptors?
- Do exposure pathways exist where receptors are in direct contact with the contaminated media?
- Do transport pathways exist at the site wherein the consumption of prey containing elevated body burdens results in chemical exposure at levels that can cause harm to predators?

For wildlife, oral exposures are predominantly considered. Because of data limitations, exposures to substances via inhalation or dermal exposures are not quantified, but should be addressed in the uncertainty assessment section of the SLERA.

Fig. 1 Example Site Conceptual Model (CSM; ASTM 1995).



2.3 Environmental Setting and Contaminants Characterization.

The description of the site environmental setting is important to the problem formulation because it determines the habitats where biota might be located as well as the chemicals to which they could be exposed. The first step is to compile the historical information for the site. The second step is to use the environmental checklist (Appendix A, USEPA 1997) during a site visit. The checklist will guide the risk assessor in evaluation of on- and off-site habitats, land uses and migration pathways.

Habitats are generally divided into two major groups (terrestrial and aquatic) and subdivided based on their biotic and abiotic characteristics. The following sources may be useful when examining the available habitat:

- The installation's Integrated Natural Resources Management Plan (INRMP)
- USGS Land Use Land Cover and Topographic maps (http://eros.usgs.gov/)
- Geo-referenced aerial photographs
- Natural Resources Conservation Service / USDA-ARS
- Detailed maps, imagery, and data resources: http://www.nrcs.usda.gov/technical/maps.html
- Site visits

The most common source of information regarding the contaminants at the site is the Preliminary Assessment (PA)/Site Investigation (SI) report. The concentrations of chemicals at various locations (both vertical and horizontal) should be examined. However, since PA/SIs often have few samples biased to areas of suspect contamination, nature and extent of contamination may need to further be characterized.

2.4 Fate and Transport.

Physical, geological, chemical, and even biological processes control contaminant fate and transport of site contaminants. The description of contaminant fate and transport in context with the environmental setting is needed in problem formulation to define the pathways for migration of potentially hazardous substances within the media and habitat types at the site. Consideration of local-scale environmental conditions and contaminant sources is also recommended. At a local scale, physical processes include gravity-driven chemical transport determined by site topography, including hills, ridges, culverts, berms, or any other feature that might affect the flow of water onto/into the ground or along the surface (sheet flow). The topography of the site should be evaluated to examine erosion patterns and channelized flow from streams. The SLERA should address preferential flow pathways that could affect off-site contamination gradients.

Media-specific sample collection should also consider temporal considerations of habitat quality (e.g., data collected during wet season may be more ecologically relevant given the importance of vernal pools in the life cycle and food resources of aquatic and wildlife species, respectively).

This completes Step 1 of the ERAGS process. The risk assessor should evaluate the CSM to determine if additional data is needed to complete the SLERA. The screening-level problem formulation summary should be included in a SLERA work plan. This can help facilitate review and approval by regulatory agencies and other stakeholders. Data needs should be identified along with Data Quality Objectives for those data.

3.0 Screening-Level Exposure Estimate and Risk Calculation.

The second step of the ERAGS process is the screening-level exposure estimate and risk calculation. In this step, potential site risks are estimated by comparing maximum exposure concentrations with the ecotoxicological benchmark values. The SLERA process will conclude with the scientific/management decision point (SMDP) at which it will be determined that: 1) ecological threats are negligible; 2) the process should continue to determine if a risk actually exists; or 3) a potential for adverse effects exists and a site-specific BERA is needed. In the sections below, details of the various components of exposure and the risk calculation processes are provided. Subsequently, the risk communication step discusses the overall confidence in the potential for risk (i.e., across relevant pathways and COPEC classes) as input into the SMDP.

3.1 Categories of Receptors.

In order to screen out COPECs it is important to demonstrate that all potentially exposed organisms have been evaluated. For this reason, receptor species that demonstrate high exposure tendencies are used to model exposure and to represent specific foraging guilds (Table 1). This is done so that it can be shown with confidence that other species, likely less exposed, are at less risk than the modeled species. Species that represent foraging guilds for risk assessment are often selected based on the extent of their exposure to soil or sediment, since these media often serve as the primary reservoir of chemical contamination at the site. A balance between choosing a receptor from which much information is known (important in accurately characterizing exposure) and most exposed (to be protective of other species within the guild) is important. Some receptors/foraging guilds may be represented at the site, but too poorly represented in the literature to allow for a quantitative estimate of risk.

Receptors selected should represent generic foraging guilds that are ecologically important at the site. Example foraging guilds include “small mammalian omnivore, large mammalian herbivore, and small avian invertivore” (see Table 1).

For terrestrial environments, the representative receptor groups typically include plants, soil invertebrates (e.g., worms and insects), small mammals, and birds that consume insects and plants, or other larger mammal grazers (e.g., deer) and predator species that utilize other small mammals, birds, amphibian, reptiles or fish as their primary food source. Potential risk to amphibians and reptiles is usually relegated to the BERA since toxicity and exposure information for these organisms is lacking for most substances.

Table 1. Example mammalian and avian foraging guilds and representative receptors.

Foraging Guild	Receptor species	Genus	Species
Small mammalian herbivore	Meadow vole	*Microtus*	*pennsylvanicus*
Medium mammalian herbivore	Woodchuck	*Marmota*	*monax*
Large mammalian herbivore	White-tailed deer	*Odocoileus*	*virginianus*
Small mammalian omnivore	Deer mouse	*Peromyscus*	*maniculatus*
	White-footed mouse		*leucopus*
Medium mammalian omnivore	Raccoon	*Procyon*	*lotor*
Large mammalian omnivore	Coyote	*Canis*	*latrans*
Small mammalian carnivore	Short-tailed shrew	*Blarina*	*brevicauda*
Medium mammalian carnivore	Long-tailed weasel	*Mustela*	*frenata*
Large mammalian carnivore	Mountain lion	*Felis*	*concolor*
Small avian granivore	American Goldfinch	*Carduelis*	*tristis*
Medium avian granivore	Mourning Dove	*Zenaida*	*macroura*
Small avian invertivore	Ruby-crowned Kinglet	*Regulus*	*calendula*
Medium avian omnivore	American Robin	*Turdus*	*migratorius*
Large avian carnivore	Red-tailed Hawk	*Buteo*	*jamaicensis*

For aquatic environments, the representative receptor groups typically include animals that might occupy streams, ponds, or marshes. These aquatic biota may include aquatic insects and worms that live in the sediment; freshwater bivalves (e.g., clams) that feed at the sediment surface; organisms that consume aquatic insects and/or bivalves; large fish that feed upon smaller fish; or semi-aquatic mammals/avian predators that consume other aquatic organisms.

3.2 Complete Exposure Pathways.

The SLERA should focus on complete exposure pathways to the identified receptors. For an exposure pathway to be complete, receptors must be exposed (via inhalation, ingestion or dermal uptake) to a COPEC. Identifying complete exposure pathways prior to a quantitative evaluation of toxicity allows the assessment to focus on only those contaminants that have a completed pathway of exposure. Risks from oral exposures (i.e. ingestion) to hazardous substances have been the focus of most SLERAs and are generally suspected to contribute the most to risk. Moreover, data to quantify and understand the potential risks to wildlife from dermal and inhalation exposures are generally not sufficient to provide meaningful or defensible quantitative estimates of risk.

The process of determining which exposure pathways may be complete in the future is often problematic and is usually dependent on future land use options. For example, soil under a building may not be available for contact now, but may be available if the building was removed. The RPM should comply with the DOD Land Use Policy (USDOD 2001) and the installation's master plan when applicable. The USEPA also has a formal land use assessment process (USEPA 2001a) that should also be considered.

3.3 Assessment and Measurement Endpoints.

For the SLERA, assessment endpoints (what trustees are interested in conserving) and measurement endpoints (what are used to infer on the assessment endpoints) are ***not*** developed until after the SMDP following the outcome of the SLERA (USEPA 1997). However, some consideration of habitats or species to be valued at the site that have the potential to be assessment endpoints can use the same modeled species profiles in the BERA (USA BTAG 2002b). A well-planned SLERA can use some of the same modeled species in the BERA if the modeled species are later identified as measurement endpoint species. This allows for a refinement of exposure and toxicity criteria that are site-specific to refine risk estimates in the BERA.

3.4 Exposure Parameters.

Since oral dose estimates involve modeling feeding events and chemical concentration in media and food items, other factors such as contact frequency (e.g., area use), food ingestion rates, amount of soil incidentally ingested, and bioavailability of chemical that is assimilated through the ingested item (e.g., soil or food) should be considered. In order to maintain the conservative nature of the SLERA, the highest reasonable exposure factors are used. ERAGS lists the following factors and provides explanation relative to how these parameters are evaluated in the SLERA and the BERA:

- Area use factor – 100%;
- Bioavailability – 100%;
- Life stage of receptor – most sensitive;
- Body weight and food ingestion rate – minimum body weight to maximum ingestion rate;
- Dietary composition – 100% of diet consists of the most contaminated dietary component.

The *Wildlife Exposure Factors Handbook* (USEPA 1993) presents profiles for selected species of birds and mammals. Each species profile provides a series of tables presenting values for developing factors important in estimating exposure such as intake factors, body weight, dietary composition, population dynamics, and seasonal activity patterns. Additional information can be found in the published literature including the ORNL *A Guide to the ORNL Ecotoxicological Screening Benchmarks: Background, Development, and Application*. (ORNL. 1998). This information and exposure profiles for additional species have been compiled in a single volume (Development of Exposure and Bioaccumulation Information for the Applied Risk Assessment Modeling System, prepared by CH2MHill for USACHPPM) available as supporting information for use in the Life History Database: http://chppm-www.apgea.army.mil/tox/HERP.aspx

When species-specific empirical data are not available, some criteria can be estimated through relationships between intake factors and body weight (allometry). Allometric equations for estimating wildlife feeding and drinking rates are provided below.

Wildlife can be exposed to contaminants in one or more components of their diet and different components can be contaminated at different levels. For example, the diet of the deer mouse, an

omnivorous key receptor commonly assessed in ERAs, primarily consists of invertebrates and terrestrial plants. The daily intake for the deer mouse is thus expressed as [(chemical concentration in invertebrates x % ingested) + (chemical concentrations in terrestrial plants x % ingested) x daily food intake] / deer mouse body weight

To calculate the daily dose for a receptor exposed to a contaminant in diet and water, the following equation may be used (note that the concentration in soil and food items is expressed in dry weight):

$$\text{Daily Intake (mg/kg-bw/d)} = \frac{[(C \times FI) + (C \times WI)] \times EMF}{BW}$$

where:

C = Chemical concentration in food or water (i.e., mg/kg, mg/L, ppm)
FI = Food Intake rate (kg-food/day)
WI = Water Intake rate (L-water/day)
BW = Body weight of receptor (kg)
EMF= Exposure modifying factors (default value is 1.0) (unitless)[1]

Birds For birds, Nagy (1987) developed the following equations for calculating food ingestion (FI) rates (in grams dry matter per day):

FI (g/day) = 0.648 $Wt^{0.651}$ (g), or	all birds
FI (kg/day) = 0.0582 $Wt^{0.651}$ (kg)	all birds
FI (g/day) = 0.398 $Wt^{0.850}$ (g)	passerines
FI (g/day) = 0.301 $Wt^{0.751}$ (g)	non-passerines
FI (g/day) = 0.495 $Wt^{0.704}$ (g)	seabirds

where Wt is the body weight (wet) of the animal in grams (g) or kilograms (kg) as indicated.

Mammals For placental mammals, Nagy (1987) developed the following equations for calculating FI rates (in grams dry matter per day):

FI (g/day) = 0.235 $Wt^{0.822}$ (g), or	all mammals
FI (kg/day) = 0.0687 $Wt^{0.822}$ (kg)	all mammals
FI (g/day) = 0.621 $Wt^{0.564}$ (g)	rodents
FI (g/day) = 0.577 $Wt^{0.727}$ (g)	herbivores

USEPA (1988) also provides the following equations for this calculation:

FI (kg/day) = 0.056 $(Wt)^{0.6611}$ (kg)	laboratory mammals
FI (kg/day) = 0.054 $(Wt)^{0.9451}$ (kg)	moist diet
FI (kg/day) = 0.049 $(Wt)^{0.6087}$ (kg)	dry diet

[1] An adjustment based on daily home range can be made in relation to the area of concern (Area Use Factor) is an example of an EMF.

WATER INTAKE RATES

Birds Calder and Braun (1983) developed the following allometric equation for drinking water ingestion (WI) for birds:

$WI\ (L/day) = 0.059\ Wt^{0.67}\ (kg)$ all birds

To estimate daily drinking water intake as a proportion of an animal's body weight (e.g., as g/g-day), the WI rate estimated above is divided by the animal's body weight in kg:

WI (g/g-day) = WI (kg/kg-day), or
= WI (L/day)/Wt (kg)

Mammals Calder and Braun (1983) developed the following allometric equation for drinking water ingestion (WI) for mammals:

$WI\ (L/day) = 0.099\ Wt^{0.90}\ (kg)$ all mammals

where Wt is the average body weight in kilograms (kg). Additional sources of water not accounted for in this equation (i.e., metabolic water and water contained in food) help to balance the animal's daily water losses.

EPA (1988) also provides the following equations for this calculation:

$WI\ (L/day) = 0.10\ (Wt)^{0.7377}\ (kg)$ laboratory mammals
$WI\ (L/day) = 0.009\ (Wt)^{1.2044}\ (kg)$ mammals, moist diet
$WI\ (L/day) = 0.093\ (Wt)^{0.7584}\ (kg)$ mammals, dry diet

To normalize drinking water intake to body weight (e.g., as g/g-day), the WI rate estimated above is divided by the animal's body weight in kg:

NWI (g/g-day) = WI (kg/kg-day), or
= WI (L/day)/Wt (kg)

For receptors that derive significant chemical exposure from the consumption of prey, estimates of the concentration of chemicals in the prey are often needed since typically the available data are focused on concentrations of chemicals in soil or water. Here, bioaccumulation factors (BAFs) are used to estimate contaminant accumulation/food-chain transfer from the food source to the receptor. For example, if the residue concentration in the body of the receptor is twice that of its prey species, the BAF is equal to two. Many environmental factors influence the degree of bioaccumulation, and BAF values among chemicals can vary by several orders of magnitude. Models that use empirically-derived values and chemical-physical properties (e.g., log Kow for organic substances) can be used, yet the former are less uncertain and provide more reliable estimates. When the COC list is established (i.e. after the SLERA during the BERA), site-specific BAF values based on collocated measurements of soil and tissue data obtained directly from the site can be used.

3.5 Assembling / Developing Toxicity Benchmarks

The next step in the SLERA process is to assemble toxicity benchmarks that represent conservative thresholds for adverse ecological effects. Unlike assessing human health risks, there are no generally accepted set of media-specific screening ecotoxicity values or TRVs. Screening ecotoxicity values are always chemical-specific, and can be either media-specific (such as soil screening levels [SSLs], ambient water quality criteria [AWQC], or sediment quality guidelines [SQGs] or dose-based (e.g., toxicity reference values [TRVs]; often expressed in mg substance/kg body weight/day). There are several sources for these values that are available (see below). Many specific values many not be available. In these cases the risk assessor can either search the literature for toxicity information and develop a value or consider this chemical/receptor-specific pathway an uncertainty and follow up addressing these data gaps in the BERA.

It is important to understand how adverse effects (i.e., toxicity) may occur. For example, is the substance particularly toxic from brief exposures, or does it biomagnify up the food chain and most likely to exert its effects on higher trophic level predators from sustained exposure? Knowledge of the organism regarding exposure is important for this interpretation. The selection of toxicity benchmarks may be influenced by the specific toxic effects from exposure (inherent in the development of TRVs or media-specific toxicity screening values (e.g., SSLs, AWQC, etc.). Background information regard screening-level ecotoxicity values sometimes provide information regarding effects from exposure. Screening values developed for aquatic media and sometimes soil (e.g., those developed for invertebrates and plants) may not be specific and address on general effects such as mortality, growth and reproduction. However, TRVs for wildlife often have supporting information that describes route, dose, length of exposure, and target of toxicity information that can help in the development of measurement endpoints (USACHPPM 2000).

3.5.1 Preferred Toxicity Data.

For relatively sessile organisms (e.g., plants, some invertebrates), media-specific screening values are applied. These are concentrations of substances in soil, water, or sediment (e.g., SSLs, AWQC, SQGs) that are based on data sets where a correlation between chemical concentration and observed effects has been shown. Below are some examples of sources for media-specific screening values.

Soil screening levels (USEPA 2002b), available at
http://www.epa.gov/oerrpage/superfund/resources/soil/index.htm
Eco-SSLs (USEPA 2003), available at http://www.epa.gov/ecotox/ecossl/,
EcoTox Thresholds database (USEPA 2005), available at http://www.epa.gov/ecotox/
Screening Quick Reference Tables (SQUIRTs)(NOAA 1999), available at
http://response.restoration.noaa.gov/cpr/sediment/squirt/squirt.html,
SQGs (Long and Morgan 1990, Long et al. 1995, Hull and Suter 1994)

For most wildlife, TRVs are established by comparing controlled laboratory study data with an estimate of dose to the receptor. Since chemical-specific toxicity data are limited, only class-specific TRVs are derived (i.e., TRVs that are for mammals and birds). Toxicity data for a mammalian species can be used to derive a value for mammals only. Data for one class of animals should not be used for another (e.g., using mammal data to derive an avian TRV) unless physiological information is robust to support such a derivation. Chemical-specific TRVs should either be based on the highest "no-observed-adverse-effect-level" (NOAEL) below the lowest "lowest-observed-adverse-effect level" (LOAEL) for chronic exposures or use another method that derives a no-effect threshold (e.g., Benchmark Dose method). Because of limited toxicity data, TRVs are rarely available for the same species as found at the site and thus procedures are necessary to establish benchmarks that are class specific (e.g., chemical-specific mammal values, avian values). The method to derive TRVs for wildlife, along with a chemical-specific toxicity profile can be found in the Wildlife Toxicity Assessment (WTA) series (USACHPPM 2000; http://chppm-www.apgea.army.mil/tox/HERP.aspx). Many of the WTAs are focused on compounds of military interest, however, USACHPPM has also compiled a list of existing TRVs in its Terrestrial Toxicity Database (TTD, USACHPPM 2005) including many state, regional and local values, as well as many SSLs. These values are scored based on their applicability for a screening application.

TRVs for wildlife and/or substances that are not available through the WTA or the TTD can be derived specific to conditions at the site. The choice of the study to derive the TRV is dependant on many factors. These include the duration of the study, the nature of the endpoint/effect investigated, the form of the compound administered, and the exposure route and medium used for administering the contaminant. Study quality must also be considered when reviewing the literature to derive TRVs. Statistical significance does not infer biological relevance and judging the ecological relevance of a finding is often tenuous decision at best and requires specific knowledge of toxicology and ecology regarding exposure and effect.

The risk assessor should concentrate on effects that can impact populations or higher levels of biological organization (e.g., development, reproduction, and survivorship). Often too few data exist that allows the risk assessor to determine the ecological relevance of the toxic effect. For example, if exposure to a substance causes central nervous system effects and alters behavior, it may or may not have profound ecological consequences (e.g., affect mating strategies, territoriality, reduce predator vigilance, etc.). Toxicological data are often derived from controlled laboratory studies that rarely evaluate ecologically-relevant criteria and are often focused on physiological effects. Therefore, any effect that has the potential to be adverse in an ecological context should be considered, providing there are other corroborating information supporting the dose level at which the effects are reported.

4.0 Risk Characterization: Screening-Level Risk Calculation.

For the SLERA, ecological risk can be estimated using the exposure estimates and the TRVs developed earlier. For the risk calculation, the hazard quotient approach, which compares point estimates of TRVs and exposure values, is standard practice. The following equation is more specific, but equivalent to that presented in Section 2.2.

HQ = Exposure Value / TRV

Where the exposure value is either a concentration (mg substance/kg media or mg substance/L water) or an estimated dose (mg substance/kg body weight-day) and the TRV is either a concentration or and estimated dose representing the threshold of a safe exposure. Thus, for each contaminant and environmental medium, the hazard quotient (HQ) is expressed as the ratio of a potential exposure level to the applicable toxicity-based benchmark.

Decision rules are applied to the results for interpretation of potential risks. For HQ values exceeding unity (1.0) the potential for adverse effects to the receptor is concluded to be possible. In contrast, if the resulting HQ is equal to or less than unity, the potential for risks due to that chemical can be considered negligible and therefore may be dropped from further consideration of risk for that exposure pathway. The logic is supported through the consistent application of conservative assumptions, biasing towards overestimating potential risks. The remaining possibility is that the present information available is insufficient to determine potential risks of exposure to the chemical, and hence that chemical is retained pending further review once additional data collection is completed.

5.0 Scientific/Management Decision Point (SMDP).

After completing Steps 1 and 2 of the USEPA's 8-step process, the results of the SLERA are communicated to the DoD RPM. The results are documented within the final SLERA report, but may also be communicated via other means. The DoD RPM should assess whether all of the required information has been obtained and is adequate to make a risk management decision. As previously mentioned, the SLERA's main function is to refine the list of COPECs, receptors and exposure pathways (decision 2 below). Or, if it can be shown that no chemical-specific HQs exceed unity (1.0), the determination can be made that no appreciable risks exists and thus supports a no action decision.[2]

At the end of the SLERA, the potential for risk from exposure to each substance can be evaluated. There can be only these possible decisions:

1 Information is adequate to conclude that potential for risk from exposure to all substances is negligible, therefore there is no need for further evaluation or remediation on the basis of ecological risk;
2 There is adequate information to dismiss some pathways/foraging guilds / COPECs from further consideration, yet further study is required to evaluate a refined list of substances (COECs; continue with a refined BERA, Step 3), or
3 There is adequate information is suggest that risk from exposure to all substances be evaluated further (i.e., carry forward all substances and pathways to a BERA).

The RPM should document the decision and the basis for it in an SMDP discussion at the end of the SLERA. Concurrence from the regulatory agencies and other stakeholders should be

[2] Given the confounding of multiple conservative assumptions used in exposure estimation, this condition rarely occurs.

obtained. If the screening-level risk characterization supports the first decision (i.e., negligible risk), the ecological risk assessment process ends here with appropriate documentation to support the decision. The documentation should include all analyses and references used in the assessment, including a discussion of the uncertainties associated with the HQ estimates. Table 2 presents a checklist of items to be included in the SLERA report.

The decision to continue beyond the SLERA does not mean that remediation is necessary at the site. Note that the SMDP made at the end of the screening-level risk calculation will ***not*** set a preliminary cleanup goal. Model parameters and screening ecotoxicological values are derived to minimize the potential of underestimating risk. Requiring a cleanup based solely on exceeding a screening value is not technically defensible. The decision for risk-based remedial action is made in Step 8 of the ERA process. Regardless, the SLERA should have reduced the number of chemicals, receptors (or foraging guilds), and/or reduce the number of pathways to consider.

6.0 Refinement of the SLERA.

In certain circumstances it may be worthwhile to refine some exposure criteria with more realistic parameters. This decision is based on the likelihood that reasonable/more realistic exposure parameters would assist in a SMDP (e.g., resolving the question of risk; i.e., results in HQs < 1.0). This would occur prior to beginning problem formulation for the BERA (Step 3 in the ERAGS process). This step would use literature data and should not include gathering more site-specific data to support less uncertain exposure parameters; gathering more site-specific information should be relegated to a BERA. However, it may include a comparison of on-site media concentrations with both naturally occurring and anthropogenic background concentrations, if available. The results of Step 3A (US Navy 1999) will be used to determine if threats to ecological receptors are negligible and an appropriate risk management decision may be made to end the ERA process, or potential threats are still indicated and a BERA should be initiated. For this refinement, the following parameters will be reevaluated, as appropriate, and HQs will be recalculated for those pathways indicating the potential for ecological risk:

- **Area use percentage (home range).** For the SLERA, area use percentage was conservatively assumed to be 1 (100%). For the BERA, the area use percentage may be adjusted, if appropriate, based on the receptor's home range. Divide the area of the contamination by the receptor's home range to establish the appropriate factor for use in the dose equation. Useful values will be ≤ 1.
- **Bioavailability < 100%.** Assumed to be 100% in the SLERA, bioavailability of the COPECs should be adjusted, based on literature information an/or site-specific considerations, if already known. Useful values will be ≤ 1.
- **Diet composition < 100% from the most contaminated media.** In the SLERA, the receptor's diet was assumed to be from the most contaminated source, irrespective of the percentage of the diet that source actually provides. Diet composition should be adjusted to reflect actual feeding habits of the receptor (based on literature information).
- **Food concentration.** Assumptions made in the SLERA were that the concentration of COPECs in food items was equal to detected media concentrations (e.g., the concentration in plant tissue was equal to the concentration in the soil). COPEC concentrations in food items

should be adjusted to reflect more reasonable transfer of contaminants, either modeled (e.g., using BAF/BSAF values) or using measured concentrations.

- **Detection frequency.** If sufficient data has been collected, the physical distribution and frequency of detection of a chemical in a site medium or exposure area can be used to remove a chemical from consideration as a COPEC. The premise behind this criterion is that a chemical with limited presence in a medium or exposure area is unlikely to be contacted frequently and, therefore, does not pose as great a potential ecological risk as do more frequently detected chemicals. The distribution of the chemicals present at a site or exposure area should be examined by identifying where the chemicals were and were not detected and their frequency of detection. If this evaluation indicates that the distribution of a chemical is low, i.e., it is detected in only one or a few locations, it may be reasonable to exclude it as a COPEC (assuming an appropriate sampling design was used).
- **Background.** In conducting a risk assessment, it may be important to distinguish site contamination from background levels due to anthropogenic or naturally-occurring contamination in order to determine the presence or absence of contamination and to compare with background concentrations (USEPA 1992a,b). Detected chemicals that are within background levels should be evaluated according to the procedures found in *Role of Background in the CERCLA Cleanup Process* (USEPA, 2002a).

7.0 Uncertainty Assessment.

The risk assessor should provide an evaluation of the uncertainties in the SLERA problem formulation. The assumptions for the SLERA are conservative by design, and the risk assessor should describe these uncertainties in context of the site.

Evaluating the potential sources of uncertainty is a necessary step in order to ascertain the confidence to be placed upon the SLERA. The purpose of the uncertainty analysis is to identify the potential uncertainty sources as well as their possible relationship to the true degree of adverse exposure or effects. Assumptions made in estimating exposures should be clearly stated. Additionally, the risk assessor should attempt to describe the magnitude and direction of the bias associated with each assumption. Where literature values have been used, indication of the range of values that could be considered appropriate should be indicated.

The list of potential uncertainties that are important and should be examined at the end of the SLERA include:

- Limitations of site characterization data; spatial (horizontal) and vertical (sediment layering) patterns, and sample representativeness (e.g., biased sampling at hot spots and few total samples);
- Data analysis techniques and data availability limitations;
- Appropriateness of TRVs and exposure model parameters for receptors at the site;
- Appropriateness of the selected receptor species as surrogates for the indigenous community species;
- Uncertainty and relative degree of overestimation inherent in exposure estimation; and,
- Applicability of HQ calculations, where the numerator and denominator each represent deterministic estimates of risk confounded through the use of conservative assumptions.

8.0 Summary.

The screening-level problem formulation and ecological effects evaluation should contain and address each of the sections as identified above. Once completed, the following tasks should have been accomplished and clearly documented:

- Description of environmental setting and contaminants known or suspected to exist at the site and the concentrations present (for each medium);
- Description of the contaminant fate and transport mechanisms that exist at the site;
- Description of the ecotoxicity benchmarks and all exposure assumptions made including references;
- Categories of receptors that could be affected and specific animals and plants for each category;
- Description of the complete exposure pathways that might exist at the site, detailing the movement of contaminants from sources to potentially affected receptors; and
- Screening ecotoxicological values designed to provide estimates of safe levels of substance exposure (based on conservative assumptions).

Table 2. Checklist for completion the SLERA Problem Formulation/Ecological Effects Evaluation.

Step 1 (Problem Formulation/Conceptual Model Development) ***Section 2.3 (Environmental Setting and Contaminants):*** ✓ A regional map based on aerial photo, USGS topographic chart, or nautical chart (as appropriate) outlining the site location, generalized habitat types, topography and hydrology, site boundaries and reference sampling locations; and ✓ A table providing descriptive and statistical information for the measured or expected contaminants in each of the media.
Section 2.4 (Contaminant Transport and Fate): ✓ A site wide facility use map should be provided to show current and historical land use (e.g., noting features such as landfills, waste piles, firing ranges, strafing areas, burn pits, explosives areas, hazardous waste storage areas, pesticide storage and wash areas, scrap (reutilization) yards, motor pools, gasoline stations, fuel farms, existing or former surface drainage channels, storm drains and storm water outfall locations, as appropriate). ✓ Conceptual diagram indicating potential contaminant transport pathways (e.g., atmospheric transport, soil erosion, surface water migration, groundwater flow) and depositional areas (depressional areas, ditches culverts, streams, marshes)
Section 3.1 (Ecotoxicity and Potential Receptors): ✓ A table containing a site habitat summary and potential receptors, including the area of the habitat, expected species, observed species, the relative occurrence of the species, and whether the species is considered to be rare, threatened or endangered.
Section 3.2 (Complete exposure pathways): ✓ A table aggregating the expected/observed species into functional groups based on common exposure pathways and foraging guilds (e.g., small herbivorous mammal). For a given contaminant, media, and exposure pathway, a decision regarding the possibility of a completed pathway is listed
Section 3.4 (Exposure modeling): ✓ A table containing a list of receptors representing the functional groups and the measurement data need/used to estimate potential effects on each receptor;
Section 3.5 (Ecotoxicity Threshold Values): ✓ A table summarizing the ecotoxicity threshold values representing safe exposure concentrations for each of the selected receptors.
Step 2 (Exposure Estimation/Risk Calculation) ***Section 4.0 (Risk Calculation):*** ✓ Exposure estimates based on conservative assumptions and maximum concentrations present; ✓ Hazard quotients (or hazard indices) indicating which, if any, contaminants and exposure pathways might pose ecological threats; and ✓A discussion of the uncertainty regarding whether there is sufficient data (quality and quantity) to determine that ecological threats are negligible.

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