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Standard Guide for Selecting and Using Ecological Endpoints for Contaminated Sites[1]

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1. Scope

1.1 This guide covers an approach to identification, selection and use of ecological endpoints (both assessment and measurement endpoints) **(1-8)**[2] that are susceptible to the direct and indirect effects of both chemical and non-chemical stressors or agents associated with wastes and contaminated media at specific sites under current and future land uses. It does not address assessment and measurement endpoints for non-site specific studies (for example, chemical-specific or regional risk assessments) or measurements in abiotic media (soil, water, or air).

1.2 This guide addresses only the identification, selection and use of assessment and measurement endpoints, not the full range of activities that occur in an ecological assessment or ecological risk assessment at a contaminated site **(1,3-8)**. These activities are addressed in other ASTM guides and references provided at the end of this guide.

1.3 This guide is intended to identify assessment and measurement endpoints to be used for screening, preliminary, focused, detailed and quantitative ecological risk assessments conducted in a linear or iterative fashion **(3,8)**. This is a partial, not complete listing of possible levels of assessment. In a tiered ecological risk assessment, it may be necessary to redefine ecological endpoints when planning to collect more data or when additional site data are obtained and evaluated.

1.4 This guide is intended to be used by trained biologists, ecologists and ecotoxicologists familiar with risk assessment, ecological and ecotoxicological concepts.

1.5 This guide (including Appendix X1) consists of a series of options or instructions and does not recommend a specific course of action or provide detailed guidelines to be followed at all sites. See 2.2.2 of *Regulations Governing ASTM Technical Committees*.[3]

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents [4]

2.1 *ASTM Standards:*

E 943 Terminology Relating to Biological Effects and Environmental Fate[5]

E 1689 Guide for Developing Conceptual Site Models for Contaminated Sites[5]

3. Terminology

3.1 *Definitions*—Definitions are provided specifically for use with this guide. Many of the terms listed in this section have been modified from those defined in other publications **(1-8)**.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *assessment endpoint*—an explicit expression of an environmental value (ecological, not monetary) to be protected **(3)**.

3.2.1.1 *Discussion*—An assessment endpoint is an ecological condition of potential concern or effect experienced by an ecological receptor with ecological and societal value that drives risk-based decision-making at a contaminated site (for example, a specific reduction in the abundance of a fish population or the disruption of the structure of benthic community). It is a qualitative quantitative or quantifiable expression, measure, metric or index involving an ecological receptor at risk. Under some circumstances, assessment endpoints may be measured and used directly for assessment purposes. Assessment endpoints are the ultimate focus in risk characterization and link measurement endpoints (see below) to policy goals and the risk management process **(1-3,5,6,8)**.

3.2.2 *chemical stressor*—a chemical, chemical mixture or radionuclide present in an environmental medium that is known or suspected to induce an adverse biological, toxicological or ecological response in an exposed ecological receptor **(3-8)**.

3.2.2.1 *Discussion*—A chemical stressor is often referred to as an ''ecological contaminant of concern."

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[2] The boldface numbers given in parentheses refer to a list of references at the end of the text.

[3] Available from ASTM Headquarters.

[4] A bibliography of related references and documents is provided in Appendix X2.

[5] *Annual Book of ASTM Standards*, Vol 11.05.

3.2.3 *exposure area*—a geographic location in which one or more site-related stressors are present and ecological receptors are potentially exposed.

3.2.4 *direct effect*—an adverse impact on an exposed ecological receptor (for example, increased mortality or reduced growth) as a result of the action of a site-related stressor.

3.2.5 *ecological endpoint*—a general term to refer to an assessment or measurement endpoint in an ecological risk assessment **(2,3)**.

3.2.5.1 *Discussion*—Measurement of chemical concentrations in soil, water or air are not ecological endpoints; these measurements indicate exposure levels that may be used to evaluate the potential for an ecological response.

3.2.6 *ecological receptor*—ecosystems, habitats, communities, populations and individual organisms (except humans) that can be exposed directly or indirectly to site stressors **(3,4,7,8)**.

3.2.7 *endpoint*—an ecological characteristic (measure, metric, or index) that may be adversely affected by a site-related stressor **(4)**.

3.2.8 *indirect effect*—an adverse impact on an ecological receptor (for example, predator) resulting from the direct effect of a stressor on another ecological receptor (for example, reduction in food supply or habitat).

3.2.9 *indicator species*—an organism that is typically common and represents a broad class of species present at the site or in surrounding areas, or both.

3.2.9.1 *Discussion*—There is sufficient information on its life history and response to contaminants to construct a model to predict (with uncertainty) the potential for effects.

3.2.10 *measurement endpoint*—a measurable response to a stressor (measure, metric or index) that is quantifiably related to the valued characteristic chosen as the assessment endpoint **(3)**.

3.2.10.1 *Discussion*—Examples of a measurement endpoint are the reduction in the growth, survival or reproduction of minnows in a standard laboratory toxicity test. These examples of measurement endpoints would be appropriate for assessment endpoints defined as specific predefined reductions in the growth, survival or reduction in a forage fish population in a stream, river or lake at the site **(2-4,8).**

3.2.10.2 *Discussion*—A measurement endpoint may serve as an assessment endpoint if the measurement endpoint (measured value) is the ecological value to be protected. See related term *measure of effect* **(9)**.

3.2.11 *non-chemical stressor*—a biological agent, physical disturbance, condition or non-chemical characteristic of a waste material, substrate or source associated with a contaminated site and corrective actions that is known or suspected to interfere with the normal functioning of an ecological receptor **(3)**.

3.2.11.1 *Discussion*—Non-native species, biologically engineered organisms and pathogens are examples of non-chemical biological stressors. Radiation other than that associated with specific radionuclides, erosion, dredging, impounding, grading, vegetation removal and similar alterations/disruptions, altered particle size distribution, substrate instability, temperature and pH extremes, dissolved oxygen content, water-holding capacity, organic content, physical effects of oil and similar site characteristics unrelated to specific chemicals are non-chemical stressors. No specific term is proposed for non-chemical stressors that corresponds to′′ ecological contaminant of concern" for chemical stressors.

4. Significance and Use

4.1 This guide assumes that a decision has been made that an ecological risk assessment is required for a contaminated site. In some cases, this decision could be made before any site data are collected.

4.2 The selection of assessment endpoints (defined as ecological values to be protected) and measurement endpoints (ecological characteristics related to the assessment endpoints) is a critical step in conducting an ecological risk assessment. Endpoint selection identifies those effects which are ecologically significant and not merely those that are adverse, thus providing a more rational and defensible basis for making risk and remedial decisions.

4.3 This guide provides an approach for identifying, selecting and using assessment and measurement endpoints in an ecological risk assessment for a contaminated site. This guide has been developed because there is no universal, simple measure of ecological health analogous to measures used in human health risk assessment. Assessment and measurement endpoints have to be identified and selected from a variety of individual circumstances on a stressor-, ecosystem- and scale-specific basis. It is important to recognize that a diverse set of ecological endpoints could be required for a specific site.

4.4 This guide is intended to be used primarily by a biologist, ecologist, ecotoxicologist or a team of environmental scientists during problem formulation and work plan development prior to initiating data collection activities at a contaminated site **(3-8,10)**.

4.5 Ecological risk assessment is usually an iterative process. In many circumstances it proceeds as a series of tiers, that is, desktop/screening, preliminary and detailed/focused phases. This guide can be used to refine or modify assessment and measurement endpoints developed in earlier phases of the process.

4.6 This guide can be used whenever assessment and measurement endpoints must be identified and selected following an initial or preliminary problem formulation/planning phase:

4.6.1 Analysis phase (exposure assessment, hazard/effects assessment, stress/dose-response assessment;

4.6.2 Risk characterization phase; or

4.6.3 Remediation phase and possible subsequent ecological monitoring.

4.7 This guide is intended to be used in the evaluation of baseline conditions (current and future) and in the evaluation of conditions resulting from remedial actions or corrective measures.

5. General Considerations

5.1 Ecological risk assessment is a process of evaluating risks to individuals (in the case of threatened or endangered species or those afforded special protection), populations,

communities and ecosystems exposed to chemical and non-chemical stressors. Stressors can act individually or together over multiple ecosystem types and diverse spatial scales. Conditions of the site and risk assessment that should be considered in identifying and selecting assessment and measurement endpoints include **(2,3)**:

5.1.1 *Stressor Characteristics*—Types, properties, intensity, interactions and spatial and temporal patterns;

5.1.2 *Ecosystem Types*—Aquatic, terrestrial and wetlands and their subcategories (for example, marine);

5.1.3 *Spatial Scale*—The exposure area over which the exposure to the stressor occurs and direct and indirect ecological effects are potentially produced;

5.1.4 *Temporal Scale*—The expected duration of exposure (acute to chronic) to the stressor, direct and indirect ecological effects and recovery time following removal of the stressor;

5.1.5 *Ecological Organization*—The level of biological organization (individual, population, community or ecosystem) at which risk to an ecological receptor is to be assessed; and

5.1.6 *Functionality/Values*—Site-specific factors contributing to the importance of local ecological receptors.

5.2 Assessment and measurement endpoints are selected for specific ecosystem and stressor combinations associated with a site. Assessment and measurement endpoints may address multiple ecosystem and habitat types, spatial and temporal scales and levels of ecological organization.

5.3 The conceptual site model describes sources, releases and transport pathways for contaminants present at a site. This information is used to define exposure pathways and exposure areas and is usually developed before identifying and selecting endpoints. Assessment and measurement endpoints should be identified for all exposure pathways considered at a site. Ecological endpoints become part of the conceptual site model. Exposure pathway/exposure area and combinations of assessment and measurement endpoints can be selected from this large set for subsequent analysis. Guide E 1689 should be consulted on procedures for developing the conceptual site model.

5.4 The following characterize some of the uses or roles of assessment and measurement endpoints in an ecological risk assessment:

5.4.1 Incorporate resources potentially at risk or that require protection into the risk assessment process;

5.4.2 Complete development of a conceptual site model and problem formulation;

5.4.3 Design field and laboratory studies, toxicity tests and other data collection requirements;

5.4.4 Focus site remediation/corrective actions;

5.4.5 Evaluate potential efficacy of remedial alternatives/technologies; and

5.4.6 Evaluate recovery of impacted populations, communities and ecosystems.

6. Desirable Characteristics of Assessment and Measurement Endpoints

6.1 Desirable characteristics of assessment endpoints include, but are not limited to the following **(2,3)**:

6.1.1 Relevant to decision-making, local public concerns and ecological considerations (societal or ecological relevance, or both);

6.1.2 Relevant to the site or surrounding area, or both, under both current or future land uses, or both (current and future endpoints may be different);

6.1.3 Potentially susceptible to adverse effects from exposure to one or more site contaminants or stressors;

6.1.4 Consistent with the spatial and temporal scale of the action of stressors present at the site;

6.1.5 Address ecological receptors that are expected to receive higher exposure to site contaminants or stressors relative to other ecological receptors;

6.1.6 Amenable to hypothesis formulation, evaluation and prediction; and

6.1.7 Value to be protected is clearly defined.

6.2 Desirable characteristics of measurement endpoints include, but are not limited to **(2,3)**:

6.2.1 Correlated with or can be used to predict or infer changes in an assessment endpoint;

6.2.2 Relevant to the site and/or surrounding area under both current and/or future land uses;

6.2.3 Consistent with the spatial and temporal scale of the action of stressors present at the site;

6.2.4 Capable of detecting an adverse effect of concern in the presence of one or more site stressors;

6.2.5 Amenable to hypothesis formulation, measurement and prediction;

6.2.6 Clearly defined; and

6.2.7 Known range of expected variability.

7. Candidate Site-Related Ecological Receptors

7.1 In general terms, ecological receptors that are subjects of assessment and measurement endpoints include, but are not limited to individuals and populations of a particular species, assemblages of species and communities, habitats and ecosystems potentially exposed at or in the area surrounding the site. All organisms within the exposure area are potential receptors. Information should be available to indicate that organisms selected are potentially affected in an adverse way by site stressors **(4)**. This may require the use of data on related or surrogate species if data on indigenous species cannot be located **(4)**.

7.1.1 Candidate species that can serve as ecological receptors at the individual organism and population level include, but are not limited to:

7.1.1.1 Endangered, threatened or rare species known or suspected to be present in the vicinity of the site;

7.1.1.2 Federal or state protected species;

7.1.1.3 Species in which populations have recreational, commercial, or other aesthetic or spiritual value to humans;

7.1.1.4 Species that contribute to the creation of important habitat for other species;

7.1.1.5 Species that show mutualistic behavior that enhances the reproduction or dispersal of other species;

7.1.1.6 Consumers (for example, parasites and predators) that are known or suspected to strongly regulate populations of other species associated with the site and surrounding area to the extent that their absence would lead to a decrease in species

diversity, changes in community composition or relative abundance of species; and

7.1.1.7 Other indicator species.

7.2 Candidate assemblages of organisms, communities and habitats that can serve as ecological receptors include, but are not limited to **(3,4,8,10,11)**:

7.2.1 Fish communities,

7.2.2 Benthic communities,

7.2.3 Avian communities,

7.2.4 Feeding guilds,

7.2.5 Wetland plant communities,

7.2.6 Terrestrial relict or protected communities and habitats,

7.2.7 Soil invertebrate and microbial communities, and

7.2.8 Other guilds, communities and habitats of unique importance to the site.

7.3 If used, indicator species should be selected on the basis of potential effects, contaminant exposure, local abundance, habitat requirements and trophic position (for example, herbivore, piscivorous bird) in the community, habitat or ecosystem being studied **(3,4,8,11)**. Indicator species can be selected on the basis of site characteristic for all potentially complete exposure pathways, exposure areas and a variety of trophic positions, as appropriate.

7.4 Mobility, seasonal migration and extent of exposure to the site and exposure areas associated with site releases should be considered, as appropriate, in selecting each receptor for the assessment.

8. Candidate Assessment Endpoints

8.1 Assessment endpoints may be stated qualitatively or quantitatively. Criteria for quantitative changes in specific candidate assessment endpoints are established during problem formulation through a dialog between the risk assessor and the risk manager. The list of possible ways to express assessment endpoints is potentially quite long **(1-6,8,9,12,13)**. The following subsections provide examples of assessment endpoints and examples of how to state them (in quotes following each list). Documentation of specific assessment endpoint statements is discussed in Section 12. Ecological significance relating to assessment endpoints is discussed in Reference **(14)**.

8.2 Candidate assessment endpoints at the ecosystem level of biological organization may include, but are not limited to:

8.2.1 Significant or a specific level of or percentage reduction in ecosystem productivity;

8.2.2 Significant or specific adverse changes in nutrient regeneration and cycling; and

8.2.3 Significant or specific adverse changes in energy flow.

8.2.4 An ecosystem-level assessment endpoint can be stated as “loss or diminishment of a specific ecological function (for example, nitrogen cycling)” or “degradation or destruction of a specific habitat associated with a site or release.” The extent of loss of function or degree of change is established during problem formulation for the specific site characteristics, receptor species and, if appropriate, reference site conditions.

8.3 Candidate assessment endpoints at the community level of biological organization include, but are not limited to:

8.3.1 A significant (or specific percentage) reduction in species diversity/richness;

8.3.2 Significant (or specific) adverse changes in the structure of a specific food web or plant community;

8.3.3 A significant (or specific) reduction in the market value of a specific sport or recreational fishery; and

8.3.4 A significant (or specific) reduction in aesthetic value of a habitat or community.

8.3.5 Community-level assessment endpoints can be stated as “a significant (or specific) reduction in the species richness of a benthic community” or “a significant (or specific) reduction in the yield and quality of a stream fishery.” A specific reduction criterion can be established during problem formulation.

8.4 Candidate assessment endpoints at the population level of biological organization include, but are not limited to:

8.4.1 A significant (or specific) reduction in population abundance;

8.4.2 A significant (or specific) lowering of reproductive success;

8.4.3 Changes in age, sex, and size structure that could lead to significant (or specific) reductions in population abundance; and

8.4.4 Local extinction in a defined area.

8.4.5 Population-level assessment endpoints can be stated as “absence of a species normally expected to occur in the vicinity of the site” or “reduction of a population or subpopulation by pre-defined criteria attributable to contaminants associated with the site.” Specific criteria for the changes listed above are developed during problem formulation.

8.5 Candidate assessment endpoints for individual organisms include, but are not limited to specific adverse changes in the following:

8.5.1 Physiological status,

8.5.2 Reproduction,

8.5.3 Growth/biomass change,

8.5.4 Development,

8.5.5 Morbidity and mortality, and

8.5.6 Behavior.

8.5.7 An organism-level assessment endpoint can be stated as “adverse effects on an individual organism sufficient to cause a decrease in survival, growth or reproduction.” Adverse effects include behavioral abnormalities, cancer, genetic mutation, physical malformation and disease and other adverse unspecified effects. Specific criteria for these assessment endpoints are established during problem formulation.

9. Selecting Measurement Endpoints for Specific Assessment Endpoints

9.1 One or more measurement endpoints may be selected for each assessment endpoint **(2,3)** if the assessment endpoint is not amenable to direct measurement. Measurement endpoints usually involve data or results from a combination of laboratory and field investigations **(2-6,8,9,12,13,15)**. These data and results are evaluated relative to the relationships between measurement and assessment endpoints defined during problem formulation. Decision criteria for their evaluation are established on a site-specific basis. Accordingly, the relationship between measurement and assessment endpoints must be clearly described as part of the measurement endpoint selection process. Variability in parameters and characteristics

must be addressed in defining measurement endpoints and their relationships to assessment endpoints **(1-3,5-8)**. The following subsections present a partial listing of representative measurement endpoints. Others could be appropriate at a specific site **(2-6,8,10,12,13,15)**.

9.1.1 *Measurement Endpoints Representing Ecosystem Assessment Endpoints*—Field measurements of biomass, productivity and nutrient dynamics are the preferred endpoints at this level of organization **(2,12,16)**. Laboratory microcosm and mesocosm studies using site media or species, or both, can also serve as measurement endpoints for the assessment endpoints at the ecosystem level.

9.2 *Measurement Endpoints Representing Community Assessment Endpoints*—Biomass, productivity/respiration, number of species, measures of species evenness, dominance and diversity, guild structure, relative abundance, community quality indices and changes in community type are appropriate measurement endpoints **(2)**. Laboratory microcosms using site media/species can also serve as measurement endpoints for the assessment endpoints at the community level. Population studies may be used to support community-level assessment endpoints.

9.3 *Measurement Endpoints Representing Population Assessment Endpoints*—Presence/absence of indicator species, abundance, biomass, plant cover (not habitat), basal area, age/sex/size distributions, reproductive performance, yield, productivity, morbidity and mass mortality are acceptable measurement endpoints at this level of biological organization. Bioassays and toxicity tests using site media also can serve as measurement endpoints for the assessment endpoints at the population level.

9.4 *Measurement Endpoints Representing Individual Organism Assessment Endpoints*:

9.4.1 Death, growth, fecundity, overt symptomology (disease, physical deformity), biomarkers, tissue concentrations and behavioral changes are acceptable measurement endpoints at this level of biological organization. With proper interpretation, bioassay and toxicity test results using site media can also serve as measurement endpoints for the assessment endpoints at the individual organism level.

9.4.2 Responses of individual organisms to stressors could be extrapolated to the population level to permit the estimation of stress effects on natality, mortality, net reproductive potential and other demographic characteristics.

10. Specific Steps in Identifying, Selecting and Using Assessment and Measurement Endpoints

10.1 This section summarizes the activities associated with identifying and selecting endpoints for a contaminated site. Appendix X1 contains instructions for a checklist to assist in identifying assessment and measurement endpoints appropriate for specific site conditions. Appendix X2 contains a bibliography of supporting ecological information. Uses of endpoints following problem formulation are discussed briefly.

10.2 *Planning/Problem Formulation Phase*:

10.2.1 Obtain clear statements of policy or societal objectives, regulatory objectives, risk management guidelines and decisions. Risk management decisions can address political considerations, land ownership and general land use trends. It might also be necessary to obtain concurrence on applicable policy, risk management decisions and ecological risk assessment objectives among responsible parties, regulators, natural resource trustees (as members of a Biological Technical Assistance Group) and other interested parties, stakeholders and the general public. Use this information during the problem formulation phase of the ecological risk assessment to formulate ecological risk assessment scope objectives, assessment endpoints and specific hypotheses to be tested **(2-8,10,17-19)**.

10.2.2 Qualitatively describe habitats, ecosystems, communities and species potentially exposed to site-related stressors at on-site and off-site exposure areas based on, but not limited to the following data sources **(17)**:

10.2.2.1 Previous studies conducted at the site and at areas surrounding the site (for example, preliminary assessment/site investigation reports);

10.2.2.2 Natural Wetlands Inventory Maps and aerial photos;

10.2.2.3 Data from the state natural heritage inventory office on Federal and State endangered and threatened species, critical habitats and other locally unique or protected species and habitats;

10.2.2.4 Experts at State and Federal agencies and local colleges and universities and reports and data they provide on locally important and sensitive (endangered, threatened and special status) species, habitats and critical ecological issues associated with the site;

10.2.2.5 Discussions with Federal, State and local agencies and organizations to identify species of local concern, e.g., recreationally and commercially important species and hunting and fishing areas; and

10.2.2.6 Field reconnaissance by a trained ecologist.

10.3 Prepare a preliminary (candidate) list of ecological receptors of potential concern (biota checklist) **(4,7)**.

10.4 If necessary, select suitable reference locations for collecting appropriate control data for measurement endpoints **(4,17)**. The complexity of community dynamics, particularly in terrestrial system, must be considered in selecting reference locations. Reference location comparisons are always useful in detailed assessments, although they may not be necessary in screening assessments.

10.5 Conduct a literature review on toxicity and potential adverse ecological effects observed at other sites and situations for site-specific chemical and non-chemical stressors **(15,20,21)**.

10.6 Using reasonable assumptions, identify potential contaminant transport pathways and exposure areas. Based on identified exposure areas, identify ecological receptors and preliminary chemical and non-chemical stressors site.

10.7 Develop a preliminary conceptual site model, including ecological receptors to identify assessment endpoints. See Guide E 1689.

10.8 Identify a preliminary set of assessment endpoints relevant to study objectives for the ecological risk assessment. Appendix X1 describes a process for identifying this preliminary set of assessment endpoints. Assessment endpoints should state specific ecological values to be protected and protection

(decision-making) criteria. Assessment endpoints should consider the ecological receptors and nature of spatial and temporal exposures to contaminants or non-chemical stressors identified at a site. Document the rationale for selection of the assessment endpoints. Use the assessment endpoints to state hypotheses to be evaluated in the ecological risk assessment.

10.9 Select at least one measurement endpoint for each assessment endpoint. A given measurement endpoint can be relevant to more than one assessment endpoint. Measurement endpoints should be consistent with spatial and temporal characteristics of assessment endpoints. If a candidate assessment endpoint does not have a measurement endpoint that supports the assessment endpoint, the assessment endpoint needs to be eliminated from consideration. Appendix X1 should be consulted for additional information on how measurement endpoints can be identified for specific assessment endpoints. Define relationships between assessment endpoints and measurement endpoints when they are not the same.

10.10 Finalize the selection of assessment and measurement endpoints based on information on chemical and non-chemical stressors and the conceptual site model. Identify and eliminate incomplete exposure pathways. Limit the number of assessment and measurement endpoints to those most likely to identify adverse environmental impacts. Address incomplete exposure pathways as a source of uncertainty.

10.11 Develop measurement endpoint using the data quality objectives process for all data collection and measurement activities. Identify the decision criteria to be used in decision making and the data required to support the decision. Incorporate the objectives and supporting rationale into appropriate planning documents and submit to the appropriate stakeholder or regulatory agency for approval, or both.

10.12 Use measurement endpoints as the basis for design of site-specific effects studies.

10.13 Incorporate assessment and measurement endpoints into an Ecological Assessment Work Plan and submit to the appropriate stakeholder or regulatory agency or both for approval.

10.14 Use endpoints in the analysis and risk characterization phases of the ecological risk assessment **(1-3,5-8,12,13)**.

10.15 Following completion of the ecological risk assessment, remedial goals and objectives should be developed for unacceptable site risks. Endpoints associated with these risks should also be the focus of evaluations of proposed remedial alternatives/corrective measures. If new information develops during the assessment process, potential new endpoints may be identified for each candidate remedial alternative/corrective measure that is expected to change baseline conditions. Consider the full range of changes in land use and the nature and extent of the original stressors when identifying additional endpoints.

11. Addressing Uncertainties in the Identification and Selection of Assessment and Measurement Endpoints

11.1 Professional judgment and available data are used to identify assessment endpoints. The assessment endpoints are ecological values to be protected, and are not subject to an uncertainty evaluation. Measurement endpoints are identified to support decision making involving the assessment endpoints. Uncertainty of how well the measurement endpoints support the assessment endpoints can be qualitatively estimated **(3,8)**. The following subsections provide a partial list of factors to consider in addressing uncertainties in the identification and selection of endpoints.

11.2 Uncertainties associated with ecological endpoints are ecosystem- and stressor-specific. Therefore, there may be site-specific sources of uncertainty.

11.3 The ecological risk assessor should consider missing potential receptors (for example, species that are highly susceptible to site stressors or important to the public) as an uncertainty in the assessment endpoint selection process.

11.4 The appropriateness of the selected measures, metrics and indices should be considered as a potential source of uncertainty in selecting measurement endpoints. The uncertainty in the measured data (collection and analysis of samples) should be evaluated.

11.5 Certain aspects of environmental uncertainty are intrinsically irreducible (natural variability due to biological variability, physical conditions, weather, etc.). Before any data collection is initiated, the range of natural variability in the variables of interest should be determined. However, endpoints are always identified and selected in the presence of some amount of environmental uncertainty.

11.6 Uncertainties in the scale (temporal, spatial and biological) of the endpoints selected for a site should be addressed.

11.7 The level of resolution in uncertainties can be highly variable. The following types of uncertainty represent different levels of resolution that may need to be addressed for some types of measurement endpoints:

11.7.1 Model structure uncertainty;

11.7.2 Model parameter uncertainty;

11.7.3 Laboratory to field extrapolation; and

11.7.4 Species-to-species extrapolation, including use of surrogate species.

11.8 In the event that the uncertainty associated with the data collected to support the initial set of endpoints is unacceptable for decision-making, the following actions may be taken:

11.8.1 Identify alternate measurement endpoints that have less uncertainty and at the same time support a defined assessment endpoint;

11.8.2 Define the acceptable level of uncertainty that the decision-maker can accept;

11.8.3 Evaluate the advantages of a weight-of-evidence approach to support the assessment endpoint;

11.8.4 Refine the scope of the risk assessment to minimize vague or poorly defined objectives or assessment endpoints (those that cannot be supported by data with an acceptable uncertainty); and

11.8.5 Compare the natural variation of the measurement endpoint to the measurement error or uncertainty.

11.9 Bias and error in data collection should be discussed. Monte Carlo and related techniques may be used to conduct a quantitative uncertainty analysis. The following may be used to discuss bias and error in data collection:

11.9.1 Laboratory study results and error analysis;

11.9.2 Field study results and error analysis; and
11.9.3 Model results and error analysis.

12. Documenting the Selection of Assessment and Measurement Endpoints

12.1 There is a relationship between the risk manager and assessment endpoints. The assessment endpoints need to evaluate the ecological values that the risk manager is interested in protecting. The risk assessor defines the measurement endpoints that support the assessment endpoints. Assessment endpoints are developed in discussions between the risk assessor and the risk manager. The following relationships involving assessment and measurement endpoints should be described in work plans and project reports:

12.1.1 The relationship of risk management decisions to specific study objectives and assessment endpoints for the site;

12.1.2 The relationship of assessment endpoints to measurement endpoints;

12.1.3 The relationship of measurement endpoints to specific hypotheses, laboratory, field and modeling studies; and

12.1.4 The relationship of assessment and measurement endpoints to site-related stressors.

12.2 It is important to report assessment and measurement endpoints in an unambiguous manner. The following are examples of ways to state assessment endpoints quantitatively. These specific examples may not be relevant to a particular site.

12.2.1 No more than a five percent probability of a ten percent or greater loss of plant species in contaminated areas; or

12.2.2 A probability of a specific reduction in game fish production greater than twenty percent.

12.2.3 A measurement endpoint could be stated as a description of an adverse effect and the concentration or dose of a chemical that causes the effect.

13. Keywords

13.1 assessment endpoint; measurement endpoint

APPENDIX

(Nonmandatory Information)

X1. INSTRUCTION FOR PREPARING A CHECKLIST OF ASSESSMENT AND MEASUREMENT ENDPOINTS FOR A SPECIFIC SITE

X1.1 This appendix provides instructions on how to develop and use a checklist for identifying relevant endpoints and documenting the endpoint identification process for a specific contaminated site. The checklist is intended to be used during the planning/problem formulation phase of a site investigation.

X1.1.1 Any number of relevant assessment endpoints can be selected based on the judgment of the risk assessor for the site. Societal values and other non-biological issues/concerns are handled at Level 4 (assessment endpoints). It is recommended that at least two measurement endpoints be identified for each assessment endpoint to strengthen conclusions regarding each assessment endpoint.

X1.2 The grouping of factors to be considered in identifying endpoints is organized as follows:

X1.2.1 *Level 1*—Stressor(s) present at the site:
X1.2.1.1 Toxic (any measurable adverse biological effect) chemicals,
X1.2.1.2 Toxic and bioaccumulative chemicals,
X1.2.1.3 Physical stressors,
X1.2.1.4 Biological stressors, and
X1.2.1.5 Ecological stressors.

X1.2.2 *Level 2*—Ecosystem(s) exposed to each stressor at the site:
X1.2.2.1 Terrestrial,
X1.2.2.2 Aquatic (freshwater, marine, estuarine), and
X1.2.2.3 Wetland.

X1.2.3 *Level 3*—Relevant levels of organization for specific ecosystem/stressor combinations:
X1.2.3.1 Ecosystem,
X1.2.3.2 Community,
X1.2.3.3 Population, and
X1.2.3.4 Individual.

X1.2.4 *Level 4*—Relevant assessment endpoints for site-specific ecological receptor/stressor combinations. (See Fig. X1.1 for illustration purposes.)

X1.2.5 *Level 5*—Relevant measurement endpoints and statement of relationships to each assessment endpoint. (See Fig. X1.1 for illustration purposes.)

X1.2.6 A portion of a hypothetical checklist with several example endpoints is provided in Fig. X1.1 to illustrate how one can be constructed. This example checklist is intentionally incomplete, since all possible site conditions cannot be anticipated. Multiple assessment and measurement endpoints are possible for specific stressor/ecosystem/receptor combinations and should be written in and checked for risk assessment purposes based on best professional judgment and site conditions.

X1.2.7 The checklist (Fig. X1.1) is used by placing an “X” or check in those blanks where the risk assessment team believes stressors and ecological characteristics are relevant to the site under consideration. The completed checklist can be retained in the project file or included in the project report.

Example Checklist

1.0 ___ Toxic (any measurable adverse biological effect) chemicals are present (present in site soils and released to a lake adjacent to a former copper ore processing site at concentrations above natural background).

1.1 ___ An aquatic ecosystem is exposed.

1. ___ Assessment Endpoint: Reduced fish populations used for recreational fishing in the lake due to sediments heavily contaminated with metals.

a. ___ Measurement Endpoint: Reduced populations of food organisms (macroinvertebrate community) in areas of the lake with contaminated sediments.

Relationship to Assessment Endpoint: Survival and growth in the game fish population depends on an adequate food supply.

b. ___ Measurement Endpoint: Reduced survival and growth in chronic toxicity tests using fathead minnows exposed to lake water from areas of contaminated sediments relative to similar tests using control sediments and sediments from site reference locations.

Relationship to Assessment Endpoint: Fathead minnows are surrogates for the game fish species of concern (walleye).

1.2 ___ A terrestrial ecosystem is exposed.

1. ___ Assessment Endpoint: Population level effects on resident species of earthworms living in soil heavily contaminated with metals. Metals are known to be toxic to earthworms. Earthworms are an important component of the soil invertebrate community and a food source for small mammals and ground-feeding birds.

a. ___ Measurement Endpoint: Toxic effects of site soils on surrogate species of earthworms in standard toxicity tests.

Relationship to Assessment Endpoint: A higher frequency of death of earthworms in site soils compared to control soils and soils from reference sites in the standardized earthworm bioassay indicates that mortality is likely to be elevated in populations of earthworms in the contaminated areas of the site.

b. ___ Measurement Endpoint: Population abundance of a selected species of earthworm is reduced 50 % in contaminated site soils compared to population abundance in soil at a similar nearby reference location.

Relationship to Assessment Endpoint: The assessment and measurement endpoints are essentially equivalent.

FIG. X1.1 Example Checklist (Intentionally Incomplete) for a Site Contaminated With Toxic Chemicals

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