Soil Ecological Risk Assessment

U.S. Environmental Protection Agency Status

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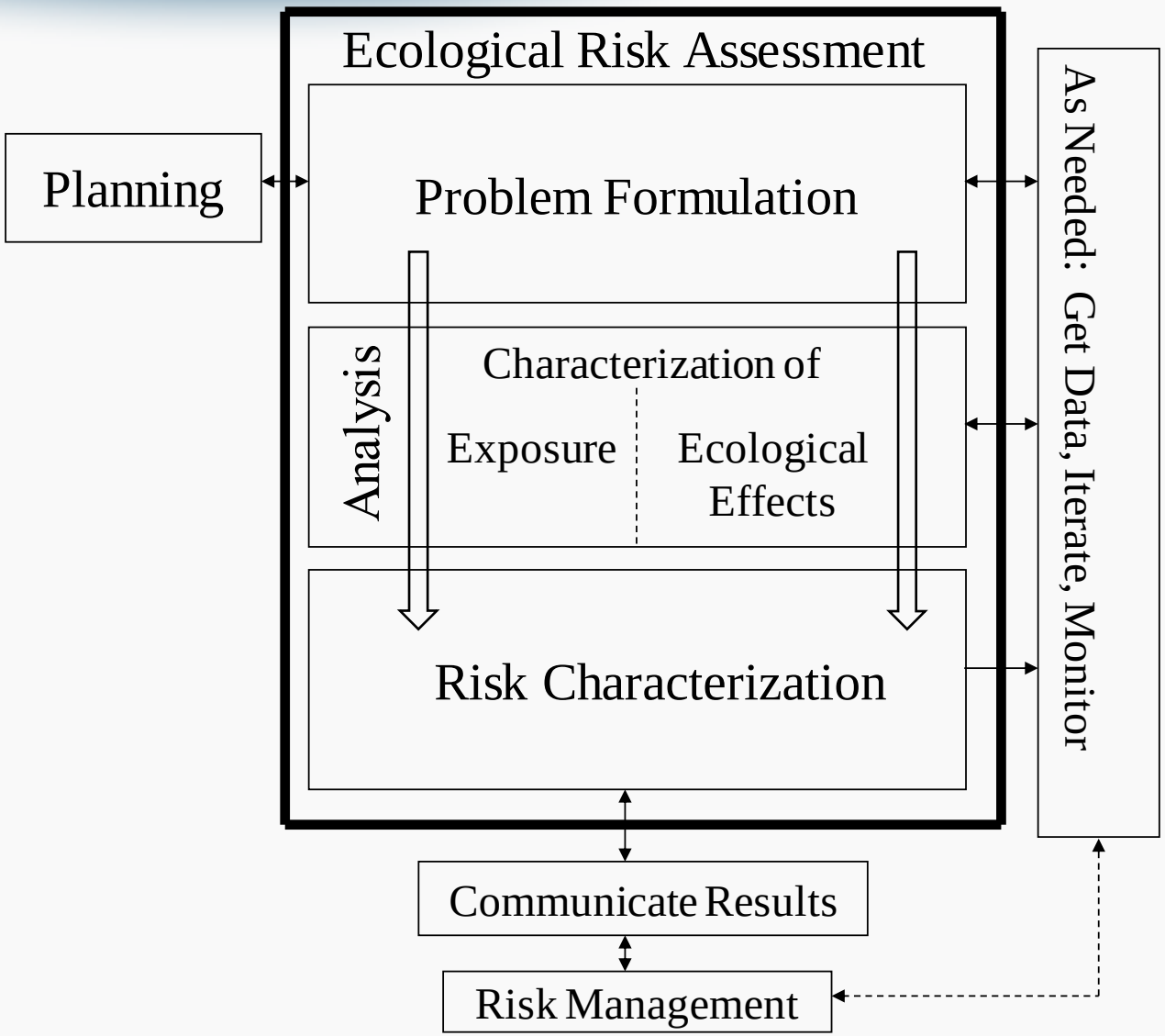
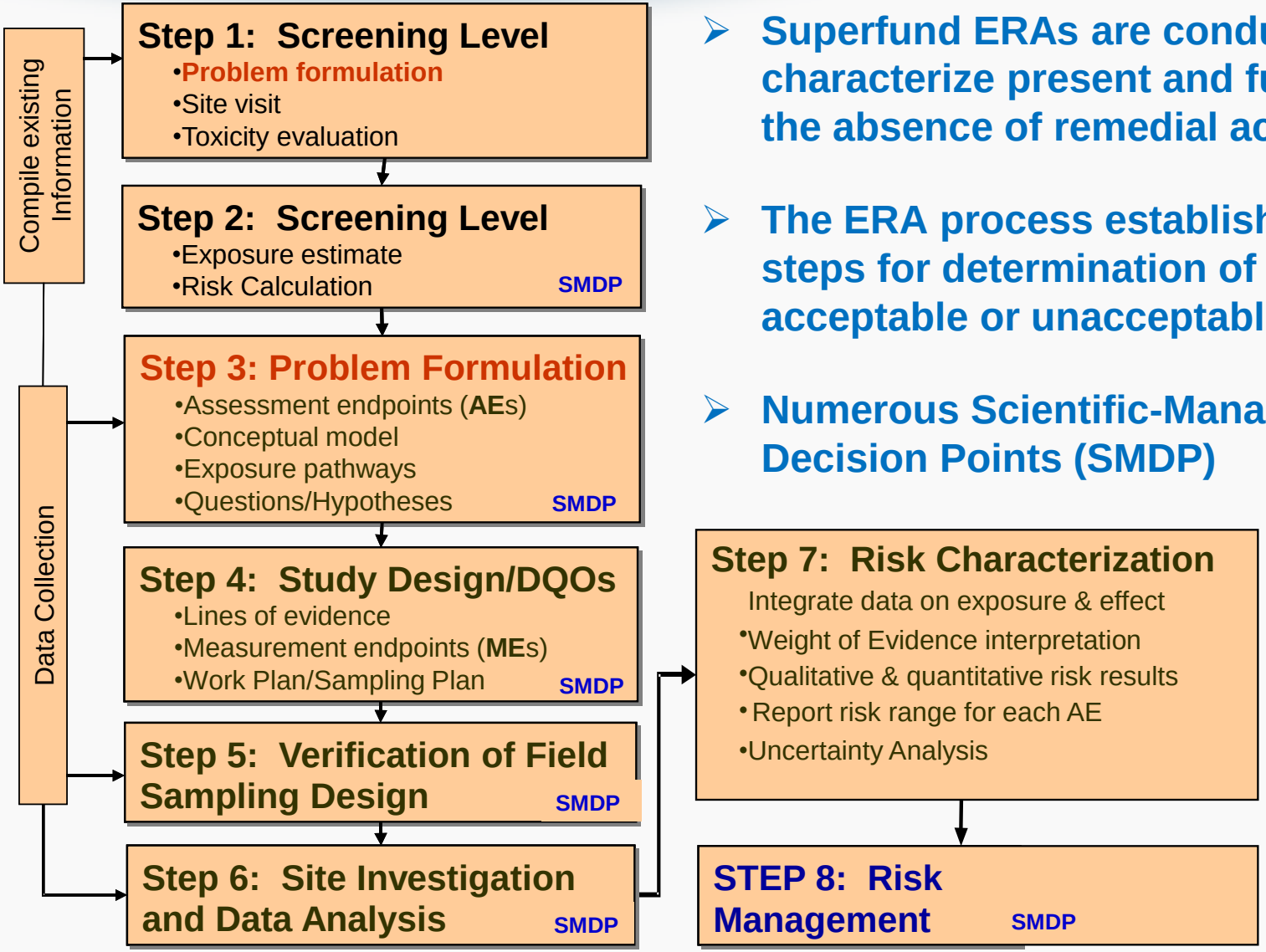
What is Superfund?

- **Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).**
- **Statute charges EPA to protect human health, welfare, and the environment by reducing risks to acceptable levels**
- **Remedial Process (RI/FS):**
  - Remedial Investigation: **Risk Assessments,** Nature & Extent
  - Feasibility Study: Screening of Alternatives
  - Record of Decision

Ecological Risk Assessment Framework
U.S. EPA (1998)



Eight Step ERA Process for Superfund



- **Superfund ERAs are conducted to characterize present and future risks in the absence of remedial action**
- **The ERA process established technical steps for determination of risk as acceptable or unacceptable**
- **Numerous Scientific-Management Decision Points (SMDP)**

U.S. EPA. 1997. Ecological Risk Assessment Guidance for Superfund, Process for Designing and Conducting Ecological Risk Assessments, OSWER 9285.7-25, EPA 540-R-97-006.

Steps 1 and 2

Step 1: Screening Level

- Problem formulation
- Site Visit
- Toxicity evaluation

Step 2: Screening Level

- Exposure estimate
- Risk calculation

SMDP

Step 3: Problem Formulation

- Refinement of Contaminants of Potential Concern
- Assessment endpoints
- Conceptual model
- Exposure pathways
- Questions (Data Quality Objectives)/Hypotheses

SMDP

Steps 3 through 8

Step 3: Problem Formulation

- Assessment Endpoints (AEs)
- Conceptual model
- Exposure pathways
- Questions/hypotheses

SMDP

Step 4: Study Design/Data Quality Objectives

- Lines of evidence
- Measurement endpoints
- Work Plan/Sampling Plan

SMDP

Step 5: Verification of Field Sampling Design

SMDP

Step 6: Site Investigation and Data Analysis

SMDP

Step 7: Risk Characterization

- Integrate data on exposure and effect
- Weight of Evidence interpretation
- Qualitative & quantitative risk results
- Report risk range for each AE
- Uncertainty Analysis

Step 8: Risk Management

SMDP

General Superfund Practice Steps 3-7

- **Collect site-specific data through laboratory and/or field studies**
- **Toxicity testing of soil invertebrates and plants are often conducted at sites.**
- **Toxicity testing on groups of individual organisms is inferred to the site area population for the ERA**
- **Synoptic or observational analyses (e.g., abundance/diversity of insects and plants) often treated as a supplemental Lines of Evidence**

Ecological Soil Screening Levels (EcoSSLs)

- **Reduce need to conduct repetitive lit searches and data evaluations**
- **Turn focus to site specific studies and evaluations**

Use of EcoSSLs

- Concentrations that are protective of ecological receptors that commonly come in contact with soil or ingest biota that live in or on soil
- Screening levels
- Per guidance, not “clean up” levels
- May clean to this level SMDP Step 2

EcoSSLs

- Soil invertebrates
- Plants
- Microbes and their processes
- Mammals
- Birds
- Reptiles
- Amphibians

Final List of EcoSSLs

- **Soil Invertebrates**
- **Plants**
- **Birds**
- **Mammals**

What did not make the EcoSSL "cut"

- **Reptile and Amphibian data, at this point, were deemed insufficient to derive EcoSSLs.**

- **Microbes and processes: EPA recognizes their importance within terrestrial systems but data are insufficient and the interpretations of test results too uncertain for establishing risk-based thresholds.**

Two EcoSSL Procedures

1. **Plant and Soil Invertebrates**

2. **Those other things that people care about that shall not be mentioned in this presentation**

Figure 3.1 The Four-Step Process for Deriving EcoSSLs for Plants and Soil Invertebrates

Step 1. Literature search, acquisition, and screening Apply 22 Literature Exclusion Criteria.

Step 2. Identify acceptable literature by applying eleven Study Acceptance Criteria to retrieved papers

Step 3. Extract and score data from acceptable literature according to nine Study Evaluation Criteria

Step 4. Derive soil invertebrate and plant Eco-SSLs according to specified procedures

- Sort study data by bioavailability score
- Complete QA review
- Calculate value

Figure 3.2 Literature Exclusion Criteria,

Biological Product	**Biological toxins (venoms, etc.)**
Chemical Methods	**Methods for measuring contaminants**
Drug	**Testing for drug effects**
Effluent	**Effluent, sewage, polluted run-off**
Contaminant Fate	**Fate and transport of substance in the environment (only)**
Human Health	**Human or primate subjects**
In Vitro	**In vitro studies, including cell cultures and excised tissues**
Methods	**Methods reported but no usable specific toxicity test results**
Mixture	**Combinations of chemicals in laboratory testing**
Modeling	**Only modeling results reported**
No Conc	**No dose or concentration reported, or not able to calculate from information given**
No Duration	**No exposure duration reported**

Figure 3.2 Literature Exclusion Criteria,

No Effect	**No effect reported for a biological test species**
No Species	**No viable plant or animal present or tested**
No Toxicant	**No toxicant used**
No Tox. Data	**Toxicant used, but no results reported that had a negative impact**
Nutrient	**Nutrition studies reporting no concentration-related negative impact**
Oil	**Oil and petroleum products**
Publ As	**Author states information is published in another source**
QSAR	**Data developed only from quantitative-structure activity relationships**
Review	**Data reported are not primary data**
Survey	**Assessment of toxicity in the field over a period of time**

QSAR = Quantitative Structure Activity Relationship

Eleven Study Acceptance Criteria

1. The document is the primary source of the test result
2. Adverse effects are caused by an identified chemical stressor (i.e., no mixture testing in laboratory studies).
3. The chemical form (e.g., metal salt used) and concentration are reported by the author(s).
4. The test medium used in the study is a natural or artificial soil.
5. The study reports the organic matter content and it is ≤10 % of the composition of the soil; or equivalent concentration reported on the basis of organic carbon.
6. Except for studies on non-ionizing substances (e.g., PCP), the study reports the pH of the soil, and the soil pH is within the range 4.0 ≤ soil pH ≤ 8.5.

Eleven Study Acceptance Criteria

7. The study includes at least one control treatment.
8. The duration of the exposure is reported, or a standard study method with a defined duration is used.
9. For studies conducted in a laboratory setting, at least three treatment levels are used (i.e., control plus two chemical exposures).
10. Biological effects are reported for ecologically relevant endpoints (ERE).
11. Either the test species' scientific name, common name, variety, or strain is reported.

Table 3.1 Ecologically Relevant Endpoints (EREs) for Soil Invertebrate Eco-SSLs

Ecologically Relevant Endpoint	Definition
Reproduction	Measures of the effect of toxicants on offspring production. Examples of EREs associated with reproduction included changes in fecundity, number of progeny produced (eggs, cocoons, etc.), rate of reproduction (hatching rates, etc.), rate of maturation, sexual development, change in sex expression, and sterility number or proportion of abnormal progeny.
Population	Measurements and endpoints regarding a group of soil invertebrates occupying the same area at a given time. Measurement included population dynamics. Examples of EREs associated with population included changes in size and age class structures, changes in sex ratio, intrinsic population growth rate, survivability of subsequent generations, diversity, evenness, index to population size (count, number, abundance), life table data, population density (number/area).
Growth	Broad category which encompassed measures of weight/mass and length. EREs associated with growth and development included responses such as a change in body weight.

Table 3.2 Ecologically Relevant Endpoints (EREs) for Plant Eco-SSLs

Ecologically Relevant Endpoint	Definition
Growth (Biomass)	Measurement of plant products including standing crop biomass, seedling emergency, shoot length/growth, root elongation/growth, fresh or dry mass, yield or production (e.g., seed production).
Physiology	For the purposes of developing Eco-SSLs, plant studies reporting EREs associated with physiological responses were used. Physiological endpoints for plants included net photosynthesis (CO_2 uptake, oxygen release), decrease in chlorophyll content or chlorophyll fluorescence, increased deformation, membrane damage, desiccation/decrease in water content, detrimental changes in dormancy measures, decreased flowering, and increased senescence.

Table 3.3 Summary of Nine Study Evaluation Criteria for Plant and Soil Invertebrate Eco-SSLs
#1: Testing was Done Under Conditions of High Bioavailability
#2A (Laboratory) and **#2B** (Field): Experimental Designs for Studies are Documented and Appropriate
#3: Concentration of Test Substance in Soil is Reported
#4: Control Responses are Acceptable
#5: Chronic or Life Cycle Test was Used
#6: Contaminant Dosing Procedure is Reported and Appropriate for Contaminant and Test
#7: A Dose-Response Relationship is Reported or can be Established from Reported Data
#8: The Statistical Tests used to Calculate the Benchmark and the Level of Significance were Described
#9: The Origin of the Test Organisms is Described

General Superfund practice

- **We still rely on the hazard quotient (HQ) method**
  - Site environmental concentrations compared to benchmarks (screening-level assessment only)
  - Site tissue concentrations compared to CBRs
  - Food-chain model estimates of dietary exposure concentration (e.g., daily dose) compared to a TRV
- **Background**
  - OSWER has **policy** (OSWER 9285.6-07P, *2002*) and **guidance** (OSWER 9285.7-41; EPA 540-R-01-003, *2002*)
  - Risks associated with background are to be considered in both risk assessment and risk management
  - Generally, Superfund does not set cleanup levels below background

There is an increased focus on bioavailability

- **Reduce uncertainties in exposure and risk assessments by including bioavailability data**
- **Recent technical guidance supports use of bioavailability information**
- **Desire for decision-oriented bioavailability methods and tools.**
- **Driving work in developing sediment amendments for use in remediation**
- **EPA has included reductions in bioavailability as a remedial action objective in site decision documents**

Why are we conducting Ecological Risk Assessments at Superfund Sites?

- **We need risk-based clean-up levels to address unacceptable risk**
  - EPA OSWER policy directive (OSWER 9285.7-17, *1994*)
  - *Related to the "level of protection" question in the workshop thought-starter #1*

- **Data related to survival, growth and reproduction are the primary LOE that we prefer for determining ecologically-protective soil concentrations.**

- **Risk range reported in the Risk Characterization**
  - Risk managers in communication with assessors able to select appropriate protective level from the range

Summary

- **The purpose of the ERA is to support development of risk-based cleanup levels where risks are determined to be unacceptable and remediation is needed**
- **The 8-step ERA Guidance for Superfund provides a flexible framework to characterize ecological risks**
- **EcoSSLs are a tool used in the Risk process**
- **Survival, growth, and reproduction endpoints are used**
  - Overall ERA includes physical, chemical, and biological endpoint measurements
- **New scientific approaches can be incorporated into Superfund ERA practice**

Thank You

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