CONSIDERATIONS FOR ASSESSING ECOLOGICAL RISKS
Interim Final: March 2015

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)
REGION I - NEW ENGLAND

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) CORRECTIVE ACTION

In the course of reviewing Ecological Risk Assessments (ERAs), EPA Region 1's RCRA Corrective Action program has identified common issues that arise on many projects. The purpose of this document is to clarify these issues and summarize available guidance.[1] The intent of EPA Region 1 is to help RCRA Corrective Action facilities present, through the up-front planning process, a more thorough and transparent assessment of ecological risk that meets ERA basic requirements and streamlines the process by avoiding extensive revisions. This document is intended for use by RCRA Corrective Action facilities in New England and their consultants.

This document does not deal with all considerations pertaining to assessing ecological risks. It only discusses the issues on which we have frequently received questions or observed misinterpretation of EPA guidance. In addition, this document only briefly summarizes the current guidance and approaches on the identified issues. In this document, suggested approaches are provided with the intent of improving the efficiency of performing ERAs. However, there are multiple approaches to performing an ERA. Parties performing an ERA should select approaches that are most appropriate for the site-specific conditions and project objectives. For complete guidance on the topics addressed in this document, please refer to applicable EPA policy and guidance, which include, but are not limited to the references listed at the end of this document. Please also consult regulations, guidance, and policy of the applicable state.

EPA expects that this document will be updated in the future as more issues or questions arise or as new guidance becomes available. We are interested in obtaining feedback from project stakeholders who have input, questions, or identify areas that need further clarification. Please contact the EPA Region 1 RCRA Corrective Action Program:
http://www.epa.gov/region1/cleanup/rcra/contacts.html

Disclaimers

General Disclaimer: The purpose of this document is to provide general information concerning common issues that arise in the course of ERA performance at RCRA Corrective Action facilities and a description of general considerations that can be used to guide the ERA process for such facilities. It does not address site-specific factors, considerations or information that may be relevant to a particular facility. The word "should" and other similar terms used in this document are intended as implying general recommendations or suggestions that might be generally applicable or appropriate, and should not be taken as providing legal, technical,

[1] Ecological risk assessment at RCRA Corrective Action facilities in Region I typically follows EPA Superfund risk assessment guidelines.

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List of Acronyms Used

AVS	Acid Volatile Sulfides
AWQC	Ambient Water Quality Criteria
BERA	Baseline Ecological Risk Assessment
COPEC	Contaminant of Potential Ecological Concern
CSM	Conceptual Site Model
DQO	Data Quality Objective
EDD	Estimated Daily Doses
EPC	Exposure Point Concentration
EPA	Environmental Protection Agency
ERA	Ecological Risk Assessment
ESV	Ecological Screening Value
HQ	Hazard Quotient
NOAEL	No-Observed-Adverse-Effect-Levels
NRWQC	National Recommended Water Quality Criteria
QAPP	Quality Assurance Project Plan
PAH	Polycyclic Aromatic Hydrocarbon
RL	Reporting Limit
SEM	Simultaneously Extracted Metals
SLERA	Screening-Level Ecological Risk Assessment
SMDP	Scientific Management Decision Point
SWPC	Surface Water Protection Criteria
RCRA	Resource Conservation and Recovery Act
TRV	Toxicity Reference Values
UCL	Upper Confidence Limit
WP	Work Plan
WQC	Water Quality Criteria

1. Importance of Up-Front Planning

An ERA can take many forms, depending on the nature and extent of contamination and types of habitats and receptors present at or near a RCRA facility. However, up-front planning, basic knowledge of the site, and understanding the basic steps of an ERA can help a facility plan in advance to identify the type, quantity, and quality of data that will be needed; determine at what stage in the investigation it should be collected; and plan how it will be evaluated. While a complete characterization of the nature and extent of site contaminants is needed for characterization of risk in a risk assessment, the initial scoping stage of a risk assessment should be performed at an early stage of site characterization so that data needs and data quality objectives (DQOs) can be identified. This early scoping and planning is key to developing a successful Work Plan (WP) and obtaining meaningful agency feedback.

The basic steps in performing an ERA for RCRA facility activities are summarized below. Detailed guidance on these steps is found in the following documents:

EPA, 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments - Interim Final, June 1997 (OSWER Publication Number 9285.7-25; NTIS Order Number PB97-963211).
http://www.epa.gov/oswer/riskassessment/ecorisk/ecorisk.htm

EPA, 1998. Guidelines for Ecological Risk Assessment, EPA/630/R-95/002F (April, 1998)
http://www.epa.gov/raf/publications/pdfs/ECOTXTBX.PDF

EPA, 1999. Issuance of Final Guidance: Ecological Risk Assessment and Risk Management Principles for Superfund Sites, October 7, 1999 (OSWER Directive 9285.7-28P).
http://www.epa.gov/oswer/riskassessment/ecorisk/pdf/final99.pdf

EPA. 2001. The role of screening-level risk assessments and refining contaminants of concern in baseline ecological risk assessments. ECO Update Publication 9345.0-14. EPA 540/F-01/014. June 2001.
http://www.epa.gov/oswer/riskassessment/ecoup/pdf/slera0601.pdf

a. Ecological Receptor Exposure Pathway Scoping Checklist:

The Ecological Receptor Exposure Pathway Scoping Checklist (Scoping Checklist available at http://www.epa.gov/region1/cleanup/rcra/EcologicalScopingChecklist.pdf) was developed by the EPA Region 1 RCRA Corrective Action Program as a planning tool to determine if the potential for complete exposure pathways exists between releases of hazardous waste at or from a facility and nearby ecological receptors, which include community-level receptors (e.g., soil invertebrates, plants, fish, amphibians, benthic invertebrates) and/or wildlife receptors (i.e., terrestrial or semi-aquatic birds and mammals).

The Scoping Checklist is intended to guide the review of available information on environmental conditions at a facility to determine the needs for a site-specific Screening-

Level Ecological Risk Assessment (SLERA) and to focus any further data collection and evaluation for the SLERA. It is important that the Scoping Checklist be completed early in the RCRA Corrective Action process so that DQOs can be developed for collecting the type, quality, and quantity of data needed to support a SLERA. The Scoping Checklist can also record previously completed work and identify data gaps if an ERA has previously been developed for the facility under another program or for other reasons.

In limited circumstances, completing the Scoping Checklist may result in a finding that there are no potentially complete exposure pathways associated with the site. In these circumstances, the EPA or state program must be consulted to review and approve such a determination. If completing the Scoping Checklist does identify potentially complete exposure pathways, the facility must proceed with performing an ERA.

b. Problem Formulation and the Conceptual Site Model

A Conceptual Site Model (CSM) is a site-specific product of the problem formulation process. It depicts the environmental conditions of a site, contaminants present, contaminant pathways from sources through the system and ultimately to ecological receptors. The CSM typically consists of a flow chart or diagram with supporting text. It links known or suspected contaminant source(s) at the site to potential aquatic or terrestrial ecological receptors by considering contaminant fate and potential exposure pathways. The CSM is used to organize and communicate exposure information to help focus the site investigation and resources on the most significant problems. The CSM also helps to prioritize data gathering and may have to be refined as the site investigation proceeds and new data become available.

The CSM at this stage of the ERA process typically defines, in a conservative fashion, the following major problem formulation elements:

1) The contaminant source(s) known or suspected to exist at the site;

2) Contaminant fate and transport mechanisms that might exist at the site;

3) The potentially complete exposure pathways that link sources with receptors (note: a complete exposure pathway is one in which the chemical can be traced or be expected to travel either directly or indirectly through abiotic or biotic media from the source to a receptor); and

4) The likely categories of aquatic and/or terrestrial community-level and wildlife receptors that could be exposed to the site-derived contaminants.

c. Structuring a Screening Level Risk Assessment (SLERA)

The SLERA is the first step in evaluating the potential for ecological risk. The primary purpose of a SLERA is to identify Contaminants of Potential Ecological Concern (COPECs) and assess the need and the level of effort necessary to perform further evaluation of the current and future site risk. Depending upon risk potential and the level of uncertainty associated with that risk determination, a refinement may be warranted, whether it be in a SLERA refinement or the initial stages of a “Baseline” Ecological Risk Assessment (BERA).

The SLERA evaluates the potentially complete exposure pathways identified in the Scoping Checklist and CSM. It compares the maximum contaminant levels to published Ecological Screening Values (ESVs) that represent No-Observed-Adverse-Effect-Levels (NOAELs) for long term (chronic) exposure to community-level aquatic or terrestrial receptors. With the presence of bioaccumulating or biomagnifying contaminants, it is also necessary to evaluate the uptake of contaminants into local aquatic or terrestrial food chains to assess exposure to receptors further up the food chain such as birds and mammals foraging at the site. The contaminant uptake from this aspect of the assessment is quantified by calculating receptor-specific conservative Estimated Daily Doses (EDDs) for comparison to bird or mammal NOAEL Toxicity Reference Values (TRVs). Both of these evaluations are deliberately conservative to ensure that potential ecological risks are not overlooked and to identify the combination of contaminants, pathways, and receptors for which ecological risks are possible.

The SLERA process includes the first two of the eight ERA steps outlined in EPA guidance (EPA, 1997), as follows:

STEP 1: Screening-level problem formulation and ecological effects evaluation

- **Screening-level problem formulation**: The problem formulation includes stressor characterization, identifying ecological receptors of concern, selecting assessment endpoints and measures of effect for each receptor group, and developing a CSM.

- **Screening-level ecological effects evaluation**: The effects evaluation quantifies the toxicity of site-related contaminants based on published no-effect ESVs (for community-level receptors, which are considered to be receptors with direct exposure to contaminated media, e.g., benthic organisms exposed to sediment, aquatic organisms exposed to surface water, soil organisms exposed to soil), or no-effect TRVs (for bird and mammal wildlife receptors).

STEP 2: Screening-Level exposure estimate and risk calculations

- **Screening-level exposure estimate**: The exposure estimate identifies the Exposure Point Concentrations (EPCs) used in the evaluation for each contaminant and medium in each habitat of interest. Maximum detected concentrations are selected when developing the EPCs to which the receptors can be exposed to at a site either directly (i.e., community-level receptors) or indirectly (i.e. birds or mammals via the food chain).

- **Screening-level risk calculation**: The risk calculations are based on Hazard Quotients (HQs). Chemical-specific HQs are obtained by dividing the EPCs by their applicable screening benchmarks, which are either ESVs for community-level receptors or TRVs for birds and mammals. A chemical is retained as a COPEC if the HQ exceeds 1.0 or no screening benchmark is available to calculate a HQ. An uncertainty analysis is included in the discussion to provide context to the screening-level risk characterization.

Note that in order to avoid unnecessary delays, EPA Region 1 strongly recommends developing a SLERA WP in advance of performing a SLERA and submitting the SLERA WP to EPA or the overseeing state environmental agency for review and comment. This step ensures that the facility and agency agree on the proposed data collection and evaluation efforts before the facility expends its resources on the SLERA.

Table 1 summarizes the variables, tools, and quality of data that are appropriate for a SLERA. The last column of the table references ESVs commonly used in SLERAs. This list is not comprehensive, but does indicate some commonly used media specific screening criteria. Other well supported ESVs may also be proposed for use with screening. All ESVs, including those shown in Table 1, should be reviewed before they are selected for use in a SLERA to verify that the conditions for which these values were designed match the exposures at the site. The screening criteria in Table 1 are listed in order of preference for use for each medium. Not all screening criteria resources need to be utilized; if a value is not found in the preferred screening criteria resource then subsequent criteria listed in Table 1 should be consulted.

The SLERA WP should include the CSM with supporting text and documentation along with the completed Scoping Checklist as an attachment. In addition, the SLERA WP should contain the following elements:

- Plans for collecting data supported by an approved Quality Assurance Project Plan (QAPP). The QAPP integrates the technical and data quality aspects of a project to provide a "blueprint" for obtaining the type and quality of environmental data needed for a specific decision or use (DQOs) and characterizing ecological exposures in media for which a complete exposure pathway(s) has/have been identified. The QAPP should include detailed plans for how, where, and when data will be collected. The type, quantity, and quality of data collected in the past should also be fully described if such data are proposed for use. As discussed in Section 6 of this document, it is particularly important that the QAPP ensures that the Reporting Limits (RLs) are lower than the ESVs or includes a description of how non-detects higher than the RL will be dealt with in the SLERA or BERA. QAPP guidance document references can be found at the EPA Region 1 Quality Assurance web page, for which the address is provided in the "References" section at the end of this document.

- Plans for evaluating the data to develop screening-level risk estimates. These plans should discuss how the EPCs will be calculated, provide the ESVs and TRVs; and summarize the wildlife exposure factors for use in food chain modeling (if applicable); and

- Plans for presenting the data and evaluating the results in a SLERA report.

d. Screening Level Ecological Risk Assessment (SLERA) Report

A SLERA Report documents the methods, results, and conclusions of the SLERA. A detailed uncertainty assessment also needs to be included to address any uncertainties introduced with each element of the SLERA.

e. Scientific Management Decision Point (SMDP)

The EPA or state ecological risk assessor communicates the SLERA results to the risk manager(s) after the SLERA report has been prepared and reviewed. After consultation with the risk assessor, the risk manager(s) decides whether the information is adequate to make a risk management decision of which one of the following three options are possible:

1) Ecological risks are negligible and do not warrant remediation;

2) The information is not adequate to make a decision about the potential for ecological risk and the ERA process should continue at least to the initial stages of a BERA; or

3) The information indicates a potential for adverse ecological effects and a more thorough, in-depth assessment is warranted (i.e., a BERA) (EPA, 1997). If the information clearly indicates that an adverse impact to ecological receptors is occurring (e.g., fish kills, separate phase pollution in a surface water body, abiotic conditions in habitat that would normally support organisms), then additional ecological risk assessment may be unnecessary except to develop risk-based preliminary remedial goals.

f. Baseline Ecological Risk Assessment (BERA)

In contrast to the SLERA, which uses generic non site-specific ESVs, the BERA is a site specific risk assessment used to 1) further refine, identify and characterize the current and potential threats to the environment from a hazardous substance release, 2) evaluate the ecological impacts of alternative remediation strategies, and 3) establish cleanup levels for the selected remedy that will protect those natural resources at risk (U.S. EPA, 1994e, OSWER Directive # 9285.7-17).

The BERA consists of the following major stages (identified as Steps 3 through 8 in the ERA process, EPA, 1997):

Step 3: Baseline Risk Assessment Problem Formulation

Step 4. Study Design and Data Quality Objectives (DQOs)

Step 5. Field Verification of Sampling Design and Scientific Management Decision Point (SMDP)

Step 6. Site Investigation and Analysis of Exposure and Effects

Step 7. Risk Characterization

Step 8. Risk Management

A Scientific Management Decision Point (SMDP) occurs at the end of each step, in which a state or EPA risk assessor, risk manager(s) and other involved parties come to agreement on the information gathered and next steps. Therefore, EPA or state involvement in the planning of each stage is critical to successful completion of the BERA.

2. Separation of the Screening Level Ecological Risk Assessment (SLERA) and Baseline Ecological Risk Assessment (BERA) Stages of the Ecological Risk Assessment (ERA)

The SLERA and BERA represent distinct stages of the ERA process. Blending the SLERA and BERA together, i.e., incorporating Step 3a of the BERA into the SLERA, has the following consequences:

- The conclusions are based on a smaller data set;
- The assessment cannot be further refined (e.g., through toxicity testing, tissue residue analysis, and field surveys);
- The risk assessment conclusions will have higher uncertainties and therefore may not be adequate to support risk management decisions; and
- The Scientific Management Decision Point (SMDP) between the SLERA and BERA is skipped.

However, Step 3a of the BERA, sometimes called the "SLERA Refinement Step," can be performed early in the BERA process and, if agreed to by EPA or state ecological risk assessors and risk managers, may be included as an appendix to the SLERA report. In the SLERA Refinement Step, considerations for evaluating risk involving the use of more realistic variables can be applied, such as: less conservative Exposure Point Concentrations (e.g., 95% Upper Confidence Limits [UCL] of the mean instead of maximum concentrations); low effects-based toxicity values (e.g. effect-based sediment benchmarks or effect-based TRVs); frequency and magnitude of detection; dietary considerations involving nutrients (EPA 2001); and bioavailability considerations (e.g., assuming less than 100% bioavailability) (USEPA, 1997). After these refinements to the SLERA conclusions have been evaluated, well characterized site (medium and habitat-specific) background values may be applied. To be clear, comparison of site data to background values is not allowed during the screening phase of an ecological risk assessment. However, if moving from a screening process into a more site specific baseline risk assessment phase, the consideration of site specific background, if agreed to by an EPA or state risk assessor, is reasonable. This approach avoids identifying compounds that are clearly not site related as COPECs when those compounds are only present at background levels. Including the refinement step as an appendix to the SLERA report does deviate procedurally from the Superfund guidelines, but may allow smaller RCRA sites, with limited and fully characterized ecological risk issues, to potentially exit from the ERA process if the need to develop a more extensive BERA is determined by the refinement to be unwarranted.

If this refinement approach is to be used, all parties must be aware that one of the reasons the SLERA is designed to be conservative is that it generally considers fewer samples than the BERA. **Therefore, if decisions to remove COPECs from further consideration are to be evaluated as part of a SLERA Refinement, the number and quality of the data needed to meet DQOs of the ERA for on-site and background samples should be enhanced up front.**

3. Selection of Data for Use in an Ecological Risk Assessment (ERA)

The specific objectives of the ERA process are to: identify and characterize the current and potential threats to the environment from a hazardous substance release; and identify cleanup levels that would protect those natural resources from unacceptable risk (EPA, 1999). It is important to note that threats to the environment to be evaluated in a risk assessment include existing current adverse ecological impacts and the risk of such impacts in the future.

As the ERA focuses on current and future potential threats to the environment, data selected for use in an ERA must be relevant for characterizing current conditions. While recently-collected environmental data are preferable, it is conceivable that, as site investigations may proceed for several years, a facility may propose using older data. **When proposing data more than 1-2 years old for use in an ERA, a facility must show definitively that the data adequately represents current conditions and meets the DQOs necessary to properly evaluate current and future risk potential** (also see Section 6 for discussion on non-detects and reporting limits). Use of data more than 1-2 years old may be reasonable if the area under investigation has not changed physically, e.g., due to dredging, significant deposition, etc., and the Contaminants of Concern (COCs) are stable. It is important that any data proposed for use in an ERA represent the exposure pathway being evaluated. Use of data that comes from other areas or depth profiles is generally not acceptable.

If an evaluation of any of the following factors indicates that the area under investigation is subject to change, then use of older data may not adequately represent current conditions and new sampling is warranted:

- Were the data collected from an area where natural or human forces could cause/have caused migration or shifts in the target environmental medium? For example, were the data collected in a fluid medium such as groundwater or surface water? Were the data collected in soil or sediment in an area subject to erosion, scouring, deposition, landscaping or construction?

- What is the potential for the target contaminants to migrate within the target medium or partition into another medium (e.g. by leaching, volatilization, etc.)?

- What is the potential for the contaminants to degrade in response to biotic and abiotic factors?

4. Background/Reference Location Data

Evaluation of data from a background or reference location provides information on naturally-occurring or anthropogenic contaminants or other conditions that are characteristic of the local general environment and may influence conditions at a RCRA Corrective Action facility. **A background data set may be used to refine the list of COPECs, as well as, to calculate incremental risk when attempting to differentiate source(s) of risk. A sufficiently robust background data set that allows for the proper characterization of background source(s) is critical for these purposes.** Largely related to this point is that the calculation of various defining values, e.g., mean, 95% UCL of mean and 95% UTL, requires a minimum number of data points to perform the calculation(s). The RLs for these data must be less than the values used in comparison to represent media-specific ecological no-effect and effect values. The following issues pertain to evaluation of background conditions in an ERA:

a. <u>Selection of background/reference locations</u>:

Published studies provide “generic” media-specific contaminant concentrations from various regions of the United States. However, in accordance with EPA ecological risk assessment guidance, which defines background as the concentration of contaminants that surround, but are unrelated to site releases, facilities should use localized site-specific background because use of more generalized background characterization greatly diminishes it’s utility in both the ERA and risk management and should only be used as a last resort. Consideration of the use of a more generalized data for background characterization, must first be proposed in the early stages during any initial discussions with regulatory agencies. If, after initial discussions, the agencies are amendable to its consideration, in order to have final agreement it must be well supported and presented including specific data sources, media specific application(s), and how the data will be interpreted and used in decision making in planning documents, including as necessary in scopes of work (SOWs), ERA work plans (WPs), sampling and analysis plans (SAPs) and ERA quality assurance project plans (QAPPs).

All background locations, for each medium and means of comparison, should be agreed upon by both the facility and EPA or the overseeing state environmental agency prior to sampling. For proper utilization, background geographic locations and the particular media sampled must be, within reason, comparable to site conditions and have similar physical-chemical characteristics. In order to achieve this, it is recommended that pre-sample screening of the various background locations be performed. For example, sediment data from a lotic water body should be compared to lotic water body sediment in an immediate upstream and/or general background reference location where the flow regime and sediment composition are similar. Background data are necessary for each different habitat type and each different medium under investigation. Reference samples for characterizing general background conditions should not be collected in areas of local impact from another known contaminant source, unless no such area is reasonably available and/or accessible. For streams, collecting reference samples immediately upstream of the site is important for documenting non-site related impacts, even if the whole stream is impacted by pollutants. Also, it is very important to strongly consider collecting background samples from more than one representative area for the following objectives and circumstances: proper characterization of the particular habitat; the collection of the minimum number of data points necessary for calculations; and in the event that sampling in one of the areas indicates it has been impacted by previously unknown sources.

Metals occur naturally and are therefore expected to be present in background samples. EPA also recommends analyzing all background samples for Polycyclic Aromatic Hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and organochlorine pesticides (if suspected to have been released at the site). These compound classes are commonly present in background locations due to road runoff/atmospheric deposition (e.g., PAHs), past pesticide use, and general industrial impact.

As always, all sampling should be performed to meet investigation DQOs. The minimum number of samples necessary to properly characterize background concentrations in all media under consideration depends on several factors, most notably the variability of the matrix in question and how the data will be used in site decision making. Enough background data points should be collected from each target medium to calculate reliable summary statistics such as a mean or 95% Upper Confidence Limit (UCL) of the mean for each medium. Any plan for collecting background samples should be approved by all parties involved and include a specific process for acquiring background data, using the data in a statistical analysis, and interpreting analysis results to clearly distinguish between contributions of background and site-related concentrations.

b. <u>Use of background data in an ERA:</u>

EPA Superfund guidelines, which are generally followed for RCRA Corrective Action ERAs, specify that constituents, which exceed their respective ESVs should be retained for evaluation in a BERA, regardless of whether the site constituents exceed background concentrations. This approach involves addressing site-specific background considerations in the risk characterization step of the BERA. Specifically, COPECs with elevated background levels should be discussed in the BERA risk characterization and, if data are available, the contribution from background to site risk should be distinguished (EPA, 2002) by calculating “incremental” risk (i.e., the residual risk that remains after background risk has been subtracted from site risk). As part of the data gathering process, it may be logistically advantageous to collect background data as part of the initial data collection. However, background data is not to be considered until at least the early stages of the BERA.

c. As discussed more fully in Section 2 of this document, background levels, where appropriate, well characterized, and if agreed upon by EPA and/or state ecological risk assessors and risk managers, may be considered in the initial stages of the BERA (EPA, 2001). In EPA Region 1, again if agreed upon by all parties (including the EPA or State ecological risk assessor), this step, where background data may be considered and, which is sometimes referred to as the "SLERA Refinement Step," may be included as an appendix to the SLERA report.

d. Additional guidance:
The following documents should be consulted regarding the issues of robustness of datasets, selection of background sample locations, and comparison of background and site related contaminants at hazardous waste sites.

EPA, 1995. Determination of Background Concentrations of Inorganics in Soils and Sediments at Hazardous Waste Sites. EPA/540/S-96/500.

EPA, 2001. The Role of Screening Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments, OSWER Publication 9345.0-14, EPA 540/F-01/014, June 2001

EPA, 2002. Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA sites. EPA/540/R-01/003.

In addition, EPA's ProUCL software may help to evaluate whether a background data set is statistically significantly different than a site data set and/or identify the presence of potential outliers in the data set which unacceptably skews the results.

When considering the importance of the background information, it is likely in the interest of all parties to be sure that the information meets the intended DQOs and is gathered appropriately so that it is of sufficient quality and quantity to allow for a representative characterization because, as has most often been the case, the background data set has insufficient power to distinguish statistically significant differences between the background data and the site data even at a reasonable probability level (e.g., $p<0.1$) .

5. Acid Volatile Sulfides – Simultaneously Extracted Metals (AVS-SEM) (Not for consideration at the Screening Level Ecological Risk Assessment stage)

AVS-SEM concentrations, in some cases and under specific site conditions, have been shown to predict the bioavailability and hence toxicity of a number of specific divalent metals present in sediment. Those metals are copper (Cu), cadmium (Cd), nickel (Ni), lead (Pb), silver (Ag) and zinc (Zn). The rationale behind the bioavailability modelling is that the AVS present in sediment reacts with the divalent metals to form an insoluble metal sulfide that is not bioavailable, and hence non-toxic through direct contact with benthic organisms. Therefore, the relationship of AVS to SEM may provide information to use in conjunction with other lines of evidence on specific divalent metal bioavailability.

If this model is proposed for use in an ERA to provide an indication of maximum exposure potential, samples intended for this purpose must be collected in accordance with an approved method specifically designed for AVS-SEM analysis and at a time of year when the least amount of sulfides are likely to be present, hence the target divalent metals would be most bioavailable. Therefore, it is recommended to sample for AVS-SEM between the end of November and early May in New England, when relatively higher dissolved oxygen levels in the water above the sediment will decrease the generation of AVS by sulfate-reducing bacteria. It is also important to note that the predictive power of this type of data is strongly linked to the specific conditions at the time of sampling. If those conditions may change, e.g. as a result of future sediment re-suspension and/or transport, then decisions on the usability of this type of modeling should consider those potential changes in site conditions.

If early in the ERA planning these six divalent metals are suspected to be a concern, it may be most efficient, purely for logistical reasons, to collect AVS-SEM data as part of the early data collection efforts. It is important to note that as bioavailability is assumed to be 100% in the SLERA, AVS-SEM data would only be considered at the BERA stage to augment the interpretation of a multi-prong approach, which includes other measurement tools such as toxicity testing and an acceptably robust benthic community survey. The results of AVS-SEM analysis can only be applied to the direct exposure pathway for benthic invertebrate receptors. AVS-SEM results do not apply to food web exposure pathways, which involve ingestion of contaminated sediments or consumption of contaminated benthos. AVS-SEM modeling does not consider additive, antagonistic, or synergistic effects. It also does not consider bioaccumulation or trophic transfer. Consequently, AVS-SEM data cannot be used by itself as a mechanism to screen out COPECs. If AVS-SEM analysis is proposed, it can only be used as a supporting line of evidence to estimate the bioavailability of divalent metals as an explanation of observed toxicity or other identified impact. AVS-SEM analysis cannot be uncoupled from bulk chemical analyses and aquatic toxicity testing (EPA, 2005) and may likely promote the need to consider additional sampling.

6. Handling Non-Detect Values in a Risk Assessment

Analytical RLs should be compared to appropriate ESVs in advance of data collection to ensure that the RLs will fall well below the ESVs for each constituent. If the RL exceeds the ESV for a particular constituent, that constituent cannot be eliminated in the SLERA from further consideration, even if it is reported as not detected in samples collected from an area of concern. In the instance where RLs cannot be reasonably achieved, a potential option for consideration is that the highest non-detect RL is retained as the exposure point concentration (EPC) for comparison against an ESV. If the maximum RL falls below the ESV, the non-detected constituent is not retained as a COPEC.

At the BERA stage, as early as Step 3a, EPA's ProUCL software can be used to calculate a 95% UCL of the mean as an EPC if the minimum number of data points is available to perform the calculation reliably (http://www.epa.gov/osp/hstl/tsc/software.htm). In the case of non-detects in the data set, ProUCL handles that situation provided that the minimum number of detects within a data set is met.

7. Evaluation of Groundwater Discharge to Surface Water

Groundwater impacts to surface water and sediment dwelling receptors are an important consideration where known or suspected contaminant plumes may discharge to surface water bodies. This pathway and its investigation can be quite complicated (EPA, 2008). Historically, this pathway has been investigated in a number of ways, most notably perhaps by collecting data from shallow groundwater wells immediately upgradient of the point(s) of discharge to a surface water body for subsequent comparison to ambient water quality aquatic life criteria.

Some regulatory agencies may be more prescriptive and address the discharge of contaminated groundwater to surface water in their own regulations. For example, Connecticut's (CT) Remediation Standard Regulations (RSRs) address this issue by including the use of default Surface Water Protection Criteria (SWPC) and the use of state chronic ambient water quality criteria depending upon particular discharge areas and dilution of the plume with upgradient drainage flow. Consequently, if a groundwater plume is known or suspected to discharge to surface water on or in proximity to a CT RCRA site, the discharge should be evaluated according to CT RSRs. For an ecological risk assessment for a facility in CT, CT requires that a SLERA screening step be performed as follows: If the areal extent of the plume occupies more than 0.5% of the upgradient drainage basin flow or the plume discharges to either a wetland or intermittent stream, the average contaminant concentrations of an entire plume, if it has been adequately characterized, or groundwater values from properly-screened wells in close proximity to the point of discharge to a receiving water body must be compared to the most stringent of the National Recommended Ambient Water Quality Criteria (NRWQC) chronic values for aquatic life (http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm) or chronic values of the CT Ambient Water Quality Criteria (AWQC) for aquatic life (http://www.ct.gov/deep/cwp/view.asp?a=2719&q=325618). If AWQC are not available, they may be able to be calculated using the Great Lakes Tier II methodology from the *Great Lakes Water Quality Initiative* (GLWQI) (40 CFR 132 et al.). If the contaminant plume is less than 0.5% of the upgradient drainage or the plume discharges to an area other than a wetland or intermittent stream, the CT RSRs specify comparison of plume contaminant concentrations to SWPC.

If a RCRA site is not under CT jurisdiction, the same type of pathway investigation may be acceptable. If a more comprehensive assessment is found to be necessary, it is recommended that the 2008 Groundwater Forum Issue Paper, located in the EPA Eco Update bulletin series, be consulted for guidance. For marine or estuarine receiving waters, the most stringent of the marine chronic state AWQC or NRWQC should be used.

If the system under investigation is tidally influenced, and the receptors can be both freshwater and marine, the lowest of marine and freshwater state AWQC or federal NRWQC should be used as the ESV.

Groundwater discharging to a surface water body, even if contaminant levels are below respective WQCs, may over time lead to unacceptable levels of contaminants accumulating in surface sediment. A determination of an acceptable risk to surface water receptors does not necessarily equate to the same determination of risk for sediment dwellers. Therefore, where discharge of contaminated groundwater to a surface water body has occurred or is occurring, evaluation of risk to ecological receptors in surface water, as well as, sediment should be considered based on the nature and extent of the release. Importantly, finding an acceptable level of risk in the surface water body may not satisfy the requirement to meet regulatory criteria such as the SWPC, which is designed to be applied to groundwater discharging to surface water.

8. Determining Appropriate Depth for Soil and Sediment Evaluation

Soil and sediment samples collected for use in an ERA must represent the biologically active zone as determined by the scenarios and pathways proposed in the conceptual site model (CSM) of the ERA. For soil, the biologically active zone typically is assumed to be within 1-2 feet of the ground surface. Deeper depths within this range assume the presence of burrowing animals. The biologically active zone for freshwater sediment may be less, but is assumed to extend between 0 and 6 inches below the sediment surface. Marine systems may have deeper zones of activity. It is recommended to perform early field screening to determine the depths actually inhabited by benthic organisms that the ERA process should consider (EPA, 2005).

Important, but separate and distinct from the actual performance of the ERA, deeper soil and sediment evaluation should be performed as necessary at distinct vertical intervals as part of overall site characterization to define the nature and extent of contamination. In addition, for any reasonably expected scenarios that could cause exposure to deeper soil or sediment horizons, the ERA should include evaluation of those horizons. These scenarios include environments subject to routine erosional activity, areas where episodic events, such as floods or storms, are likely to create erosional situations, or areas where a dam removal is planned or expected.

In addition, deeper soils and sediments should be considered in an ERA where contaminants in the surface soil or sediment may pose an unacceptable risk and therefore may need to be removed. Any deeper soils or sediments that could become exposed at the surface should be evaluated and considered in the ERA unless the remedial alternative includes replacing removed surface soils and sediments with clean material.

9. Water Samples: Filtered vs. Unfiltered and Hardness Considerations

Analyses of surface water samples for metals should be performed on both unfiltered samples (for total metals) and filtered samples (for dissolved metals). Dissolved metal concentrations represent the bioavailable fraction responsible for toxicity to surface water receptors such as aquatic invertebrates, fish, or the larval stages of amphibians. Total concentrations are used for direct contact comparison and in the SLERA process as a conservative estimation of the exposure point concentrations (EPCs) for wildlife receptors drinking surface water.

Commonly, adjustment of certain metals whose surface water toxicities are affected by hardness is also an important consideration. This adjustment requires that water samples be analyzed for hardness directly. Alternatively, hardness (mg equivalent $CaCO_3$/L) can be estimated based on the following formula (APHA, 1998):

$$\text{Hardness} = 2.497\ [\text{Ca, mg/L}] + 4.118\ [\text{Mg, mg/L}]$$

Note that the National Recommended Water Quality Criteria (NRWQC) for hardness-dependent metals are based on a hardness of 100 mg/L. The ecological screening values (ESVs) for hardness-dependent metals developed by individual states may be based on a different hardness, which should be taken into consideration. If the state standards do not provide for hardness adjustment, then such adjustments should not be made for comparison to those standards. Everything else being equal, the toxicity of all hardness-dependent metals increases with decreasing hardness.

10. Carrying Constituents that Bioaccumulate or Biomagnify through the Screening Level Ecological Risk Assessment (SLERA)

Constituents that have the potential to bioaccumulate (i.e., increase in concentration in an organism) or biomagnify (i.e., increase in concentration in a food chain) through aquatic or terrestrial food webs must be carried through the SLERA and at a minimum into the refined SLERA or the BERA even if their maximum detected concentrations, or their maximum detection limits, fall below the community-level ecological screening values (ESVs).

Table 4.2 in *Bioaccumulation Testing and Interpretation for The Purpose of Sediment Quality Assessment Status and Needs*. EPA-823-R-00-001. February 2000 (available at http://water.epa.gov/polwaste/sediments/cs/upload/bioaccum.pdf) provides the full list of constituents that EPA considers as bioaccumulators or biomagnifiers.

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Great Lakes Water Quality Initiative (GLWQI) (40 CFR 132 et al.).

Table 1: Potential Data and Screening Criteria for Use in a Screening Level Ecological Risk Assessment

Media[i]	Data Requirements [ii]	Exposure Point Concentration	Ecological Screening Values[iii]	Commonly Used Ecological Screening Values[iv]
Soil	Samples characterizing the biologically active zone (typically top 1 foot), or deeper for burrowing animals	Initially based on most conservative exposure assumptions and maximum concentration measured or estimated	Screening eco toxicity values representing no-observed-adverse-effect-levels for chronic exposures	• US EPA Eco SSLs[v] • US EPA Region 5 Ecological Screening Levels[vi] • US EPA Region 4 Ecological Screening Levels[vii]
Sediment	Samples characterizing the biologically active zone (typically top 6 inches for freshwater, marine may be deeper)	Initially based on most conservative exposure assumptions and maximum concentration measured or estimated	Screening eco toxicity values representing no-observed-adverse-effect-levels for chronic exposures	• Consensus Based Threshold Effect Concentrations[viii] • NOAA Sediment Quality Guidelines, ER-Ls[ix] • US EPA Region 5 Ecological Screening Levels [vi]
Groundwater[ix]	Samples from the entire plume or from properly screened wells close to receiving water body or wetland	Average concentration of an entire plume, if adequately characterized; maximum concentrations from wells close to a receiving water body; or projected concentrations at point of discharge from fate and transport modeling	Screening eco toxicity values representing no-observed-adverse-effect-levels for chronic exposures	• National Recommended Water Quality Criteria Criterion Continuous Concentration [x] • State chronic aquatic life criteria • US EPA Region 5 Ecological Screening Levels [vi]
Surface Water	Samples from the water column or near discharge point of contaminated groundwater	Initially based on most conservative exposure assumptions and maximum concentration measured or estimated	Screening eco toxicity values representing no-observed-adverse-effect-levels for chronic exposures	• National Recommended Water Quality Criteria Continuous Concentration [xi] (or comparable state chronic aquatic life criteria) • US EPA Region 5 Ecological Screening Levels [vi]

[i] Only media from which complete exposure pathways exist, as identified in the site conceptual model, should be considered.

[ii] Data must be planned and collected under the requirements of a site specific Quality Assurance Project Plan (QAPP) and must be of documented quality adequate for decision-making.

[iii] Contaminants of Potential Ecological Concern (COPECs) that have the potential to biomagnify should not be eliminated from further consideration, even if concentrations are below the appropriate screening criteria. For more information, see EPA. 2000a. Bioaccumulation Testing and Interpretation for The Purpose of Sediment Quality Assessment Status and Needs. EPA-823-R-00-001. February 2000 http://water.epa.gov/polwaste/sediments/cs/upload/bioaccum.pdf

[iv] This is not a comprehensive list of screening criteria: others may be proposed for use. Any screening criteria, including those included in Table 1, should be carefully reviewed before being selected for use in a Screening Level Ecological Risk Assessment (SLERA) to verify that the conditions for which the criteria were designed match the conditions of the site. The screening criteria are listed in order of preference, with the intention that the sets of criteria appearing lower on the list may only need to be considered for constituents for which criteria are not specified in the sets of criteria appearing at the upper part of the list. Please ensure that only the most current versions of screening criteria are proposed for use.

[v] US EPA Ecological Soil Screening Levels http://www.epa.gov/ecotox/ecossl/

[vi] US EPA Region 5 Ecological Screening Levels http://www.epa.gov/Region5/waste/cars/esl.htm

[vii] http://www.epa.gov/region4/superfund/programs/riskassess/ecolbul.html#tbl4

[viii] McDonald et al., 2000 Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems, Arch. Environ. Contam. Toxicol. 39, 20–31 (2000), http://ptc.mtech.edu/pmunday/CFRevival/MacDonald%202000%20Sediment%20Quality%20Guidelines.pdf

[ix]Groundwater need only be considered to support an ecological risk assessment if it is known to discharge to surface water. Where discharge of contaminated groundwater to a surface water body has occurred or is occurring, evaluation of actual risk to ecological receptors in surface water and sediment should be considered based on the nature and extent of the release.

[x] http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm