Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia

Ministry of Environment, Lands and Parks
Environment and Resource Management Department
Pollution Prevention and Remediation Branch
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BRITISH COLUMBIA

Recommended Guidance and Checklist for
Tier 1 Ecological Risk Assessment
of Contaminated Sites in British Columbia

Prepared for

Ministry of Environment, Lands and Parks

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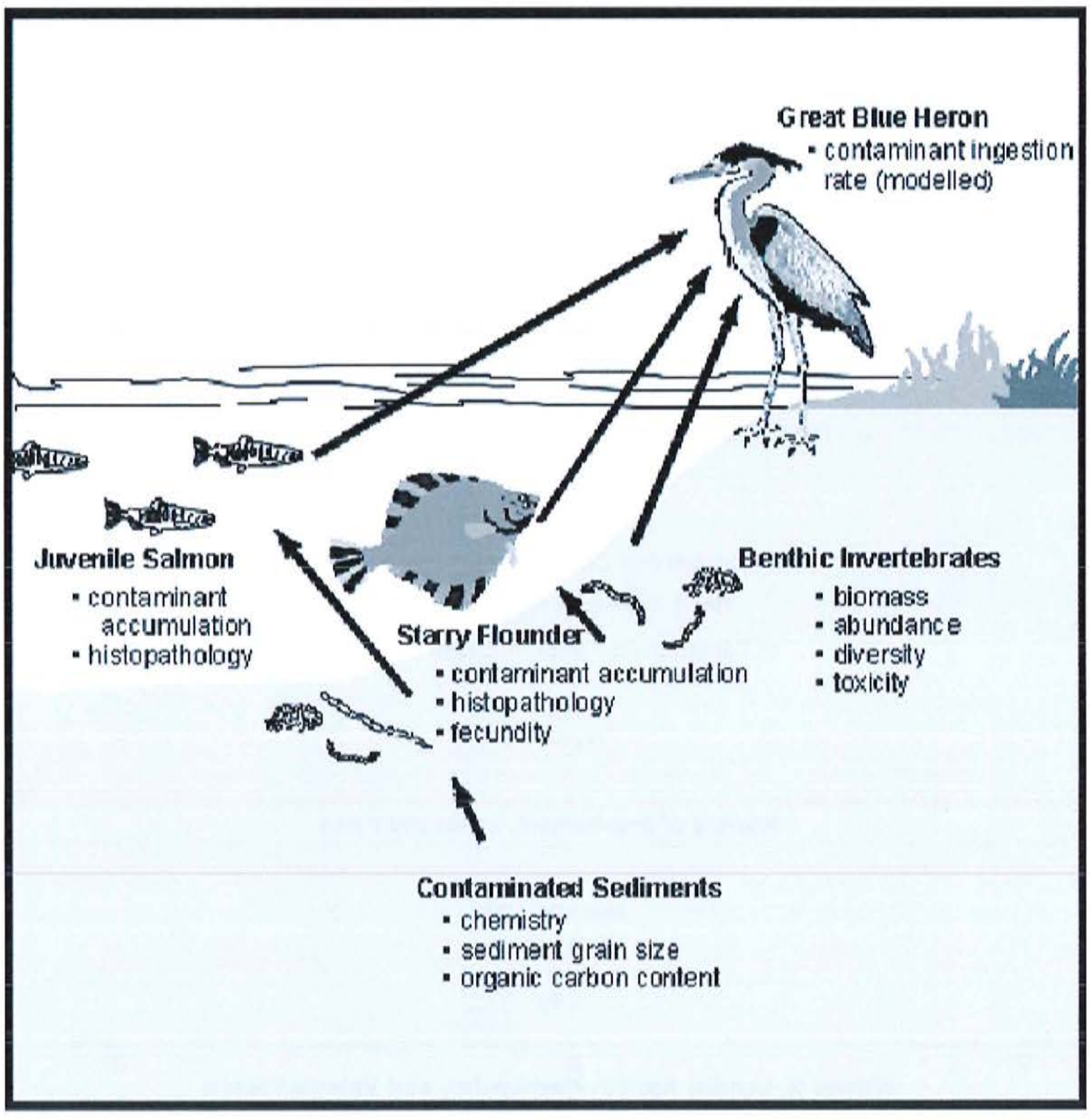

Acknowledgements

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Along with the primary authors, we had numerous contributors to this final product: Janice Wiegers, Mary Moores, and Kyra Freestar of the Institute of Environmental Toxicology and Chemistry; Richard S. Bennett, Larry Kapustka, and Bill Williams of **e**cological **p**lanning and **t**oxicology, inc.; Linda Nestic and Elizabeth Power of EVS Environmental Consultants. Michael Macfarlane, Doug Walton and Glyn Fox of the B.C. Ministry of Environment, Lands and Parks provided numerous resources, comments, and suggestions.

Request for Comments

This document builds on the basic national framework and concept for tiered assessment that have been provided by the Canadian Council of Ministers of the Environment, Environment Canada and the US Environmental Protection Agency and elaborated upon in numerous books. The checklist is organized to facilitate risk assessments for the five land uses designated by the Province: industrial, commercial, residential, agricultural, and urban park. The scope of the assessment endpoints is controlled by criteria specific to each land use. BC Environment's intent is to implement the use of this document for Tier-1 Ecological Risk Assessments performed under BCE's Contaminated Sites Regulation.

The guide includes some significant departures from some previous policies that have been applied to risk assessments at contaminated site in the province. BC Environment welcomes comments and suggestions on ways to improve the document with the objective to providing a practical and pragmatic checklist for screening level assessments at contaminated sites in the Province. BC Environment anticipates that changes may be warranted to clarify, improve and incorporate new scientific information. The format of the document is designed to accommodate such changes. Such revisions and amendments will be incorporated in later editions of this document. BC Environment will not formally respond to comments submitted in response to the document.

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Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia - Chapter 1. Introduction

1.0 INTRODUCTION

1.1 Scope and Organization of the Document

This document provides specific guidance on how to perform screening (Tier 1) ecological risk assessments (**T1 EcoRA**) for sites within the Province of British Columbia. A number of ecological risk assessment framework, issue, and guidance documents have been prepared by a variety of agencies in North America. These are written primarily for specialists in the field of ecological risk assessment and do not give specific recommendations, although all have similar themes. The purpose of this document is markedly different, although based on the framework prepared by Environment Canada (CCME, 1992).

This document provides a checklist for the performance of **T1 EcoRA** in the Province of British Columbia as regulated and enforced by the British Columbia Ministry of Environment (BCE). It is intended to promote consistent and technically defensible **T1 EcoRA 's** under BCE's Contaminated Sites Regulation (BCE, 1996a). The document is for use in conjunction with the procedures for human health risk assessment at contaminated sites recommended by BCE.

Ecological risk assessment is an interdisciplinary field that draws on concepts, data, models and opinions from environmental toxicology, ecology, physiology and environmental chemistry, as well as other scientific disciplines such as mathematics. It is important to recognize that ecological risk assessment is a complex and nonlinear process that can include many parallel activities. The checklist provided in the following sections is designed to facilitate the **T1 EcoRA** for a typical site in a site-specific manner. Particular emphasis is placed upon situations typical of the Province, including land uses and characteristic types of ecological structures. As a screening process, the emphasis is on the individual organism. Ecological properties such as population dynamics, species diversity, and production or nutrient cycling are not considered. The document is not intended to provide guidance for wide area and complex sites. These types of sites require specialized expertise and more consultation with BCE.

The organization of the document is linear. This introduction (Section 1) provides an overview of the document and the regulatory framework specific to British Columbia. Section 2 (Problem Formulation) introduces the checklist with the basic collection of information so that a determination of current and future land use can be made. Sections 3 through 7 present specific checklists for the **T1 EcoRA** for each of several land uses: industrial, commercial, residential, urban park and agricultural, respectively. Each land use is treated independently and the required steps for gathering data for both exposure and effects assessment are listed. The final section of the checklist is Risk Calculation (Section 8). Risk calculation presents the steps for the calculation of risk for both aquatic and terrestrial environments and must be applied to any of the applicable land uses. This section also contains the documentary requirements of BCE.

Appendices provide lists and references for analytical techniques, toxicological and sampling methods, and some additional background on the formulation of a site-specific conceptual model. While the Appendices contain additional biological and toxicological information, they do not replace a good library or other data repositories. Finally, an example risk assessment is presented for a site containing both aquatic and terrestrial components.

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1.2 The Basic Framework for Ecological Risk Assessment

The basic framework for ecological risk assessment (EcoRA) has been provided by Environment Canada (1993) and elaborated upon in numerous books (Suter 1993, Landis and Yu 1995). Recent reports have also been published that cover the use of EcoRA for the remediation of contaminated sites (CCME 1996, Environment Canada 1994).

The classical definition of ecological risk assessment is the determination of the probability of an effect occurring to an ecological system.. The critical component of a risk assessment is probability, which estimates the hazard resulting from exposure to a chemical stressor.

A stressor, for the purposes of this document, is a chemical that causes impacts, either positive or negative, upon a biological system. Stressors could be as wide ranging as chemical effects, ionizing radiation, or rapid changes in temperature.

Exposure is the interaction of an organism with a chemical. Exposure often involves measuring the concentrations and persistence of a chemical within the defined ecosystem. In EcoRA it is usual to measure the concentration of the chemical in a particular medium (*e.g.*, water, soil, air). A particular effect resulting from exposure can be estimated based on the environmental concentration (*i.e.*, the concentration of the chemical in a medium) or by the dose of chemical received by the receptor of concern. Whenever possible it is better to measure the dose, which is the amount of chemical gaining entry to the organism of concern, because dose provides a more accurate representation of the potential for toxic effects due to the contamination.

Hazard is the potential of a chemical to cause particular deleterious effects upon a organism or ecosystem. Hazard assumes that exposure has occurred. The determination of an LD50 or the mutagenicity of a material are estimations of the hazard posed by a stressor to a particular receptor.

The receptor is the organism of concern or ecosystem that is being investigated. A receptor could be a specific species of salmon or bird. In some cases like a wide area site, the freshwater benthic community could be the receptor of concern.

A chemical poses no risk to an organism unless exposure occurs. This is extremely crucial as virtually all materials have some biological effect. However, unless enough of the chemical interacts with a biological system, no effects can occur. Risk is a combination of exposure, receptor and hazard expressed as a probability (Figure 1-1). Without overlap between a chemical(s) and a biological entity, there is no risk.

Figure 1-1. The three components of EcoRA

As described in CCME (1996), there are three tiered levels of EcoRA (Figure 1-2). The first level is a screening assessment or Tier 1. In this document a T1 EcoRA is composed of both qualitative and quantitative elements, but the overall process is very straightforward. We expect that 90 percent of the sites within British Columbia can be successfully evaluated using a T1 EcoRA. The Tier 2 EcoRA involves more detailed analysis using techniques such as Monte Carlo analysis and extensive sampling of the site and the resident organisms. Tier 3 EcoRAs address less than 1 percent of contaminated sites, but will typically involve an extensive analysis which can entail a series of unrelated chemical stressors, a wide variety of habitat and terrain types, and a wide geographical area.

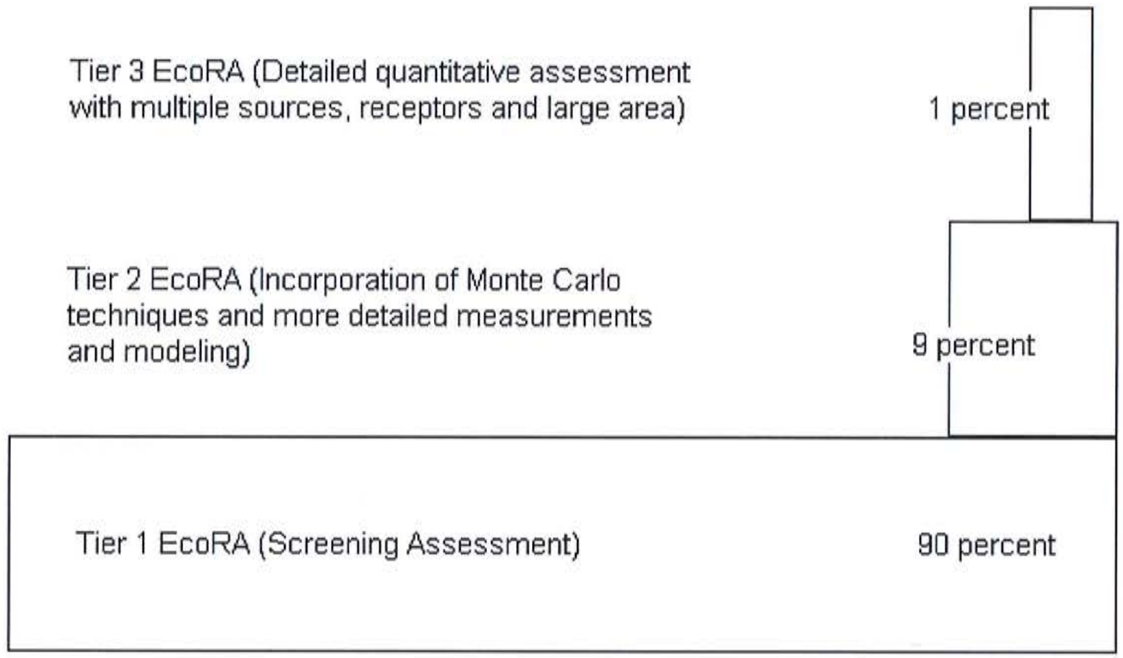

Figure 1-2. The tiered approach to EcoRA. T1 EcoRA is expected to be able to cover 90 percent of the sites in British Columbia.

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1.3 Regulatory Context, or How Did I Get to the Risk Assessment Option?

British Columbia's Contaminated Sites Regulation (BCE, 1996a) provides technical support for the *Waste Management Act*. The regulations cover, but are not limited to, the following:

1. a process for determining whether a site is contaminated, and
2. if a site requires cleanup, a process to establish remediation requirements. Both these processes rely upon:

   a) numerical standards, which include generic and matrix (in schedules) and site-specific standards, or
   b) risk-based standards.

Under the Contaminated Sites Regulation, cleaning up a site to meet risk-based standards requires a quantitative human health risk assessment and an environmental impact assessment. The risk management approach to contaminated site remediation can be both scientifically defensible and cost-effective. However, it has limitations that may make its use inappropriate at some sites. Recognizing that risk assessment may not be a useful tool for all sites, guidance is provided on:

a) when to use ecological risk assessment
b) roles of ecological risk assessment in the site remediation process

1.3.1 Deciding if a Site is Contaminated

The Contaminated Sites Regulation outlines the general process leading to the decision that a site is contaminated; this process is illustrated in Figure 1-3.

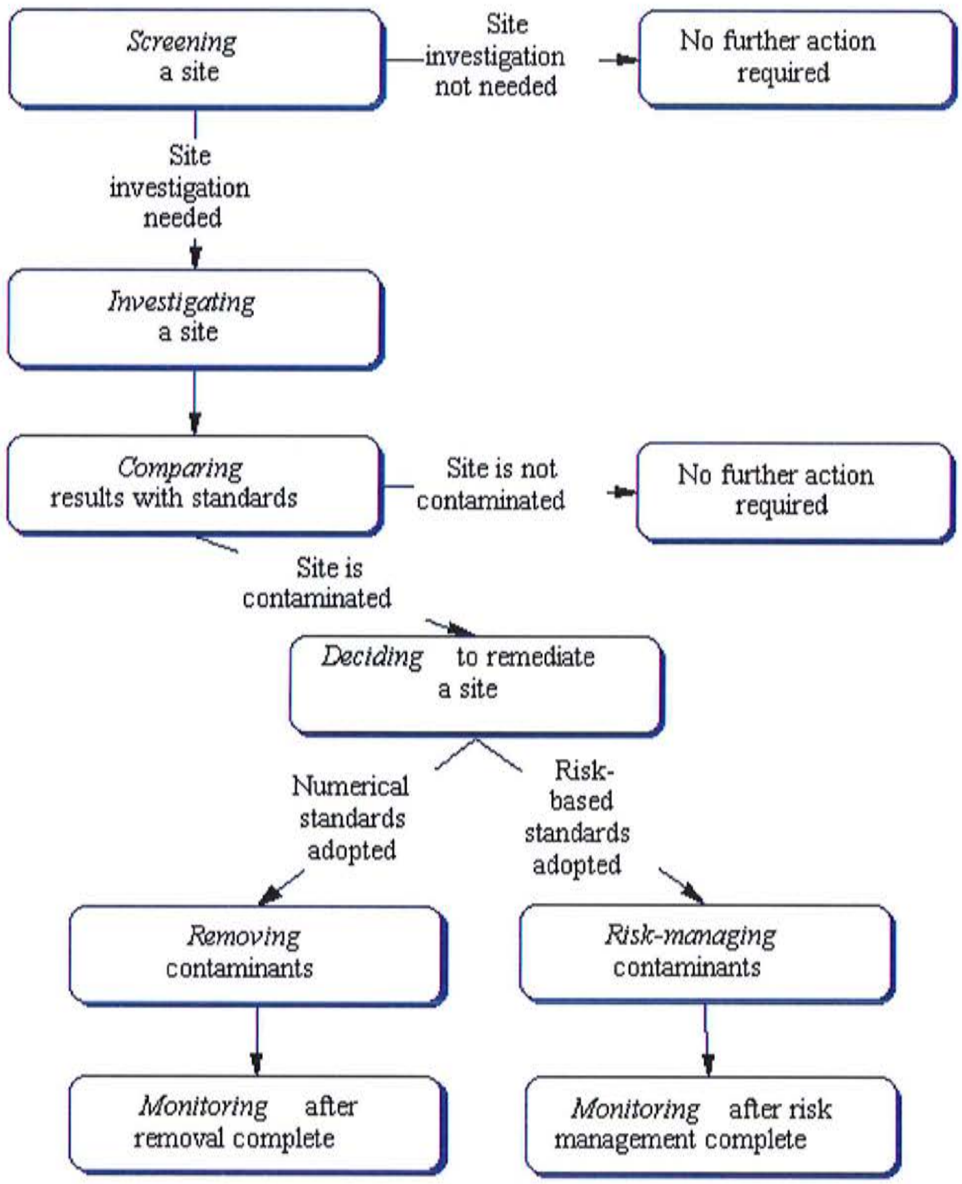

Figure 1-3. General process for managing contaminated sites in B.C.

Filling out a site profile, an early part of site assessment, is a qualitative exercise. Suspected contamination based on a site profile can trigger a site investigation, which may consist of two stages:

3. a preliminary site investigation (PSI) which assesses the present and historical site use and management practices. It includes a review of records, a site visit, and limited sampling of the relevant environmental media.

4. A detailed site investigation (DSI) which characterizes a site within a reasonable degree of certainty, identifying areas, depth and degree of contamination and extent of contaminant migration. Comparison of results with the applicable environmental quality standards can lead to the conclusion that a site is or is not contaminated or that a remedial plan for the site is required.

1.3.2 Remediation Options

The overall goal of contaminated site remediation is to restore the environmental quality of the site to a level that does not pose unacceptable risks to humans or ecological resources. The regulations provide the responsible party with a choice of two approaches related to the determination of acceptable cleanup levels (*i.e.*, remediation standards) for contaminated sites:

a) Use numerical standards provided in the regulation or derive site-specific numerical standards, or
b) Use risk assessment to determine if a risk management scenario will meet risk-based remediation standards.

These are also shown in Figure 1-3.

The numerical standards (generic or matrix) provided in the Contaminated Sites Regulation (BCE, 1996) represent acceptable substance concentrations for various media for various land and water uses. The standards derivation process considered differences in what constitutes acceptable risks for various land and water use designations. The standards are believed to be generally protective of each land and water use. Sites are cleaned up to these standards by removal or treatment of contaminated soil and/or water.

Recognizing that it is not scientifically defensible to have a single numerical standard that protects all sites and site uses in British Columbia (BCE, 1996b), the regulations support the development of site-specific standards and the consideration of local background concentrations. Local physical, biological, or chemical factors may make the application of the generic and matrix numerical standards inappropriate. Site-specific standards consider some of these local factors, and more accurately reflect the conditions at the site. As with the generic and matrix standards, sites are remediated by removal or treatment of contaminants so that the concentrations in soil and water no longer exceed the numerical standards.

The risk-based approach allows contaminants to be managed in place. The capability of a **T1 EcoRA** to estimate the risks on a site-specific basis is the goal of this checklist.

All the approaches can account for natural elevations in substances, particularly metals, and allow, where appropriate, the use of local background concentrations as remediation standards.

1.3.3 Monitoring a Site After Cleanup

As shown in Figure 1-3, the use of both the numerical and risk-based standards approaches to cleaning up sites requires site monitoring after remediation is complete. If the numerical standards have been used, the residual soil and water must be checked to ensure that it meets the numerical standards. In cases where the risk-based standards have been used, long-term custom monitoring programs must be adopted, to ensure the effectiveness of risk management works and to assess where applicable the effectiveness of no-action alternatives.

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1.4 What is the Checklist?

The checklist is a step-by-step process that uses a specific protocol to collect the types of data necessary for a **T1 EcoRA**. The types of data are explained and when multiple management options are possible they are listed in order of preference (*i.e.*, most preferred option is given first).

The process emphasizes using data available from the site rather than extrapolation from complex models. Looking at the site and making observations and measurements is always given the highest priority. Each **T1 EcoRA** is by definition site-specific, but the checklist provides a common reporting format that should facilitate comparisons between sites.

It is assumed that the **T1 EcoRA** is being conducted in parallel with the human health risk assessment. At several points in the checklist this overlap is highlighted. Sampling and characterization of the site should be coordinated for the two distinctly different types of risk assessments.

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1.5 Use of the Checklist

The overall flow of the **T1 EcoRA** checklist is portrayed in Figure 1-4. The first step is the performance of the Problem Formulation Checklist (Section 2). This checklist is used to define the type of land use and to gather preliminary information about the site. As the Problem Formulation Checklist is completed, the reader is directed to one of the next five sections, which are specific to the land uses included in the Contaminated Site Regulation (*i.e.* industrial, commercial, residential, urban park, or agricultural land uses).

The land use specific sections direct the gathering of effect and exposure information that will be used in the final risk calculation. Although each of the sections follows an identical format, there are differences in the rules that determine which species are considered, what toxicity values are used as limits, and what kind of analytical work will have to be accomplished.

The land use specific sections also define typical conceptual models. Conceptual models are the framework of the risk assessment and identify the types of organisms to be considered, potential routes of exposure for these receptors, and delineate the contamination sources at the site. Conceptual models for all contaminants of concern at a site should be completed, recognizing that these models may differ due to differences in the chemical, physical, and environmental fate and transport properties of the contaminants. The generic basis for each type of conceptual model is presented as a graphical figure, and the proper derivation of a site specific conceptual model in presented is Appendix A.

The checklist and accompanying conceptual models are intended to represent the generic conditions anticipated for most contaminated sites. On occasion, site specific consideration and habitat management objectives may require the adjustment of these generic models and receptor assumptions.

As the checklist is followed in the appropriate section, tables of effects and exposure information are generated. By the end of the checklist all of the information necessary for the calculation of risk should have been acquired.

The final section, which like the Problem Formulation is common to all of the risk assessments, is Section 8, Risk Calculation and Reporting,. Detailed instructions on how to estimate risk are included and a variety of options presented in order of preference.

The last part of Section 8 lists the reporting requirements for the **T1 EcoRA**. If properly followed, the checklist should provide sufficient information for a risk management or clean-up decision. The standardized reporting format should expedite review of the risk assessment by BCE and other interested parties.

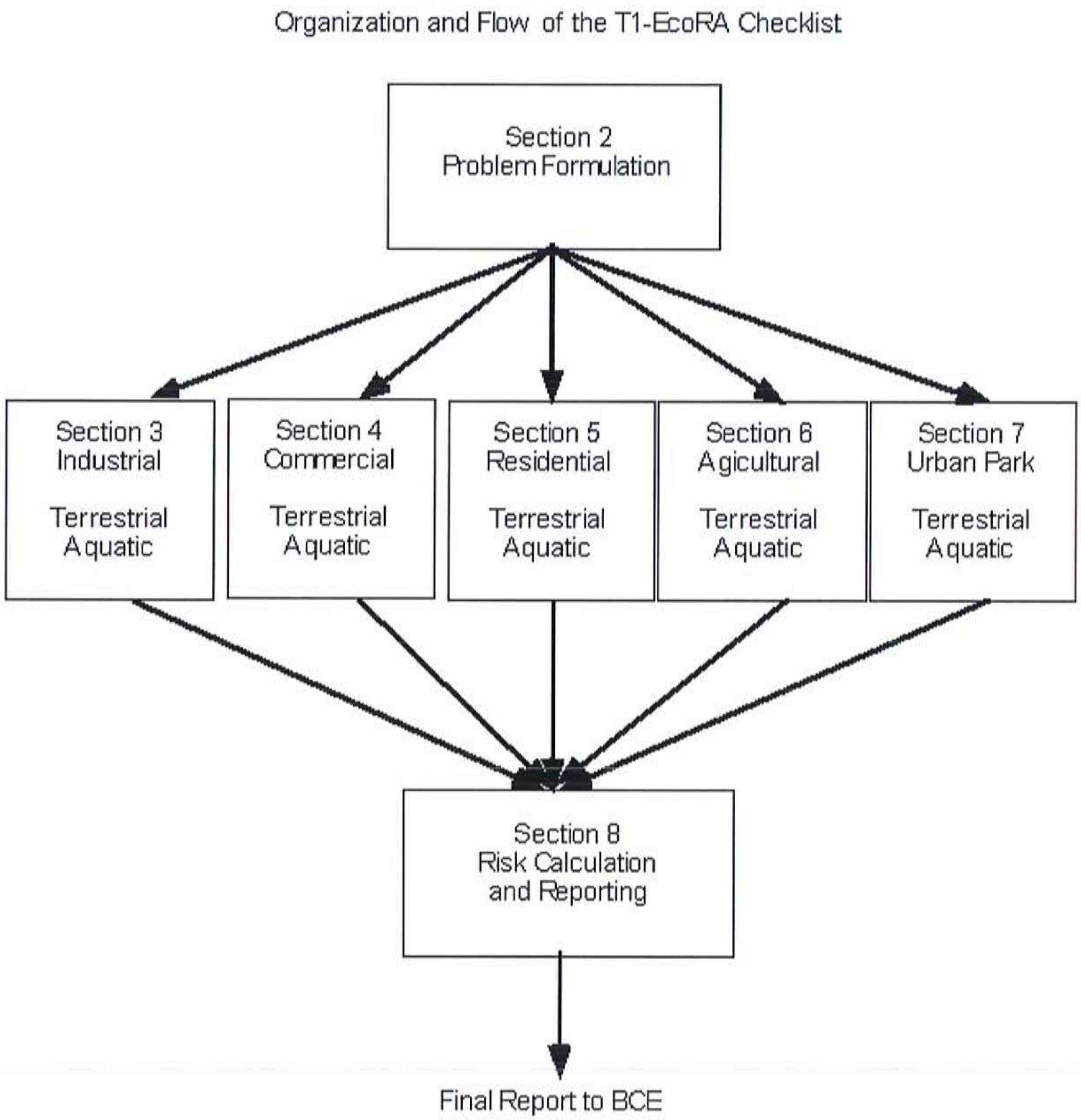

Figure 1-4. Flow diagram for the **T1 EcoRA** checklist

References

CCME (1996) A Framework for Ecological Risk Assessment : General Guidance. Winnipeg, Manitoba

Environment Canada (1993) A Framework for Ecological Risk Assessment at Contaminated Sites in Canada. Environment Canada, Hull, Quebec.

Environment Canada (1994) A Framework for Ecological Risk Assessment at Contaminated Sites in Canada: Review and Recommendations. 1994. Scientific Series No. 199. Ottawa.

Landis, W.G. and Yu, M.H. (1995) Introduction to Environmental Toxicology and Chemistry. Lewis Publishers, Boca Raton, FL.

Suter, G.W. (1993) Ecological Risk Assessment. Lewis Publishers, Boca Raton, FL.

Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia - Chapter 2. Problem Formulation

2.0 PROBLEM FORMULATION

Purpose: To clearly define the remaining issues: which matrix standards have been exceeded, the scope of the problem, and what needs to be done.

2.1 Background

a) Name of person(s) completing this checklist, company affiliation, address, telephone and facsimile number. Attach additional pages, as needed.

b) Name of site owner, company affiliation, address, telephone and facsimile number. Attach additional pages, as needed.

c) Describe the history of use and contamination on the site in question. Please list any previous studies done on the site. Attach additional pages, as needed.

d) Why is this risk assessment being performed? Attach additional pages, as needed.

2.2 Site Description

2.2.1 Site Location

Geoclimatic Region:

Municipality (if not applicable, list closest):

Street Address (include Postal Code):

Legal Description of Property:

Lot: ____

Block: ____

District Lot: ____

Plan Number: _______________________________________

PID #: ____

Coordinates (using the North American Datum 1983 convention) for the center of the site:

Latitude: Degrees ________ Minutes ________ Seconds ________

Longitude: Degrees ________ Minutes ________ Seconds ________

Please attach a map showing the exact location of the site.

☐ Map attached

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2.2.2 Site Use

Current use of the site:

☐ Industrial ☐ Commercial ☐ Residential ☐ Urban ☐ Park ☐ Agricultural

Describe (e.g., gas station, shopping mall, subdivision, park, dairy farm):

____

____

____

____

Proposed use of the site:

☐ Industrial ☐ Commercial ☐ Residential ☐ Urban ☐ Park ☐ Agricultural

Will the proposed development include buildings?

☐ yes ☐ no

If yes, how many? __________________________

Covering what percent of the site? ______________

Will they be new ☐ or existing ☐ buildings or both ☐ ?

Describe proposed development (e.g., gas station, shopping mall, subdivision, park, dairy farm):

____

____

____

____

Attach a map of the proposed development, including blueprints of any proposed buildings, parking lots, and vegetation (landscaping).

☐ **Map attached**

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2.2.3 Site Description

Size of the site (in hectares): ____________________________________

Does the site have buildings on it? ☐ yes ☐ no

If yes, how many? _________________

Covering what percent of the site? ____________ %

Is the site paved? ☐ yes ☐ no

If yes, what percent of the site is paved? ____________ %

Is the land sloped ☐ or flat ☐ ?

If sloped, what percent of the land is sloped? ____________ %

Which direction does the slop face (the slope aspect)? _____________________________________

Are there plants on the site? ☐ yes ☐ no

If yes, are there: trees ☐ yes ☐ no, how many? ____________________

bushes ☐ yes ☐ no, how many? ____________________

grass ☐ yes ☐ no, how much? ____________________

Are there any ditches, sloughs, lagoons, streams, rivers, or lakes on the site?

☐ yes ☐ no

If yes, please name and/or describe them (attach additional sheets if needed):

____

____

Are there any streams, rivers, lakes, estuaries, oceans or other water bodies adjacent to the site?

☐ yes ☐ no

If yes, please name and/or describe them. Include distance from the site to the waterbody (attach additional sheets if needed.):

☐ **Draw and attach a map (i.e., site description) or schematic drawing of the site, including all buildings, parking lots, and trees, shrubs, grass, and other vegetation on the site. Include any body of water that is on or next to the site.**

Attach aerial and ground photos of the site, if available.

Does the site cover an extensive geographic area and comprise several individual properties? Are many of these individual properties likely to be determined by the manager to be contaminated?

☐ Yes. The site is a Wide Area Site, which is a Tier 3 EcoRA and is beyond the scope of this checklist. Contact BCE for further guidance.

☐ No. Continue with the checklist below.

If the proposed use of the site is:

Industrial - go to Section 3

Commercial - go to Section 4

Residential - go to Section 5

Urban Park - go to Section 6

Agricultural - go to Section 7

Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia - Chapter 3. Industrial

3.0 INDUSTRIAL

3.1 Problem Formulation (continued)

Which standard or criteria was exceeded (for any chemical)?

a) ☐ Toxicity to soil invertebrates and plants

b) ☐ Groundwater flow, surface run-off, or direct discharge to surface water or sediments used by aquatic life

If a) is exceeded, go to Section 3.1.1
If b) is exceeded, go to Section 3.1.2
If BOTH are exceeded, do BOTH sections

☐ **Attach a list of the chemicals exceeding the standards. These chemicals will be considered "chemicals of concern" for the remainder of the risk assessment. Please use the following format. If available, attach the Detailed Site Investigation Report as well.**

Chemical	Measured Concentrations (range)	Standard/Criteria Exceeded	Standard/Criteria Value

3.1.1 Potential Terrestrial Receptors

3.1.1.1 Regional Species Lists

Refer to Appendix B to identify the biogeoclimatic zone in which the site is located.

Biogeoclimactic zone: ______________________________

Refer to Appendix C and attach the list of terrestrial plants found in the site's biogeoclimatic zone.

☐ **Plant list attached**

Refer to Appendix D and attach the list of terrestrial birds found in the site's biogeoclimatic zone.

☐ **Bird list attached**

Refer to Appendix E and attach the list of terrestrial mammals found in the site's biogeoclimatic zone.

☐ **Mammal list attached**

Refer to Appendix E and attach the list of amphibians and reptiles found in the site's biogeoclimatic zone.

☐ **Amphibian and reptile list attached**

3.1.1.2 Site-specific Species Lists for Terrestrial Plants and Animals

Which plants, birds, and mammals actually are, or are likely to be, on the site? Several avenues are open to determine the receptors of concern for the risk assessment. Site visits by trained biologists are useful for making informed decisions regarding receptor selection. However, there are other sources of information that should be consulted (*e.g.*, local BCE wildlife officers, Canadian Wildlife Service, etc.). Assessing the ecological risks of contaminated sites to all potential receptors would be an unworkable task. Therefore, strategic selection of key receptors provides an efficient and effective way to meet the overall management goals of the site. Guidance on reducing the regional species lists down to relevant site-specific organisms is provided in the following sections and Appendices C through F.

3.1.1.2.1 Terrestrial Plants

Check off on the biogeoclimatic zone plant list those plants that are actually on the site and are fairly ubiquitous. *This requires a visit to the site or a review of detailed photographs by someone knowledgeable about general plant types and names.*

☐ **Site plants checked on attached list**

☐ **Species selected as receptors of concern are noted on the species list**

3.1.1.2.2 Terrestrial Birds

Check off on the biogeoclimatic zone bird list those birds likely to use the site and that are of potential concern, using the following rules:

a) Birds are present only if there is vegetation on the site.
b) Birds must be resident for at least one season (do not include migrants that just pass through).
c) Shorebirds (*e.g.*, dowitchers, sandpipers), wading birds (*e.g.*, herons, egrets), waterfowl (*e.g.*, ducks and geese), and seabirds (*e.g.*, gulls, cormorants) are not considered.
d) Raptors (*e.g.*, hawks, owls, and eagles) are considered only if they are threatened or endangered species.
e) Galliforms (*e.g.*, pheasant and quail) are not present in urban areas.
f) Cavity-dwellers (*e.g.*, flickers and woodpeckers) and birds that eat foliar invertebrates are not considered.
g) Hummingbirds are not considered.
h) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site birds checked on attached list**

Group the bird species on the list according to feeding groups.

☐ **Feeding group list attached**

☐ **Species selected as receptors of concern are noted on the species list**

3.1.1.2.3 Terrestrial Mammals

Check off on the biogeoclimatic zone mammal list those animals likely to use the site and that are of potential concern, using the following rules:

a) Mammals are present only if there is vegetation on the site.
b) Mammals must be resident for at least one season (do not include migrants that just pass through).
c) Large mammals (*e.g.*, deer, elk, bear, coyotes, fox, skunk, raccoons) are not considered.
d) Rabbits and large rodents (*e.g.*, beaver) do not occur in urban areas.
e) Mustelids are not considered.
f) Small rodents (mice and voles) may occur in all areas.
g) Non-native pest species (rats and house mice) are not of concern anywhere.
h) Bats are not considered.
i) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site mammals checked on attached list**

Group the mammal species on the list according to feeding groups.

☐ **Feeding group list attached**

☐ **Species selected as receptors of concern are noted on the species list**

3.1.1.2.4 Amphibians and reptiles

Check off on the biogeoclimatic zone amphibian and reptile list those animals likely to use the site and that are of potential concern.

☐ **Site amphibians and reptiles checked on attached list**

☐ **Species selected as receptors of concern are noted on the species list**

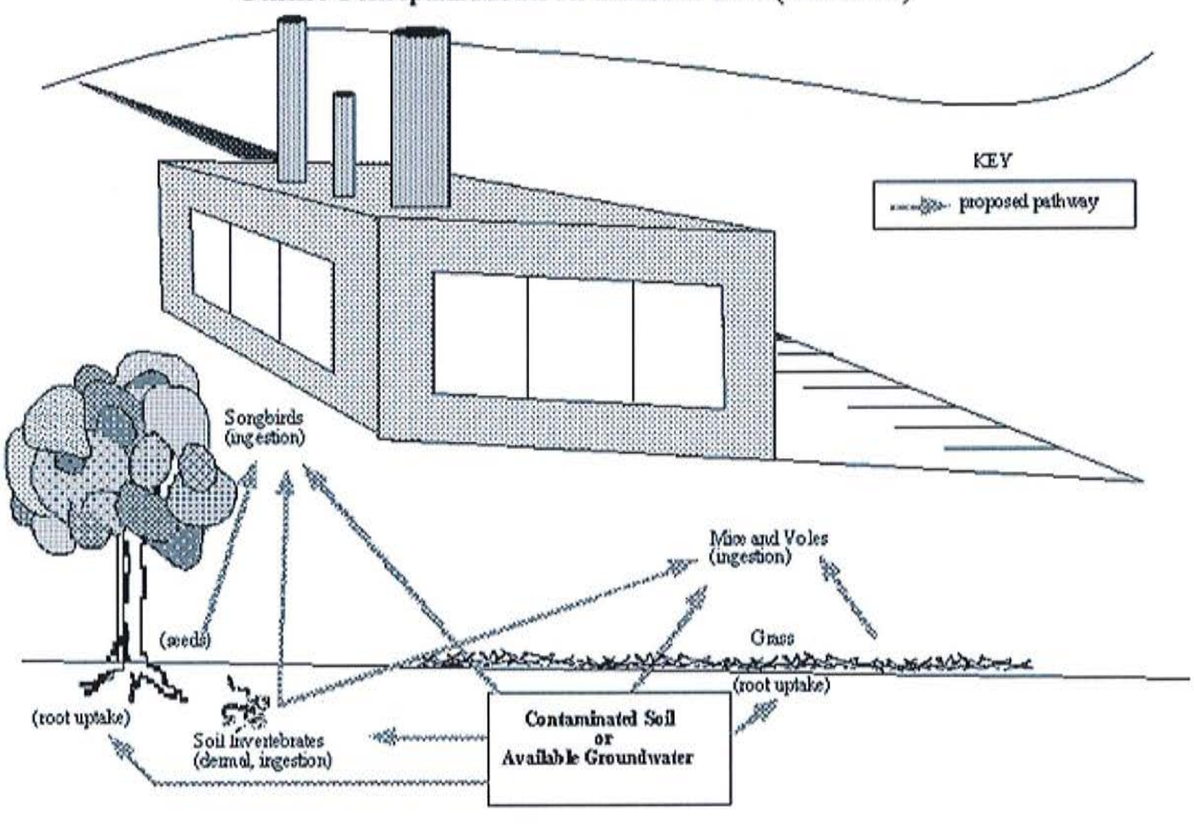
3.1.1.2.5 Soil Invertebrates

Assume that earthworms, as representative soil invertebrates, should be present at the site.

3.1.1.3 Conceptual Site Model

Use the representation of the site on the next page to show how the contaminants of concern (those chemicals that exceed the standard/criteria) could potentially move through the food chain to animals that may be onsite. If something in the picture (*e.g.*, trees) is missing on the site, remove it and all its associated connections from the picture. Refer to Appendix A for more guidance on development of Conceptual Site Models.

Generic Conceptual Model for Industrial Sites (Terrestrial)



3.1.2 Potential Aquatic Life Receptors

Is the water

- ☐ fresh (river, stream, lake, wetland)?
- ☐ brackish (estuary, salt marsh)?

☐ salt (ocean shore)?

3.1.2.1 Regional Species Lists

Refer to Appendix C and attach the list of aquatic plants in the site's biogeoclimatic zone. Be sure to use an appropriate list for fresh, brackish or salt water plants.

☐ **Aquatic plant list attached**

Refer to Appendix F and attach the list of fish in the site's biogeoclimatic zone. Be sure to use an appropriate list for fresh, brackish or salt water fish.

☐ **Fish list attached**

Refer to Appendix D and attach the list of birds in the site's biogeoclimatic zone.

☐ **Bird list attached**

Refer to Appendix E and attach the list of mammals in the site's biogeoclimatic zone.

☐ **Mammal list attached**

3.1.2.2 Site-specific Species Lists for Aquatic Plants and Organisms

Which fish, plants, birds, and mammals actually are, or are likely to be, on the site? Several avenues are open to determine the receptors of concern for the risk assessment. Site visits by trained biologists are useful for making informed decisions regarding receptor selection. However, there are other sources of information that should be consulted (*e.g.*, local BCE wildlife officers, Canadian Wildlife Service, etc.). Assessing the ecological risks of contaminated sites to all potential receptors would be an unworkable task. Therefore, strategic selection of key receptors provides an efficient and effective way to ensure that the overall management goals of the site are met. Guidance on reducing the regional species lists down to relevant site-specific organisms is provided in the following sections and Appendices C through F.

3.1.2.2.1 Plants

Check off on the aquatic plant list those plants that are actually on the site and are fairly ubiquitous. *This requires a visit to the site or a review of detailed photographs by someone knowledgeable about general plant types and names.*

☐ **Site plants checked on attached list**

☐ **Species selected as receptors of concern are noted on the species list**

3.1.2.2.2 Fish

Check off on the ecoregion list those fish likely to use the site and that are of potential concern, using the following rules:

a) Fish must be resident species.
b) Salmonids and their various lifestages may be present without a breeding population due to hatchery input. These fish are economically important and should be included.
c) Transient water bodies do not have resident fish populations.
d) Ditches and other shallow drainage systems should not be considered as important fish habitat.
e) Fish lists must be tied to water chemistry such as salinity, pH, dissolved oxygen and hardness. Remove species that cannot live in the site's environment.
f) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site fish checked on attached list**

☐ **Species selected as receptors of concern are noted on the species list**

3.1.2.2.3 Aquatic Birds

Check off on the bird list those birds likely to use the site and that are of potential concern, using the following rules:

a) Birds must be resident species (do not include migrants).
b) Small shorebirds (*e.g.*, dowitchers) are considered only in shallow marshes, estuaries, or beaches.
c) Waterfowl (*e.g.*, ducks and geese) are not present on small streams.

d) Seabirds (*e.g.*, gulls, cormorants, sandpipers) are considered only for brackish or saltwater sites.

e) Raptors (*e.g.*, hawks, owls, and eagles) are considered only if they are threatened or endangered species.

f) Galliforms (*e.g.*, pheasant and quail) are not present.

g) Cavity-dwellers (*e.g.*, flickers and woodpeckers are not considered).

h) Hummingbirds are not considered.

i) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site birds checked on attached list**

Group the bird species on the list according to feeding groups.

☐ **Feeding group list attached (e.g., fish-eating, insectivores)**

☐ **Species selected as receptors of concern are noted on the species list**

3.1.2.2.4 Aquatic mammals

Check off on the biogeoclimatic zone mammal list those animals likely to use the site and that are of potential concern, using the following rules:

a) Mammals must be resident species (do not include migrants).

b) Mammals are not considered for small streams or ponds.

c) Large mammals (*e.g.*, deer, elk, bear, coyotes) do not occur.

d) Wholly land mammals (*e.g.*, rabbits, small rodents) do not occur.

e) Aquatic mustelids (*e.g.*, otters) may be considered.

f) Non native pest species (nutria) are not of concern.

g) Bats are not considered.

h) Include all species that are listed as threatened, endangered or sensitive

☐ **Site mammals checked on attached list**

Group the mammal species on the list according to feeding groups.

☐ **Feeding group list attached (e.g., herbivores, fish carnivores, etc.)**

Species selected as receptors of concern are noted on the species list

3.1.2.2.5 Aquatic Invertebrates

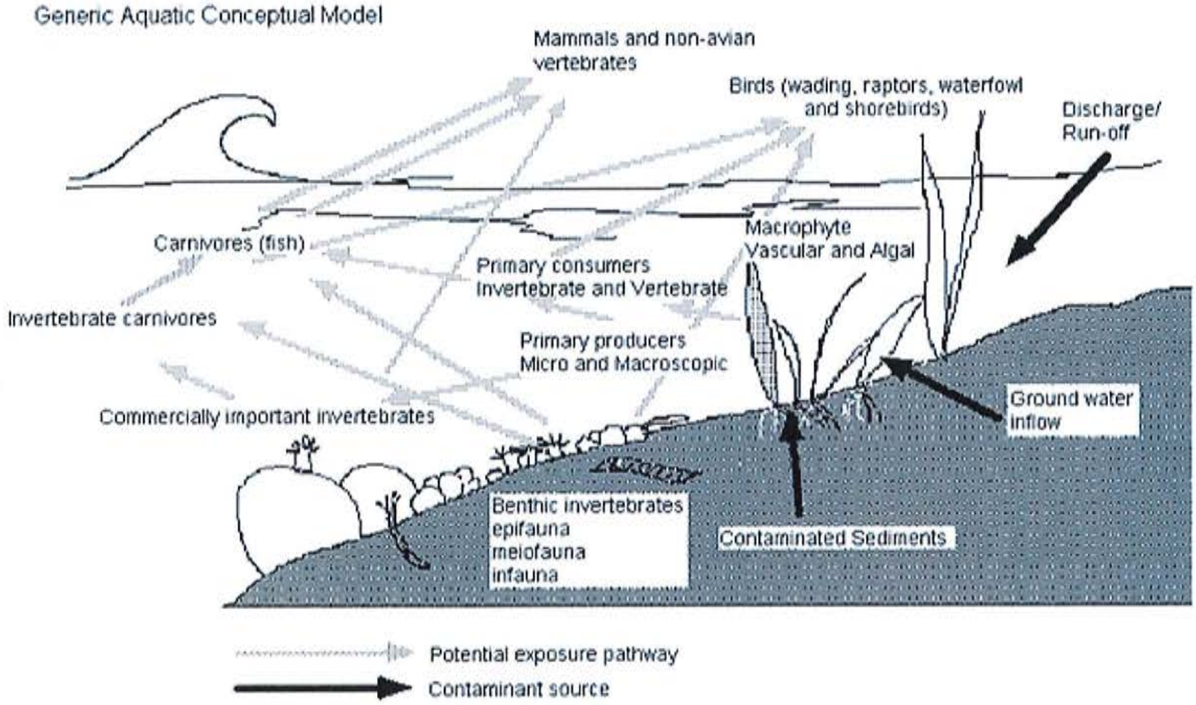
Assume that bottom-dwelling (benthic) invertebrates are present at the site.

3.1.2.3 Conceptual Site Model

Use the representation of the site on the next page to show how the contaminants of concern (those chemicals that exceed the standard/criteria) could potentially move through the food chain to the animals that may be onsite. If something in the picture (*e.g.*, cattails) is missing on the site, remove it and all its associated connections from the picture. Refer to Appendix A for more guidance on development of Conceptual Site Models.

Recommendation: BCE should review the data package at this time to reach agreement on the contaminants of concern and the plants and animals of interest, prior to collecting samples for analysis.

Generic Aquatic Conceptual Model



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3.2 Effects Assessment

Purpose: To determine if any adverse environmental effects currently are occurring and to develop appropriate concentration-response relationships to predict if adverse affects will occur in the future.

This section asks a series of questions to help assess, through a simple site visit, whether current conditions are deleterious to plants and animals using the site or in water that receives run-off or groundwater discharge from the site.

You will then be directed how to find information about what concentrations of pollutants of concern cause effects in the plants and animals at your site. You may choose to use the same toxicity values developed by BCE for the matrix standards or you have the option of using a different set of data, provided you justify why you chose a different approach.

You also will be given the option of conducting simple soil or water laboratory bioassays using samples from the most contaminated areas in order to demonstrate whether the media are toxic to plants or animals and, if so, at what concentration of the toxicant in the media (*e.g.*, soil or water). *In situ* bioassays are also an option for determining if soil or water can support the plants or animals of interest.

3.2.1 Site Observations

3.2.1.1 Terrestrial Plants

If there currently is no vegetation on the site, skip this section.

Vegetation present? ☐ yes (continue) ☐ no (skip section)

If this assessment is being done in the winter, skip this section and return to complete the section in the spring/summer.

Assessment being done in:

☐ spring (continue) ☐ summer (continue)

☐ fall (continue) ☐ winter (skip section)

Date (MM/DD/YY): ______________________________

Comments: ____

____

____

____

For terrestrial plants, refer to EPA SOP #2037 in Appendix G for *Terrestrial Plant Community Sampling Methods* and answer the following questions in this section.

3.2.1.1.1 Grass

Look closely at the grass.

Does it evenly cover an area or are there bare patches of soil showing?

☐ even cover

☐ bare patches size _____________ m^2 (bare patches must be 1 m^2 or larger)

Is the grass green or are there brown spots or is it brown all over?

☐ green ☐ brown spots ☐ brown all over

Show any brown spots on the site map. Be sure the map shows where all the grass cover is.

Comments: ____

____

3.2.1.1.2 Shrubs and Forbs (small leafy plants)

Look closely at the shrubs, flowers, and other leafy small plants.

Do they have all their leaves?

☐ yes ☐ no

Are the leaves all green, spotted with yellow or brown spots, or all brown?

☐ all green ☐ spotted ☐ all brown

Are there a lot of dead leaves at the base of the plants?

☐ yes ☐ no

Are the above statements true for all the plants on the site or only a few?

☐ all plants ☐ only a few

Show on the site map the location of any plants that are dead, that have spotted leaves, or that have lost a large number of leaves.

Comments: ____

____

____

3.2.1.1.3 Trees

Look closely at the trees.

Do they have all their leaves or needles?

☐ yes ☐ no

Are the leaves (or needles) all green, spotted with yellow or brown spots, or all brown?

☐ all green ☐ spotted ☐ all brown

Are there a lot of dead leaves at the base of the plants?

☐ yes ☐ no

Are the above statements true for all the trees on the site or only a few?

☐ all trees ☐ only a few

Do the above statements pertain to deciduous trees, evergreen trees, or both?

☐ deciduous ☐ evergreen ☐ both

Show on the site map the location of any trees that are dead, that have spotted leaves, or that have lost a large number of leaves.

Comments: ____

____

____

____

3.2.1.2 Soil Invertebrates

If the entire area is under buildings or pavement, skip this section.

Entire area built or paved? ☐ no (continue) ☐ yes (skip section)

If this assessment is being done when the ground is frozen, skip this section and return and complete in the spring/summer.

Ground frozen? ☐ no (continue) ☐ yes (skip section)

Comments: ____

____

____

____

Dig up a patch of soil from several areas with no vegetation, from several areas with grass or shrubs, and from areas near trees. Pass the soil through a sieve (if dry) or rinse it in a bucket (if wet) to look for earthworms and other soil invertebrates.

For each area, are invertebrates present? ☐ yes ☐ no

If yes, ☐ many ☐ few

If yes, describe what they look like?

____

____

(Note: unhealthy worms may have lesions, constrictions, or discolorations)

3.2.1.3 Birds

Attach a list of any birds seen or heard during the site visit. If the site is small, walk the entire site. Look in trees or shrubs for evidence of current or old nests. If the site is large, walk transects (lines) at least every 50 meters.

If a river, marsh, or other water body is of concern due to potential run-off or groundwater contamination, walk transects on either side of the stream or river, or in 50 meter intervals across a wetland OR conduct bird observations from a boat or other suitable flotation method OR from any suitable observation point or platform. Pay particular attention to areas of marsh grasses, woody shrubs, or trees.

☐ **Bird observations attached**

3.2.1.4 Mammals

Attach a list of any mammals seen or heard during the site visit. Look under shrubs and in the grass for mouse holes or vole runways (packed down or bare strips in the grass). Look in dirt, mud, and other areas for mammal tracks, footprints, and scat (fecal material).

If a river, marsh, or other water body is of concern due to potential run-off or groundwater contamination, walk transects on either side of the stream or river, or in 50 meter intervals across a wetland. Pay particular attention to areas of marsh grasses, woody shrubs, or trees.

☐ **Mammal observations attached**

3.2.1.5 Aquatic Plants

If the site does not contain or border on aquatic habitat, skip Sections 3.2.1.5 through 3.2.1.7.

Assessment being done in:

☐ spring ☐ summer ☐ fall ☐ winter

Date (MM/DD/YY) ________________

Is aquatic vegetation present? ☐ yes ☐ no

If no, why do you think it's not ____

____

Do the aquatic plants appear healthy? ☐ yes ☐ no

Are there any visual signs of stress (e.g., discolored parts)? ☐ yes ☐ no

If yes, describe ____

____

Comments: ____

____

____

☐ **Aquatic plant list and observations attached**

3.2.1.6 Fish

For marine or estuarine habitats, consult the following references and conduct a brief fish habitat description.

For freshwater habitats, consult the following references and conduct a brief fish habitat survey. For lake habitats, use the principles discussed for marine or estuarine habitats in the following references to conduct the habitat survey.

Department of Fisheries and Oceans (DFO) and Environment Canada. 1989. Coastal/estuarine fish habitat description and assessment manual - Part II: Habitat description procedures. Prepared by G.L. Williams and Associates, Coquitlam, BC. 38 pp. + appendices.

Department of Fisheries and Oceans (DFO) and BC Ministry of Environment (BCE). 1989. Fish habitat inventory and information program - Stream survey field guide. 29 pp. + appendices.

☐ **Attach habitat survey card(s), photos or maps of habitat, and a brief description of fish resources.**

3.2.1.7 Aquatic Invertebrates

Walk along the shoreline observing the habitat and take samples with a small plankton net.

a) If a fresh water site, sample the shoreline every 10 m with several strokes of the net. Put the contents in a jar and note the presence of daphnia, worms, insect larvae, snails, and other invertebrates.
b) If a marine site, sample the shoreline every 10 m with several strokes of the plankton net noting the presence of copepods, shellfish, and other invertebrates.
c) In a marine intertidal site, observe at low tide and note the shellfish, copepods, crabs, starfish, and worms present.

☐ **Aquatic invertebrate observations attached**

3.2.2 Bioassays

OPTIONAL: Bioassays provide the opportunity to demonstrate whether the most highly contaminated media (soil and/or water) are toxic to the plants, invertebrates, or aquatic life of concern, particularly *in situ*ations where vegetation or aquatic life are not currently present. Soil and/or water samples are taken into the laboratory and growth, reproduction and survival of test species are measured following standardized, peer-reviewed methods.

Bioassays can be considered in such cases where environmental concentrations are above toxicity reference values (TRVs), but organisms are still present on the site. Other factors such as toxicant bioavailability and natural selection may apply to site conditions. For example, soils with metal contamination may not be bioavailable to earthworms due to soil conditions (*e.g.*, soil composition or pH). Therefore, earthworms may be present in sites with environmental conditions above the TRV for earthworms. In such cases, bioassay toxicity testing will establish site-specific conditions and TRVs for a particular site.

Methods developed and modified by the British Columbia Ministry of Environment and Environment Canada are recommended and listed first (Appendices H). A listing of comparable, alternative, and additional standard methods also are provided to supplement and expand bioassay and analytical capabilities. Methods developed by the American Public Health Association (APHA), American Water Works Association (AWWA), Water Environment Federation (WEF), American Society of Testing and Materials (ASTM), Organization of Economic Cooperation and Development (OECD), and the United States Environmental Protection Agency (USEPA) are included and, in many cases, are referenced in the Canadian protocols.

Bioassays may be conducted after completing the entire risk assessment, to confirm results or to understand the extent of cleanup that will be required. However, bioassays also may be done during the Effects Assessment phase as part of the development of the weight-of-evidence of environmental risk.

3.2.2.1 General Procedures for Laboratory Bioassays

a) Collect soil, water, or sediment from the most highly contaminated areas.
b) Refer to Appendix H for a list of suggested companies that can conduct standard bioassays and for references for bioassay protocols. Consider the use of field replicates rather than laboratory replicates.
c) Suggested species for bioassays:

plants:	rye grass (*Lolium perenne*)
earthworms:	red worms (*Eisenia foetida*)
fish: (freshwater)	rainbow trout (*Oncorhynchus mykiss)*
	bluegill (Lepomis macrochirus)
	sunfish (Lepomis sp.)
	chinook
	top smelt (*Atherinops affinis*)
(marine)	*Champia parvula*
	echinoderm fertilization

	inland silverside (*Menidia*)
	stickelback
aquatic	ceriodaphnia, *Daphnia magna*
invertebrates:	amphipod test
(water)	
(sediments)	

☐ **Bioassay(s) conducted - report(s) attached**

3.2.2.1.1 In Situ Bioassays

a) Visit site. Use an area of the site with suspected contamination based on media sampling or source input.
b) Take field measurements of dissolved oxygen, temperature, conductivity, and pH.
c) Inform and obtain approval from Regional Ministry of the Environment and Department of Fisheries and Oceans habitat staff for *in situ* bioassay test.
d) Suggested species for *in situ* bioassays:

eyed salmonid eggs: pacific salmon
rainbow trout (*Oncorhynchus mykiss*)
caged fish: rainbow trout (*Oncorhynchus mykiss*)
caged mussels: sea mussels (*Mytilus edulis)*

3.2.3 Toxicity Reference Values (TRVs)

To determine if a particular level of contamination at a site poses a risk to plants or animals, you need to know how much of that material the plants or animals can tolerate before toxic effects are seen. The concentration of the pollutant in the soil or water where toxicity begins to occur is called the *toxicity threshold*. However, for environmental receptors such as plants or animals (*i.e.*, not humans), the goal is not to protect each individual from any toxic effect, but rather to protect enough individuals so that a viable population and community of organisms can be maintained (provided other habitat factors are suitable). Therefore, a TRV is chosen from the concentration-response curve that provides reasonable protection for a specified percentage of the organisms. For terrestrial organisms on industrial sites, this is the EC50, or the concentration that affects 50% of the organisms exposed. For aquatic organisms at industrial sites, this is the EC20.

To find the ECx for plants and animals at your site for pollutants of concern, do any (or all) of the following. Be sure to specify whether this value is dry weight (dw) or wet weight (ww).

a) Use the BCE standard/criteria or information from its supporting documentation.

BCE standard/criteria used? ☐ yes ☐ no

b) Refer to Appendix I for a list of database and other reference sources that contain information about toxic responses of plants, animals, and aquatic organisms.

List databases searched

____

____

____

c) Search the scientific literature

List databases searched

____

____

____

Use the following rules to select the appropriate EC_x:

a) Give preference to generally accepted toxicity reference values generated for that particular medium (accepted with caveats, peer reviewed, governmental, or NGO groups). For example, water quality criteria.

b) Give preference to reproductive endpoints, but use lethality studies if they are the only ones available.

c) Acceptable endpoints of a toxicity include:

- any reproductive endpoint (*e.g.*, number of offspring, number of eggs laid, eggshell quality, fruit size and yield, presence of deformities in embryos or young);
- growth rates;
- lethality;
- tumor formation or other gross deformities in embryos or young.

Unacceptable endpoints include:

- changes in enzyme activities;
- DNA breakage;
- other subcellular responses and hematological parameters.

d) If an EC_x is not reported, generate the concentration-response curve from the data provided and calculate the ECx. As a last resort, use the lowest observed adverse effects level rather than the EC_x and do not divide by any uncertainty factors.

e) If data are available from more than one study for an organism of concern, use the lowest EC_x.

f) Use information for the contaminant of concern from any test (*e.g.*, bioassay, laboratory, field study) conducted with the organisms under consideration, if available.

g) If the organism of concern has not been tested, use the most closely related (phylogenetically) organism. Carefully consider the phylogenetic histories of the test species compared to the organisms of concern and consider any drawbacks to extrapolating between species.

For birds and mammals:

1. use EC_{50};
2. give preference to those with the same feeding group;
3. give preference to feeding studies (not single dose studies, or injection studies), particularly of weeks to months in duration;
4. if you have data from similar animals (*e.g.*, rodent data to compare with rodents or duck data to compare to other waterfowl), do not use any uncertainty factors. If your animals are not so closely related, divide the value by 10;

5. if the ONLY data available for any animal species are from injection or oral dosing studies, convert the dose to concentration in food, assuming an average body weight (bw) for the species and an average food consumption rate. Food consumption may be estimated from the following equations:

$$F = 0.621\ (bw)^{0.564}\ \text{(rodents)}$$
$$F = 0.577\ (bw)^{0.727}\ \text{(mammalian herbivores)}$$
$$F = 0.235\ (bw)^{0.822}\ \text{(other mammals)}$$
$$F = 0.398\ (bw)^{0.850}\ \text{(song birds)}$$
$$F = 0.648\ (bw)^{0.651}\ \text{(other birds)}$$

For plants:

1. use EC_{50};
2. if extrapolating within the same Family, do not use any uncertainty factors;
3. if extrapolating to another Family, divide by 2;
4. if extrapolating to another Order, divide by 20;
5. if extrapolating to another Class, divide by 500.

For soil invertebrates:

1. use EC_{50};
2. use whatever data are available without adjustments.

For aquatic organisms:

1. use EC_{50};
2. use species from same class, teleost (ray finned fish) is typical. Agnatha (jawless fish) and Chondricithyes (sharks and rays) have very different biochemistries, especially in regards to PCBs and other estrogenic compounds;
3. that arepelagic invertebrates, use species similar to organism of concern, although most of the data will be on daphnia;
4. use test species with similar routes of exposure as the organism of concern. Sediment tests conducted to estimate the toxicity of a burrowing worm should use burrowing organisms as the test organism. Filter-feeding mollusks should be the organism of choice when estimating muscle or oyster sensitivity;
5. aquatic phytoplankton are represented by single species algal toxicity tests and many kinds of test organisms are available;

6. aquatic macrophytes are represented by Lemma (duckweed), although a number of new methods are under development;
7. give preference to tests conducted during a significant portion, or the most sensitive portion, of the test organism's lifespan.

Attach a list of the selected ECx with the appropriate references. Structure the list in the following format:

Organism of Concern	Test Organism	Measurement (reproduction, mortality, etc.)	Endpoint (LOAEL EC_x)	Uncertainty Factor	Value	Dry weight or wet weight	Ref.

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3.3 Exposure Assessment

Purpose: ***To determine the concentration in media (food, water, soil, etc.) of pollutants of concern to which the plants and animals of concern are actually exposed and to demonstrate how the plants and animals came in contact with the contaminated media.***

For plants and animals to be at risk from pollutants, the compounds must exist in the environment at concentrations above the toxicity reference values and the plants or animals must come in contact with the contaminated media. This section describes appropriate sampling of the site to understand the magnitude and spatial extent of any contamination. The answers to the series of questions that follows will help determine pertinent life-history patterns of plants and animals on the site to determine if, when, and for how long they may come in contact with the contaminated environment.

Note: All environmental sampling should be conducted in cooperation with the human health effects assessment to reduce the need to sample the same area twice. Coordination between the two processes should take place at this time.

3.3.1 Exposure Patterns of Plants and Animals

Plants and animals must come in contact with a contaminant to be considered at risk. This section helps determine the potential for organisms on the site to come in contact with contaminated media. Note that it is assume that only plants may be directly affected by contaminated groundwater. Other organisms are potentially at risk only if the groundwater contaminates surface water or is used for irrigation.

3.3.1.1 Plants

All plants on the site are assumed to be exposed to contaminated soil, as their roots have the potential to take up materials out of the soil. Deep-rooted plants also may contact contaminated groundwater. Rooted aquatic plants (also called macrophytes) such as cattails, rushes, or salt grass take up contaminants from the water column (through their leaves) as well as by their roots from sediment. Non-rooted aquatic plants (*e.g.*, duckweed, waterlilies) also take up contaminants from the water column through their leaves. Therefore, exposure to plants should be assumed, unless the contamination is present only during the dormant period of the year (winter, for most plants, if the ground freezes).

3.3.1.2 Soil Invertebrates

All soil invertebrates (such as earthworms, centipedes, and beetles) are considered exposed through ingestion of soil or movement of contaminant across their skin. Therefore, exposure to soil invertebrates should be assumed, unless the contamination is present only during the dormant period of the year (*e.g.*, when the ground is frozen).

3.3.1.3 Birds

Birds are exposed only if they eat soil invertebrates or plants (leaves or seeds) on the terrestrial portion of the site, or if they eat aquatic invertebrates or fish from a contaminated water source. In addition, it is assumed that most birds consume some soil or sediment along with the actual foodstuff and may get additional contamination from this route.

Birds may not feed on the site for their entire life. Many birds leave the area during the winter and so have the potential to be exposed only during the late spring, summer, and early fall. In addition, if the site is small or the only vegetation present is along the edge of the site, then birds are likely to get some of their diet off-site.

Therefore, the following habits of the birds using the site must be known:

a) proportion of the year the bird resides in the area
b) proportion of total foraging area provided by the site
c) composition of diet (seeds, leaves, invertebrates and/or soil)

3.3.1.3.1 Residency

For each of the birds on the site-specific checklist (see Section 3.1.1.2.2) indicate whether the bird is a year-round resident (YR), summer resident (SR), or winter resident (WR).

☐ **Bird list annotated**

3.3.1.3.2 Foraging Area

See Appendix J for a list of references containing information about bird foraging areas. For each bird that may use the site, indicate on the site-specific checklist whether its foraging area is greater (G) or smaller (S) than the size of the site. If foraging area information is not available, use information about territory size. If no information is available, assume the foraging area is equal (E) in size to the site.

☐ **Bird list annotated**

3.3.1.3.3 Diet

Refer to Appendix J for a list of references on dietary preferences of birds.

For each species present on the site, list the dietary composition in a table such as the following:

Feeding Group	% Seeds	% Other Plant	% Soil Invertebrates	% Aquatic Invertebrates	% Fish	% Other (specify)	% Soil (assume	TOTAL (100%)

		Material					**2%)**	
							2	100
							2	100

3.3.1.4 Mammals

Mammals are exposed only if they eat soil invertebrates or plants (leaves or seeds) on the terrestrial portion of the site or if they eat fish from a contaminated water source. In addition, it is assumed that most mammals consume some soil or sediment along with the actual foodstuff and may get additional contamination from this route.

Some mammals hibernate during the winter and are exposed only during the spring, summer, or fall. If the site is small or the only vegetation present is along the edge of the site, then mammals are likely to get some or all of their diet off-site.

Therefore, the following habits of the mammals using the site must be known:

a) whether the animal hibernates
b) proportion of total foraging area provided by the site, and
c) composition of its diet (seeds, leaves, invertebrates and/or soil)

3.3.1.4.1 Residency

For each mammal on the site-specific checklist (see Section 3.1.2.2.3), indicate whether or not it hibernates (H)

Mammal list annotated

3.3.1.4.2 Foraging Area

See Appendix K for a list of references containing information about mammal foraging areas. For each mammal that may use your site, indicate on the site-specific checklist whether its foraging area is greater (G) or smaller (S) than the size of the site. If foraging area information is not available, use information about territory size. If no information is available, assume that the foraging area is equal (E) in size to the site.

Mammal list annotated

3.3.1.4.3 Diet

Refer to Appendix K for a list of references on dietary preferences of mammals.

For each species present on the site list the dietary composition in a table such as the following:

Feeding Group	% Seeds	% Other Plant Material	% Soil Invertebrates	% Fish	% Other (specify)	% Soil (assume 2%)	TOTAL (100%)
						2	100
						2	100

3.3.1.5 Aquatic Invertebrates

Use the following rules to determine exposure:

a) Planktonic invertebrates are exposed to toxicants primarily by absorption from the water column, although ingestion is an additional route.
b) Aquatic insects can be exposed through the water column, sediment, or ingestion of plant material or other insects.
c) Clams and other shellfish are exposed through the water column and this will be the primary route for water-soluble materials. Ingestion is the main exposure pathway for materials bound to particulates or that bioconcentrate in plankton.

3.3.1.6 Fish

Fish have 100% exposure to the water column. However, lifestyle determines exposure to the sediment. Flatfish or other bottom dwellers and borrowers are exposed to the interstitial water concentration of the sediment so that should be used as an exposure pathway instead of water concentration. Higher trophic level fish (such as some of the salmonids) also are exposed by eating smaller fish with contaminants in their tissues.

3.3.2 Environmental Concentrations

The following sections describe how to collect various media for determining the concentration of the contaminants of concern and provide guidance on how to select appropriate analytical chemistry methods.

3.3.2.1 Selection of Media

To determine which media to sample, refer to the Conceptual Site Model diagrams and to the dietary composition tables for birds and mammals (sections 3.3.1.3.3 and 3.3.1.4.3) to help answer the following questions. The goal is to sample food eaten by birds, mammals, and fish as well as the contaminated soil and/or water. In addition, if groundwater contamination is of concern (either due to drainage to surface waters or because of uptake by plant roots), groundwater should be sampled to describe the direction, extent, and concentration of the plume. Answers to the following questions will help determine which media to sample.

a) Are there terrestrial plants or animal receptors of concern?

- [ ] No. Skip to question b)
- [ ] Yes. Take the following samples:

soil (Section 3.3.2.2)
plants (Section 3.3.2.5)
soil invertebrates (Section 3.3.2.6)

b) Are there aquatic plants or animal receptors of concern (fish, shellfish, birds, mammals)?

- [ ] No. Skip this question.
- [ ] Yes. Take the following samples:

groundwater (Section 3.3.2.7)

surface water (Section 3.3.2.8)

sediment (Section 3.3.2.8)

aquatic invertebrates (Section 3.3.2.9)

fish (Section 3.3.2.9)

aquatic plants (Section 3.3.2.10)

3.3.2.2 Sampling Design

The number of samples taken should be sufficient to characterize all different parts of the site. This will vary depending on site size. More detail is provided in each media sampling section. Note that the goal is to provide sufficient data to use the techniques in Risk Quotient Calculation (Section 8.1.1.3). These techniques require a spatially explicit approach to chemical concentration. Refer to the following text for more detailed discussion of environmental sampling designs:

Gilbert, R.O. 1987. *Statistical Methods for Environmental Pollution Monitoring*. Van Norstrand Reinhold, New York, New York.

3.3.2.3 Analytical Chemistry

All environmental media samples should be submitted for chemical analysis as soon as possible. Keep samples cool (<10° C) between time of collection and analysis. Be sure to specify whether the results should be reported as dry weight (dw) or wet weight (ww) concentrations. The measurement units of these results should be comparable to the measurement units of the toxicity reference values selected in Section 3.2.3. Asking the laboratory to report percent moisture will provide flexibility for converting between wet weight and dry weight at any time. Soil and water pH, soil organic carbon, and water hardness should also be requested from the testing laboratory ate the time of sample submission. See Appendix L for a list of analytical chemistry laboratories in British Columbia.

3.3.2.3.1 Methods

A variety of methods exist for sample analysis. The method chosen depends on the matrix being analyzed (soil, water, biota), the required precision and accuracy, and the required level of detection.

See Appendix M for a list of methods available Consult with your analytical laboratory on their preferred method. List the method(s) used in the following table:

Media	Chemical	Method	Detection Limit (dw or ww)	No. of Site Samples	No. of QA / QC Samples
soil					
water					
etc.					

3.3.2.3.2 Detection Limits

Detection limits should be set at 0.1 times the lowest toxicity reference value for organisms exposed to each media, unless current methodology precludes doing so. Include the detection limits in the above table.

3.3.2.3.3 Quality Assurance/Quality Control (QA/QC)

A trip blank, a spike, and a split sample must be included with at least every 20 site samples. Include the number of QA/QC samples in the above table.

See the British Columbia Field Sampling Manual, 1996 edition for a more complete discussion of QA/QC. Data quality objectives (DQOs) are formal data quality specifications, which must be tabulated within a quality assurance manual. These DQOs establish the maximum amount of error allowed for the data to meet its specified use. The DQOs should be established before sample collection to avoid situations where resources are spent collecting samples which do not fit the DQOs. Once DQOs are established and sampling has begun, regular performance checks are performed to verify that the DQOs are satisfied. Corrective action must be taken when DQOs are not met. Out-of-control events and actions must be recorded.

It is highly recommended that before implementing any environmental samples, all monitoring/sampling plans be approved by BCE. Remember to coordinate with the human health effects risk assessment sample collections.

3.3.2.4 Soil Sampling

When collecting samples, observations on the appearance and abundance of soil organisms can be recorded as additional information. This information can serve as anecdotal evidence in Tier 1 or 2 EcoRAs.

3.3.2.4.1 Number and Spatial Distribution

At least three sample points should be taken in each different area of the site (*e.g.*, grass-covered, bare ground, under vegetation). If there are suspected point source(s) of contamination, a greater number of samples should be taken near the source with diminishing numbers forming concentric rings outward. Additional samples should be taken in any down-gradient area (downwind or downslope).

It may be necessary to take samples off-site to completely characterize the extent of a gradient. One option is to characterize the site first and return for additional off-site sampling if a gradient is not completely defined.

Number of samples ____

Show sample locations on the site map

☐ **Map attached**

3.3.2.4.2 Depth

Composite samples should be taken at 0 to 15 cm depth for characterization of plant exposure. However, for sandy soil (*e.g.*, Fraser River sand), take a soil sample at 0 to 50 or 70 cm depth.

Optional: Deeper core samples of various soil strata can be taken to characterize current and potential migration of contaminants.

Number of samples taken at 0 to 15 cm depth: ________________

Number of samples taken at deeper depth:

Depth: ____________________ cm

Number: ____________________

Label all sample locations on the site map with sampling depth.

☐ **Map labelled**

3.3.2.4.3 Methods

Samples may be collected using either a soil corer or a trowel for surface samples and with appropriate coring devices for deeper samples.

If contaminants of concern are metals or metalloids, use only plastic trowels and corers. Samples should be packaged in plastic bags and stored under cool conditions until analyzed. Decontaminate sampling device between each sample.

☐ Contaminants are metals/metalloids - use plastic devices

If contaminants of concern are organic compounds, use only metal sampling devices. Store samples in glass containers and keep cool until analyzed. Decontaminate sampling device between each sample.

☐ Contaminants are organic compounds - use metal and glass devices

See Appendix N for references for specific soil collection methods. List which methods were used.

☐ **List of methods attached**

3.3.2.5 Terrestrial Plant Sampling

3.3.2.5.1 Number and Spatial Distribution

At each soil sample location, collect a vegetation sample (if vegetation is present).

Collect grass, shrubs, and tree leaves separately at each location. Collect at least 50 grams of each.

Number of plant samples taken:

Grass: ____________________

Shrubs: ____________________

Tree leaves: ________________

Label all sample locations on the site map with the depth of sampling. Note which types of vegetation samples were collected at each sample point.

☐ **Map labelled**

3.3.2.5.2 Methods

Samples are collected using either metal or plastic scissors.

If contaminants of concern are metals or metalloids, use plastic scissors. Samples should be packaged in plastic bags and stored under cool conditions until analyzed. Decontaminate scissors between each sample.

☐ Contaminants are metals/metalloids - use plastic devices

If contaminants of concern are organic compounds, use only metal sampling devices. Store samples in glass containers and keep cool until analyzed. Decontaminate sampling device between each sample.

☐ Contaminants are organic compounds - use metal and glass devices

See Appendix G for reference for specific plant collection methods.

3.3.2.6 Soil Invertebrates

When collecting soil samples, remove to a separate sampling container any invertebrates (*e.g.*, earthworms, centipedes, beetles) found in the soil. These may be taken from the same sample that will be analyzed for soil chemistry or may be taken from a separate sample collected adjacent to the core collection site.

Invertebrates are separated from the soil either by picking them out with a tweezers or by passing the soil through a small diameter sieve. Collect all the invertebrates in the sample or 50 grams, whichever is the least.

If contaminants of concern are metals or metalloids, use plastic tweezers. Invertebrates should be packaged in plastic bags or glass containers and stored frozen until analyzed.

- [ ] Contaminants are metals/metalloids - use plastic devices

If contaminants of concern are organic compounds, use metal tweezers. Invertebrates should be packaged in glass containers and stored frozen until analyzed.

- [ ] Contaminants are metals/metalloids - use plastic devices

Label all sample locations on the site map where invertebrates were found.

- [ ] **Map labelled**

3.3.2.7 Groundwater Samples

3.3.2.7.1 Number and Spatial Distribution

Groundwater sampling should be conducted in a manner that will illustrate the amount of chemical currently in the groundwater aquifers, both under the site and downgradient off-site. Sufficient number of samples should be taken to define the boundaries of any plume of contamination.

During all drilling, appropriate care should be taken not to penetrate any barriers that prevent the movement of surface water into deeper aquifers. Otherwise, previously uncontaminated groundwater may become contaminated solely as a result of the sampling process.

A minimum of 10 samples is required to find the general location of potential plumes of contamination. This may have been done during the initial site assessment, in which case this portion of the risk assessment can immediately focus on better defining the plume.

Once a general area of contamination is identified, a sufficient number of groundwater samples must be taken to define the boundaries of the plume, particularly its extent downgradient. The number of samples required to do this will depend on the plume size.

3.3.2.7.2 Methods

If contaminants of concern are metals or metalloids, use plastic sampling devices (with the exception of metal-tipped drills, if needed). Samples should be stored in glass or Teflon-lined jars and stored under cool conditions until analyzed.

☐ Contaminants are metals/metalloids - use plastic and glass devices

If contaminants of concern are organic compounds, use only metal sampling devices. Store samples in glass containers and keep cool until analyzed.

☐ Contaminants are organic compounds - use metal and glass devices

Refer to Appendix N for detailed methods for groundwater sampling. List which methods were used.

☐ **List of methods attached**

3.3.2.8 Surface Water and Sediment Sampling

When collecting samples, observations on the appearance and abundance of sediment organisms can be recorded as additional information. This information can serve as anecdotal evidence in Tier 1 or 2 EcoRAs.

3.3.2.8.1 Number and Spatial Distribution

Use a sufficient number of samples to characterize the surface water variability so that a spatially explicit model can be used in calculating risk values (see Section 8.1.1.3.2).

3.3.2.8.2 Methods

Refer to Appendix N for detailed methods for surface water and sediment sampling. List which methods were used.

☐ List of methods attached

3.3.2.9 Fish and Aquatic Invertebrate Sampling

3.3.2.9.1 Number and Spatial Distribution

The fish and aquatic invertebrate sampling should occur concurrently with the chemical sampling. Samples should be taken at the same location and at the same time as much as is possible. This approach to sampling will facilitate the calculation of risk values as delineated in section 8.1.1.3.

Permits are required for the collection of fish and other aquatic species. Proponents are advised to contact their local office of the Department of Fisheries and Oceans and BC Environment for specific permit requirements.

3.3.2.9.2 Methods

Refer to Appendix N for detailed methods for sampling of fish and aquatic invertebrates. List which methods were used.

☐ **List of methods attached**

3.3.2.10 Aquatic Plant Sampling

3.3.2.10.1 Number and Spatial Distribution

Sampling strategies for aquatic plants depend on the type of plant and the planned use of the data. Aquatic plants can be divided into two main types according to whether the plants are physically attached to the sediment (*i.e.*, rooted plants) or whether they float on the water (*i.e.*, floating plants). Plant tissue sampling is conducted to address risks to herbivores (animals that eat the plants), but can also be conducted to address risks to the plants themselves if the appropriate effect data are available. Therefore, be sure to collect samples from each type of plant that is an important food for animals or that is desired for its own sake. Collect stems, roots and leaves, as these parts are edible for many aquatic plants.

To properly address spatial issues, the pattern of contamination in the receiving environment (sediment or water) must contain some gradient (*i.e.*, is not homogeneous). For example, there is no benefit in sampling duckweed (a floating plant) along with water samples if no contaminant gradient exists in the water. A spatially explicit sampling program, however, should always be considered for rooted plants when addressing which areas of the aquatic portion of the site might require remediation. The number and spatial distribution of samples for a spatially explicit sampling program is driven by the scale of the contamination gradient.

Methods

Sampling methods for aquatic plants are the same as those described for terrestrial plants (Section 3.3.2.5).

This completes the Analysis Phase. Go to Section 8 to put all the information together into a Risk Calculation.

Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites

4.0 COMMERCIAL

4.1 Problem Formulation (continued)

Which standard/criteria was exceeded (for any chemical)?

a) ☐ Toxicity to soil invertebrates and plants

b) ☐ Groundwater flow, surface run-off, or direct discharge to surface water or sediments used by aquatic life

If a) is exceeded, go to Section 4.1.1

If b) is exceeded, go to Section 4.1.2

If BOTH are exceeded, do BOTH sections

☐ **Attach a list of the chemicals exceeding the standards. These chemicals will be considered "chemicals of concern" for the remainder of the risk assessment. Please use the following format. If available, attach the Detailed Site Investigation Report as well.**

Chemical	Measured Concentrations (range)	Standard/Criteria Exceeded	Standard/Criteria Value

4.1.1 Potential Terrestrial Receptors

4.1.1.1 Regional Species Lists

Refer to Appendix B to identify the biogeoclimatic zone in which the site is located.

Biogeoclimatic zone: ____

Refer to Appendix C and attach the list of terrestrial plants in the site's biogeoclimatic zone.

☐ **Plant list attached**

Refer to Appendix D and attach the list of terrestrial birds in the site's biogeoclimatic zone.

☐ **Bird list attached**

Refer to Appendix E and attach the list of terrestrial mammals in the site's biogeoclimatic zone.

☐ **Mammal list attached**

Refer to Appendix E and attach the list of amphibians and reptiles in the site's biogeoclimatic zone.

☐ **Amphibians and reptiles list attached**

4.1.1.2 Site-specific Species Lists for Terrestrial Plants and Animals

Which plants, birds, and mammals actually are, or are likely to be, on the site? Several avenues are open to determine the receptors of concern for the risk assessment. Site visits by trained biologists are useful for making informed decisions regarding receptor selection. However, there are other sources of information that should be consulted (*e.g.*, local BCE wildlife officers, Canadian Wildlife Service, etc.). Assessing the ecological risks of contaminated sites to all potential receptors would be an unworkable task. Therefore, strategic selection of key receptors provides an efficient and effective way to meet the overall management goals of the site. Guidance on reducing the regional species lists down to relevant site-specific organisms is provided in the following sections and Appendices C through F.

4.1.1.2.1 Terrestrial Plants

Check off on the biogeoclimatic zone plant list those plants that are actually on the site and are fairly ubiquitous. *This requires a visit to the site or a review of detailed photographs by someone knowledgeable about general plant types and names.*

☐ **Site plants checked on attached list**

☐ **Species selected as receptors of concern are noted on the species list**

4.1.1.2.2 Terrestrial Birds

Check off on the biogeoclimatic zone bird list those birds likely to use the site and that are of potential concern, using the following rules:

a) Birds are present only if there is vegetation on the site.
b) Birds must be resident species for at least one season (do not include migrants that just pass through).
c) Shorebirds (*e.g.*, dowitchers, sandpipers), wading birds (*e.g.*, herons, egrets), waterfowl (*e.g.*, ducks, geese), and seabirds (*e.g.*, gulls, cormorants) are not considered.
d) Raptors (*e.g.*, hawks, owls, and eagles) are considered only if they are threatened or endangered species.
e) Galliforms (*e.g.*, pheasant and quail) are not present in urban areas.
f) Cavity-dwellers (*e.g.*, flickers and woodpeckers) and birds that eat foliar invertebrates are not considered.
g) Hummingbirds are not considered.
h) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site birds checked on attached list**

Group the bird species according to feeding groups.

☐ **Feeding group list attached**

☐ **Species selected as receptors of concern are noted on the species list**

4.1.1.2.3 Terrestrial Mammals

Check off on the biogeoclimatic zone mammal list those animals likely to use the site and that are of potential concern, using the following rules:

a) Mammals are present only if there is vegetation on the site.
b) Mammals must be resident for at least one season (do not include migrants that just pass through).
c) Large mammals (*e.g.*, deer, elk, bear, coyotes, fox, skunk, raccoons) are not considered.
d) Rabbits and large rodents (*e.g.*, beaver) do not occur in urban areas.
e) Mustelids are not considered.
f) Small rodents (mice and voles) may occur in all areas.
g) Non-native pest species (rats and house mice) are not of concern.
h) Bats are not considered.
i)Include all species that are listed as threatened, endangered or sensitive.

☐ **Site mammals checked on attached list**

Group the mammal species according to feeding groups.

☐ **Feeding group list attached**

☐ **Species selected as receptors of concern are noted on the species list**

4.1.1.2.4 Amphibians and Reptiles

Check off on the biogeoclimatic zone amphibian and reptile list those animals likely to use the site and that are of potential concern.

☐ **Site amphibians and reptiles checked on attached list**

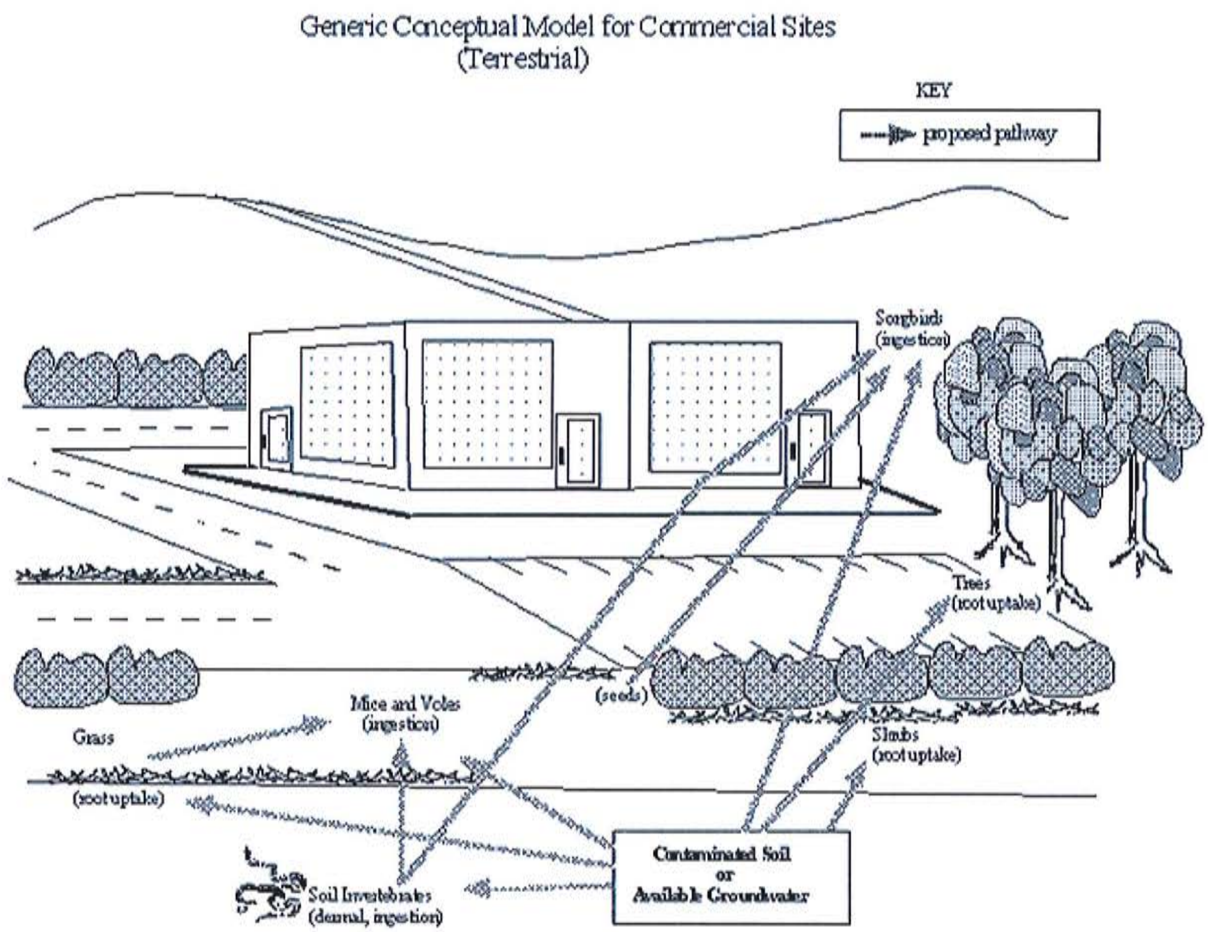
☐ **Species selected as receptors of concern are noted on the species list**

4.1.1.2.5 Soil Invertebrates

Assume that earthworms, as representative soil invertebrates, should be present at the site.

4.1.1.3 Conceptual Site Model

Use the representation of the site on the next page to show how the contaminants of concern (those chemicals that exceed the standard/criteria) could potentially move through the food chain to the animals that may be onsite. If something in the picture (*e.g.*, trees) is missing on the site, remove it and all its associated connections from the picture. Refer to Appendix A for more guidance on development of Conceptual Site Models.



4.1.2 Potential Aquatic Life Receptors

Is the water

- [ ] fresh (river, stream, lake, wetland)?
- [ ] brackish (estuary, saltmarsh)?
- [ ] salt (ocean shore)?

4.1.2.1 Regional Species Lists

Refer to Appendix C and attach the list of the aquatic plants in the site's biogeoclimatic zone. Be sure to use an appropriate list for fresh, brackish, or salt water plants.

☐ **Aquatic plant list attached**

Refer to Appendix F and attach the list of fish in the site's biogeoclimatic zone. Be sure to use an appropriate list for fresh, brackish, or salt water fish.

☐ **Fish list attached**

Refer to Appendix D and attach the list of birds in the site's biogeoclimatic zone.

☐ **Bird list attached**

Refer to Appendix E and attach the list of mammals in the site's biogeoclimatic zone.

☐ **Mammal list attached**

4.1.2.2 Site-specific Species Lists for Aquatic Plants and Organisms

Which fish, plants, birds, and mammals actually are, or are likely to be, on the site? Several avenues are open to determine the receptors of concern for the risk assessment. Site visits by trained biologists are useful for making informed decisions regarding receptor selection. However, there are other sources of information that should be consulted (*e.g.*, local BCE wildlife officers, Canadian Wildlife Service, etc.). Assessing the ecological risks of contaminated sites to all potential receptors would be an unworkable task. Therefore, strategic selection of key receptors provides an efficient and effective way to ensure the that the overall management goals of the site are met. Guidance on reducing the regional species lists down to relevant site-specific organisms is provided in the following sections and Appendices C through F.

4.1.2.2.1 Plants

Check off on the aquatic plant list those plants that are actually on the site and are fairly ubiquitous. *This requires a visit to the site or a review of detailed photographs by someone knowledgeable about general plant types and names.*

☐ **Site plants checked on attached list**

☐ **Species selected as receptors of concern are noted on the species list**

4.1.2.2.2 Fish

Check off on the biogeoclimatic zone list those fish that are likely to use the site and that are of potential concern, using the following rules:

a) Fish must be resident species and those species known to use the habitat for breeding.
b) Salmonids and their various lifestages may be present without a breeding population due to hatchery input. These fish are economically important and should be included.
c) Transient water bodies do not have resident fish populations.
d) Ditches and other shallow drainage systems should not be considered as important fish habitat.
e) Pay particular attention to run-off into creeks and other water bodies that may used for drainage control but also contribute fish habitat.
f) Fish lists must be tied to water chemistry such as salinity, pH, dissolved oxygen and hardness. Remove species that cannot live in the site's environment.
g) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site fish checked on attached list**

☐ **Species selected as receptors of concern are noted on the species list**

4.1.2.2.3 Aquatic Birds

Check off on the biogeoclimatic zone bird list those birds likely to use the site and that are of potential concern, using the following rules:

a) Birds must be resident species for at least one season (do not include migrants that just pass through).

b) Small shorebirds (*e.g.*, dowitchers) are considered only in shallow marshes, estuaries, or beaches.

c) Waterfowl (*e.g.*, ducks and geese) are not present on small streams.

d) Seabirds (*e.g.*, gulls, cormorants, sandpipers) are considered only for brackish or saltwater sites.

e) Raptors (*e.g.*, hawks, owls, and eagles) are considered only if they are threatened or endangered species.

f) Galliforms (*e.g.*, pheasant and quail) are not present.

g) Cavity-dwellers (*e.g.*, flickers and woodpeckers) are not considered.

h) Hummingbirds are not considered.

i) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site birds checked on attached list**

Group the bird species on the list according to feeding groups.

☐ **Feeding group list attached (e.g., fish-eating, insectivores)**

☐ **Species selected as receptors of concern are noted on the species list**

4.1.2.2.4 Aquatic Mammals

Check off on the biogeoclimatic zone mammal list those animals likely to use the site and that are of potential concern, using the following rules:

a) Mammals must be resident for at least one season (do not include migrants that just pass through).

b) Mammals are not considered for small streams or ponds.

c) Large mammals (*e.g.*, deer, elk, bear, coyotes) do not occur.

d) Wholly land mammals (*e.g.*, rabbits, small rodents) do not occur.

e) Aquatic mustelids (*e.g.*, otters) may be considered.

f) Non-native pest species (nutria) are not of concern anywhere.

g) Bats are not considered.

h) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site mammals checked on attached list**

Group the mammal species on the list according to feeding groups.

☐ **Feeding group list attached (e.g., herbivores, fish carnivores, etc.)**

☐ **Species selected as receptors of concern are noted on the species list**

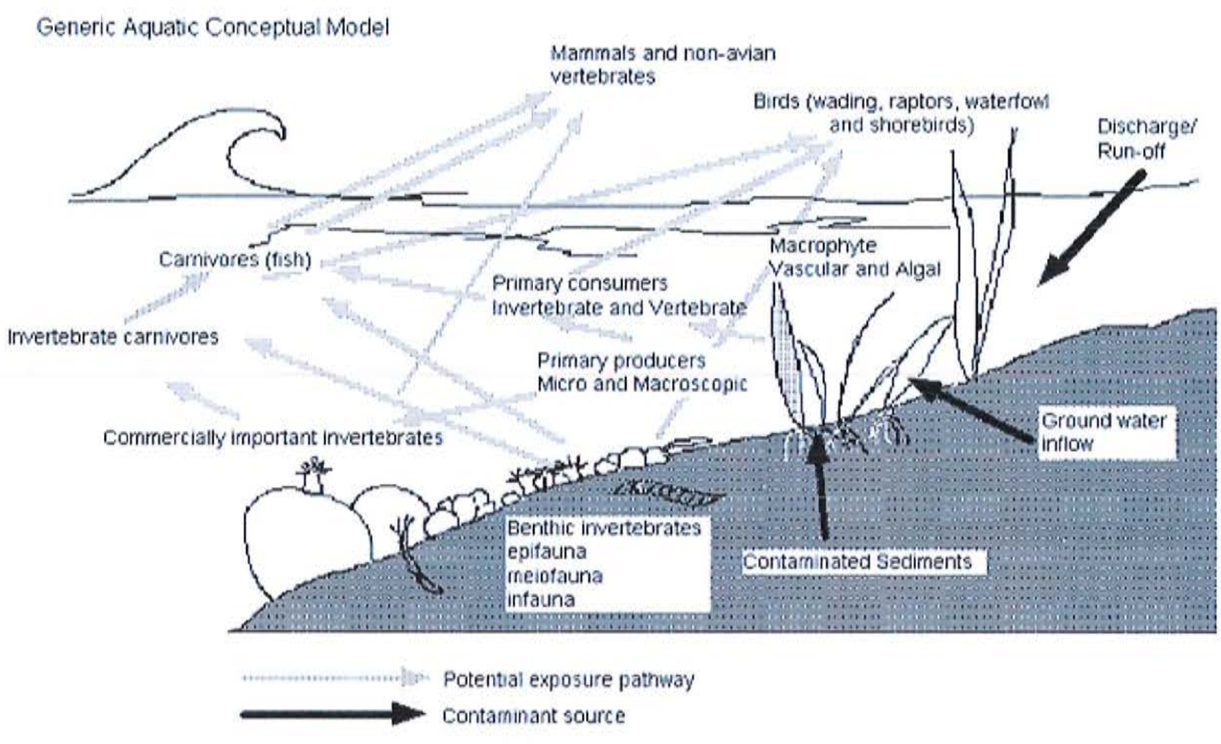
4.1.2.2.5 Aquatic Invertebrates

Assume that bottom-dwelling (benthic) invertebrates are present at the site.

4.1.2.3 Conceptual Site Model

Use the representation of the site on the next page to show how the contaminants of concern (those chemicals that exceed the standard/criteria) could potentially move through the food chain to the animals that may be onsite. If something in the picture (*e.g.*, cattails) is missing on the site, remove it and all its associated connections from the picture. Refer to Appendix A for more guidance on development of Conceptual Site Models.

Recommendation: BCE should review the data package at this time to reach agreement on the contaminants of concern and the plants and animals of interest, prior to collecting samples for analysis.



Top

4.2 Effects Assessment

Purpose: To determine if any adverse environmental effects currently are occurring and to develop appropriate concentration-response relationships to predict if adverse affects will occur in the future.

This section asks a series of questions to help assess, through a simple site visit, whether current conditions are deleterious to plants and animals using the site or in water that receives run-off or groundwater discharge from the site.

You will then be directed how to find information about what concentrations of pollutants of concern cause effects in the plants and animals at your site. You may choose to use the same toxicity values developed by BCE for the matrix standards or you have the option of using a different set of data, provided you justify why you chose a different approach.

You also will be given the option of conducting simple soil or water laboratory bioassays using samples from the most contaminated areas in order to demonstrate whether the media are toxic to plants or animals and, if so, at what concentration of the toxicant in the media (*e.g.*, soil or water). *In situ* bioassays are also an option for determining if soil or water can support the plants or animals of interest.

4.2.1 Site Observations

4.2.1.1 Terrestrial Plants

If there currently is no vegetation on the site, skip this section.

Vegetation present? ☐ yes (continue) ☐ no (skip section)

If this assessment is being done in the winter, skip this section and return to complete this section in the spring/summer.

Assessment being done in:

☐ spring (continue) ☐ summer (continue) ☐ fall (continue) ☐ winter (skip section)

Date (MM/DD/YY): ______________________________

Comments:

____

____

____

____

For terrestrial plants, refer to EPA SOP #2037 in Appendix G for *Terrestrial Plant Community Sampling Methods* and answer the following questions in this section.

4.2.1.1.1 Grass

Look closely at the grass.

Does it evenly cover an area or are there bare patches of soil showing?

☐ even cover

☐ bare patches size __________ m^2 (bare patches must be 1 m^2 or larger)

Is the grass green or are there brown spots or is it brown all over?

☐ green ☐ brown spots ☐ brown all over

Show any brown spots on the site map. Be sure the map shows where all the grass cover is.

Comments:

____

__

____

__

____

__

____

__

4.2.1.1.2 Shrubs and forbs (small leafy plants)

Look closely at the shrubs, flowers, and other leafy small plants.

Do they have all their leaves?

☐ yes ☐ no

Are the leaves all green, spotted with yellow or brown spots, or all brown?

☐ all green ☐ spotted ☐ all brown

Are there a lot of dead leaves at the base of the plants?

☐ yes ☐ no

Are the above statements true for all the plants on the site or only a few?

☐ all plants ☐ only a few

Show on the site map the location of any plants that are dead, that have spotted leaves, or that have lost a large number of leaves.

Comments:

____

____

____

____

4.2.1.1.3 Trees

Look closely at the trees.

Do they have all their leaves or needles?

☐ yes ☐ no

Are the leaves (or needles) all green, spotted with yellow or brown spots, or all brown?

☐ all green ☐ spotted ☐ all brown

Are there a lot of dead leaves at the base of the trees?

☐ yes ☐ no

Are the above statements true for all the trees on the site or only a few?

☐ all trees ☐ only a few

Do the above statements pertain to deciduous trees, evergreen trees, or both?

☐ deciduous ☐ evergreen ☐ both

Show on the site map the location of any trees that are dead, that have spotted leaves, or that have lost a large number of leaves.

Comments:

____

____

____

____

4.2.1.2 Soil Invertebrates

If the entire area is under buildings or pavement, skip this section.

Ground frozen? ☐ no (continue) ☐ yes (skip section)

Comments:

____

Dig up a patch of soil from several areas with no vegetation, from several areas with grass or shrubs, and from areas near trees. Pass the soil through a sieve (if dry) or rinse it in a bucket (if wet) to look for earthworms and other soil invertebrates.

For each area, are invertebrates present? ☐ yes ☐ no

If yes, ☐ many ☐ few

If yes, describe what they look like?

(Note: Unhealthy worms may have lesions, constrictions, or discolorations)

4.2.1.3 Birds

Attach a list of any birds seen or heard during the site visit. If the site is small, walk the entire site. Look in trees or shrubs for evidence of current or old nests. If the site is large, walk transects (lines) at least every 50 meters.

If a river, marsh, or other waterbody is of concern due to potential runoff or groundwater contamination, walk transects on either side of the stream or river, or in 50 meter intervals across a wetland OR conduct bird observations from a boat or other suitable flotation method OR from any suitable observation point or platform. Pay particular attention to areas of marsh grasses, woody shrubs, or trees.

☐ **Bird observations attached**

4.2.1.4 Mammals

Attach a list of any mammals seen or heard during the site visit. Look under shrubs and in the grass for mouse holes or vole runways (packed down or bare strips in the grass). Look in dirt, mud and other areas for mammal tracks, footprints, and scat (fecal material).

If a river, marsh, or other waterbody is of concern due to potential run-off or groundwater contamination, walk transects on either side of the stream or river, or in 50 meter intervals across a wetland. Pay particular attention to areas of marsh grasses, woody shrubs, or trees.

☐ **Mammal observations attached**

4.2.1.5 Aquatic Plants

If the site does not contain or border on aquatic habitat, skip Sections 4.2.1.5 through 4.2.1.7.

Assessment being done in:

☐ spring ☐ summer ☐ fall ☐ winter

Date (MM/DD/YY): ______________________________

Is aquatic vegetation present? ☐ yes ☐ no

If no, why do you think it's not

____

Do the aquatic plants appear healthy? ☐ yes ☐ no

Are there any visual signs of stress (*e.g.*, discolored parts)? ☐ yes ☐ no

If yes, describe

Comments:

☐ **Aquatic plant list and observations attached**

4.2.1.6 Fish

For marine or estuarine habitats, consult the following references and conduct a brief fish habitat description.

For freshwater habitats, consult the following references and conduct a brief fish habitat survey. For lake habitats, use the principles discussed for marine or estuarine habitats in the following references to conduct the habitat survey.

Department of Fisheries and Oceans (DFO) and Environment Canada. 1989. Coastal/estuarine fish habitat description and assessment manual-Part II: Habitat description procedures. Prepared by G.L. Williams and Associates, Coquitlam, BC. 38 pp. + appendices.

Department of Fisheries and Oceans (DFO) and BC Ministry of Environment (BCE). 1989. Fish habitat inventory and information program - Stream survey field guide. 29 pp. + appendices.

☐ **Attach habitat survey card(s), photos or maps of habitat, and a brief description of fish resources**

4.2.1.7 Aquatic Invertebrates

Walk along the shoreline observing the habitat and sample with a small plankton net.

a) If a fresh water site, sample the shoreline every 10 m with several strokes of the net. Put the contents in a jar and note the presence of daphnia, worms, insect larvae, snails, and other invertebrates.
b) If a marine site, sample the shoreline every 10 m with several strokes of the plankton net noting the presence of copepods, shellfish, and other invertebrates.
c) In a marine intertidal site, observe at low tide and note the shellfish, copepods, crabs, starfish, and worms present.

☐ **Aquatic invertebrate observations attached**

4.2.2 Bioassays

OPTIONAL: Bioassays provide the opportunity to demonstrate whether the most highly contaminated media (soil and/or water) are toxic to the plants, invertebrates, or aquatic life of concern, particularly *in situ*ations where vegetation or aquatic life are not currently present. Soil and/or water samples are taken into the laboratory and growth, reproduction and survival of test species are measured following standardized, peer-reviewed methods.

Bioassays can be considered in such cases where environmental concentrations are above toxicity reference values (TRVs), but organisms are still present on the site. Other factors such as toxicant bioavailability and natural selection may apply to site conditions. For example, soils with metal contamination may not be bioavailable to earthworms due to soil conditions (*e.g.*, soil composition or pH). Therefore, earthworms may be present in sites with environmental conditions above the TRV for earthworms. In such cases, bioassay toxicity testing will establish site-specific conditions and TRVs for a particular site.

Methods developed and modified by the British Columbia Ministry of Environment and Environment Canada are recommended and listed first (Appendix H). A listing of comparable, alternative, and additional standard methods also are provided to supplement and expand bioassay and analytical capabilities. Methods developed by the American Public Health Association (APHA), American Water Works Association (AWWA), Water Environment Federation (WEF), American Society of Testing and Materials (ASTM), Organization of Economic Cooperation and Development (OECD), and the United States Environmental Protection Agency (USEPA) are included and, in many cases, are referenced in the Canadian protocols.

Bioassays may be conducted after completing the entire risk assessment, to confirm results or to understand the extent of cleanup that will be required. However, bioassays also may be done during the Effects Assessment phase as part of the development of the weight-of-evidence of environmental risk.

4.2.2.1 General Procedures for Laboratory Bioassays

a) Collect soil, water, or sediment from the most highly contaminated areas.
b) Refer to Appendix H for a list of suggested companies that can conduct standard bioassays and for references for bioassay protocols. Consider the use of field replicates rather than laboratory replicates.
c) Suggested species for bioassays:

plants	rye grass (*Lolium perenne*)
earthworms	red worms (*Eisenia foetida*)
fish: freshwater	rainbow trout (*Oncorhynchus mykiss)*
	bluegill (*Lepomis macrochirus*)
	sunfish (*Lepomis sp.)*
	chinook top smelt (*Atherinops affinis*)

(marine)	*Champia parvula*
	echinoderm fertilization
	inland silverside (Menidia)
	stickelback
aquatic invertebrates:	ceriodaphnia, *Daphnia magna*
(water)	amphipod test
(sediments)	

☐ **Bioassay(s) conducted - report(s) attached**

4.2.2.2 *In Situ* Bioassays

a) Visit site. Use an area of the site with suspected contamination based on media sampling or source input.
b) Take field measurements of dissolved oxygen, temperature, conductivity, and pH.
c) Inform and obtain approval from Regional Ministry of the Environment and Department of Fisheries and Oceans habitat staff for *in situ* bioassay testing.
d) Suggested species for in situ bioassays:

eyed salmonid eggs: pacific salmon
rainbow trout (*Oncorhynchus mykiss*)
caged fish: rainbow trout (*Oncorhynchus mykiss*)
caged mussels: sea mussels (*Mytilus edulis)*

4.2.3 Toxicity Reference Values (TRVs)

In order to determine if a particular level of contamination at a site poses a risk to plants or animals, you need to know how much of that material the plants or animals can tolerate before toxic effects are seen. The concentration of the pollutant in the soil or water where toxicity begins to occur is called the *toxicity threshold*. However, for environmental receptors such as plants or animals (*i.e.*, not humans), the goal is not to protect each individual from any toxic effect, but rather to protect enough individuals so that a viable population and community of organisms can be maintained (provided other habitat factors are suitable). Therefore, a TRV is chosen from the concentration-response curve that provides reasonable protection for a specified percentage of the organisms. For terrestrial organisms on *commercial sites,* this is the EC_{50}, or the concentration that affects 50% of the organisms exposed. For aquatic organisms at *commercial sites*, this is the EC_{20}.

To find the EC_x for plants and animals at your site for pollutants of concern, do any (or all) of the following. Be sure to specify whether this value is dry weight (dw) or wet weight (ww).

a) Use the BCE standard or criteria or information from its supporting documentation.

BCE standard/criteria used: ☐ yes ☐ no

b) Refer to Appendix I for a list of database and other references sources that contain information about toxic responses of plants, animals, and aquatic organisms.

List databases searched

____

____

____

c) Search the scientific literature.

List databases searched

____

____

Use the following rules to select the appropriate EC_x:

a) Give preference to a generally accepted toxicity reference value that has been generated for that particular medium (accepted with caveats, peer reviewed, governmental or NGO groups). For example, water quality criteria.

b) Give preference to reproductive endpoints, but use lethality studies if they are the only ones available.

c) Acceptable toxicological endpoints include:

- any reproductive endpoint (*e.g.*, number of offspring, number of eggs laid, eggshell quality, fruit size and yield, presence of deformities in embryos or young)
- growth rates
- lethality
- tumour formation or other gross deformities in embryos or young

Unacceptable endpoints include:

- changes in enzyme activities
- DNA breakage
- other subcellular responses and hematological parameters

d) If an EC_x is not reported, generate the concentration-response curve from the data provided and calculate the EC_x. As a last resort, use the lowest observed adverse effects level rather than the EC_x and do not divide by any uncertainty factors.

e) If data are available from more than one study for an organism of concern, use the lowest EC_x.

f) Use information for the contaminant of concern from any test (*e.g.*, bioassay, laboratory, field study) conducted with the organisms under consideration, if available.

g) If the organism of concern has not been tested, use the most closely related (phylogenetically) organism. Carefully consider the phylogenetic histories of the test species compared to the organisms of concern and consider any drawbacks to extrapolating between species.

For birds and mammals:

1. use EC_{50}
2. give preference to those in the same feeding group
3. give preference to feeding studies (not single dose studies, or injection studies), particularly of weeks to months in duration
4. if you have data from similar animals (*e.g.*, rodent data to compare with rodents or duck data to compare to other waterfowl), do not use any uncertainty factors. If your animals are not so closely related, divide the value by 10
5. if the ONLY data available for any animal species are from injection or oral dosing studies, convert the dose to concentration in food, assuming an average body weight (bw) for the species and an average food consumption rate. Food consumption may be estimated from the following equations:

   F = 0.621 (bw)0.564 (*rodents*)

   F = 0.577 (bw)0.727 (*mammalian herbivores*)

   F = 0.235 (bw)0.822 (*other mammals*)

   F = 0.398 (bw)0.850 (*song birds*)

   F = 0.648 (bw)0.651 (*other birds*)

For plants:

1. use EC_{50}
2. if extrapolating within the same Family, do not use any uncertainty factors
3. if extrapolating to another Family, divide by 2
4. if extrapolating to another Order, divide by 20
5. if extrapolating to another Class, divide by 500

For soil invertebrates:

6. use EC_{50}
7. use whatever data are available without adjustments

For aquatic organisms (algae, invertebrates, and fish):

8. use EC_{20}

9. use species from same class, teleost (ray finned fish) is typical. Agnatha (jawless fish) and Chondricithyes (sharks and rays) have very different biochemistries, especially in regards to PCBs and other estrogenic compounds
10. that are pelagic invertebrates, use species similar to organism of concern, although most of the data will be on daphnia
11. use test species with similar routes of exposure as the organism of concern. Sediment tests conducted to estimate the toxicity of a burrowing worm should use burrowing organisms as the test organism. Filter-feeding mollusks should be the organism of choice when estimating mussel or oyster sensitivity.
12. aquatic phytoplankton are represented by single species algal toxicity tests and many kinds of test organisms are available
13. aquatic macrophytes are represented by Lemma (duckweed) although a number of new methods are under development
14. give preference to tests conducted during a significant portion, or the most sensitive portion, of the test organism's lifespan

Attach a list of the selected ECx with the appropriate references. Structure the list in the following format:

Organism of Concern	**Test Organism**	**Measurement (reproduction, mortality, etc.)**	**Endpoint (LOAEL) ECx**	**Uncertainty Factor**	**Value**	**Dry Weight or wet weight**	**Reference**

Top

4.3 Exposure Assessment

Purpose: To determine the concentration of pollutants in media of concern to which the plants and animals of concern are actually exposed (food, water, soil, etc.) and to demonstrate how the plants and animals came in contact with the contaminated media.

For plants and animals to be at risk from pollutants, the compounds must exist in the environment at concentrations above the toxicity reference values and the plants or animals must come in contact with the contaminated media. This section describes an appropriate sampling of the site to understand the magnitude and spatial extent of any contamination. The answers to the series of questions that follows will help determine pertinent life-history patterns of the plants and animals on your site to determine if, when, and for how long they may come in contact with the contaminated environment.

Note: All environmental sampling should be conducted in cooperation with the human health effects assessment to reduce the need to sample the same area twice. Coordination between the two processes should take place at this time.

4.3.1 Exposure Patterns of Plants and Animals

Plants and animals must come in contact with a contaminant in order to be considered at risk. This section defines the potential for organisms on the site to come in contact with contaminated media. Note that it is assumed that only plants may be directly affected by contaminated groundwater. Other organisms are potentially at risk only if the groundwater contaminates surface water or is used for irrigation.

4.3.1.1 Plants

All plants on the site are assumed to be exposed to contaminated soil, as their roots have the potential to take up materials out of the soil. Deep-rooted plants also may contact contaminated groundwater. Rooted aquatic plants (also called macrophytes) such as cattails, rushes, or salt grass take up contaminants from the water column (through their leaves) as well as by their roots from sediment. Non-rooted aquatic plants (*e.g.*, duckweed, waterlilies) also take up contaminants from the water column through their leaves. Therefore, exposure to plants should be assumed, unless the contamination is present only during the dormant period of the year (winter, for most plants, if the ground freezes).

4.3.1.2 Soil Invertebrates

All soil invertebrates (such as earthworms, centipedes, and beetles) are considered exposed through ingestion of soil or movement of contaminant across their skin. Therefore, exposure to soil invertebrates should be assumed, unless the contamination is present only during the dormant period of the year (*e.g.*, when the ground is frozen).

4.3.1.3 Birds

Birds are exposed only if they eat soil invertebrates or plants (leaves or seeds) on the terrestrial portion of the site, or if they eat aquatic invertebrates or fish from a contaminated water source. In addition, it is assumed that most birds consume some soil or sediment along with the actual foodstuff and may get additional contamination from this route.

Birds may not feed on the site for their entire life. Many birds leave the area during the winter and so have the potential to be exposed only during the late spring, summer, and early fall. In addition, if the site is small or the only vegetation present is along the edge of the site, then birds are likely to get some of their diet off-site.

Therefore, the following habits of the birds using the site must be known:

a) proportion of the year the bird may be resides in the area,
b) proportion of total foraging area provided by the site, and
c) composition of diet (seeds, leaves, invertebrates and/or soil)

4.3.1.3.1 Residency

For each of the birds on the site-specific checklist (see Sections 4.1.1.2.2), indicate whether the bird is a year-round resident (YR), summer resident (SR), or winter resident (WR).

☐ **Bird list annotated**

4.3.1.3.2 Foraging Area

See Appendix J for a list of references containing information about bird foraging areas. For each bird that may use your site, indicate on the site-specific checklist whether its foraging area is greater (G) or smaller (S) than the size of the site. If foraging area information is not available, use information about territory size. If no information is available, assume that the foraging area is equal (E) in size to the site.

☐ **Bird list annotated**

4.3.1.3.3 Diet

Refer to Appendix J for a list of references on dietary preferences of birds.

For each species present on the site list the dietary composition in a table such as the following:

Feeding Group	**% seeds**	**% other plant material**	**% soil invertebrates**	**% aquatic invertebrates**	**% fish**	**% other (specify)**	**% soil (assume 2%)**	**TOTAL (100%)**
							2	100
							2	100

4.3.1.4 Mammals

Mammals are exposed only if they eat soil invertebrates or plants (leaves or seeds) on the terrestrial portion of the site or if they eat fish from a contaminated water source. In addition, it is assumed that most mammals consume some soil or sediment along with the actual foodstuff and may get additional contamination from this route.

Some mammals hibernate during the winter and are exposed only during the spring, summer, or fall. If the site is small or the only vegetation present is along the edge of the site, then mammals are likely to get some or all of their diet off-site.

Therefore, the following habits of the mammals using the site must be known:

a) whether the animal hibernates
b) proportion of total foraging area provided by the site
c) composition of its diet (seeds, leaves, invertebrates and/or soil)

4.3.1.4.1 Residency

For each mammal on the site-specific checklist (see Section 4.1.1.2.3), indicate whether or not it hibernates (H)

☐ **Mammal list annotated**

4.3.1.4.2 Foraging Area

See Appendix K for a list of references containing information about mammal foraging areas. For each mammal that may use your site, indicate on the site-specific checklist whether its foraging area is greater (G) or smaller (S) than the size of the site. If foraging area information is not available, use information about territory size. If no information is available, assume that the foraging area is equal (E) in size to the site.

☐ **Mammal list annotated**

4.3.1.4.3 Diet

Refer to Appendix K for a list of references on dietary preferences of mammals.

For each species present on the site list the dietary composition in a table such as the following:

Feeding Group	% seeds	% other plant material	% soil invertebrates	% fish	% other (specify)	% soil (assume 2%)	TOTAL (100%)
						2	100
						2	100

4.3.1.5 Aquatic Invertebrates

Use the following rules to determine exposure:

a) Planktonic invertebrates are exposed to toxicants primarily by the absorption from the water column, although ingestion is an additional route.
b) Aquatic insects can be exposed through the water column, sediment, or ingestion of plant material or other insects.

c) Clams and other shellfish are exposed through the water column and this will be the primary route for water-soluble materials. Ingestion is the main exposure pathway for materials bound to particulates or that bioconcentrate in plankton.

4.3.1.6 Fish

Fish have 100% exposure to the water column. However, lifestyle determines exposure to the sediment. Flatfish or other bottom dwellers and borrowers are exposed to the interstitial water concentration of the sediment so that should be used as an exposure pathway instead of water concentration. Higher trophic level fish (such as some of the salmonids) also are exposed by eating smaller fish with contaminants in their tissues.

4.3.2 Environmental Concentrations

The following sections describe how to collect various media for determining the concentration of the contaminants of concern and provides guidance on how to select appropriate analytical chemistry methods.

4.3.2.1 Selection of Media

To determine which media to sample, refer to the Conceptual Site Model diagrams and to the dietary composition tables for birds and mammals (sections 4.3.1.3.3 and 4.3.1.4.3) to help answer the following questions. The goal is to sample the food that is eaten by birds, mammals, and fish as well as the contaminated soil and/or water. In addition, if groundwater contamination is of concern (either due to drainage to surface waters or because of uptake by plant roots), groundwater should be sampled to describe the direction, extent and concentration of the plume. Answers to the following questions will help determine which media to sample.

a) Are there terrestrial plants or animal receptors of concern?

- [ ] No. Skip to question b).
- [ ] Yes. Take the following samples:

soil (Section 4.3.2.4)

plants (Section 4.3.2.5)

soil invertebrates (Section 4.3.2.6)

b) Are there aquatic plants or animal receptors of concern (fish, shellfish, birds, mammals)?

- [ ] No. Skip this question.

- [ ] Yes. Take the following samples:

groundwater (Section 4.3.2.7)

surface water (Section 4.3.2.8)

sediment (Section 4.3.2.8)

aquatic invertebrate (Section 4.3.2.9)

fish (Section 4.3.2.9)

aquatic plants (Section 4.3.2.10)

4.3.2.2 Sampling Design

The number of samples taken should be sufficient to characterize all different parts of the site. This will vary depending on the site size. More detail is provided in each media sampling section. Note that the goal is to provide sufficient data to use the techniques in Risk Quotient Calculation (Section 8.1.1.3). These techniques require a spatially explicit approach to chemical concentration. Refer to the following text for more detailed discussion of environmental sampling designs:

Gilbert, R.O. 1987. *Statistical Methods for Environmental Pollution Monitoring*. Van Norstrand Reinhold, New York, New York.

4.3.2.3 Analytical Chemistry

All environmental media samples should be submitted for chemical analysis as soon as possible. Keep samples cool (< 10° C) between time of collection and analysis. Be sure to specify whether the results should be reported as dry weight (dw) or wet weight (ww) concentrations. The measurement units of these results should be comparable to the measurement units of the toxicity reference values selected in Section 4.2.3. Asking the laboratory to report percent moisture will provide flexibility for converting between wet weight and dry weight at any time. Soil and water pH, soil organic carbon, and water hardness should also be requested from the testing laboratory ate the time of sample submission. See Appendix L for a list of analytical chemistry laboratories in British Columbia.

4.3.2.3.1 Methods

A variety of methods exists for sample analysis. The method chosen depends on the media being analyzed (soil, water, biota), the required precision and accuracy, and the required level of detection.

See Appendix M for a list of methods available Consult with your analytical laboratory on their preferred method. List the method(s) used in the following table:

Media	**Chemical**	**Method**	**Detection Limit (dw or ww)**	**No. of Site Samples**	**No. of QA/QC Samples**
soil					
water					
etc.					

4.3.2.3.2 Detection Limits

Detection limits should be set at 0.1 times the lowest toxicity reference value for organisms exposed to each media, unless current methodology precludes doing so. Include the detection limits in the above table.

4.3.2.3.3 Quality Assurance/Quality Control (QA/QC)

A trip blank, a spike, and a split sample must be included with at least every 20 site samples. Include the number of QA/QC samples in the above table.

See the British Columbia Field Sampling Manual, 1996 edition for a more complete discussion of QA/QC. Data quality objectives (DQOs) are formal data quality specifications, which must be tabulated within a quality assurance manual. These DQOs establish the maximum amount of error allowed for the data to meet its specified use. The DQOs should be established before sample collection to avoid situations where resources are spent collecting samples which do not fit the DQOs. Once DQOs are established and sampling has begun, regular performance checks are performed to verify that the DQOs are satisfied. Corrective action must be taken when DQOs are not met. Out-of-control events and actions must be recorded.

It is highly recommended that before implementing any environmental samples, all monitoring/sampling plans be approved by BCE. Remember to coordinate with the human health effects risk assessment sample collections.

4.3.2.4 Soil Sampling

When collecting samples, observations on the appearance and abundance of soil organisms can be recorded as additional information. This information can serve as anecdotal evidence in Tier 1 or 2 EcoRAs.

4.3.2.4.1 Number and Spatial Distribution

At least three sample points should be taken in each different area of the site (*e.g.*, grass-covered, bare ground, under vegetation). If there are suspected point source(s) of contamination, a greater number of samples should be taken near the source with diminishing numbers forming concentric rings outward. Additional samples should be taken in any down-gradient area (downwind or downslope).

It may be necessary to take samples off-site to completely characterize the extent of a gradient. One option is to characterize the site first and return for additional off-site sampling if a gradient is not completely defined.

Number of samples: ____________________

Show sample locations on the site map

☐ **Map attached**

4.3.2.4.2 Depth

Composite samples should be taken at 0 to 15 cm depth for characterization of plant exposure. However, for sandy soil (*e.g.*, Fraser River sand), take a soil sample at 0 to 50 or 70 cm depth.

Optional: Deeper cores into various soil strata can be taken to characterize current and potential migration of contaminants.

Number of samples taken at 0 to 15 cm depth: ____________________

Number of samples taken at deeper depth:

Depth: ____________________ cm

Number: ____________________

Label all sample locations on the site map with the sampling depth.

☐ **Map labelled**

4.3.2.4.3 Methods

Samples may be collected using either a soil corer or a trowel for surface samples and with appropriate coring devices for deeper samples.

If contaminants of concern are metals or metalloids, use only plastic trowels and corers. Samples should be packaged in plastic bags and stored under cool conditions until analyzed. Decontaminate sampling device between each sample.

☐ contaminants are metals/metalloids - use plastic devices

If contaminants of concern are organic compounds, use only metal sampling devices. Store samples in glass containers and keep cool until analyzed. Decontaminate sampling device between each sample.

☐ contaminants are organic compounds - use metal and glass devices

See Appendix N for references for specific soil collection methods. List which methods were used.

☐ **List of methods attached**

4.3.2.5 Terrestrial Plant Sampling

4.3.2.5.1 Number and Spatial Distribution

At each soil sample location, collect a vegetation sample (if vegetation is present).

Collect grass, shrubs, and tree leaves separately at each location. Collect at least 50 grams of each.

Number of plant samples taken:

Grass: ______________________

Shrubs: ____________________

Tree leaves: ________________

Label all sample locations on the site map with the depth of sampling. Note which types of vegetation samples were collected at each sample point.

☐ **Map labelled**

4.3.2.5.2 Methods

Samples are collected using either metal or plastic scissors.

If contaminants of concern are metals or metalloids, use plastic scissors. Samples should be packaged in plastic bags and stored under cool conditions until analyzed. Decontaminate scissors between each sample.

☐ contaminants are metals/metalloids - use plastic devices

If contaminants of concern are organic compounds, use only metal sampling devices. Store samples in glass containers and keep cool until analyzed. Decontaminate sampling device between each sample.

- [ ] contaminants are organic compounds - use metal and glass devices

See Appendix G for reference for specific plant collection methods.

4.3.2.6 Soil Invertebrates

When collecting soil samples, remove to a separate sampling container any invertebrates (*e.g.*, earthworms, centipedes, beetles) found in the soil. These may be taken from the same sample that will be analyzed for soil chemistry or may be taken from a separate sample collected adjacent to the core collection site.

Invertebrates are separated from the soil either by picking them out with a tweezers or by passing the soil through a small diameter sieve. Collect all the invertebrates in the sample or 50 grams, whichever is the least.

If contaminants of concern are metals or metalloids, use plastic tweezers. Invertebrates should be packaged in plastic bags or glass containers and stored frozen until analyzed.

- [ ] contaminants are metals/metalloids - use plastic devices

If contaminants of concern are organic compounds, use a metal tweezers. Invertebrates should be packaged in glass containers and stored frozen until analyzed.

- [ ] contaminants are organic compounds - use metal and glass devices

Label all sample locations on the site map where invertebrates were found.

- [ ] **Map labelled**

4.3.2.7 Groundwater Samples

4.3.2.7.1 Number and Spatial Distribution

Groundwater sampling should be conducted in a manner that will illustrate the amount of chemical currently in the groundwater aquifers, both under the site and downgradient off-site. Sufficient number of samples should be taken to define the boundaries of any plume of contamination.

During all drilling, appropriate care should be taken not to penetrate any barriers that prevent the movement of surface water into deeper aquifers. Otherwise, previously uncontaminated groundwater may become contaminated solely as a result of the sampling process.

A minimum of 10 samples is required to find the general location of potential plumes of contamination. This may have been done during the initial site assessment, in which case this portion of the risk assessment can immediately focus on better defining the plume.

Once a general area of contamination is identified, a sufficient number of groundwater samples must be taken to define the boundaries of the plume, particularly its extent downgradient. The number of samples required to do this will depend on the plume size.

4.3.2.7.2 Methods

If contaminants of concern are metals or metalloids, use plastic sampling devices (with the exception of metal tipped drills, if needed). Samples should be stored in glass or Teflon-lined jars and stored under cool conditions until analyzed.

☐ contaminants are metals/metalloids - use plastic devices

If contaminants of concern are organic compounds, use only metal sampling devices. Store samples in glass containers and keep cool until analyzed.

☐ contaminants are organic compounds - use metal and glass devices

Refer to Appendix N for detailed methods for groundwater sampling. List which methods were used.

☐ **List of methods attached**

4.3.2.8 Surface Water and Sediment Sampling

When collecting samples, observations on the appearance and abundance of sediment organisms can be recorded as additional information. This information can serve as anecdotal evidence in Tier 1 or 2 EcoRAs.

4.3.2.8.1 Number and Spatial Distribution

Use a sufficient number of samples to characterize the surface water variability so that a spatially explicit model can be used in calculating risk values (see Section 8.1.1.3.2).

4.3.2.8.2 Methods

Refer to Appendix N for detailed methods for surface water and sediment sampling. List which methods were used.

☐ **List of methods attached**

4.3.2.9 Fish and Aquatic Invertebrate Sampling

4.3.2.9.1 Number and Spatial Distribution

The fish and aquatic invertebrate sampling should occur concurrently with the chemical sampling. It is important the samples be taken at the same location and at the same time as much as is possible. This approach to sampling will facilitate the calculation of risk values as delineated in Section 8.1.1.3.

Permits are required for the collection of fish and other aquatic species. Proponents are advised to contact their local office of the Department of Fisheries and Oceans and BC Environment for specific permit requirements.

4.3.2.9.2 Methods

Refer to Appendix N for detailed methods for sampling of fish and aquatic invertebrates. List which methods were used.

☐ **List of methods attached**

4.3.2.10 Aquatic Plant Sampling

4.3.2.10.1 Number and Spatial Distribution

Sampling strategies for aquatic plants depend on the type of plant and the planned use of the data. Aquatic plants can be divided into two main types according to whether the plants are physically attached to the sediments (*i.e.*, rooted plants) or whether they float on the water (*i.e.*, floating plants). Plant tissue sampling is conducted to address risks to herbivores (animals that eat the plants), but can also be conducted to address risks to the plants themselves if the appropriate effect data are available. Therefore, be sure to collect samples from each type of plant that is an important food for animals or that is desired for its own sake. Collect stems, roots and leaves, as these parts are edible for many aquatic plants..

To properly address spatial issues, the pattern of contamination in the receiving environment (sediment or water) must contain some gradient (*i.e.*, is not homogeneous). For example, there is no benefit in sampling duckweed (a floating plant) along with water samples if no contaminant gradient exists in the water. A spatially explicit sampling program, however, should always be considered for rooted plants when addressing which areas of the aquatic portion of the site might require remediation. The number and spatial distribution of samples for a spatially explicit sampling program is driven by the scale of the contamination gradient.

4.3.2.10.2 Methods

Sampling methods for aquatic plants are the same as those described for terrestrial plants (Section 4.3.2.5).

This completes the Analysis Phase. Go to Section 8 to put all the information together into a Risk Calculation.

Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia - Chapter 5. Residential

5.0 RESIDENTIAL

5.1 Problem Formulation (continued)

Which standard/criteria was exceeded (for any chemical)?

a) ☐ Toxicity to soil invertebrates and plants

b) ☐ Groundwater flow, surface run-off, or direct discharge to surface water or sediments used by aquatic life

c) ☐ Groundwater used for irrigation watering

If a) is exceeded, go to Section 5.1.1

If b) is exceeded, go to Section 5.1.2

If c) is exceeded, go to Section 5.1.3

If TWO or MORE are exceeded, do all applicable sections

☐ **Attach a list of the chemicals exceeding the standards. These chemicals will be considered "chemicals of concern" for the remainder of the risk assessment. Please use the following format. If available, attach the Detailed Site Investigation Report as well.**

Chemical	Measured Concentrations (range)	Standard/Criteria Exceeded	Standard/Criteria Value

5.1.1 Potential Terrestrial Receptors

5.1.1.1 Regional Species Lists

Refer to Appendix B to identify the biogeoclimatic zone in which the site is located.

Biogeoclimatic zone: ____

Refer to Appendix C and attach the list of terrestrial plants in the site's biogeoclimatic zone.

☐ **Plant list attached**

Refer to Appendix D and attach the list of terrestrial birds in the site's biogeoclimatic zone.

☐ **Bird list attached**

Refer to Appendix E and attach the list of terrestrial mammals in the site's biogeoclimatic zone.

☐ **Mammal list attached**

Refer to Appendix E and attach the list of amphibians and reptiles in the site's biogeoclimatic zone.

☐ **Amphibian and reptile list attached**

5.1.1.2 Site-specific Species Lists for Terrestrial Plants and Animals

Which plants, birds, and mammals actually are, or are likely to be, on the site? Several avenues are open to determine the receptors of concern for the risk assessment. Site visits by trained biologists are useful for making informed decisions regarding receptor selection. However, there are other sources of information that should be consulted (*e.g.*, local BCE wildlife officers, Canadian Wildlife Service, etc.). Assessing the ecological risks of contaminated sites to all potential receptors would be an unworkable task. Therefore, strategic selection of key receptors provides an efficient and effective way to meet the overall management goals of the site. Guidance on reducing the regional species lists down to relevant site-specific organisms is provided in the following sections and Appendices C through F.

5.1.1.2.1 Terrestrial Plants

Check off on the biogeoclimatic zone plant list those plants that are actually on the site and are fairly ubiquitous. *This requires a visit to the site or a review of detailed photographs by someone knowledgeable about general plant types and names.*

☐ **Site plants checked on attached list**

☐ **Species selected as receptors of concern are noted on the species list**

5.1.1.2.2 Terrestrial Birds

Check off on the biogeoclimatic zone bird list those birds likely to use the site and that are of potential concern, using the following rules:

a) Birds are present only if there is vegetation on the site.
b) Birds must be resident species or at least present for the breeding season (do not include migrants).
c) Shorebirds (*e.g.*, dowitchers, sandpipers), wading birds (*e.g.*, herons, egrets), waterfowl (*e.g.*, ducks and geese), and seabirds (*e.g.*, gulls, cormorants) are not considered.
d) Raptors (*e.g.*, hawks, owls, and eagles) are considered only if they are threatened or endangered species.
e) Galliforms (*e.g.*, pheasant and quail) are not present.
f) Hummingbirds are not considered.
g) All other birds may be considered.
h) Include all species that are listed as threatened, endangered or sensitive.

5.1.1.2.3 Terrestrial Mammals

Check off on the biogeoclimatic zone mammal list those animals likely to use the site and that are of potential concern, using the following rules:

a) Mammals are present only if there is vegetation on the site.
b) Mammals must be resident species or at least present for the breeding season (do not include migrants).
c) Large mammals (*e.g.*, deer, elk, bear, coyotes, fox, skunk, raccoons) are not included.
d) Rabbits and large rodents (*e.g.*, beaver) do not occur.

e) Mustelids are not considered.

f) Small rodents (mice and voles) may occur.

g) Non-native pest species (rats and house mice) are not of concern.

h) Bats may be considered.

i) Domestic cats may be considered.

j) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site mammals checked on attached list**

Group the mammal species on the list according to feeding groups.

☐ **Feeding group list attached**

☐ **Species selected as receptors of concern are noted on the species list**

5.1.1.2.4 Amphibians and Reptiles

Check off on the biogeoclimatic zone amphibian and reptile list those animals likely to use the site and that are of potential concern.

☐ **Site amphibians and reptiles checked on attached list**

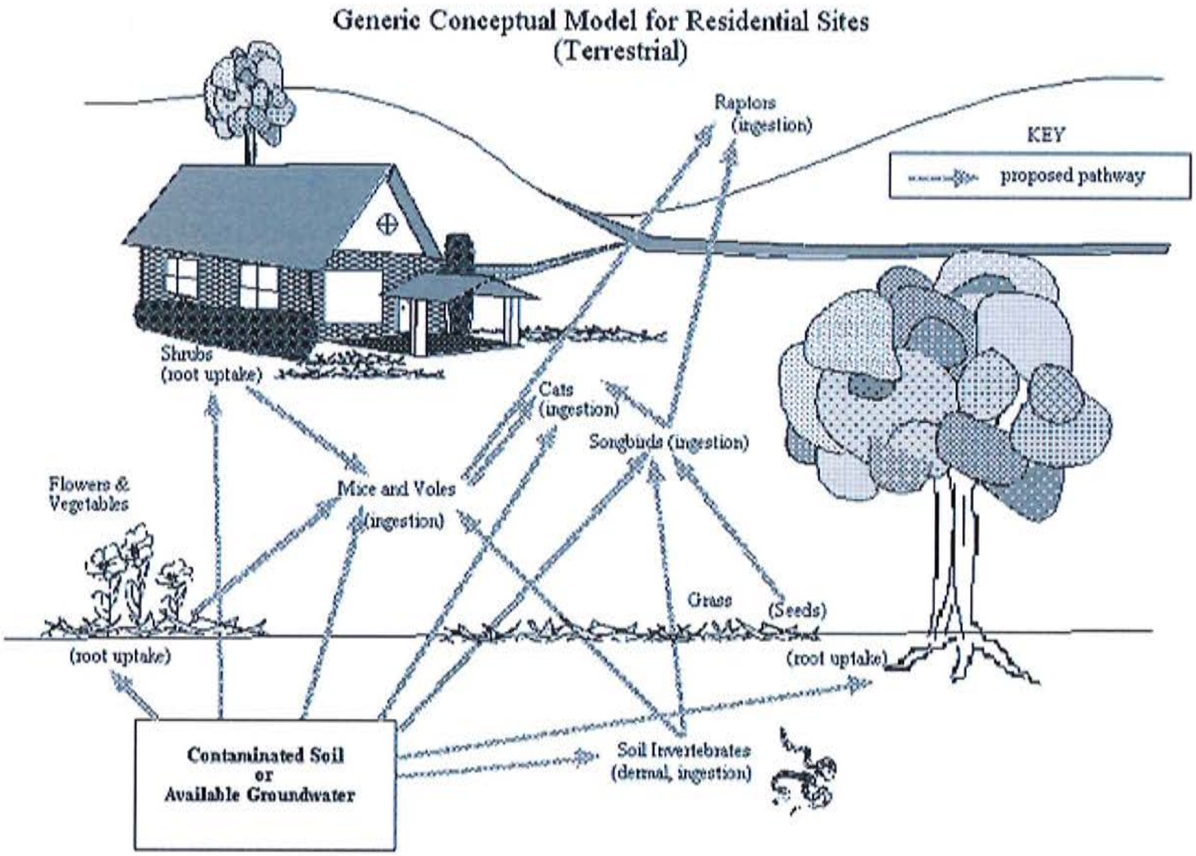
☐ **Species selected as receptors of concern are noted on the species list**

5.1.1.2.5 Soil Invertebrates

Assume that earthworms, as representative soil invertebrates, should be present at the site.

5.1.1.3 Conceptual Site Model

Use the representation of the site on the next page to show how the contaminants of concern (those chemicals that exceed the standard/criteria) could potentially move through the food chain to the animals that may be onsite. If something in the picture (*e.g.*, trees) is missing on the site, remove it and all its associated connections from the picture. Refer to Appendix A for more guidance on development of Conceptual Site Models.



5.1.2 Potential Aquatic Life Receptors

Is the water

- [ ] fresh (river, stream, lake, wetland)?
- [ ] brackish (estuary, saltmarsh)?
- [ ] salt (ocean shore)?

5.1.2.1 Regional Species Lists

Refer to Appendix C and attach the list of the aquatic plants in the site's biogeoclimatic zone. Be sure to use an appropriate list for fresh, brackish or salt water plants.

- [ ] **Aquatic plant list attached**

Refer to Appendix F and attach the list of fish in the site's biogeoclimatic zone. Be sure to use an appropriate list for fresh, brackish or salt water fish.

☐ **Fish list attached**

Refer to Appendix D and attach the list of birds in the site's biogeoclimatic zone.

☐ **Bird list attached**

Refer to Appendix E and attach the list of mammals in the site's biogeoclimatic zone.

☐ **Mammal list attached**

5.1.2.2 Site-specific Species Lists for Aquatic Plants and Organisms

Which fish, plants, birds, and mammals actually are, or are likely to be, on the site? Several avenues are open to determine the receptors of concern for the risk assessment. Site visits by trained biologists are useful for making informed decisions regarding receptor selection. However, there are other sources of information that should be consulted (*e.g.*, local BCE wildlife officers, Canadian Wildlife Service, etc.). Assessing the ecological risks of contaminated sites to all potential receptors would be an unworkable task. Therefore, strategic selection of key receptors provides an efficient and effective way to meet the overall management goals of the site. Guidance on reducing the regional species lists down to relevant site-specific organisms is provided in the following sections and Appendices C through F.

5.1.2.2.1 Plants

Check off on the aquatic plant list those plants that are actually on the site and are fairly ubiquitous. *This requires a visit to the site or a review of detailed photographs by someone knowledgeable about general plant types and names.*

☐ **Site plants checked on attached list**

☐ **Species selected as receptors of concern are noted on the species list**

5.1.2.2.2 Fish

Check off on the biogeoclimatic zone list those fish likely to use the site and that are of potential concern, using the following rules:

a) Fish must be resident species and those species known to use the habitat for breeding.
b) Salmonids and their various lifestages may be present without a breeding population due to hatchery input. These fish are economically and recreationally important and should be included.
c) Transient water bodies do not have resident fish populations.
d) Ditches and other shallow drainage systems (man-made) that drain into other water bodies should be considered as important fish habitat.
e) Pay particular attention to run-off into creeks and other water bodies that may be used for drainage control but also contribute to fish habitat.
f) Fish lists must be tied to water chemistry such as salinity, pH, dissolved oxygen and hardness. Remove species that cannot live in the site's environment.
g) Recreational fish species that may be introduced to artificial ponds should be included in the assessment.
h) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site fish checked on attached list**

☐ **Species selected as receptors of concern are noted on the species list**

5.1.2.2.3 Aquatic Birds

Check off on the biogeoclimatic zone bird list those birds likely to use the site and that are of potential concern, using the following rules:

a) Birds must be resident species or at least resident during the breeding season (do not include migrants).
b) Small shorebirds (*e.g.*, dowitchers) are considered only in shallow marshes, estuaries, or beaches.
c) Waterfowl (*e.g.*, ducks and geese) are not present on small streams.
d) Seabirds (*e.g.*, gulls, cormorants, sandpipers) are considered only for brackish or saltwater sites.
e) Raptors (*e.g.*, hawks, owls, and eagles) are considered only if they are threatened or endangered species.

f) Galliforms (*e.g.*, pheasant and quail) are not present.

g) Cavity-dwellers (*e.g.*, flickers and woodpeckers) are not considered.

h) Hummingbirds are not considered.

i) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site birds checked on attached list**

Group the bird species on the list according to feeding groups.

☐ **Feeding group list attached (e.g., fish-eating, insectivores)**

☐ **Species selected as receptors of concern are noted on the species list**

5.1.2.2.4 Aquatic Mammals

Check off on the biogeoclimatic zone mammal list those animals likely to use the site and that are of potential concern, using the following rules:

a) Mammals must be resident species or at least resident during the breeding season (do not include migrants).

b) Mammals are not considered for small streams or ponds.

c) Large mammals (*e.g.*, deer, elk, bear, coyotes) do not occur.

d) Wholly land mammals (*e.g.*, rabbits, small rodents) do not occur.

e) Aquatic mustelids (*e.g.*, otters) may be considered.

f) Non-native pest species (nutria) are not of concern.

g) Bats are not considered.

h) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site mammals checked on attached list**

Group the mammal species on the list according to feeding groups.

☐ **Feeding group list attached (e.g., herbivores, fish carnivores, etc.)**

☐ **Species selected as receptors of concern are noted on the species list**

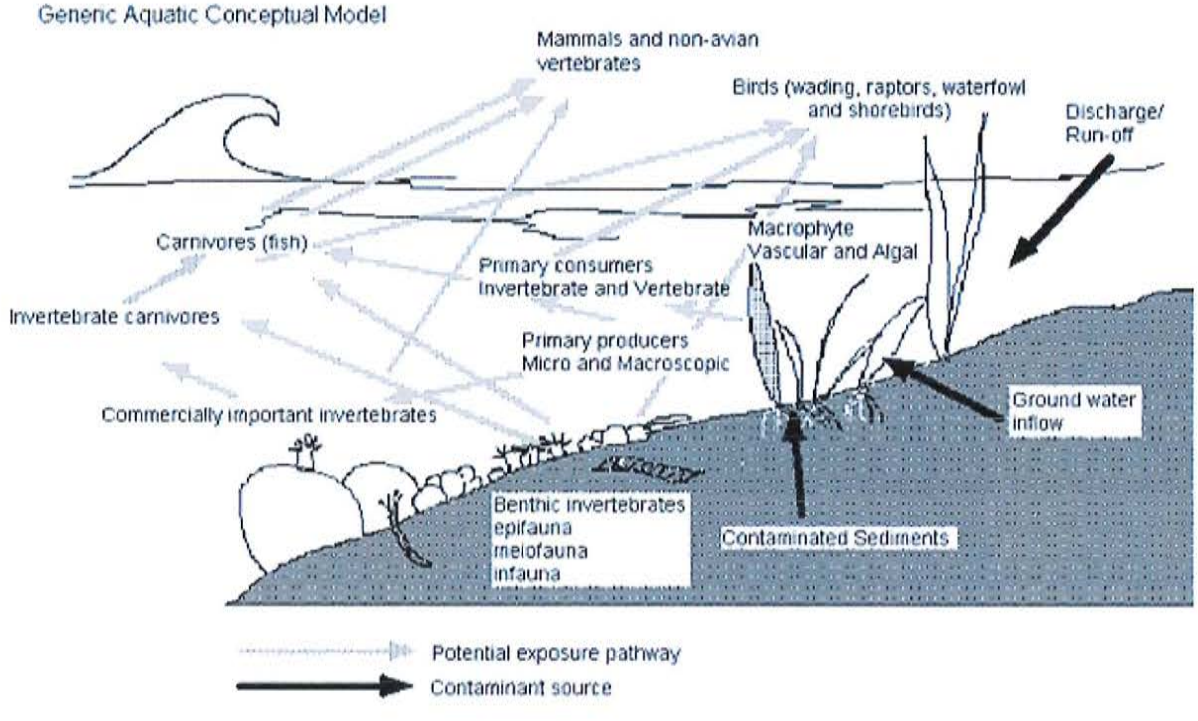
5.1.2.2.5 Aquatic Invertebrates

Assume that bottom-dwelling (benthic) invertebrates are present at the site.

5.1.2.3 Conceptual Site Model

Use the representation of the site on the next page to show how the contaminants of concern (those chemicals that exceed the standard/criteria) could potentially move through the food chain to the animals that may be onsite. If something in the picture (*e.g.*, cattails) is missing on the site, remove it and all its associated connections from the picture. Refer to Appendix A for more guidance on development of Conceptual Site Models.

Generic Aquatic Conceptual Model



5.1.3 Potential Plant Receptors from Irrigation Watering

Does your irrigation water come from a source separate from your drinking water?

☐ No. Skip this section.

☐ Yes. Complete this section.

5.1.3.1 Regional Species List

Refer to Appendix B to identify the biogeoclimatic zone in which the site is located.

Biogeoclimatic zone: ______________________________

Refer to Appendix C and attach the list of native plants found in the site's biogeoclimatic zone.

☐ **Plant list attached**

5.1.3.2 Site-specific Species Lists

Which plants actually are, or are likely to be, on the site?

5.1.3.2.1 Plants

Check off on the biogeoclimatic zone plant list those plants that are actually on the site. *This requires a visit to the site or a review of detailed photographs by someone knowledgeable about general plant types and names.*

☐ **Site plants checked on attached list**

5.1.3.3 Conceptual Site Model

Refer to the generic conceptual model for residential sites in Section 5.1.1.3.

Recommendation: BCE should review the data package at this time to reach agreement on the contaminants of concern and the plants and animals of interest, prior to collecting samples for analysis.

Top

5.2 Effects Assessment

Purpose: To determine if any adverse environmental effects currently are occurring and to develop appropriate concentration-response relationships to predict if adverse affects will occur in the future.

This section asks a series of questions to you assess, through a simple site visit, whether current conditions are deleterious to plants and animals that may use the site or in water that receives run-off or groundwater discharge from the site.

You will then be directed how to find information about what concentrations of pollutants of concern cause effects in the plants and animals at your site. You may choose to use the same toxicity values developed by BCE for the matrix standards or you have the option of using a different set of data, provided you justify why you chose a different approach.

You also will be given the option of conducting simple soil or water laboratory bioassays using samples from the most contaminated areas in order to demonstrate whether the media are toxic to plants or animals and, if so, at what concentration of the toxicant in the media (*e.g.*, soil or water). *In situ* bioassays are also an option for determining if soil or water can support the plants or animals of interest.

5.2.1 Site Observations

5.2.1.1 Terrestrial Plants

If there currently is no vegetation on the site, skip this section.

Vegetation present? ☐ yes (continue) ☐ no (skip section)

If this assessment is being done in the winter, skip this section and return to complete this section in the spring/summer.

Assessment being done in: ☐ spring (continue) ☐ summer (continue) ☐ fall (continue) ☐ winter (skip section)

Date (MM/DD/YY): ________________________________

Comments:

____

____

For terrestrial plants, refer to EPA SOP #2037 in Appendix G for *Terrestrial Plant Community Sampling Methods* and answer the following questions in this section.

5.2.1.1.1 Grass

Look closely at the grass.

Does it evenly cover an area or are there bare patches of soil showing?

☐ even ☐ cover ☐ bare patches size m^2 (bare patches must be $1m^2$ or larger)

Is the grass green or are there brown spots or is it brown all over?

☐ green ☐ brown spots ☐ brown all over

Show any brown spots on the site map. Be sure the map shows where all the grass cover is.

Comments:

5.2.1.1.2 Shrubs and Forbs (small leafy plants)

Look closely at the shrubs, flowers, and other leafy small plants.

Do they have all their leaves?

☐ yes ☐ no

Are the leaves all green, spotted with yellow or brown spots, or all brown?

☐ all green ☐ spotted ☐ all brown

Are there a lot of dead leaves at the base of the plants?

☐ yes ☐ no

Are the above statements true for all the plants on the site or only a few?

☐ all plants ☐ only a few

Show on the site map the location of any plants that are dead, that have spotted leaves, or that have lost a large number of leaves.

Comments:

5.2.1.1.3 Trees

Look closely at the trees.

Do they have all their leaves or needles?

☐ yes ☐ no

Are the leaves (or needles) all green, spotted with yellow or brown spots, or all brown?

☐ all green ☐ spotted ☐ all brown

Are there a lot of dead leaves at the base of the trees?

☐ yes ☐ no

Are the above statements true for all the trees on the site or only a few?

☐ all trees ☐ only a few

Do the above statements pertain to deciduous trees, evergreen trees, or both?

☐ deciduous ☐ evergreen ☐ both

Show on the site map the location of any trees that are dead, that have spotted leaves, or that have lost a large number of leaves.

Comments:

5.2.1.2 Soil Invertebrates

If the entire area is under buildings or pavement, skip this section.

Entire area built or paved? ☐ no (continue) ☐ yes (skip section)

If this assessment is being done when the ground is frozen, skip this section and return to complete this section in the spring/summer.

Ground frozen? ☐ no (continue) ☐ yes (skip section)

Comments:

Dig up a patch of soil from several areas with no vegetation, from several areas with grass or shrubs, and from areas near trees. Pass the soil through a sieve (if dry) or rinse it in a bucket (if wet) to look for earthworms and other soil invertebrates.

For each area, are invertebrates present? ☐ yes ☐ no

If yes, many ☐ few ☐

If yes, describe what they look like:

(Note: Unhealthy worms may have lesions, constrictions, or discolorations.)

5.2.1.3 Birds

Attach a list of any birds seen or heard during the site visit. If the site is small, walk the entire site. Look in trees or shrubs for evidence of current or old nests. If the site is large, walk transects (lines) at least every 50 meters.

If a river, marsh, or other waterbody is of concern due to potential run-off or groundwater contamination, walk transects on either side of the stream or river, or in 50 meter intervals across a wetland OR conduct bird observations from a boat or other suitable flotation method OR from any suitable observation point or platform. Pay particular attention to areas of marsh grasses, woody shrubs, or trees.

☐ **Bird observations attached**

5.2.1.4 Mammals

Attach a list of any mammals seen or heard during the site visit. Look under shrubs and in the grass for mouse holes or vole runways (packed down or bare strips in the grass). Look in dirt, mud and other areas for mammal tracks, footprints, and scat (fecal material).

If a river, marsh, or other waterbody is of concern due to potential run-off or groundwater contamination, walk transects on either side of the stream or river, or in 50 meter intervals across a wetland. Pay particular attention to areas of marsh grasses, woody shrubs, or trees.

☐ **Mammal observations attached**

5.2.1.5 Aquatic Plants

If the site does not contain or border on aquatic habitat, skip Sections 5.2.1.5 through 5.2.1.7.

Assessment being done in:

☐ spring ☐ summer ☐ fall ☐ winter

Date: (MM/DD/YY): ____________________________________

Is aquatic vegetation present? ☐ yes ☐ no

If no, why do you think it is not

____

____

____

Do the aquatic plants appear healthy? ☐ yes ☐ no

Are there any visual signs of stress (*e.g.*, discolored parts)? ☐ yes ☐ no

If yes, describe

Comments:

☐ **Aquatic plant list and observations attached**

5.2.1.6 Fish

For marine or estuarine habitats, consult the following references and conduct a brief fish habitat description.

For freshwater habitats, consult the following references and conduct a brief fish habitat survey. For lake habitats, use the principles discussed for marine or estuarine habitats in the following references to conduct the habitat survey.

Department of Fisheries and Oceans (DFO) and Environment Canada. 1989. Coastal/estuarine fish habitat description and assessment manual - Part II: Habitat description procedures. Prepared by G.L. Williams and Associates, Coquitlam, BC. 38 pp. + appendices.

Department of Fisheries and Oceans (DFO) and BC Ministry of Environment (BCE). 1989. Fish habitat inventory and information program - Stream survey field guide. 29 pp. + appendices.

☐ **Attach habitat survey card(s), photos or maps of habitat, and a brief description of fish resources.**

5.2.1.7 Aquatic Invertebrates

Walk along the shoreline observing the habitat and sample with a small plankton net.

If a fresh water site, sample the shoreline every 10 m with several strokes of the net. Put the contents in a jar and note the presence of daphnia, worms, insect larvae, snails, and other invertebrates. If a marine site, sample the shoreline every 10 m with several strokes of the plankton net noting the presence of copepods, shellfish, and other invertebrates. In a marine intertidal site, observe at low tide and note the shellfish, copepods, crabs, starfish, and worms present.

☐ **Aquatic invertebrates observations attached**

5.2.2 Bioassays

OPTIONAL: Bioassays provide the opportunity to demonstrate whether the most highly contaminated media (soil and/or water) are toxic to the plants, invertebrates, or aquatic life of concern, particularly *in situ*ations where vegetation or aquatic life are not currently present. Soil and/or water samples are taken into the laboratory and growth, reproduction and survival of test species are measured following standardized, peer-reviewed methods.

Bioassays can be considered in such cases where environmental concentrations are above toxicity reference values (TRVs), but organisms are still present on the site. Other factors such as toxicant bioavailability and natural selection may apply to site conditions. For example, soils with metal contamination may not be bioavailable to earthworms due to soil conditions (*e.g.*, soil composition or pH). Therefore, earthworms may be present in sites with environmental conditions above the TRV for earthworms. In such cases, bioassay toxicity testing will establish site-specific conditions and TRVs for a particular site.

Methods developed and modified by the British Columbia Ministry of Environment and Environment Canada are recommended and listed first (Appendix H). A listing of comparable, alternative, and additional standard methods also are provided to supplement and expand bioassay and analytical capabilities. Methods developed by the American Public Health Association (APHA), American Water Works Association (AWWA), Water Environment Federation (WEF), American Society of Testing and Materials (ASTM), Organization of Economic Cooperation and Development (OECD), and the United States Environmental Protection Agency (USEPA) are included and, in many cases, are referenced in the Canadian protocols.

Bioassays may be conducted after completing the entire risk assessment, to confirm results or to understand the extent of cleanup that will be required. However, bioassays also may be done during the Effects Assessment phase as part of the development of the weight-of-evidence of environmental risk.

5.2.2.1 General Procedures for Laboratory Bioassays

a) Collect soil or water or sediment from the most highly contaminated areas.
b) Refer to Appendix H for a list of suggested companies that can conduct standard bioassays and for references for bioassay protocols .Consider the use of field replicates rather than laboratory replicates.
c) *Suggested species for bioassays:*

plants:	rye grass (*Lolium perenne*)
	lettuce (*Lactuca sativa*)
earthworms:	red worms (*Eisenia foetida*)
fish (freshwater):	rainbow trout (*Oncorhynchus mykiss)*
	bluegill (*Lepomis macrochirus*)
	sunfish (*Lepomis sp.*)

	chinook
	top smelt (*Atherinops affinis*)
fish (marine):	*Champia parvula*
	echinoderm fertilization
	inland silverside (Menidia)
	stickelback
aquatic invertebrates (water sediments):	ceriodaphnia, *Daphnia magna* amphipod test

Bioassay(s) conducted - report(s) attached

5.2.2.1.1 In Situ Bioassays

a) Visit site. Use an area of the site with suspected contamination based on media sampling or source input.

b) Take field measurements of dissolved oxygen, temperature, conductivity, and pH.

c) Inform and obtain approval from Regional Ministry of the Environment and Department of Fisheries and Oceans habitat staff for *in situ* bioassay testing.

d) Suggested species for in situ bioassays:

eyed salmonid eggs: pacific salmon
rainbow trout (*Oncorhynchus mykiss*)
caged fish: rainbow trout (*Oncorhynchus mykiss*)
caged mussels: sea mussels (*Mytilus edulis)*

5.2.3 Toxicity Reference Values (TRVs)

To determine if a particular level of contamination at a site poses a risk to plants or animals, you need to know how much of that material the plants or animals can tolerate before toxic effects are seen. The concentration of the pollutant in the soil or water where toxicity begins to occur is called the *toxicity threshold*. However, for environmental receptors such as plants or animals (*i.e.*, not humans), the goal is not to protect each individual from any toxic effect, but rather to protect enough individuals so that a viable population and community of organisms can be maintained (provided other habitat factors are suitable). Therefore, a TRVis chosen from the concentration-response curve that provides reasonable protection for a specified percentage of the organisms. For terrestrial organisms on *residential sites,* this is the EC20, or the concentration that affects 20% of the organisms exposed. For aquatic organisms at *residential sites*, this is the EC20.

To find the ECx for the plants and animals at your site for pollutants of concern, do any (or all) of the following. Be sure to specify whether this value is dry weight (dw) or wet weight (ww).

a) Use the BCE standard/criteria or information from its supporting documentation.

BCE standard/criteria used? ☐ yes ☐ no

b) Refer to Appendix I for a list of database and other references sources that contain information about toxic responses of plants, animals, and aquatic organisms.

List databases searched:

____

____

____

____

____

____

____

____

Use the following rules to select the appropriate ECx:

a) Give preference to a generally accepted toxicity reference value generated for that particular medium (accepted with caveats, peer reviewed, governmental, or NGO groups). For example, water quality criteria.

b) Give preference to reproductive endpoints, but use lethality studies if they are the only ones available.

c) Acceptable toxicological endpoints include:

- any reproductive endpoint (*e.g.*, number of offspring, number of eggs laid, eggshell quality, fruit size and yield, presence of deformities in embryos or young);
- growth rates;
- lethality;
- tumour formation or other gross deformities in embryos or young.

Unacceptable endpoints include:

- changes in enzyme activities;
- DNA breakage;
- other subcellular responses and hematological parameters.

d) If an ECx is not reported, generate the concentration-response curve from the data provided and calculate the ECx. As a last resort, use the lowest observed adverse effects level rather than the ECx and do not divide by any uncertainty factors.
e) If data are available from more than one study for an organism of concern, use the lowest ECx.
f) Use information for the contaminant of concern from any test (*e.g.*, bioassay, laboratory, field study) conducted with the organisms under consideration, if available.
g) If the organism of concern has not been tested, use the most closely related (phylogenetically) organism. Carefully consider the phylogenetic histories of the test species compared to the organisms of concern and consider any drawbacks to extrapolating between species.

For birds and mammals:

2. use EC_{20};
3. give preference to those in the same feeding group;
4. give preference to feeding studies (not single dose studies, or injection studies), particularly of weeks to months in duration;
5. if you have data from similar animals (*e.g.*, rodent data to compare with rodents or duck data to compare to other waterfowl), do not use any uncertainty factors. If your animals are not so closely related, divide the value by 10;
6. if the ONLY data available for any animal species are from injection or oral dosing studies, convert the dose to concentration in food, assuming an average body weight (bw) for the

species and an average food consumption rate. Food consumption may be estimated from the following equations:

$F = 0.621\ (bw)^{0.564}$ (*rodents*)

$F = 0.577\ (bw)^{0.727}$ (*mammalian herbivores*)

$F = 0.235\ (bw)^{0.822}$ (*other mammals*)

$F = 0.398\ (bw)^{0.850}$ (*song birds*)

$F = 0.648\ (bw)^{0.651}$ (*other birds*)

For plants:

7. use EC_{20};
8. if extrapolating within the same Family, do not use any uncertainty factors;
9. if extrapolating to another Family, divide by 2;
10. if extrapolating to another Order, divide by 20;
11. if extrapolating to another Class, divide by 500.

For soil invertebrates:

12. use EC_{20};
13. use whatever data are available without adjustments.

For aquatic organisms (algae, invertebrates, and fish):

14. use EC_{20};
15. use species from same class, teleost (ray finned fish) is typical. Agnatha (jawless fish) and Chondricithyes (sharks and rays) have very different biochemistries, especially in regards to PCBs and other estrogenic compounds;
16. that are pelagic invertebrates, use species similar to organism of concern, although most of the data will be on daphnia;
17. use test species with similar routes of exposure as the organism of concern. Sediment tests conducted to estimate the toxicity of a burrowing worm should use burrowing organisms as the

test organism. Filter-feeding mollusks should be the organism of choice when estimating mussel or oyster sensitivity;

18. aquatic phytoplankton are represented by single species algal toxicity tests and many kinds of test organisms are available;
19. aquatic macrophytes are represented by Lemma (duckweed) although a number of new methods are under development;
20. give preference to tests conducted during a significant portion, or the most sensitive portion, of the test organism's lifespan.

Attach a list of the selected ECx with the appropriate references. Structure the list in the following format:

Organism of Concern	Test Organism	Measurement (reproduction, mortality, etc.)	Endpoint (LOAEL ECx)	Uncertainty Factor	Value	Dry Weight or Wet Weight	Reference

Top

5.3 Exposure Assessment

Purpose: To determine the concentration in media (food, water, soil, etc.) of pollutants of concern to which the plants and animals of concern are actually exposed and to demonstrate how the plants and animals came in contact with the contaminated media.

For plants and animals to be at risk from pollutants, the compounds must exist in the environment at concentrations above the toxicity reference values and the plants or animals must come in contact with the contaminated media. This section will direct you towards an appropriate sampling of the site in order to understand the magnitude and spatial extent of any contamination. It will then ask a series of questions to help you describe pertinent life-history patterns of the plants and animals on your site to determine if, when, and for how long they may come in contact with the contaminated environment.

Note: All environmental sampling should be conducted in cooperation with the human health effects assessment to reduce the need to sample the same area twice. Coordination between the two processes should take place at this time.

5.3.1 Exposure Patterns of Plants and Animals

Plants and animals must come in contact with a contaminant in order to be considered at risk. This section helps determine the potential for organisms on the site to come in contact with contaminated media. Note that it is assumed that only plants may be directly affected by contaminated groundwater. Other organisms are potentially at risk only if the groundwater contaminates surface water or is used for irrigation.

5.3.1.1 Plants

All plants on the site are assumed to be exposed to contaminated soil, as their roots have the potential to take up materials out of the soil. Deep-rooted plants also may contact contaminated groundwater. Rooted aquatic plants (also called macrophytes) such as cattails, rushes, or salt grass take up contaminants from the water column (through their leaves) as well as by their roots from sediment. Non-rooted aquatic plants (*e.g.*, duckweed, waterlilies) also take up contaminants from the water column through their leaves. Therefore, exposure to plants should be assumed, unless the contamination is present only during the dormant period of the year (winter, for most plants, if the ground freezes).

5.3.1.2 Soil Invertebrates

All soil invertebrates (such as earthworms, centipedes, and beetles) are considered exposed through ingestion of soil or movement of contaminant across their skin. Therefore, exposure to soil invertebrates should be assumed, unless the contamination is present only during the dormant period of the year (*e.g.*, when the ground is frozen).

5.3.1.3 Birds

Birds are exposed only if they eat soil invertebrates or plants (leaves or seeds) on the terrestrial portion of the site, or if they eat aquatic invertebrates or fish from a contaminated water source. In addition, it is assumed that most birds consume some soil or sediment along with the actual foodstuff and may get additional contamination from this route.

Birds may not feed on the site for their entire life. Many birds leave the area during the winter and so have the potential to be exposed only during the late spring, summer, and early fall. In addition, if the site is small or the only vegetation present is along the edge of the site, then birds are likely to get some of their diet off-site.

Therefore, the following habits of the birds using the site must be known:

a) proportion of the year that the bird resides in the area,
b) proportion of total foraging area provided by the site, and
c) composition of diet (seeds, leaves, invertebrates and/or soil).

5.3.1.3.1 Residency

For each bird on the site-specific checklist (see Section 5.1.1.2.2), indicate whether the bird is a year-round resident (YR), summer resident (SR), or winter resident (WR).

Bird list annotated

5.3.1.3.3 Diet

Refer to Appendix J for a list of references on dietary preferences of birds.

For each species present on the site list the dietary composition in a table such as the following:

Feeding Group	**% Seeds**	**% Other Plant Material**	**% Soil Invertebrates**	**% Aquatic Invertebrates**	**% Fish**	**% Other (specify)**	**% Soil (assume 2%)**	**TOTAL (100%)**
							2	100
							2	100

5.3.1.4 Mammals

Mammals are exposed only if they eat soil invertebrates or plants (leaves or seeds) that are on the terrestrial portion of the site or if they eat fish from a contaminated water source. In addition, it is assumed that most mammals consume some soil or sediment along with the actual foodstuff and may get additional contamination from this route.

5.3.1.4.1 Residency

Some mammals hibernate during the winter and are exposed only during the spring, summer, or fall. If the site is small or the only vegetation present is along the edge of the site, then mammals are likely to get some or all of their diet off-site.

Therefore, the following habits of the mammals using the site must be known:

a) whether the animal hibernates,
b) proportion of total foraging area that is provided by the site, and
c) composition of its diet (seeds, leaves, invertebrates and/or soil).

For each mammal on the site-specific checklist (see Section 5.1.1.2.3), indicate whether or not it hibernates (H).

☐ **Mammal list annotated**

5.3.1.4.2 Foraging Area

See Appendix K for a list of references containing information about mammal foraging areas. For each mammal that may use your site, indicate on the site-specific checklist whether its foraging area is greater (G) or smaller (S) than the size of the site. If foraging area information is not available, use information about territory size. If no information is available, assume that the foraging area is equal (E) in size to the site.

☐ **Mammal list annotated**

5.3.1.4.3 Diet

Refer to Appendix K for a list of references on dietary preferences of mammals.

For each species present on the site list the dietary composition in a table such as the following:

Feeding Group	% Seeds	% Other Plant Material	% Soil Invertebrates	% Fish	% Other (specify)	% Soil (assume 2%)	TOTAL (100%)
						2	100
						2	100

5.3.1.5 Aquatic Invertebrates

Use the following rules to determine exposure:

a) Planktonic invertebrates are exposed to toxicants primarily by the absorption from the water column, although ingestion is an additional route.
b) Aquatic insects can be exposed through the water column, sediment, or ingestion of plant material or other insects.
c) Clams and other shell fish are exposed through the water column and this will be the primary route for water-soluble materials. Ingestion is the main exposure pathway for materials bound to particulates or that bioconcentrate in plankton.

5.3.1.6 Fish

Fish have 100% exposure to the water column. However, lifestyle determines exposure to the sediment. Flatfish or other bottom dwellers and borrowers are exposed to the interstitial water concentration of the sediment so that should be used as an exposure pathway instead of water concentration. Higher trophic level fish (such as some of the salmonids) also are exposed by eating smaller fish with contaminants in their tissues.

5.3.2 Environmental Concentrations

The following sections describe how to collect various media for determining the concentration of the contaminants of concern and provides guidance on how to select appropriate analytical chemistry methods.

5.3.2.1 Selection of Media

To determine which media to sample, refer to the Conceptual Site Model diagrams and to the dietary composition tables for birds and mammals (Sections 5.3.1.3.3 and 5.3.1.4.3) to help answer the following questions. The goal is to sample the food that is eaten by birds, mammals, and fish as well as the contaminated soil and/or water. In addition, if groundwater contamination is of concern (either due to drainage to surface waters or because of uptake by plant roots), groundwater should be sampled to describe the direction, extent and concentration of the plume. Answers to the following questions will help determine which media to sample.

a) Are there terrestrial plants or animal receptors of concern?

- [ ] No. Skip to question b)
- [ ] Yes. Take the following samples:

soil (Section 5.3.2.4)
plants (Section 5.3.2.5)
soil invertebrates (Section 5.3.2.6)
small mammals (Section 5.3.2.7)

b) Are there aquatic plants or animal receptors of concern (fish, shellfish, birds, mammals)?

- [ ] No. Skip this question.
- [ ] Yes. Take the following samples:

groundwater (Section 5.3.2.8)
surface water (Section 5.3.2.9)
sediment (Section 5.3.2.9)
aquatic invertebrates (Section 5.3.2.10)
fish (Section 5.3.2.10)
aquatic plants (Section 5.3.2.11)

5.3.2.2 Sampling Design

The number of samples taken should be sufficient to characterize all different parts of the site. This will vary depending on the site size. More detail is provided in each media sampling section. Note that the goal is to provide sufficient data to use the techniques in Risk Quotient Calculation (Section 8.1.1.3). These techniques require a spatially explicit approach to chemical concentration. Refer to the following text for more detailed discussion of environmental sampling designs:

Gilbert, R.O. 1987. *Statistical Methods for Environmental Pollution Monitoring*. Van Norstrand Reinhold, New York, New York.

5.3.2.3 Analytical Chemistry

All environmental media samples should be submitted for chemical analysis as soon as possible. Keep samples cool (< 10° C) between time of collection and analysis. Be sure to specify whether the results should be reported as dry weight (dw) or wet weight (ww) concentrations. The measurement units of these results should be comparable to the measurement units of the toxicity reference values selected in Section 5.2.3. Asking the laboratory to report percent moisture will provide flexibility for converting between wet weight and dry weight at any time. Soil and water pH, soil organic carbon, and water hardness should also be requested from the testing laboratory at the time of sample submission. See Appendix L for a list of analytical chemistry laboratories in British Columbia.

5.3.2.3.1 Methods

A variety of methods exist for sample analysis. The method chosen depends on the matrix being analyzed (soil, water, biota), the required precision and accuracy, and the required level of detection.

See Appendix M for a list of methods available Consult with your analytical laboratory on their preferred method. List the method(s) used in the following table:

Media	**Chemical**	**Method**	**Detection Limit (dw or ww)**	**No. of Site Samples**	**No. of QA/QC Samples**
soil					
water					

etc.					

5.3.2.3.2 Detection Limits

Detection limits should be set at 0.1 times the lowest toxicity reference value for organisms exposed to each media, unless current methodology precludes doing so. Include the detection limits in the above table.

5.3.2.3.3 Quality Assurance/Quality Control (QA/QC)

A trip blank, a spike, and a split sample must be included with at least every 20 site samples. Include the number of QA/QC samples in the above table.

See the British Columbia Field Sampling Manual, 1996 edition for a more complete discussion of QA/QC. Data quality objectives (DQOs) are formal data quality specifications, which must be tabulated within a quality assurance manual. These DQOs establish the maximum amount of error allowed for the data to meet its specified use. The DQOs should be established before sample collection to avoid situations where resources are spent collecting samples which do not fit the DQOs. Once DQOs are established and sampling has begun, regular performance checks are performed to verify that the DQOs are satisfied. Corrective action must be taken when DQOs are not met. Out-of-control events and actions must be recorded.

It is highly recommended that before implementing any environmental samples, all monitoring/sampling plans be approved by BCE. Remember to coordinate with the human health effects risk assessment sample collections.

5.3.2.4 Soil Sampling

When collecting samples, observations on the appearance and abundance of soil organisms can be recorded as additional information. This information can serve as anecdotal evidence in Tier 1 or 2 EcoRAs.

5.3.2.4.1 Number and Spatial Distribution

At least three sample points should be taken in each different area of the site (*e.g.*, grass-covered, bare ground, under vegetation). If there are suspected point source(s) of contamination, a greater number of samples should be taken near the source with diminishing numbers forming concentric rings outward. Additional samples should be taken in any down-gradient area (downwind or downslope).

It may be necessary to take samples off-site to completely characterize the extent of a gradient. One option is to characterize the site first and return for additional off-site sampling if a gradient is not completely defined.

Number of samples: ______________________________

Show sample locations on the site map

☐ **Map attached**

5.3.2.4.2 Depth

Composite samples should be taken at 0 to 15 cm depth for characterization of plant exposure. However, for sandy soil (*e.g.*, Fraser River sand), take a soil sample at 0 to 50 or 70 cm depth.

Optional: Deeper cores into various soil strata can be taken to characterize current and potential migration of contaminants.

Number of samples taken at 0 to 15 cm depth: ______________________________

Number of samples taken at deeper depth:

Depth: ___________________ cm

Number:_____________________

Label all sample locations on the site map with sampling depth.

☐ **Map labelled**

5.3.2.4.3 Methods

Samples may be collected using either a soil corer or a trowel for surface samples and with appropriate coring devices for deeper samples.

If contaminants of concern are metals or metalloids, use only plastic trowels and corers. Samples should be packaged in plastic bags and stored under cool conditions until analyzed. Decontaminate sampling device between each sample.

- [ ] contaminants are metals/metalloids - use plastic devices

If contaminants of concern are organic compounds, use only metal sampling devices. Store samples in glass containers and keep cool until analyzed. Decontaminate sampling device between each sample.

- [ ] contaminants are organic compounds - use metal and glass devices

See Appendix N for references for specific soil collection methods. List which methods were used.

- [ ] **List of methods attached**

5.3.2.5 Terrestrial Plant Sampling

5.3.2.5.1 Number and Spatial Distribution

At each soil sample location, collect a vegetation sample (if vegetation is present).

Collect grass, shrubs, and tree leaves separately at each location. Collect at least 50 grams of each.

Number of plant samples taken:

Grass: ______________________

Shrubs: _____________________

Tree leaves: __________________

Label all sample locations on the site map with the depth of sampling. Note which types of vegetation samples were collected at each sample point.

☐ **Map labelled**

5.3.2.5.2 Methods

Samples are collected using either metal or plastic scissors.

If contaminants of concern are metals or metalloids, use plastic scissors. Samples should be packaged in plastic bags and stored under cool conditions until analyzed. Decontaminate scissors between each sample.

☐ contaminants are metals/metalloids - use plastic devices

If contaminants of concern are organic compounds, use only metal sampling devices. Store samples in glass containers and keep cool until analyzed. Decontaminate sampling device between each sample.

☐ contaminants are organic compounds - use metal and glass devices

See Appendix G for reference for specific plant collection methods.

5.3.2.6 Soil Invertebrates

When collecting soil samples, remove to a separate sampling container any invertebrates (*e.g.*, earthworms, centipedes, beetles) found in the soil. These may be taken from the same sample that will be analyzed for soil chemistry or may be taken from a separate sample collected adjacent to the core collection site.

Invertebrates are separated from the soil either by picking them out with tweezers or by passing the soil through a small diameter sieve. Collect all the invertebrates in the sample or 50 grams, whichever is the least.

If contaminants of concern are metals or metalloids, use plastic tweezers. Invertebrates should be packaged in plastic bags or glass containers and stored frozen until analyzed.

- [ ] contaminants are metals/metalloids - use plastic devices

If contaminants of concern are organic compounds, use metal tweezers. Invertebrates should be packaged in glass containers and stored frozen until analyzed.

- [ ] contaminants are organic compounds - use metal and glass devices

Label all sample locations on the site map where invertebrates were found.

- [ ] **Map labelled**

5.3.2.7 Small Rodent Sampling

Before collecting any small rodents check with the local (to the site) Fish and Wildlife Manager in the Regional British Columbia Ministry of the Environment Office about whether trapping permits are required. Personnel should wear protective clothing to reduce the potential for transmission of diseases from rodents to humans (*e.g.*, disposable rubber gloves and outer garments that are either disposed of or washed after being used in the field).

Set snap traps (*e.g.*, Victor® mouse traps or Museum Specials®) baited with peanut butter or other suitable material either in areas likely to harbor rodents, in a grid across the entire area, or in a grid across the most contaminated area. Traps should be spaced no more than 15 m apart. Traps should be set in the evening and checked at dawn. Refer to the following reference, or equivalent, for more details on trapping methods.

Schemnitz, S.D. 1980. *Wildlife Management Techniques Manual, 4th Edition*. The Wildlife Society, Inc., Washington, D.C.

Place all collected animals in plastic bags that are labeled, sealed, and stored on wet ice or other cool location for transport to the analytical laboratory.

Label all locations on the site map where traps were placed AND where small mammals were captured.

☐ **Map labelled**

5.3.2.8 Groundwater Samples

5.3.2.8.1 Number and Spatial Distribution

Groundwater sampling should be conducted in a manner that will illustrate the amount of chemical currently in the groundwater aquifers, both under the site and downgradient off-site. Sufficient number of samples should be taken to define the boundaries of any plume of contamination.

During all drilling, appropriate care should be taken not to penetrate any barriers that prevent the movement of surface water into deeper aquifers. Otherwise, previously uncontaminated groundwater may become contaminated solely as a result of the sampling process.

A minimum of 10 samples is required to find the general location potential plumes of contamination. This may have been done during the initial site assessment, in which case this portion of the risk assessment can immediately focus on better defining the plume.

Once a general area of contamination is identified, a sufficient number of groundwater samples must be taken to define the boundaries of the plume, particularly its extent downgradient. The number of samples required to do this will depend on the plume size.

5.3.2.8.2 Methods

If contaminants of concern are metals or metalloids, use plastic sampling devices (with the exception of metal tipped drills, if needed). Samples should be stored in glass or Teflon-lined jars and stored under cool conditions until analyzed.

☐ contaminants are metals/metalloids - use plastic devices

If contaminants of concern are organic compounds, use only metal sampling devices. Store samples in glass containers and keep cool until analyzed.

☐ contaminants are organic compounds - use metal and glass devices

Refer to Appendix N for detailed methods for groundwater sampling. List which methods were used.

☐ **List of methods attached**

5.3.2.9 Surface Water and Sediment Sampling

When collecting samples, observations on the appearance and abundance of sediment organisms can be recorded as additional information. This information can serve as anecdotal evidence in Tier 1 or 2 EcoRAs.

5.3.2.9.1 Number and Spatial Distribution

Use a sufficient number of samples to characterize the surface water variability so that a spatially explicit model can be used in calculating risk values (see Section 8.1.1.3.2).

5.3.2.9.2 Methods

Refer to Appendix N for detailed methods for surface water and sediment sampling. List which methods were used.

☐ **List of methods attached**

5.3.2.10 Fish and Aquatic Invertebrate Sampling

5.3.2.10.1 Number and Spatial Distribution

The fish and aquatic invertebrate sampling should occur concurrently with the chemical sampling. It is important the samples be taken at the same location and at the same time as much as is possible. This approach to sampling will facilitate the calculation of risk values as delineated in Section 8.1.1.3.

Permits are required for the collection of fish and other aquatic species. Proponents are advised to contact their local office of the Department of Fisheries and Oceans and BC Environment for specific permit requirements.

5.3.2.10.2 Methods

Refer to Appendix N for detailed methods for sampling of fish and aquatic invertebrates. List which methods were used.

☐ **List of methods attached**

5.3.2.11 Aquatic Plant Sampling

5.3.2.11.1 Number and spatial distribution

Sampling strategies for aquatic plants depend on the type of plant and the planned use of the data. Aquatic plants can be divided into two main types according to whether the plants are physically attached to the sediments (*i.e.*, rooted plants) or whether they float on the water (*i.e.*, floating plants). Plant tissue sampling is conducted to address risks to herbivores (animals that eat the plants), but can also be conducted to address risks to the plants themselves if the appropriate effect data are available. Therefore, be sure to collect samples from each type of plant that is an important food for animals or that is desired for its own sake. Collect stems, roots and leaves, as these parts are edible for many aquatic plants.

To properly address spatial issues, the pattern of contamination in the receiving environment (sediment or water) must contain some gradient (*i.e.*, is not homogeneous). For example, there is no benefit in sampling duckweed (a floating plant) along with water samples if no contaminant gradient exists in the water. A spatially explicit sampling program, however, should always be considered for rooted plants when addressing which areas of the aquatic portion of the site might require remediation. The number and spatial distribution of samples for a spatially explicit sampling program is driven by the scale of the contamination gradient.

5.3.2.11.2 Methods

Sampling methods for aquatic plants are the same as those described for terrestrial plants (Section 5.3.2.5).

This completes the Analysis Phase. Go to Section 8 to put all the information together into a Risk Calculation.

Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia - Chapter 6. Urban Park

6.0 URBAN PARK

6.1 Problem Formulation (continued)

Which standard/criteria was exceeded (for any chemical)?

a) ☐ Toxicity to soil invertebrates and plants

b) ☐ Groundwater flow, surface run-off, or direct discharge to surface water or sediments used by aquatic life

c) ☐ Groundwater used for irrigation watering

If a) is exceeded, go to Section 6.1.1

If b) is exceeded, go to Section 6.1.2

If c) is exceeded, go to Section 6.1.3

If TWO or MORE are exceeded, do all applicable sections

☐ **Attach a list of the chemicals exceeding the standards. These chemicals will be considered "chemicals of concern" for the remainder of the risk assessment. Please use the following format. If available, attach the Detailed Site Investigation Report as well.**

Chemical	Measured Concentrations (range)	Standard/Criteria Exceeded	Standard/Criteria Value

6.1.1 Potential Terrestrial Receptors

6.1.1.1 Regional Species Lists

Refer to Appendix B to identify the biogeoclimatic zone in which the site is located.

Biogeoclimatic zone: ____

Refer to Appendix C and attach the list of terrestrial plants in the site's biogeoclimatic zone.

☐ **Plant list attached**

Refer to Appendix D and attach the list of terrestrial birds in the site's biogeoclimatic zone.

☐ **Bird list attached**

Refer to Appendix E and attach the list of terrestrial mammals in the site's biogeoclimatic zone.

☐ **Mammal list attached**

Refer to Appendix E and attach the list of amphibians and reptiles in the site's biogeoclimatic zone.

☐ **Amphibian and reptile list attached**

6.1.1.2 Site-specific Species Lists for Terrestrial Plants and Animals

Which plants, birds, and mammals actually are, or are likely to be, on the site? Several avenues are open to determine the receptors of concern for the risk assessment. Site visits by trained biologists are useful for making informed decisions regarding receptor selection. However, there are other sources of information that should be consulted (*e.g.*, local BCE wildlife officers, Canadian Wildlife Service, etc.). Assessing the ecological risks of contaminated sites to all potential receptors would be an unworkable task. Therefore, strategic selection of key receptors provides an efficient and effective way to meet the overall management goals of the site. Guidance on reducing the regional species lists down to relevant site-specific organisms is provided in the following sections and Appendices C through F.

6.1.1.2.1 Terrestrial Plants

Check off on the biogeoclimatic zone plant list those plants that are actually on the site and are fairly ubiquitous. *This requires a visit to the site or a review of detailed photographs by someone knowledgeable about general plant types and names.*

☐ **Site plants checked on attached list**

☐ **Species selected as receptors of concern are noted on the species list**

6.1.1.2.2 Terrestrial Birds

Check off on the biogeoclimatic zone bird list those birds likely to use the site and that are of potential concern, using the following rules:

a) Birds are present only if there is vegetation on the site.
b) Birds may be resident species or migrants.
c) Shorebirds (*e.g.*, dowitchers, sandpipers), wading birds (*e.g.*, herons, egrets), waterfowl (*e.g.*, ducks and geese), and seabirds (*e.g.*, gulls, cormorants) are not considered.
d) Raptors (*e.g.*, hawks, owls, and eagles) are considered.
e) Galliforms (*e.g.*, pheasant and quail) may be considered.
f) Cavity-dwellers (*e.g.*, flickers and woodpeckers) are considered only if there are trees on the site.
g) Hummingbirds are not considered.
h) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site birds checked on attached list**

Group the bird species on the list according to feeding group.

☐ **Feeding group list attached**

☐ **Species selected as receptors of concern are noted on the species list**

6.1.1.2.3 Terrestrial Mammals

Check off on the biogeoclimatic zone mammal list those animals likely to use the site and that are of potential concern, using the following rules:

a) Mammals are present only if there is vegetation on the site.

b) Mammals may be resident species or migrants

c) Aquatic mustelids (*e.g.*, otters) and marine mammals (*e.g.*, whales) are not considered.

d) Non-native pest species (rats and house mice) are not of concern.

e) Rabbits and large rodents (*e.g.*, beaver) do not occur.

f) All other species may be considered.

g) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site mammals checked on attached list**

Group the mammal species on the list according to feeding groups.

☐ **Feeding group list attached**

☐ **Species selected as receptors of concern are noted on the species list**

6.1.1.2.4 Amphibians and Reptiles

Check off on the biogeoclimatic zone amphibian and reptile list those animals likely to use the site and that are of potential concern.

☐ **Site amphibians and reptiles checked on attached list**

☐ **Species selected as receptors of concern are noted on the species list**

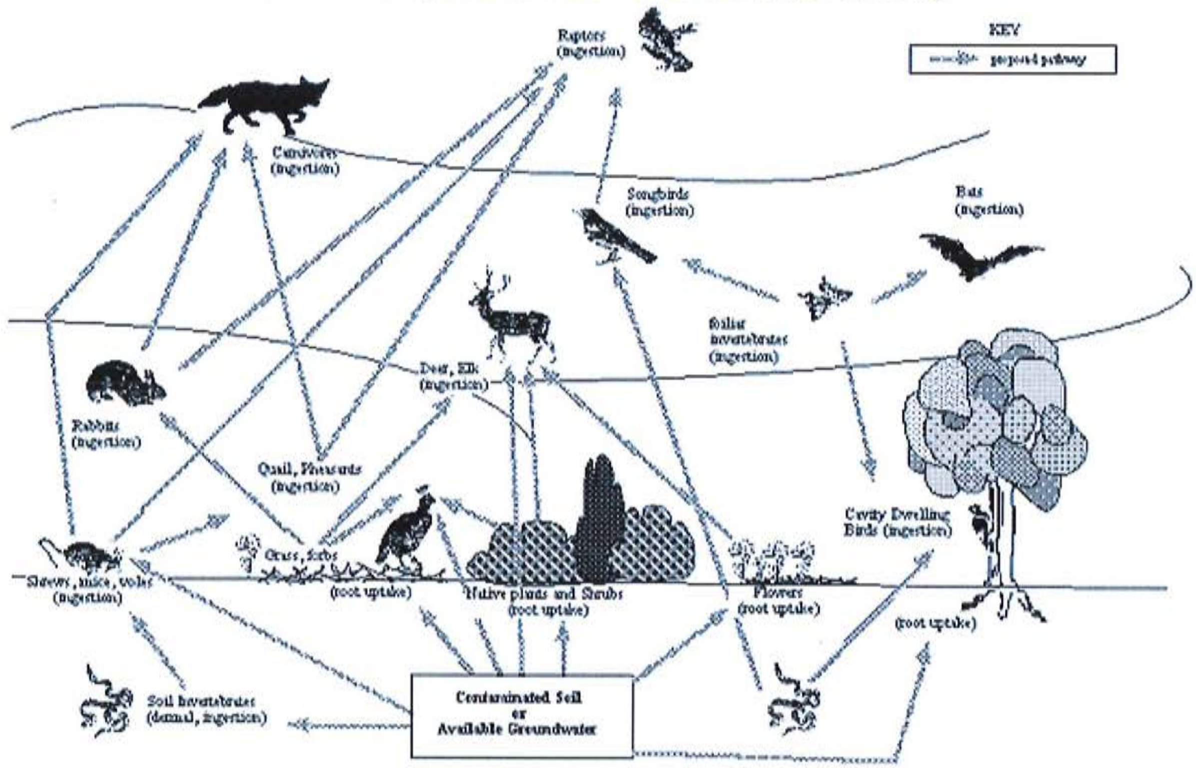
6.1.1.2.5 Soil Invertebrates

Assume that earthworms, as representative soil invertebrates, should be present at the site.

6.1.1.3 Conceptual Site Model

Use the representation of the site on the next page to show how the contaminants of concern (those chemicals that exceed the standard/criteria) could potentially move through the food chain to the animals that may be onsite. If something in the picture (*e.g.*, trees) is missing on the site, remove it and all its associated connections from the picture. Refer to Appendix A for more guidance on development of Conceptual Site Models.

Generic Conceptual Model for Urban Parks (Terrestrial)



6.1.2 Potential Aquatic Life Receptors

Is the water

- fresh (river, stream, lake, wetland)?
- brackish (estuary, saltmarsh)?
- salt (ocean shore)?

6.1.2.1 Regional Species Lists

Refer to Appendix C and attach the list of the aquatic plants in the site's biogeoclimatic zone. Be sure to use an appropriate list for fresh, brackish or salt water plants.

Aquatic plant list attached

Refer to Appendix F and attach the list of fish in the site's biogeoclimatic zone. Be sure to use an appropriate list for fresh, brackish or salt water fish.

Fish list attached

Refer to Appendix D and attach the list of birds in the site's biogeoclimatic zone.

Bird list attached

Refer to Appendix E and attach the list of mammals in the site's biogeoclimatic zone.

Mammal list attached

6.1.2.2 Site-specific Species Lists for Aquatic Plants and Organisms

Which fish, plants, birds, and mammals actually are, or are likely to be, on the site? Several avenues are open to determine the receptors of concern for the risk assessment. Site visits by trained biologists are useful for making informed decisions regarding receptor selection. However, there are other sources of information that should be consulted (*e.g.*, local BCE wildlife officers, Canadian Wildlife Service, etc.). Assessing the ecological risks of contaminated sites to all potential receptors would be an unworkable task. Therefore, strategic selection of key receptors provides an efficient and effective way to meet the overall management goals of the site. Guidance on reducing the regional species lists down to relevant site-specific organisms is provided in the following sections and Appendices C through F.

6.1.2.2.1 Plants

Check off on the aquatic plant list those plants that are actually on the site and are fairly ubiquitous. *This requires a visit to the site or a review of detailed photographs by someone knowledgeable about general plant types and names.*

Site plants checked on attached list

☐ **Species selected as receptors of concern are noted on the species list**

6.1.2.2.2 Fish

Check off on the biogeoclimatic zone list those fish likely to use the site and that are of potential concern, using the following rules:

a) Fish must be resident species and those species known to use the habitat for breeding.
b) Salmonids and their various lifestages may be present without a breeding population due to hatchery input. These fish are economically and recreationally important and should be included.
c) Transient water bodies do not have resident fish populations.
d) Ditches and other shallow drainage systems (man-made) that drain into other water bodies should be considered as important fish habitat.
e) Pay particular attention to run-off into creeks and other water bodies that may be used for drainage control but also contribute to fish habitat.
f) Fish lists must be tied to water chemistry such as salinity, pH, dissolved oxygen and hardness. Remove species that cannot live in the site's environment.
g) Recreational fish species that may be introduced to artificial ponds should be included in the assessment.
h) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site fish checked on attached list**

☐ **Species selected as receptors of concern are noted on the species list**

6.1.2.2.3 Aquatic Birds

Check off on the biogeoclimatic zone bird list those birds likely to use the site and that are of potential concern, using the following rules:

a) Birds may be resident species or migrants.
b) Small shorebirds (*e.g.*, dowitchers) are considered only in shallow marshes, estuaries, or beaches.
c) Waterfowl (*e.g.*, ducks and geese) are not present on small streams.
d) Seabirds (*e.g.*, gulls, cormorants, sandpipers) are considered only for brackish or saltwater sites.
e) Fish-eating raptors (*e.g.*, bald eagles) may be considered.

f) Galliforms (*e.g.*, pheasant and quail) are not present.

g) Cavity-dwellers (*e.g.*, flickers and woodpeckers) are considered only if there are trees along the shoreline.

h) Hummingbirds are not considered.

i) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site birds checked on attached list**

Group the bird species on the list according to feeding group.

☐ **Feeding group list attached**

☐ **Species selected as receptors of concern are noted on the species list**

6.1.2.2.4 Aquatic Mammals

Check off on the biogeoclimatic zone mammal list those animals likely to use the site and that are of potential concern, using the following rules:

a) Mammals must be resident species or migrants.

b) Wholly land mammals (*e.g.*, rabbits, small rodents) do not occur.

c) Aquatic mustelids (*e.g.*, otters) may be considered.

d) Non-native pest species (nutria) are not of concern.

e) Large mammals (*e.g.*, bears, seals) may be considered.

f) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site mammals checked on attached list**

Group the mammal species on the list according to feeding group.

☐ **Feeding group list attached**

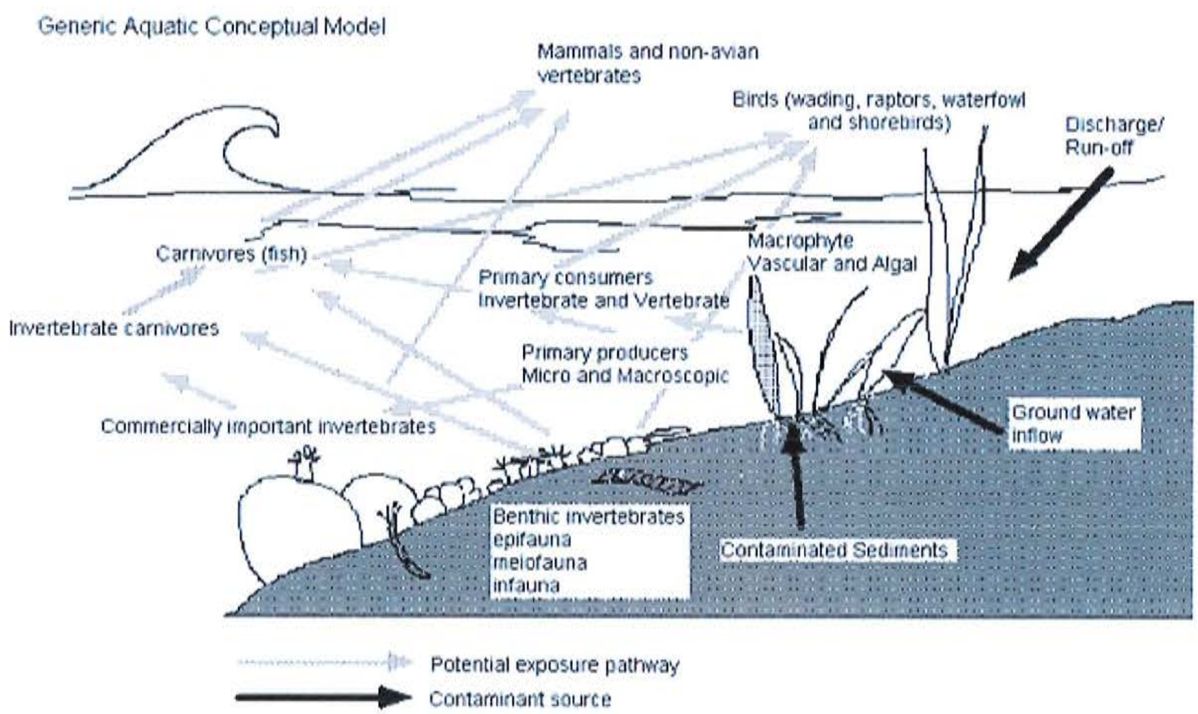
☐ **Species selected as receptors of concern are noted on the species list**

6.1.2.2.5 Aquatic Invertebrates

Assume that bottom-dwelling (benthic) invertebrates are present at the site.

6.1.2.3 Conceptual Site Model

Use the representation of the site on the next page to show how the contaminants of concern (those chemicals that exceed the standard/criteria) could potentially move through the food chain to the animals that may be onsite. If something in the picture (*e.g.*, cattails) is missing on the site, remove it and all its associated connections from the picture. Refer to Appendix A for more guidance on development of Conceptual Site Models.



6.1.3 Potential Plant Receptors from Irrigation Watering

Does your irrigation water come from a source separate from your drinking water?

☐ No. Skip this section.

☐ Yes. Complete this section.

6.1.3.1 Regional Species Lists

Refer to Appendix B to identify the biogeoclimatic zone in which the site is located.

Biogeoclimatic zone: ______________________________

Refer to Appendix C and attach the list of native plants found in the site's biogeoclimatic zone.

☐ **Plant list attached**

6.1.3.2 Site-specific Plant Species Lists

Check off on the biogeoclimatic zone plant list those plants that are actually on the site. *This requires a visit to the site or a review of detailed photographs by someone knowledgeable about general plant types and names.*

☐ **Site plants checked on attached list**

Additional species include ornamental plants. Attach a list of the ornamentals that currently exist or are likely to be on your site.

☐ **List of ornamental plants attached**

6.1.3.3 Conceptual Site Model

Refer to the generic conceptual model for urban parks in Section 6.1.1.3.

Recommendation: BCE should review the data package at this time to reach agreement on the contaminants of concern and the plants and animals of interest, prior to collecting samples for analysis.

Top

6.2 Effects Assessment

Purpose: To determine if any adverse environmental effects currently are occurring and to develop appropriate concentration-response relationships to predict if adverse affects will occur in the future.

This section asks a series of questions to help assess, through a simple site visit, whether or not current conditions are deleterious to plants and animals using the site or in water that receives run-off or groundwater discharge from the site.

You will then be directed how to find information about what concentrations of pollutants of concern cause effects in the plants and animals at your site. You may choose to use the same toxicity values developed by BCE for the matrix standards or you have the option of using a different set of data, provided you justify why you chose a different approach.

You also will be given the option of conducting simple soil or water laboratory bioassays using samples from the most contaminated areas in order to demonstrate whether the media are toxic to plants or animals and, if so, at what concentration of the toxicant in the media (*e.g.*, soil or water). *In situ* bioassays are also an option for determining if soil or water can support the plants or animals of interest.

6.2.1 Site Observations

6.2.1.1 Terrestrial Plants

If there currently is no vegetation on the site, skip this section.

Vegetation present? ☐ yes (continue) ☐ no (skip section)

If this assessment is being done in the winter, skip this section and return to complete this section in the spring/summer.

Assessment being done in: ☐ spring (continue) ☐ summer (continue) ☐ fall (continue) ☐ winter (skip section)

Date (MM/DD/YY): ________________________________

Comments:

____

____

For terrestrial plants, refer to EPA SOP #2037 in Appendix G for *Terrestrial Plant Community Sampling Methods* and answer the following questions in this section.

6.2.1.1.1 Grass

Look closely at the grass.

Does it evenly cover an area or are there bare patches of soil showing?

☐ even ☐ cover ☐ bare patches size m^2 (bare patches must be 1m^2 or larger)

Is the grass green or are there brown spots or is it brown all over?

☐ green ☐ brown spots ☐ brown all over

Show any brown spots on the site map. Be sure the map shows where all the grass cover is.

Comments:

6.2.1.1.2 Shrubs and Forbs (small leafy plants)

Look closely at the shrubs, flowers, and other leafy small plants.

Do they have all their leaves?

☐ yes ☐ no

Are the leaves all green, spotted with yellow or brown spots, or all brown?

☐ all green ☐ spotted ☐ all brown

Are there a lot of dead leaves at the base of the plants?

☐ yes ☐ no

Are the above statements true for all the plants on the site or only a few?

☐ all plants ☐ only a few

Show on the site map the location of any plants that are dead, that have spotted leaves, or that have lost a large number of leaves.

Comments:

____

____

____

____

6.2.1.1.3 Trees

Look closely at the trees.

Do they have all their leaves or needles?

☐ yes ☐ no

Are the leaves (or needles) all green, spotted with yellow or brown spots, or all brown?

☐ all green ☐ spotted ☐ all brown

Are there a lot of dead leaves at the base of the trees?

☐ yes ☐ no

Are the above statements true for all the trees on the site or only a few?

☐ all trees ☐ only a few

Do the above statements pertain to deciduous trees, evergreen trees, or both?

☐ deciduous ☐ evergreen ☐ both

Show on the site map the location of any trees that are dead, that have spotted leaves, or that have lost a large number of leaves.

Comments:

6.2.1.2 Soil Invertebrates

If the entire area is under buildings or pavement, skip this section.

Entire area built or paved? ☐ no (continue) ☐ yes (skip section)

If this assessment is being done when the ground is frozen, skip this section and return to complete this section in the spring/summer.

Ground frozen? ☐ no (continue) ☐ yes (skip section)

Comments:

____

____

Dig up a patch of soil from several areas with no vegetation, from several areas with grass or shrubs, and from areas near trees. Pass the soil through a sieve (if dry) or rinse it in a bucket (if wet) to look for earthworms and other soil invertebrates.

For each area, are invertebrates present? ☐ yes ☐ no

If yes, many ☐ few ☐

If yes, describe what they look like:

____

____

____

____

____

____

____

____

(Note: Unhealthy worms may have lesions, constrictions, or discolorations.)

6.2.1.3 Birds

Attach a list of any birds seen or heard during the site visit. If the site is small, walk the entire site. Look in trees or shrubs for evidence of current or old nests. If the site is large, walk transects (lines) at least every 50 meters.

If a river, marsh, or other waterbody is of concern due to potential run-off or groundwater contamination, walk transects on either side of the stream or river, or in 50 meter intervals across a wetland OR conduct bird observations from a boat or other suitable flotation method OR from any suitable observation point or platform. Pay particular attention to areas of marsh grasses, woody shrubs, or trees.

☐ **Bird observations attached**

6.2.1.4 Mammals

Attach a list of any mammals seen or heard during the site visit. Look under shrubs and in the grass for mouse holes or vole runways (packed down or bare strips in the grass). Look in dirt, mud and other areas for mammal tracks, footprints, and scat (fecal material).

If a river, marsh, or other waterbody is of concern due to potential run-off or groundwater contamination, walk transects on either side of the stream or river, or in 50 meter intervals across a wetland. Pay particular attention to areas of marsh grasses, woody shrubs, or trees.

☐ **Mammal observations attached**

6.2.1.5 Aquatic Plants

If the site does not contain or border on aquatic habitat, skip Sections 6.2.1.5 through 6.2.1.7.

Assessment being done in:

☐ spring ☐ summer ☐ fall ☐ winter

Date (MM/DD/YY): ____

Is aquatic vegetation present? ☐ yes ☐ no

If no, why do you think it's not

____

____

____

Do the aquatic plants appear healthy? ☐ yes ☐ no

Are there any visual signs of stress (e.g., discoloured parts)? ☐ yes ☐ no

If yes, describe

Comments:

☐ **Aquatic plant list and observations attached**

6.2.1.6 Fish

For marine or estuarine habitats, consult the following references and conduct a brief fish habitat description.

For freshwater habitats, consult the following references and conduct a brief fish habitat survey. For lake habitats, use the principles discussed for marine or estuarine habitats in the following references to conduct the habitat survey.

Department of Fisheries and Oceans (DFO) and Environment Canada. 1989. Coastal/estuarine fish habitat description and assessment manual - Part II: Habitat description procedures. Prepared by G.L. Williams and Associates, Coquitlam, BC. 38 pp. + appendices.

Department of Fisheries and Oceans (DFO) and BC Ministry of Environment (BCE). 1989. Fish habitat inventory and information program - Stream survey field guide. 29 pp. + appendices.

☐ **Attach habitat survey card(s), photos or maps of habitat, and a brief description of fish resources.**

6.2.1.7 Aquatic Invertebrates

Walk along the shoreline observing the habitat and sample with a small plankton net.

If a fresh water site, sample the shoreline every 10 m with several strokes of the net. Put the contents in a jar and note the presence of daphnia, worms, insect larvae, snails, and other invertebrates. If a marine site, sample the shoreline every 10 m with several strokes of the plankton net noting the presence of copepods, shellfish, and other invertebrates. In a marine intertidal site, observe at low tide and note the shellfish, copepods, crabs, starfish, and worms present.

☐ **Aquatic invertebrate observations attached**

6.2.2 Bioassays

OPTIONAL: Bioassays provide the opportunity to demonstrate whether the most highly contaminated media (soil and/or water) are toxic to the plants, invertebrates, or aquatic life of concern, particularly *in situ*ations where vegetation or aquatic life are not currently present. Soil and/or water samples are taken into the laboratory and growth, reproduction and survival of test species are measured following standardized, peer-reviewed methods.

Bioassays can be considered in such cases where environmental concentrations are above toxicity reference values (TRVs), but organisms are still present on the site. Other factors such as toxicant bioavailability and natural selection may apply to site conditions. For example, soils with metal contamination may not be bioavailable to earthworms due to soil conditions (*e.g.*, soil composition or pH). Therefore, earthworms may be present in sites with environmental conditions above the TRV for earthworms. In such cases, bioassay toxicity testing will establish site-specific conditions and TRVs for a particular site.

Methods developed and modified by the British Columbia Ministry of Environment and Environment Canada are recommended and listed first (Appendix H). A listing of comparable, alternative, and additional standard methods also are provided to supplement and expand bioassay and analytical capabilities. Methods developed by the American Public Health Association (APHA), American Water Works Association (AWWA), Water Environment Federation (WEF), American Society of Testing and Materials (ASTM), Organization of Economic Cooperation and Development (OECD), and the United States Environmental Protection Agency (USEPA) are included and, in many cases, are referenced in the Canadian protocols.

Bioassays may be conducted after completing the entire risk assessment, to confirm results or to understand the extent of cleanup that will be required. However, bioassays also may be done during the Effects Assessment phase as part of the development of the weight-of-evidence of environmental risk.

6.2.2.1 General Procedures for Laboratory Bioassays

a) Collect soil, water, or sediment from the most highly contaminated areas.
b) Refer to Appendix H for a list of suggested companies that can conduct standard bioassays and for references for bioassay protocols. Consider the use of field replicates rather than laboratory replicates.
c) *Suggested species for bioassays:*

plants:	rye grass (*Lolium perenne*)
	lettuce (*Lactuca sativa*)
earthworms:	red worms (*Eisenia foetida*)
fish (freshwater):	rainbow trout (*Oncorhynchus mykiss)*
	bluegill (*Lepomis macrochirus*)
	sunfish (*Lepomis sp.*)
	chinook
	top smelt (*Atherinops affinis*)
fish (marine):	*Champia parvula*
	echinoderm fertilization
	inland silverside (Menidia)

	stickelback
aquatic invertebrates (water sediments):	ceriodaphnia, *Daphnia magna* amphipod test

☐ **Bioassay(s) conducted - report(s) attached**

6.2.2.1.1 In Situ Bioassays

a) Visit site. Use an area of the site with suspected contamination based on media sampling or source input.
b) Take field measurements of dissolved oxygen, temperature, conductivity, and pH.
c) Inform and obtain approval from Regional Ministry of the Environment and Department of Fisheries and Oceans habitat staff for *in situ* bioassay testing.
d) *Suggested species for in situ bioassays:*

eyed salmonid eggs: pacific salmon
rainbow trout (*Oncorhynchus mykiss*)
caged fish: rainbow trout (*Oncorhynchus mykiss*)
caged mussels: sea mussels (*Mytilus edulis)*

6.2.3 Toxicity Reference Values (TRVs)

To determine if a particular level of contamination at a site poses a risk to plants or animals, you need to know how much of that material the plants or animals can tolerate before toxic effects are seen. The concentration of the pollutant in the soil or water where toxicity begins to occur is called the *toxicity threshold*. However, for environmental receptors such as plants or animals (*i.e.*, not humans), the goal is not necessary to protect each individual from any toxic effect, but rather to protect enough individuals so that a viable population and community of organisms can be maintained (provided other habitat factors are suitable). Therefore, a TRV is chosen from the concentration-response curve that provides reasonable protection for a specified percentage of the organisms. For terrestrial organisms on *urban parks,* this is the EC_{20}, or the concentration that affects 10% of the organisms exposed. For aquatic organisms at *urban parks*, this is the EC_{20}.
To find the ECx for the plants and animals at your site for pollutants of concern, do any (or all) of the following. Be sure to specify whether this value is dry weight (dw) or wet weight (ww).
a) Use the BCE matrix/criteria standard or information from its supporting documentation.

BCE standard/criteria used? ☐ yes ☐ no

b) Refer to Appendix I for a list of database and other references sources that contain information about toxic responses of plants, animals, and aquatic organisms.

List databases searched:

____

____

____

____

Search the scientific literature.

List databases searched:

____

____

____

____

Use the following rules to select the appropriate ECx:

a) Give preference to a generally accepted toxicity reference value that has been generated for that particular medium (accepted with caveats, peer reviewed, governmental or NGO groups). For example, water quality criteria.

b) Give preference to reproductive endpoints, but use lethality studies if they are the only ones available. Acceptable toxicological endpoints include:

- any reproductive endpoint (*e.g.*, number of offspring, number of eggs laid, eggshell quality, fruit size and yield, presence of deformities in embryos or young);
- growth rates;
- lethality;

- tumour formation or other gross deformities in embryos or young.

Unacceptable endpoints include:

- changes in enzyme activities;
- DNA breakage;
- other subcellular responses and hematological parameters.

c) If an ECx is not reported, generate the concentration-response curve from the data provided and calculate the ECx. As a last resort, use the lowest observed adverse effects level rather than the ECx and do not divide by any uncertainty factors.
d) If data are available from more than one study for an organism of concern, use the lowest ECx.
e) Use information for the contaminant of concern from any test (*e.g.*, bioassay, laboratory, field study) conducted with the organisms under consideration, if available.
f) If the organism of concern has not been tested, use the most closely related (phylogenetically) organism. Carefully consider the phylogenetic histories of the test species compared to the organisms of concern and consider any drawbacks to extrapolating between species.

For birds and mammals:

2. use EC_{20};
3. give preference to those in the same feeding group;
4. give preference to feeding studies (not single dose studies, or injection studies), particularly of weeks to months in duration;
5. if you have data from similar animals (*e.g.*, rodent data to compare with rodents or duck data to compare to other waterfowl), do not use any uncertainty factors. If your animals are not so closely related, divide the value by 10;
6. if the ONLY data available for any animal species are from injection or oral dosing studies, convert the dose to concentration in food, assuming an average body weight (bw) for the species and an average food consumption rate. Food consumption may be estimated from the following equations:

   $F = 0.621\ (bw)^{0.564}$ (*rodents*)

   $F = 0.577\ (bw)^{0.727}$ (*mammalian herbivores*)

   $F = 0.235\ (bw)^{0.822}$ (*other mammals*)

$F = 0.398\ (bw)^{0.850}$ (*song birds*)

$F = 0.648\ (bw)^{0.651}$ (*other birds*)

For plants:

7. use EC_{20};
8. if extrapolating within the same Family, do not use any uncertainty factors;
9. if extrapolating to another Family, divide by 2;
10. if extrapolating to another Order, divide by 20;
11. if extrapolating to another Class, divide by 500.

For soil invertebrates:

12. use EC_{20};
13. use whatever data are available without adjustments.

For aquatic organisms (algae, invertebrates, and fish):

14. use EC_{20};
15. use species from same class, teleost (ray finned fish) is typical. Agnatha (jawless fish) and Chondricithyes (sharks and rays) have very different biochemistries, especially in regards to PCBs and other estrogenic compounds;
16. that are pelagic invertebrates, use species similar to organism of concern, although most of the data will be on daphnia;
17. use test species with similar routes of exposure as the organism of concern. Sediment tests conducted to estimate the toxicity of a burrowing worm should use burrowing organisms as the test organism. Filter-feeding mollusks should be the organism of choice when estimating mussel or oyster sensitivity;
18. aquatic phytoplankton are represented by single species algal toxicity tests and many kinds of test organisms are available;
19. aquatic macrophytes are represented by Lemma (duckweed) although a number of new methods are under development;
20. give preference to tests conducted during a significant portion, or the most sensitive portion, of the test organism's lifespan.

Attach a list of the selected ECx with the appropriate references. Structure the list in the following format:

Organism of Concern	Test Organism	Measurement (reproduction, mortality, etc.)	Endpoint (LOAEL ECx)	Uncertainty Factor	Value	Dry Weight or Wet Weight	Reference

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6.3 Exposure Assessment

Purpose: To determine the concentration of pollutants in media (food, water, soil, etc.) of concern to which the plants and animals of concern are actually exposed and to demonstrate how the plants and animals came in contact with the contaminated media.

For plants and animals to be at risk from pollutants, the compounds must exist in the environment at concentrations above the toxicity reference values and the plants or animals must come in contact with the contaminated media. This section describes an appropriate sampling of the site to understand the magnitude and spatial extent of any contamination. The answers to the series of questions describe pertinent life-history patterns of plants and animals on the site to determine if, when, and for how long they may come in contact with the contaminated environment.

Note: All environmental sampling should be conducted in cooperation with the human health effects assessment to reduce the need to sample the same area twice. Coordination between the two processes should take place at this time.

6.3.1 Exposure Patterns of Plants and Animals

Plants and animals must come in contact with a contaminant in order to be considered at risk. This section helps determine the potential for organisms on the site to come in contact with contaminated media. Note that it is assumed that only plants may be directly affected by contaminated groundwater. Other organisms are potentially at risk only if the groundwater contaminates surface water or is used for irrigation.

6.3.1.1 Plants

All plants on the site are assumed to be exposed to contaminated soil, as their roots have the potential to take up materials out of the soil. Deep-rooted plants also may contact contaminated groundwater. Rooted aquatic plants (also called macrophytes) such as cattails, rushes, or saltgrass take up contaminants from the water column (through their leaves) as well as by their roots from sediment. Non-rooted aquatic plants (*e.g.*, duckweed, waterlilies) also take up contaminants from the water column through their leaves. Therefore, exposure to plants should be assumed, unless the contamination is present only during the dormant period of the year (winter, for most plants, if the ground freezes).

6.3.1.2 Soil Invertebrates

All soil invertebrates (such as earthworms, centipedes, and beetles) are considered exposed through ingestion of soil or movement of contaminant across their skin. Therefore, exposure to soil invertebrates should be assumed, unless the contamination is present only during the dormant period of the year (*e.g.*, when the ground is frozen).

6.3.1.3 Birds

Birds are exposed only if they eat soil invertebrates or plants (leaves or seeds) on the terrestrial portion of the site, or if they eat aquatic invertebrates or fish from a contaminated water source. In addition, it is assumed that most birds consume some soil or sediment along with the actual foodstuff and may get additional contamination from this route.

Birds may not feed on the site for their entire life. Many birds leave the area during the winter and so have the potential to be exposed only during the late spring, summer, and early fall. In addition, if the site is small or the only vegetation present is along the edge of the site, then birds are likely to get some of their diet off-site.

Therefore, the following habits of the birds that may use the site must be known:

a) proportion of the year that the bird resides in the area,

b) proportion of total foraging area provided by the site, and

c) composition of diet (seeds, leaves, invertebrates and/or soil).

6.3.1.3.1 Residency

For each bird on the site-specific checklist (see Section 6.1.1.2.2), indicate whether the bird is a year-round resident (YR), summer resident (SR), or winter resident (WR).

☐ **Bird list annotated**

6.3.1.3.2 Foraging Area

See Appendix J for a list of references containing information about bird foraging areas. For each bird that may use your site, indicate on the site-specific checklist whether its foraging area is greater (G) or smaller (S) than the size of the site. If foraging area information is not available, use information about territory size. If no information is available, assume that the foraging area is equal (E) in size to the site.

Bird list annotated

6.3.1.3.3 Diet

Refer to Appendix J for a list of references on dietary preferences of birds.

For each species present on the site list the dietary composition in a table such as the following:

Feeding Group	% Seeds	% Other Plant Material	% Soil Invertebrates	% Aquatic Invertebrates	% Fish	% Other (specify)	% Soil (assume 2%)	TOTAL (100%)
							2	100
							2	100

6.3.1.4 Mammals

Mammals are exposed only if they eat soil invertebrates or plants (leaves or seeds) that are on the terrestrial portion of the site or if they eat fish from a contaminated water source. In addition, it is assumed that most mammals consume some soil or sediment along with the actual foodstuff and may get additional contamination from this route.

Some mammals hibernate during the winter and are exposed only during the spring, summer, or fall. If the site is small or the only vegetation present is along the edge of the site, then mammals are likely to get some or all of their diet off-site.

Therefore, the following habits of the mammals using the site must be known:

a) whether the animal hibernates,

b) proportion of total foraging area that is provided by the site, and

c) composition of its diet (seeds, leaves, invertebrates and/or soil).

6.3.1.4.1 Residency

For each mammal on the site-specific checklist (see Section 6.1.1.2.3), indicate whether or not it hibernates (H).

Mammal list annotated

6.3.1.4.2 Foraging Area

See Appendix K for a list of references containing information about mammal foraging areas. For each mammal that may use your site, indicate on the site-specific checklist whether its foraging area is greater (G) or smaller (S) than the size of the site. If foraging area information is not available, use information about territory size. If no information is available, assume that the foraging area is equal (E) in size to the site.

Mammal list annotated

6.3.1.4.3 Diet

Refer to Appendix K for a list of references on dietary preferences of mammals.

For each species present on the site list the dietary composition in a table such as the following:

Feeding Group	% Seeds	% Other Plant Material	% Soil Invertebrates	% Fish	% Other (specify)	% Soil (assume 2%)	TOTAL (100%)
						2	100
						2	100

6.3.1.5 Aquatic Invertebrates

Use the following rules to determine exposure:

a) Planktonic invertebrates are exposed to toxicants primarily by the absorption from the water column, although ingestion is an additional route.

b) Aquatic insects can be exposed through the water column, sediment, or ingestion of plant material or other insects.

c) Clams and other shell fish are exposed through the water column and this will be the primary route for water-soluble materials. Ingestion is the main exposure pathway for materials bound to particulates or that bioconcentrate in plankton.

6.3.1.6 Fish

Fish have 100% exposure to the water column. However, lifestyle determines exposure to the sediment. Flatfish or other bottom dwellers and borrowers are exposed to the interstitial water concentration of the sediment so that should be used as an exposure pathway instead of water concentration. Higher trophic level fish (such as some of the salmonids) also are exposed by eating smaller fish with contaminants in their tissues.

6.3.2 Environmental Concentrations

The following sections describe how to collect various media for determining the concentration of the contaminants of concern and provides guidance on how to select appropriate analytical chemistry methods.

6.3.2.1 Selection of Media

To determine which media to sample, refer to the Conceptual Site Model diagrams and to the dietary composition tables for birds and mammals (sections 6.3.1.3.3 and 6.3.1.4.3) to help answer the following questions. The goal is to sample the food that is eaten by birds, mammals, and fish as well as the contaminated soil and/or water. In addition, if groundwater contamination is of concern (either due to drainage to surface waters or because of uptake by plant roots), groundwater should be sampled to describe the direction, extent and concentration of the plume. Answers to the following questions will help determine which media to sample.

a) Are there terrestrial plants or animal receptors of concern?

- [ ] No. Skip to question b)
- [ ] Yes. Take the following samples:

soil (Section 6.3.2.4)
plants (Section 6.3.2.5)
soil invertebrates (Section 6.3.2.6)
foliar invertebrates (Section 6.3.2.7)
small mammals (Section 6.3.2.7)

b) Are there aquatic plants or animal receptors of concern (fish, shellfish, birds, mammals)?

- [ ] No. Skip this question.
- [ ] Yes. Take the following samples:

groundwater (Section 6.3.2.9)
surface water (Section 6.3.2.10)
sediment (Section 6.3.2.10)
aquatic invertebrates (Section 6.3.2.11)

fish (Section 6.3.2.11)

aquatic plants (Section 6.3.2.12)

6.3.2.2 Sampling Design

The number of samples taken should be sufficient to characterize all different parts of the site. This will vary depending on the site size. More detail is provided in each media sampling section. Note that the goal is to provide sufficient data to use the techniques in Risk Quotient Calculation (8.1.1.3). These techniques require a spatially explicit approach to chemical concentration. Refer to the following text for more detailed discussion of environmental sampling designs:

Gilbert, R.O. 1987. *Statistical Methods for Environmental Pollution Monitoring*. Van Norstrand Reinhold, New York, New York.

6.3.2.3 Analytical Chemistry

All environmental media samples should be submitted for chemical analysis as soon as possible. Keep samples cool (< 10° C) between time of collection and analysis. Be sure to specify whether the results should be reported as dry weight (dw) or wet weight (ww) concentrations. The measurement units of these results should be comparable to the measurement units of the toxicity reference values selected in Section 6.2.3. Asking the laboratory to report percent moisture will provide flexibility for converting between wet weight and dry weight at any time. Soil and water pH, soil organic carbon, and water hardness should also be requested from the testing laboratory at the time of sample submission. See Appendix L for a list of analytical chemistry laboratories in British Columbia.

6.3.2.3.1 Methods

A variety of methods exist for sample analysis. The method chosen depends on the media being analyzed (soil, water, biota), the required precision and accuracy, and the required level of detection. See Appendix M for a list of methods available Consult with your analytical laboratory on their preferred method. List the method(s) used in the following table:

Media	**Chemical**	**Method**	**Detection Limit (dw or ww)**	**No. of Site Samples**	**No. of QA/QC Samples**
soil					
water					
etc.					

6.3.2.3.2 Detection Limits

Detection limits should be set at 0.1 times the lowest toxicity reference value for organisms exposed to each media, unless current methodology precludes doing so. Include the detection limits in the above table.

6.3.2.3.3 Quality Assurance/Quality Control (QA/QC)

A trip blank, a spike, and a split sample must be included with at least every 20 site samples. Include the number of QA/QC samples in the above table.

See the British Columbia Field Sampling Manual, 1996 edition for a more complete discussion of QA/QC. Data quality objectives (DQOs) are formal data quality specifications, which must be tabulated within a quality assurance manual. These DQOs establish the maximum amount of error allowed for the data to meet its specified use. The DQOs should be established before sample collection to avoid situations where resources are spent collecting samples which do not fit the DQOs. Once DQOs are established and sampling has begun, regular performance checks are performed to verify that the DQOs are satisfied. Corrective action must be taken when DQOs are not met. Out-of-control events and actions must be recorded.

It is highly recommended that before implementing any environmental samples, all monitoring/sampling plans be approved by BCE. Remember to coordinate with the human health effects risk assessment sample collections.

6.3.2.4 Soil Sampling

When collecting samples, observations on the appearance and abundance of soil organisms can be recorded as additional information. This information can serve as anecdotal evidence in Tier 1 or 2 EcoRAs.

6.3.2.4.1 Number and Spatial Distribution

At least three sample points should be taken in each different area of the site (*e.g.*, grass-covered, bare ground, under vegetation). If there are suspected point source(s) of contamination, a greater number of samples should be taken near the source with diminishing numbers forming concentric rings outward. Additional samples should be taken in any down-gradient area (downwind or downslope).

It may be necessary to take samples off-site to completely characterize the extent of a gradient. One option is to characterize the site first and return for additional off-site sampling if a gradient is not completely defined.

Number of samples:

Show sample locations on the site map

☐ **Map attached**

6.3.2.4.2 Depth

Composite samples should be taken at 0 to 15 cm depth for characterization of plant exposure. However, for sandy soil (*e.g.*, Fraser River sand), take a soil sample at 0 to 50 or 70 cm depth. Optional: Deeper cores into various soil strata can be taken to characterize current and potential migration of contaminants.

Number of samples taken at 0 to 15 cm depth:

Number of samples taken at deeper depth:

Depth: cm

Number:

Label all sample locations on the site map with sampling depth.

☐ **Map labelled**

6.3.2.4.3 Methods

Samples may be collected using either a soil corer or a trowel for surface samples and with appropriate coring devices for deeper samples.

If contaminants of concern are metals or metalloids, use only plastic trowels and corers. Samples should be packaged in plastic bags and stored under cool conditions until analyzed. Decontaminate sampling device between each sample.

☐ contaminants are metals/metalloids - use plastic devices

If contaminants of concern are organic compounds, use only metal sampling devices. Store samples in glass containers and keep cool until analyzed. Decontaminate sampling device between each sample.

☐ contaminants are organic compounds - use metal and glass devices

See Appendix N for references for specific soil collection methods. List which methods were used.

☐ **List of methods attached**

6.3.2.5 Terrestrial Plant Sampling

6.3.2.5.1 Number and Spatial Distribution

At each soil sample location, collect a vegetation sample (if vegetation is present).

Collect grass, shrubs, and tree leaves separately at each location. Collect at least 50 grams of each.

Number of plant samples taken:

Grass: ________________________

Shrubs: ____________________

Tree leaves: _________________

Label all sample locations on the site map with the depth of sampling. Note which types of vegetation samples were collected at each sample point.

☐ **Map labelled**

6.3.2.5.2 Methods

Samples are collected using either metal or plastic scissors.

If contaminants of concern are metals or metalloids, use plastic scissors. Samples should be packaged in plastic bags and stored under cool conditions until analyzed. Decontaminate scissors between each sample.

☐ contaminants are metals/metalloids - use plastic devices

If contaminants of concern are organic compounds, use only metal sampling devices. Store samples in glass containers and keep cool until analyzed. Decontaminate sampling device between each sample.

☐ contaminants are organic compounds - use metal and glass devices

See Appendix G for reference for specific plant collection methods.

6.3.2.6 Soil Invertebrates

When collecting soil samples, remove to a separate sampling container any invertebrates (*e.g.*, earthworms, centipedes, beetles) found in the soil. These may be taken from the same sample that will be analyzed for soil chemistry or may be taken from a separate sample collected adjacent to the core collection site.

Invertebrates are separated from the soil either by picking them out with tweezers or by passing the soil through a small diameter sieve. Collect all the invertebrates in the sample or 50 grams, whichever is the least.

If contaminants of concern are metals or metalloids, use plastic tweezers. Invertebrates should be packaged in plastic bags or glass containers and stored frozen until analyzed.

☐ contaminants are metals/metalloids - use plastic devices

If contaminants of concern are organic compounds, use metal tweezers. Invertebrates should be packaged in glass containers and stored frozen until analyzed.

☐ contaminants are organic compounds - use metal and glass devices

Label all sample locations on the site map where invertebrates were found.

☐ **Map labelled**

6.3.2.7 Foliar Invertebrate Sampling

Use sweepnets to collect foliar invertebrates. Sweepnetting can be done at midday by walking throughout each sampling site sweeping the net in a figure 8 pattern through available vegetation. At least 50 sweeps should be done at each location; using the same number of sweeps each time at each location.

If contaminants of concern are metals or metalloids, use plastic tweezers to remove the invertebrates from the net. Invertebrates should be packaged in plastic bags or glass containers and stored frozen until analyzed.

☐ contaminants are metals/metalloids - use plastic devices

If contaminants of concern are organic compounds, use metal tweezers. Invertebrates should be packaged in glass containers and stored frozen until analyzed.

☐ contaminants are organic compounds - use metal and glass devices

Label all sample locations on the site map where sweeps were conducted and which ones netted invertebrates.

☐ **Map labelled**

6.3.2.8 Small Rodent Sampling

Before collecting any small rodents check with the local (to the site) Fish and Wildlife Manager in the Regional British Columbia Ministry of the Environment Office about whether trapping permits are required. Personnel should wear protective clothing to reduce the potential for transmission of diseases from rodents to humans (*e.g.*, disposable rubber gloves and outer garments that are either disposed of or washed after being used in the field).

Set snap traps (*e.g.*, Victor® mouse traps or Museum Specials®) baited with peanut butter or other suitable material either in areas likely to harbor rodents, in a grid across the entire area, or in a grid across the most contaminated area. Traps should be spaced no more than 15 m apart. Traps should be set in the evening and checked at dawn. Refer to the following reference, or equivalent, for more details on trapping methods.

Schemnitz, S.D. 1980. *Wildlife Management Techniques Manual, 4th Edition*. The Wildlife Society, Inc., Washington, D.C.

Place all collected animals in plastic bags that are labeled, sealed, and stored on wet ice or other cool location for transport to the analytical laboratory.

Label all locations on the site map where traps were placed AND where small mammals were captured.

☐ **Map labelled**

6.3.2.9 Groundwater Samples

6.3.2.9.1 Number and Spatial Distribution

Groundwater sampling should be conducted in a manner that will illustrate the amount of chemical currently in the groundwater aquifers, both under the site and downgradient off-site. Sufficient number of samples should be taken to define the boundaries of any plume of contamination.

During all drilling, appropriate care should be taken not to penetrate any barriers that prevent the movement of surface water into deeper aquifers. Otherwise, previously uncontaminated groundwater may become contaminated solely as a result of the sampling process.

A minimum of 10 samples is required to find the general location of potential plumes of contamination. This may have been done during the initial site assessment, in which case this portion of the risk assessment can immediately focus on better defining the plume.

Once a general area of contamination is identified, a sufficient number of groundwater samples must be taken to define the boundaries of the plume, particularly its extent downgradient. The number of samples required to do this will depend on the plume size.

6.3.2.9.2 Methods

If contaminants of concern are metals or metalloids, use plastic sampling devices (with the exception of metal tipped drills, if needed). Samples should be stored in glass or Teflon-lined jars and stored under cool conditions until analyzed.

☐ contaminants are metals/metalloids - use plastic devices

If contaminants of concern are organic compounds, use only metal sampling devices. Store samples in glass containers and keep cool until analyzed.

☐ contaminants are organic compounds - use metal and glass devices

Refer to Appendix N for detailed methods for groundwater sampling. List which methods were used.

☐ **List of methods attached**

6.3.2.10 Surface Water and Sediment Sampling

When collecting samples, observations on the appearance and abundance of sediment organisms can be recorded as additional information. This information can serve as anecdotal evidence in Tier 1 or 2 EcoRAs.

6.3.2.10.1 Number and Spatial Distribution

Use sufficient numbers of samples to characterize the surface water variability so that a spatially explicit model can be used in calculating risk values (see Section 8.1.1.3.2).

6.3.2.10.2 Methods

Refer to Appendix N for detailed methods for surface water and sediment sampling. List which methods were used.

☐ **List of methods attached**

6.3.2.11 Fish and Aquatic Invertebrate Sampling

6.3.2.11.1 Number and Spatial Distribution

The fish and aquatic invertebrate sampling should occur concurrently with the chemical sampling. Samples should be taken at the same location and at the same time as much as is possible. This approach to sampling will facilitate the calculation of risk values as delineated in Section 8.1.1.3. Permits are required for the collection of fish and other aquatic species. Proponents are advised to contact their local office of the Department of Fisheries and Oceans and BC Environment for specific permit requirements.

6.3.2.11.2 Methods

Refer to Appendix N for detailed methods for sampling of fish and aquatic invertebrates. List which methods were used.

☐ **List of methods attached**

6.3.2.12 Aquatic Plant Sampling

6.3.2.12.1 Number and Spatial Distribution

Sampling strategies for aquatic plants depend on the type of plant and the planned use of the data. Aquatic plants can be divided into two main types according to whether the plants are physically attached to the sediments (*i.e.*, rooted plants) or whether they float on the water (*i.e.*, floating plants). Plant tissue sampling is conducted to address risks to herbivores (animals that eat the plants), but can also be conducted to address risks to the plants themselves if the appropriate effect data are available. Therefore, be sure to collect samples from each type of plant that is an important food for animals or is desired for its own sake. Collect stems, roots and leaves, as these parts are edible for many aquatic plants..

To properly address spatial issues, the pattern of contamination in the receiving environment (sediment or water) must contain some gradient (*i.e.*, is not homogeneous). For example, there is no benefit in sampling duckweed (a floating plant) along with water samples if no contaminant gradient exists in the water. A spatially explicit sampling program, however, should always be considered for rooted plants when addressing which areas of the aquatic portion of the site might require remediation. The number and spatial distribution of samples for a spatially explicit sampling program is driven by the scale of the contamination gradient.

6.3.2.12.2 Methods

Sampling methods for aquatic plants are the same as those described for terrestrial plants (Section 6.3.2.5).

This completes the Analysis Phase. Go to Section 8 to put all the information together into a Risk Calculation.

Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia - Chapter 7. Agriculture

7.0 AGRICULTURAL

7.1 Problem Formulation (continued)

Which standard/criteria was exceeded (for any chemical)?

a) ☐ Toxicity to soil invertebrates and plants

b) ☐ Groundwater flow, surface run-off, or direct discharge to surface water or sediments used by aquatic life

c) ☐ Groundwater used for irrigation watering

d) ☐ Groundwater used for livestock watering

If a) is exceeded, go to Section 7.1.1

If b) is exceeded, go to Section 7.1.2

If c) is exceeded, go to Section 7.1.3

If d) is exceeded, go to Section 7.1.4

If TWO or MORE are exceeded, do all applicable sections

Attach a list of the chemicals exceeding the standards. These chemicals will be considered "chemicals of concern" for the remainder of the risk assessment. Please use the following format. If available, attach the Detailed Site Investigation Report as well.

Chemical	Measured Concentrations (range)	Standard/Criteria Exceeded	Standard/Criteria Value

7.1.1 Potential Terrestrial Receptors

7.1.1.1 Regional Species Lists

Refer to Appendix B to identify the biogeoclimatic zone in which the site is located.

Biogeoclimatic zone: ____

Refer to Appendix C and attach the list of terrestrial plants in the site's biogeoclimatic zone.

☐ **Plant list attached**

Refer to Appendix D and attach the list of terrestrial birds in the site's biogeoclimatic zone.

☐ **Bird list attached**

Refer to Appendix E and attach the list of terrestrial mammals in the site's biogeoclimatic zone.

☐ **Mammal list attached**

Refer to Appendix E and attach the list of amphibians and reptiles in the site's biogeoclimatic zone.

☐ **Amphibian and reptile list attached**

7.1.1.2 Site-specific Species Lists for Terrestrial Plants and Animals

Which plants, birds, and mammals actually are, or are likely to be, on the site? Several avenues are open to determine the receptors of concern for the risk assessment. Site visits by trained biologists are useful for making informed decisions regarding receptor selection. However, there are other sources of information that should be consulted (*e.g.*, local BCE wildlife officers, Canadian Wildlife Service, etc.). Assessing the ecological risks of contaminated sites to all potential receptors would be an unworkable task. Therefore, strategic selection of key receptors provides an efficient and effective way to meet the overall management goals of the site. Guidance on reducing the regional species lists down to relevant site-specific organisms is provided in the following sections and Appendices C through F.

7.1.1.2.1 Terrestrial Plants

Check off on the biogeoclimatic zone plant list those plants that are actually on the site and are fairly ubiquitous. This requires a visit to the site or a review of detailed photographs by someone knowledgeable about general plant types and names.

☐ **Site plants checked on attached list**

☐ **Species selected as receptors of concern are noted on the species list**

7.1.1.2.2 Terrestrial Birds

Check off on the biogeoclimatic zone bird list those birds likely to use the site and that are of potential concern, using the following rules:

a) Birds are present only if there is vegetation on the site.
b) Birds may be resident species or migrants.
c) Shorebirds (*e.g.*, dowitchers, sandpipers), wading birds (*e.g.*, herons, egrets), waterfowl (*e.g.*, ducks and geese), and seabirds (*e.g.*, gulls, cormorants) are not considered.
d) Raptors (*e.g.*, hawks, owls, and eagles) are considered.
e) Galliforms (*e.g.*, pheasant and quail) may be considered.
f) Cavity-dwellers (*e.g.*, flickers and woodpeckers) are considered only if there are trees on the site.
g) Hummingbirds are not considered.
h) Livestock (*e.g.*, chickens, ducks) expected on the farm are considered.
i) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site birds checked on attached list**

Group the bird species on the list according to feeding group.

☐ **Feeding group list attached**

☐ **Species selected as receptors of concern are noted on the species list**

7.1.1.2.3 Terrestrial Mammals

Check off on the biogeoclimatic zone mammal list those animals likely to use the site and that are of potential concern, using the following rules:

a) Mammals are present only if there is vegetation on the site.
b) Mammals may be resident species or migrants
c) Aquatic mustelids (*e.g.*, otters) and marine mammals (*e.g.*, whales) are not considered.
d) Non-native pest species (rats and house mice) are not of concern.
e) All other species may be considered.
f) Livestock (*e.g.*, horses, cattle, sheep, pigs) expected on the farm are considered.
g) Domestic cats are considered.
h) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site mammals checked on attached list**

Group the mammal species on the list according to feeding groups.

☐ **Feeding group list attached**

☐ **Species selected as receptors of concern are noted on the species list**

7.1.1.2.4 Amphibians and Reptiles

Check off on the biogeoclimatic zone amphibian and reptile list those animals likely to use the site and that are of potential concern.

☐ **Site amphibians and reptiles checked on attached list**

☐ **Species selected as receptors of concern are noted on the species list**

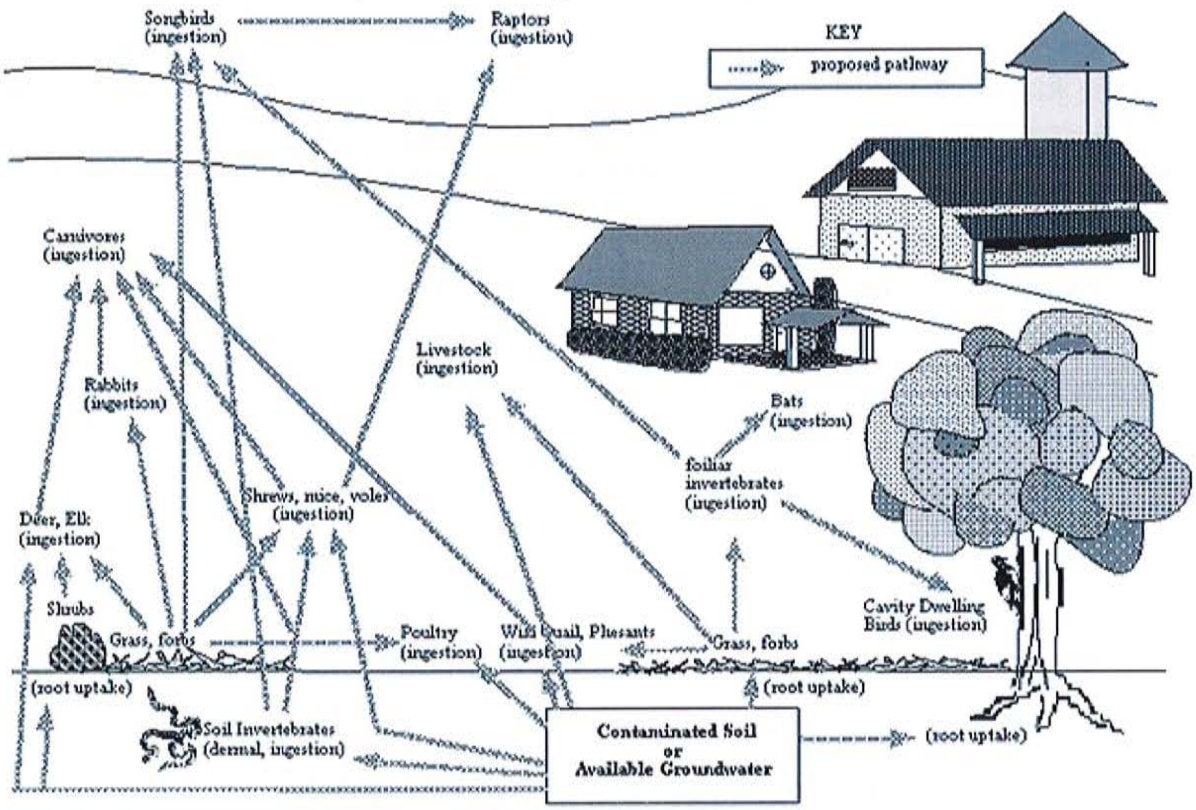
7.1.1.2.5 Soil Invertebrates

Assume that earthworms, as representative soil invertebrates, should be present at the site.

7.1.1.3 Conceptual Site Model

Use the representation of the site on the next page to show how the contaminants of concern (those chemicals that exceed the standard/criteria) could potentially move through the food chain to the animals that may be onsite. If something in the picture (*e.g.*, trees) is missing on the site, remove it and all its associated connections from the picture. Refer to Appendix A for more guidance on development of Conceptual Site Models.

Generic Conceptual Model for Agricultural Sites (Terrestrial)



7.1.2 Potential Aquatic Life Receptors

Is the water

- ☐ fresh (river, stream, lake, wetland)?
- ☐ brackish (estuary, saltmarsh)?
- ☐ salt (ocean shore)?

7.1.2.1 Regional Species List

Refer to Appendix C and attach the list of the aquatic plants in the site's biogeoclimatic zone. Be sure to use an appropriate list for fresh, brackish or salt water plants.

☐ **Aquatic plant list attached**

Refer to Appendix F and attach the list of fish in the site's biogeoclimatic zone. Be sure to use an appropriate list for fresh, brackish or salt water fish.

☐ **Fish list attached**

Refer to Appendix D and attach the list of birds in the site's biogeoclimatic zone.

☐ **Bird list attached**

Refer to Appendix E and attach the list of mammals in the site's biogeoclimatic zone.

☐ **Mammal list attached**

7.1.2.2 Site-specific Species Lists for Aquatic Plants and Organisms

Which fish, plants, birds, and mammals actually are, or are likely to be, on the site? Several avenues are open to determine the receptors of concern for the risk assessment. Site visits by trained biologists are useful for making informed decisions regarding receptor selection. However, there are other sources of information that should be consulted (*e.g.*, local BCE wildlife officers, Canadian Wildlife Service, etc.). Assessing the ecological risks of contaminated sites to all potential receptors would be an unworkable task. Therefore, strategic selection of key receptors provides an efficient and effective way to meet the overall management goals of the site. Guidance on reducing the regional species lists down to relevant site-specific organisms is provided in the following sections and Appendices C through F.

7.1.2.2.1 Plants

Check off on the aquatic plant list those plants that are actually on the site and are fairly ubiquitous. *This requires a visit to the site or a review of detailed photographs by someone knowledgeable about general plant types and names.*

☐ **Site plants checked on attached list**

☐ **Species selected as receptors of concern are noted on the species list**

7.1.2.2.2 Fish

Check off on the biogeoclimatic zone list those fish likely to use the site and that are of potential concern, using the following rules:

a) Fish must be resident species and those species known to use the habitat for breeding.
b) Salmonids and their various lifestages may be present without a breeding population due to hatchery input. These fish are economically and recreationally important and should be included.
c) Transient water bodies do not have resident fish populations.
d) Ditches and other shallow drainage systems (man-made) that drain into other water bodies should be considered as important fish habitat.
e) Pay particular attention to run-off into creeks and other water bodies that may be used for drainage control but also contribute to fish habitat.
f) Fish lists must be tied to water chemistry such as salinity, pH, dissolved oxygen and hardness. Remove species that cannot live in the site's environment.
g) Recreational fish species that may be introduced to artificial ponds should be included in the assessment.
h) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site fish checked on attached list**

☐ **Species selected as receptors of concern are noted on the species list**

7.1.2.2.3 Aquatic Birds

Check off on the biogeoclimatic zone bird list those birds likely to use the site and that are of potential concern, using the following rules:

a) Birds may be resident species or migrants.

b) Small shorebirds (*e.g.*, dowitchers) are considered only in shallow marshes, estuaries, or beaches.

c) Waterfowl (*e.g.*, ducks and geese) are not present on small streams.

d) Seabirds (*e.g.*, gulls, cormorants, sandpipers) are considered only for brackish or saltwater sites.

e) Fish-eating raptors (*e.g.*, bald eagles) may be considered.

f) Galliforms (*e.g.*, pheasant and quail) are not present.

g) Cavity-dwellers (*e.g.*, flickers and woodpeckers) are considered only if there are trees along the shoreline.

h) Hummingbirds are not considered.

i) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site birds checked on attached list**

Group the bird species on the list according to feeding group.

☐ **Feeding group list attached**

☐ **Species selected as receptors of concern are noted on the species list**

7.1.2.2.4 Aquatic Mammals

Check off on the biogeoclimatic zone mammal list those animals likely to use the site and that are of potential concern, using the following rules:

a) Mammals must be resident species or migrants.

b) Wholly land mammals (*e.g.*, rabbits, small rodents) do not occur.

c) Aquatic mustelids (*e.g.*, otters) may be considered.

d) Non-native pest species (nutria) are not of concern.

e) Large mammals (*e.g.*, bears, seals) may be considered.

f) Include all species that are listed as threatened, endangered or sensitive.

☐ **Site mammals checked on attached list**

Group the mammal species on the list according to feeding group.

☐ **Feeding group list attached**

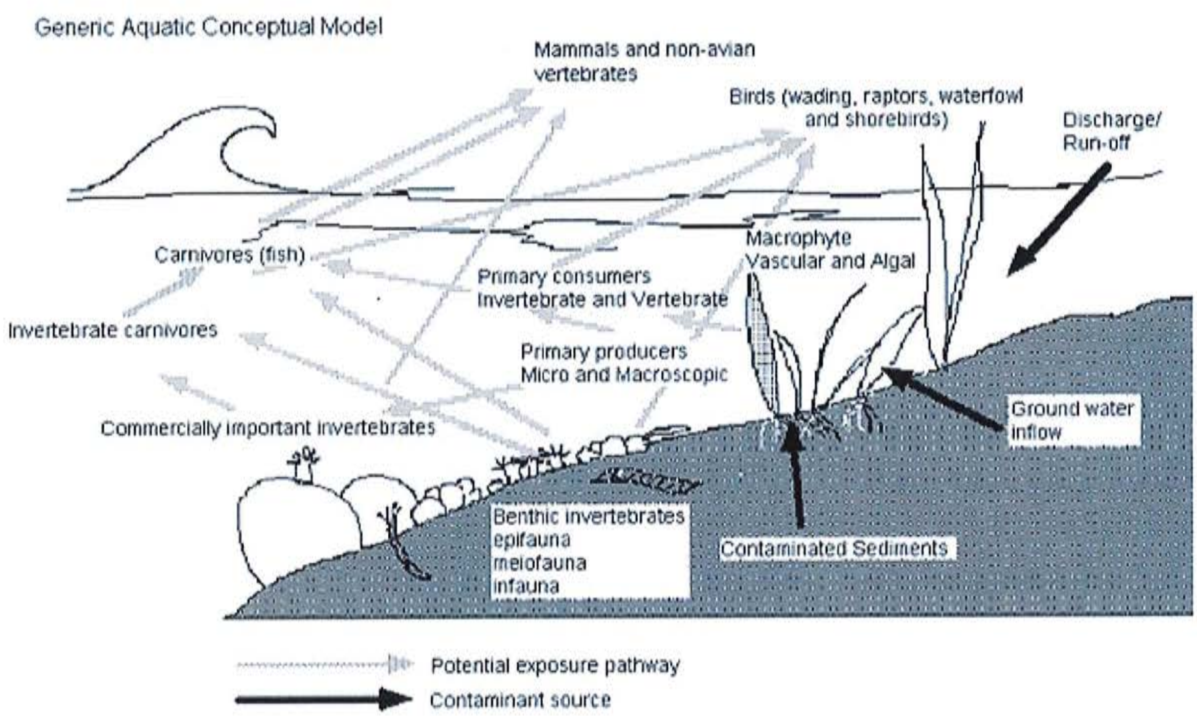
☐ **Species selected as receptors of concern are noted on the species list**

7.1.2.2.5 Aquatic Invertebrates

Assume that bottom-dwelling (benthic) invertebrates are present at the site.

7.1.2.3 Conceptual Site Model

Use the representation of the site on the next page to show how the contaminants of concern (those chemicals that exceed the standard/criteria) could potentially move through the food chain to the animals that may be onsite. If something in the picture (*e.g.*, cattails) is missing on the site, remove it and all its associated connections from the picture. Refer to Appendix A for more guidance on development of Conceptual Site Models.



7.1.3 Potential Receptors from Irrigation Watering

Does your irrigation water come from a source separate from your drinking water?

☐ No. Skip this section.

☐ Yes. Complete this section.

7.1.3.1 Regional Plant Species Lists

Refer to Appendix B to identify the biogeoclimatic zone in which the site is located.

Biogeoclimatic zone: ____

Refer to Appendix C and attach the list of native plants found in the site's biogeoclimatic zone.

☐ **Plant list attached**

7.1.3.2 Site-specific Plant Species List

Which plants actually are, or are likely to be, using irrigation water on the site?

Check off on the biogeoclimatic zone plant list those plants that are actually on the site. This requires a visit to the site or a review of detailed photographs by someone knowledgeable about general plant types and names.

☐ **Site plants checked on attached list**

Additional species include ornamental plants. Attach a list of the ornamentals that currently exist or are likely to be on your site.

☐ **List of ornamental plants attached**

7.1.3.3 Conceptual Site Model

Refer to the generic conceptual model for agricultural sites in Section 7.1.1.3.

7.1.4 Potential Livestock Receptors Drinking from Groundwater Wells

Does your livestock drinking water come from a source separate from your drinking water?

☐ No. Skip this section.

☐ Yes. Complete this section.

7.1.4.1 Actual Livestock Receptors

Which livestock actually are, or are likely to be, on the site?

This requires knowledge about the current and intended use of the site to determine which of the following livestock species are, or will be, on site:

☐ horses ☐ dairy cattle ☐ beef cattle ☐ sheep ☐ pigs ☐ poultry (chickens, turkey, ducks)

☐ others (llamas, mink, fallow deer, buffalo, ostrich)

7.1.4.2 Conceptual Site Model

Refer to the generic conceptual model for agricultural sites in Section 7.1.2.3.

Recommendation: BCE should review the data package at this time to reach agreement on the contaminants of concern and the plants and animals of interest, prior to collecting samples for analysis.

Top

7.2 Effects Assessment

Purpose: To determine if any adverse environmental effects currently are occurring and to develop appropriate concentration-response relationships to predict if adverse affects will occur in the future.

This section asks a series of questions to help assess, through a simple site visit, whether current conditions are deleterious to plants and animals using the site or in water that receives run-off or groundwater discharge from the site.

You will then be directed how to find information about what concentrations of pollutants of concern cause effects in the plants and animals at your site. You may choose to use the same toxicity values developed by BCE for the matrix standards or you have the option of using a different set of data, provided you justify why you chose a different approach.

You also will be given the option of conducting simple soil or water laboratory bioassays using samples from the most contaminated areas in order to demonstrate whether the media are toxic to plants or animals and, if so, at what concentration of the toxicant in the media (*e.g.*, soil or water). *In situ* bioassays are also an option for determining if soil or water can support the plants or animals of interest.

7.2.1 Site Observations

7.2.1.1 Terrestrial Plants

If there currently is no vegetation on the site, skip this section.

Vegetation present? ☐ yes (continue) ☐ no (skip section)

If this assessment is being done in the winter, skip this section and return to complete this section in the spring/summer.

Assessment being done in: ☐ spring (continue) ☐ summer (continue) ☐ fall (continue) ☐ winter (skip section)

Date (MM/DD/YY): ____________________________________

Comments:

____
____

____
____

For terrestrial plants, refer to EPA SOP #2037 in Appendix G for *Terrestrial Plant Community Sampling Methods* and answer the following questions in this section.

7.2.1.1.1 Grass

Look closely at the grass.

Does it evenly cover an area or are there bare patches of soil showing?

☐ even ☐ cover ☐ bare patches size m^2 (bare patches must be $1m^2$ or larger)

Is the grass green or are there brown spots or is it brown all over?

☐ green ☐ brown spots ☐ brown all over

Show any brown spots on the site map. Be sure the map shows where all the grass cover is.

Comments:

7.2.1.1.2 Shrubs and Forbs (small leafy plants)

Look closely at the shrubs, flowers, and other leafy small plants.

Do they have all their leaves?

☐ yes ☐ no

Are the leaves all green, spotted with yellow or brown spots, or all brown?

☐ all green ☐ spotted ☐ all brown

Are there a lot of dead leaves at the base of the plants?

☐ yes ☐ no

Are the above statements true for all the plants on the site or only a few?

☐ all plants ☐ only a few

Show on the site map the location of any plants that are dead, that have spotted leaves, or that have lost a large number of leaves.

Comments:

____

____

____

____

7.2.1.1.3 Trees

Look closely at the trees.

Do they have all their leaves or needles?

☐ yes ☐ no

Are the leaves (or needles) all green, spotted with yellow or brown spots, or all brown?

☐ all green ☐ spotted ☐ all brown

Are there a lot of dead leaves at the base of the trees?

☐ yes ☐ no

Are the above statements true for all the trees on the site or only a few?

☐ all trees ☐ only a few

Do the above statements pertain to deciduous trees, evergreen trees, or both?

☐ deciduous ☐ evergreen ☐ both

Show on the site map the location of any trees that are dead, that have spotted leaves, or that have lost a large number of leaves.

Comments:

____

____

____

____

7.2.1.2 Soil Invertebrates

If the entire area is under buildings or pavement, skip this section.

Entire area built or paved? ☐ no (continue) ☐ yes (skip section)

If this assessment is being done when the ground is frozen, skip this section and return to complete this section in the spring/summer.

Ground frozen? ☐ no (continue) ☐ yes (skip section)

Comments:

Dig up a patch of soil from several areas with no vegetation, from several areas with grass or shrubs, and from areas near trees. Pass the soil through a sieve (if dry) or rinse it in a bucket (if wet) to look for earthworms and other soil invertebrates.

For each area, are invertebrates present? ☐ yes ☐ no

If yes, many ☐ few ☐

If yes, describe what they look like:

____

____

____

____

(Note: Unhealthy worms may have lesions, constrictions, or discolorations.)

7.2.1.3 Birds

Attach a list of any birds seen or heard during the site visit. If the site is small, walk the entire site. Look in trees or shrubs for evidence of current or old nests. If the site is large, walk transects (lines) at least every 50 meters.

If a river, marsh, or other waterbody is of concern due to potential run-off or groundwater contamination, walk transects on either side of the stream or river, or in 50 meter intervals across a wetland OR conduct bird observations from a boat or other suitable flotation method OR from any suitable observation point or platform. Pay particular attention to areas of marsh grasses, woody shrubs, or trees.

☐ **Bird observations attached**

7.2.1.4 Mammals

Attach a list of any mammals seen or heard during the site visit. Look under shrubs and in the grass for mouse holes or vole runways (packed down or bare strips in the grass). Look in dirt, mud and other areas for mammal tracks, footprints, and scat (fecal material).

If a river, marsh, or other waterbody is of concern due to potential run-off or groundwater contamination, walk transects on either side of the stream or river, or in 50 meter intervals across a wetland. Pay particular attention to areas of marsh grasses, woody shrubs, or trees.

☐ **Mammal observations attached**

7.2.1.5 Aquatic Plants

f the site does not contain or border on aquatic habitat, skip Sections 6.2.1.5 through 6.2.1.7.

Assessment being done in:

☐ spring ☐ summer ☐ fall ☐ winter

Date: (MM/DD/YY): ______________________________

Is aquatic vegetation present? ☐ yes ☐ no

If no, why do you think it is not

____

____

____

Do the aquatic plants appear healthy? ☐ yes ☐ no

Are there any visual signs of stress (*e.g.*, discolored parts)? ☐ yes ☐ no

If yes, describe

____

____

Comments:

____

____

____

____

☐ **Aquatic plant list and observations attached**

7.2.1.6 Fish

For marine or estuarine habitats, consult the following references and conduct a brief fish habitat description.

For freshwater habitats, consult the following references and conduct a brief fish habitat survey. For lake habitats, use the principles discussed for marine or estuarine habitats in the following references to conduct the habitat survey.

Department of Fisheries and Oceans (DFO) and Environment Canada. 1989. Coastal/estuarine fish habitat description and assessment manual - Part II: Habitat description procedures. Prepared by G.L. Williams and Associates, Coquitlam, BC. 38 pp. + appendices.

Department of Fisheries and Oceans (DFO) and BC Ministry of Environment (BCE). 1989. Fish habitat inventory and information program - Stream survey field guide. 29 pp. + appendices.

☐ **Attach habitat survey card(s), photos or maps of habitat, and a brief description of fish resources.**

7.2.1.7 Aquatic Invertebrates

Walk along the shoreline observing the habitat and sample with a small plankton net.

a) If a fresh water site, sample the shoreline every 10 m with several strokes of the net. Put the contents in a jar and note the presence of daphnia, worms, insect larvae, snails, and other invertebrates.
b) If a marine site, sample the shoreline every 10 m with several strokes of the plankton net noting the presence of copepods, shellfish, and other invertebrates.
c) In a marine intertidal site, observe at low tide and note the shellfish, copepods, crabs, starfish, and worms present.

☐ **Aquatic invertebrate observations attached**

7.2.2 Bioassays

OPTIONAL: Bioassays provide the opportunity to demonstrate whether the most highly contaminated media (soil and/or water) are toxic to the plants, invertebrates, or aquatic life of concern, particularly in situations where vegetation or aquatic life are not currently present. Soil and/or water samples are taken into the laboratory and growth, reproduction and survival of test species are measured following standardized, peer-reviewed methods.

Bioassays can be considered in such cases where environmental concentrations are above toxicity reference values (TRVs), but organisms are still present on the site. Other factors such as toxicant bioavailability and natural selection may apply to site conditions. For example, soils with metal contamination may not be bioavailable to earthworms due to soil conditions (*e.g.*, soil composition or pH). Therefore, earthworms may be present in sites with environmental conditions above the TRV for earthworms. In such cases, bioassay toxicity testing will establish site-specific conditions and TRVs for a particular site.

Methods developed and modified by the British Columbia Ministry of Environment and Environment Canada are recommended and listed first (Appendix H). A listing of comparable, alternative, and additional standard methods also are provided to supplement and expand bioassay and analytical capabilities. Methods developed by the American Public Health Association (APHA), American Water Works Association (AWWA), Water Environment Federation (WEF), American Society of Testing and Materials (ASTM), Organization of Economic Cooperation and Development (OECD), and the United States Environmental Protection Agency (USEPA) are included and, in many cases, are referenced in the Canadian protocols.

Bioassays may be conducted after completing the entire risk assessment, to confirm results or to understand the extent of cleanup that will be required. However, bioassays also may be done during the Effects Assessment phase as part of the development of the weight-of-evidence of environmental risk.

7.2.2.1 General Procedures for Laboratory Bioassays

a) Collect soil, water, or sediment from the most highly contaminated areas.
b) Refer to Appendix H for a list of suggested companies that can conduct standard bioassays and for references for bioassay protocols. Consider the use of field replicates rather than laboratory replicates.
c) *Suggested species for bioassays:*

plants:	rye grass (*Lolium perenne*)
	lettuce (*Lactuca sativa*)
earthworms:	red worms (*Eisenia foetida*)
fish (freshwater):	rainbow trout (*Oncorhynchus mykiss)*
	bluegill (*Lepomis macrochirus*)
	sunfish (*Lepomis sp*.)
	chinook
	top smelt (*Atherinops affinis*)
fish (marine):	*Champia parvula*
	echinoderm fertilization
	inland silverside (Menidia)
	stickelback
aquatic	ceriodaphnia, *Daphnia magna*
invertebrates	amphipod test

(water sediments):

☐ **Bioassay(s) conducted - report(s) attached**

7.2.2.2 In Situ Bioassays

a) Visit site. Use an area of the site with suspected contamination based on media sampling or source input.
b) Take field measurements of dissolved oxygen, temperature, conductivity, and pH.
c) Inform and obtain approval from Regional Ministry of the Environment and Department of Fisheries and Oceans habitat staff for *in situ* bioassay testing.
d) *Suggested species for in situ bioassays:*

eyed salmonid eggs: pacific salmon
rainbow trout (*Oncorhynchus mykiss*)
caged fish: rainbow trout (*Oncorhynchus mykiss*)
caged mussels: sea mussels (*Mytilus edulis)*

7.2.3 Toxicity Reference Values (TRVs)

To determine if a particular level of contamination at a site poses a risk to plants or animals, you need to know how much of that material the plants or animals can tolerate before toxic effects are seen. The concentration of the pollutant in the soil or water where toxicity begins to occur is called the *toxicity threshold*. However, for environmental receptors such as plants or animals (*i.e.*, not humans), the goal is not to protect each individual from any toxic effect, but rather to protect enough individuals so that a viable population and community of organisms can be maintained (provided other habitat factors are suitable). Therefore, a TRV is chosen from the concentration-response curve that provides reasonable protection for a specified percentage of the organisms. For terrestrial organisms on agricultural sites, this is the EC_{20}, or the concentration that affects 20% of the organisms exposed. For aquatic organisms at agricultural sites, this is the EC_{20}.
To find the ECx for the plants and animals at your site for pollutants of concern, do any or all of the following. Be sure to specify whether this value is dry weight (dw) or wet weight (ww).
a) Use the BCE matrix/criteria standard or information from its supporting documentation.

BCE standard/criteria used? ☐ yes ☐ no

b) Refer to Appendix I for a list of database and other references sources that contain information about toxic responses of plants, animals, and aquatic organisms.

List databases searched:

____

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Search the scientific literature.

List databases searched:

____

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Use the following rules to select the appropriate ECx:

a) Give preference to a generally accepted toxicity reference value that has been generated for that particular medium (accepted with caveats, peer reviewed, governmental or NGO groups). For example, water quality criteria.

b) Give preference to reproductive endpoints, but use lethality studies if they are the only ones available.

c) Acceptable toxicological endpoints include:

- any reproductive endpoint (*e.g.*, number of offspring, number of eggs laid, eggshell quality, fruit size and yield, presence of deformities in embryos or young);
- growth rates;
- lethality;
- tumour formation or other gross deformities in embryos or young.

Unacceptable endpoints include:

- changes in enzyme activities;
- DNA breakage;
- other subcellular responses and hematological parameters.

d) If an ECx is not reported, generate the concentration-response curve from the data provided and calculate the ECx. As a last resort, use the lowest observed adverse effects level rather than the ECx and do not divide by any uncertainty factors.
e) If data are available from more than one study for an organism of concern, use the lowest ECx.
f) Use information for the contaminant of concern from any test (*e.g.*, bioassay, laboratory, field study) conducted with the organisms under consideration, if available.
g) If the organism of concern has not been tested, use the most closely related (phylogenetically) organism. Carefully consider the phylogenetic histories of the test species compared to the organisms of concern and consider any drawbacks to extrapolating between species.

For birds and mammals:

2. use EC_{20};
3. give preference to those in the same feeding group;
4. give preference to feeding studies (not single dose studies, or injection studies), particularly of weeks to months in duration;
5. if you have data from similar animals (*e.g.*, rodent data to compare with rodents or duck data to compare to other waterfowl), do not use any uncertainty factors. If your animals are not so closely related, divide the value by 10;
6. if the ONLY data available for any animal species are from injection or oral dosing studies, convert the dose to concentration in food, assuming an average body weight (bw) for the species and an average food consumption rate. Food consumption may be estimated from the following equations:

   $F = 0.621\ (bw)^{0.564}$ (*rodents*)

   $F = 0.577\ (bw)^{0.727}$ (*mammalian herbivores*)

   $F = 0.235\ (bw)^{0.822}$ (*other mammals*)

   $F = 0.398\ (bw)^{0.850}$ (*song birds*)

$F = 0.648 \, (bw)^{0.651}$ (*other birds*)

For plants:

7. use EC_{20};
8. if extrapolating within the same Family, do not use any uncertainty factors;
9. if extrapolating to another Family, divide by 2;
10. if extrapolating to another Order, divide by 20;
11. if extrapolating to another Class, divide by 500.

For soil invertebrates:

12. use EC_{20};
13. use whatever data are available without adjustments.

For aquatic organisms (algae, invertebrates, and fish):

14. use EC_{20};
15. use species from same class, teleost (ray finned fish) is typical. Agnatha (jawless fish) and Chondricithyes (sharks and rays) have very different biochemistries, especially in regards to PCBs and other estrogenic compounds;
16. that are pelagic invertebrates, use species similar to organism of concern, although most of the data will be on daphnia;
17. use test species with similar routes of exposure as the organism of concern. Sediment tests conducted to estimate the toxicity of a burrowing worm should use burrowing organisms as the test organism. Filter-feeding mollusks should be the organism of choice when estimating mussel or oyster sensitivity;
18. aquatic phytoplankton are represented by single species algal toxicity tests and many kinds of test organisms are available;
19. aquatic macrophytes are represented by Lemma (duckweed) although a number of new methods are under development;
20. give preference to tests conducted during a significant portion, or the most sensitive portion, of the test organism's lifespan.

Attach a list of the selected ECx with the appropriate references. Structure the list in the following format:

Organism of Concern	Test Organism	Measurement (reproduction, mortality, etc.)	Endpoint (LOAEL ECx)	Uncertainty Factor	Value	Dry Weight or Wet Weight	Reference

Top

7.3 Exposure Assessment

Purpose: To determine the concentration in media (food, water, soil, etc.) of pollutants of concern to which the plants and animals of concern are actually exposed and to demonstrate how the plants and animals came in contact with the contaminated media.

For plants and animals to be at risk from pollutants, the compounds must exist in the environment at concentrations above the toxicity reference values and the plants or animals must come in contact with the contaminated media. This section describes an appropriate sampling of the site to understand the magnitude and spatial extent of any contamination. The answers to the series of questions that follows will help determine pertinent life-history patterns of the plants and animals on site to determine if, when, and for how long they may come in contact with the contaminated environment. *Note:* All environmental sampling should be conducted in cooperation with the human health effects assessment to reduce the need to sample the same area twice. Coordination between the two processes should take place at this time.

7.3.1 Exposure Patterns of Plants and Animals

Plants and animals must come in contact with a contaminant in order to be considered at risk. This section helps determine the potential for organisms on the site to come in contact with contaminated media. Note that it is assumed that only plants may be directly affected by contaminated groundwater. Other organisms are potentially at risk only if the groundwater contaminates surface water, is used for irrigation or used for livestock watering.

7.3.1.1 Plants

All plants on the site are assumed to be exposed to contaminated soil, as their roots have the potential to take up materials out of the soil. Deep-rooted plants also may contact contaminated groundwater. Rooted aquatic plants (also called macrophytes) such as cattails, rushes, or salt grass take up contaminants from the water column (through their leaves) as well as by their roots from sediment. Non-rooted aquatic plants (*e.g.*, duckweed, waterlilies) also take up contaminants from the water column through their leaves. Therefore, exposure to plants should be assumed, unless the contamination is present only during the dormant period of the year (winter, for most plants, if the ground freezes).

7.3.1.2 Soil Invertebrates

All soil invertebrates (such as earthworms, centipedes, and beetles) are considered exposed through ingestion of soil or movement of contaminant across their skin. Therefore, exposure to soil invertebrates should be assumed, unless the contamination is present only during the dormant period of the year (*e.g.*, when the ground is frozen).

7.3.1.3 Birds

Birds are exposed only if they eat soil invertebrates or plants (leaves or seeds) that are on the terrestrial portion of the site, or if they eat aquatic invertebrates or fish from a contaminated water source. In addition, it is assumed that most birds consume some soil or sediment along with the actual foodstuff and may get additional contamination from this route.

Birds may not feed on the site for their entire life. Many birds leave the area during the winter and so have the potential to be exposed only during the late spring, summer, and early fall. In addition, if the site is small or the only vegetation present is along the edge of the site, then birds are likely to get some of their diet off-site.

Therefore, the following habits of the birds that may use the site must be known:

a) proportion of the year that the bird resides in the area,

b) proportion of total foraging area provided by the site, and

c) composition of diet (seeds, leaves, invertebrates and/or soil).

7.3.1.3.1 Residency

For each bird on the site-specific checklist (see Section 7.1.1.2.2), indicate whether the bird is a year-round resident (YR), summer resident (SR), or winter resident (WR).

☐ **Bird list annotated**

7.3.1.3.2 Foraging Area

See Appendix J for a list of references containing information about bird foraging areas. For each bird that may use your site, indicate on the site-specific checklist whether its foraging area is greater (G) or smaller (S) than the size of the site. If foraging area information is not available, use information about territory size. If no information is available, assume that the foraging area is equal (E) in size to the site.

Bird list annotated

7.3.1.3.3 Diet

Refer to Appendix J for a list of references on dietary preferences of birds.

For each species present on the site list the dietary composition in a table such as the following:

Feeding Group	% Seeds	% Other Plant Material	% Soil Invertebrates	% Aquatic Invertebrates	% Fish	% Other (specify)	% Soil (assume 2%)	TOTAL (100%)
							2	100
							2	100

7.3.1.4 Mammals

Mammals are exposed only if they eat soil invertebrates or plants (leaves or seeds) that are on the terrestrial portion of the site or if they eat fish from a contaminated water source. In addition, it is assumed that most mammals consume some soil or sediment along with the actual foodstuff and may get additional contamination from this route.

7.3.1.4.1 Residency

Some mammals hibernate during the winter and are exposed only during the spring, summer, or fall. If the site is small or the only vegetation present is along the edge of the site, then mammal are likely to get some or all of their diet off-site.

Therefore, the following habits of the mammals using the site must be known:

a) whether the animal hibernates,

b) proportion of total foraging area that is provided by the site, and

c) composition of its diet (seeds, leaves, invertebrates and/or soil).

For each mammal on the site-specific checklist (see Section 7.1.1.2.3), indicate whether or not it hibernates (H)

Mammal list annotated

7.3.1.4.2 Foraging Area

See Appendix K for a list of references containing information about mammal foraging areas. For each mammal that may use your site, indicate on the site-specific checklist whether its foraging area is greater (G) or smaller (S) than the size of the site. If foraging area information is not available, use information about territory size. If no information is available, assume that the foraging area is equal (E) in size to the site.

Mammal list annotated

7.3.1.4.3 Diet

Refer to Appendix K for a list of references on dietary preferences of mammals.

For each species present on the site list the dietary composition in a table such as the following:

Feeding Group	% Seeds	% Other Plant Material	% Soil Invertebrates	% Fish	% Other (specify)	% Soil (assume 2%)	TOTAL (100%)
						2	100
						2	100

7.3.1.5 Aquatic Invertebrates

Use the following rules to determine exposure:

a) Planktonic invertebrates are exposed to toxicants primarily by the absorption from the water column, although ingestion is an additional route.

b) Aquatic insects can be exposed through the water column, sediment, or ingestion of plant material or other insects.

c) Clams and other shell fish are exposed through the water column and this will be the primary route for water-soluble materials. Ingestion is the main exposure pathway for materials bound to particulates or that bioconcentrate in plankton.

7.3.1.6 Fish

Fish have 100% exposure to the water column. However, lifestyle determines exposure to the sediment. Flatfish or other bottom dwellers and borrowers are exposed to the interstitial water concentration of the sediment so that should be used as an exposure pathway instead of water concentration. Higher trophic level fish (such as some of the salmonids) also are exposed by eating smaller fish with contaminants in their tissues.

7.3.2 Environmental Concentrations

The following sections describe how to collect various media for determining the concentration of the contaminants of concern and provides guidance on how to select appropriate analytical chemistry methods.

7.3.2.1 Selection of Media

To determine which media to sample, refer to the Conceptual Site Model diagrams and to the dietary composition tables for birds and mammals (sections 7.3.1.3.3 and 7.3.1.4.3) to help answer the following questions. The goal is to sample food eaten by birds, mammals, and fish as well as the contaminated soil and/or water. In addition, if groundwater contamination is of concern (either due to drainage to surface waters or because of uptake by plant roots), groundwater should be sampled to describe the direction, extent and concentration of the plume. Answers to the following questions will help determine which media to sample.

a) Are there terrestrial plants or animal receptors of concern?

- [ ] No. Skip to question b)

- [ ] Yes. Take the following samples:

soil (Section 7.3.2.4)
plants (Section 73.2.5)
soil invertebrates (Section 7.3.2.6)
foliar invertebrates (Section 7.3.2.7)
small mammals (Section 7.3.2.7)

b) Are there aquatic plants or animal receptors of concern (fish, shellfish, birds, mammals)?

- [ ] No. Skip this question.

- [ ] Yes. Take the following samples:

groundwater (Section 7.3.2.9)
surface water (Section 7.3.2.10)
sediment (Section 7.3.2.10)
aquatic invertebrates (Section 7.3.2.11)
fish (Section 7.3.2.11)
aquatic plants (Section 7.3.2.12)

7.3.2.2 Sampling Design

The number of samples taken should be sufficient to characterize all different parts of the site. This will vary depending on the site size. More detail is provided in each media sampling section. Note that the goal is to provide sufficient data to use the techniques in Risk Quotient Calculation (Section 8.1.1.3). These techniques require a spatially explicit approach to chemical concentration. Refer to the following text for more detailed discussion of environmental sampling designs.

Gilbert, R.O. 1987. *Statistical Methods for Environmental Pollution Monitoring*. Van Norstrand Reinhold, New York, New York.

7.3.2.3 Analytical Chemistry

All environmental media samples should be submitted for chemical analysis as soon as possible. Keep samples cool (< 10° C) between time of collection and analysis. Be sure to specify whether the results should be reported as dry weight (dw) or wet weight (ww) concentrations. The measurement units of these results should be comparable to the measurement units of the toxicity reference values selected in Section 7.2.3. Asking the laboratory to report percent moisture will provide flexibility for converting between wet weight and dry weight at any time. Soil and water pH, soil organic carbon, and water hardness should also be requested from the testing laboratory at the time of sample submission. See Appendix L for a list of analytical chemistry laboratories in British Columbia.

7.3.2.3.1 Methods

A variety of methods exist for sample analysis. The method chosen depends on the media being analyzed (soil, water, biota), the required precision and accuracy, and the required level of detection. See Appendix M for a list of methods available Consult with your analytical laboratory on their preferred method. List the method(s) used in the following table:

Media	Chemical	Method	Detection Limit (dw or ww)	No. of Site Samples	No. of QA/QC Samples
soil					
water					
etc.					

7.3.2.3.2 Detection Limits

Detection limits should be set at 0.1 times the lowest toxicity reference value for organisms exposed to each media, unless current methodology precludes doing so. Include the detection limits in the above table.

7.3.2.3.3 Quality Assurance/Quality Control (QA/QC)

A trip blank, a spike, and a split sample must be included with at least every 20 site samples. Include the number of QA/QC samples in the above table.

See the British Columbia Field Sampling Manual, 1996 edition for a more complete discussion of QA/QC. Data quality objectives (DQOs) are formal data quality specifications, which must be tabulated within a quality assurance manual. These DQOs establish the maximum amount of error allowed for the data to meet its specified use. The DQOs should be established before sample collection to avoid situations where resources are spent collecting samples which do not fit the DQOs. Once DQOs are established and sampling has begun, regular performance checks are performed to verify that the DQOs are satisfied. Corrective action must be taken when DQOs are not met. Out-of-control events and actions must be recorded.

It is highly recommended that before implementing any environmental samples, all monitoring/sampling plans be approved by BCE. Remember to coordinate with the human health effects risk assessment sample collections.

7.3.2.4 Soil Sampling

When collecting samples, observations on the appearance and abundance of soil organisms can be recorded as additional information. This information can serve as anecdotal evidence in Tier 1 or 2 EcoRAs.

7.3.2.4.1 Number and Spatial Distribution

At least three sample points should be taken in each different area of the site (*e.g.*, grass-covered, bare ground, under vegetation). If there are suspected point source(s) of contamination, a greater number of samples should be taken near the source with diminishing numbers forming concentric rings outward. Additional samples should be taken in any down-gradient area (downwind or downslope).

It may be necessary to take samples off-site to completely characterize the extent of a gradient. One option is to characterize the site first and return for additional off-site sampling if a gradient is not completely defined.

Number of samples:

Show sample locations on the site map

☐ **Map attached**

7.3.2.4.2 Depth

Composite samples should be taken at 0 to 15 cm depth for characterization of plant exposure. However, for sandy soil (*e.g.*, Fraser River sand), take a soil sample at 0 to 50 or 70 cm depth. Optional: Deeper cores into various soil strata can be taken to characterize current and potential migration of contaminants.

Number of samples taken at 0 to 15 cm depth:

Number of samples taken at deeper depth:

Depth: cm

Number:

Label all sample locations on the site map with the sampling depth.

☐ **Map labelled**

7.3.2.4.3 Methods

Samples may be collected using either a soil corer or a trowel for surface samples and with appropriate coring devices for deeper samples.

If contaminants of concern are metals or metalloids, use only plastic trowels and corers. Samples should be packaged in plastic bags and stored under cool conditions until analyzed. Decontaminate sampling device between each sample.

☐ contaminants are metals/metalloids - use plastic devices

If contaminants of concern are organic compounds, use only metal sampling devices. Store samples in glass containers and keep cool until analyzed. Decontaminate sampling device between each sample.

☐ contaminants are organic compounds - use metal and glass devices

See Appendix N for references for specific soil collection methods. List which methods were used.

☐ **List of methods attached**

7.3.2.5 Terrestrial Plant Sampling

7.3.2.5.1 Number and Spatial Distribution

At each soil sample location, collect a vegetation sample (if vegetation is present).

Collect grass, shrubs, and tree leaves separately at each location. Collect at least 50 grams of each.

Number of plant samples taken:

Grass: ____________________

Shrubs: ____________________

Tree leaves: ________________

Label all sample locations on the site map with the depth of sampling. Note which types of vegetation samples were collected at each sample point.

☐ **Map labelled**

7.3.2.5.2 Methods

Samples are collected using either metal or plastic scissors.

If contaminants of concern are metals or metalloids, use plastic scissors. Samples should be packaged in plastic bags and stored under cool conditions until analyzed. Decontaminate scissors between each sample.

☐ contaminants are metals/metalloids - use plastic devices

If contaminants of concern are organic compounds, use only metal sampling devices. Store samples in glass containers and keep cool until analyzed. Decontaminate sampling device between each sample.

☐ contaminants are organic compounds - use metal and glass devices

See Appendix G for reference for specific plant collection methods.

7.3.2.6 Soil Invertebrates

When collecting soil samples, remove to a separate sampling container any invertebrates (*e.g.*, earthworms, centipedes, beetles) found in the soil. These may be taken from the same sample that will be analyzed for soil chemistry or may be taken from a separate sample collected adjacent to the core collection site.

Invertebrates are separated from the soil either by picking them out with tweezers or by passing the soil through a small diameter sieve. Collect all the invertebrates in the sample or 50 grams, whichever is the least.

If contaminants of concern are metals or metalloids, use plastic tweezers. Invertebrates should be packaged in plastic bags or glass containers and stored frozen until analyzed.

☐ contaminants are metals/metalloids - use plastic devices

If contaminants of concern are organic compounds, use metal tweezers. Invertebrates should be packaged in glass containers and stored frozen until analyzed.

☐ contaminants are organic compounds - use metal and glass devices

Label all sample locations on the site map where invertebrates were found.

☐ **Map labelled**

7.3.2.7 Foliar Invertebrate Sampling

Use sweepnets to collect foliar invertebrates. Sweepnetting can be done at midday by walking throughout each sampling site sweeping the net in a figure 8 pattern through available vegetation. At least 50 sweeps should be done at each location using the same number of sweeps each time at each location.

If contaminants of concern are metals or metalloids, use plastic tweezers to remove the invertebrates from the net. Invertebrates should be packaged in plastic bags or glass containers and stored frozen until analyzed.

☐ contaminants are metals/metalloids - use plastic devices

If contaminants of concern are organic compounds, use metal tweezers. Invertebrates should be packaged in glass containers and stored frozen until analyzed.

☐ contaminants are organic compounds - use metal and glass devices

Label all sample locations on the site map where sweeps were conducted and which ones netted invertebrates.

☐ **Map labelled**

7.3.2.8 Small Rodent Sampling

Before collecting any small rodents check with the local (to the site) Fish and Wildlife Manager in the Regional British Columbia Ministry of the Environment Office about whether trapping permits are required. Personnel should wear protective clothing to reduce the potential for transmission of diseases from rodents to humans (*e.g.*, disposable rubber gloves and outer garments that are either disposed of or washed after being used in the field).

Set snap traps (*e.g.*, Victor® mouse traps or Museum Specials®) baited with peanut butter or other suitable material either in areas likely to harbor rodents, in a grid across the entire area, or in a grid across the most contaminated area. Traps should be spaced no more than 15 m apart. Traps should be set in the evening and checked at dawn. Refer to the following reference, or equivalent, for more details on trapping methods.

Schemnitz, S.D. 1980. *Wildlife Management Techniques Manual, 4th Edition*. The Wildlife Society, Inc., Washington, D.C.

Place all collected animals in plastic bags that are labeled, sealed, and stored on wet ice or other cool location for transport to the analytical laboratory.

Label all locations on the site map where traps were placed AND where small mammals were captured.

☐ **Map labelled**

7.3.2.9 Groundwater Samples

7.3.2.9.1 Number and Spatial Distribution

Groundwater sampling should be conducted in a manner that will illustrate the amount of chemical currently in the groundwater aquifers, both under the site and downgradient off-site. Sufficient number of samples should be taken to define the boundaries of any plume of contamination.

During all drilling, appropriate care should be taken not to penetrate any barriers that prevent the movement of surface water into deeper aquifers. Otherwise, previously uncontaminated groundwater may become contaminated solely as a result of the sampling process.

A minimum of 10 samples is required to find the general location of potential plumes of contamination. This may have been done during the initial site assessment, in which case this portion of the risk assessment can immediately focus on better defining the plume.

Once a general area of contamination is identified, a sufficient number of groundwater samples must be taken to define the boundaries of the plume, particularly its extent downgradient. The number of samples required to do this will depend on the plume size.

7.3.2.9.2 Methods

If contaminants of concern are metals or metalloids, use plastic sampling devices (with the exception of metal tipped drills, if needed). Samples should be stored in glass or Teflon-lined jars and stored under cool conditions until analyzed.

- [ ] contaminants are metals/metalloids - use plastic devices

If contaminants of concern are organic compounds, use only metal sampling devices. Store samples in glass containers and keep cool until analyzed.

- [ ] contaminants are organic compounds - use metal and glass devices

Refer to Appendix N for detailed methods for groundwater sampling. List which methods were used.

- [ ] **List of methods attached**

7.3.2.10 Surface Water and Sediment Sampling

When collecting samples, observations on the appearance and abundance of sediment organisms can be recorded as additional information. This information can serve as anecdotal evidence in Tier 1 or 2 EcoRAs.

7.3.2.10.1 Number and Spatial Distribution

Use a sufficient number of samples to characterize the surface water variability so that a spatially explicit model can be used in calculating risk values (see Section 8.1.1.3.2).

7.3.2.10.2 Methods

Refer to Appendix N for detailed methods for surface water and sediment sampling. List which methods were used.

☐ **List of methods attached**

7.3.2.11 Fish and Aquatic Invertebrate Sampling

7.3.2.11.1 Number and Spatial Distribution

The fish and aquatic invertebrate sampling should occur concurrently with the chemical sampling. It is important the samples be taken at the same location and at the same time as much as is possible. This approach to sampling will facilitate the calculation of risk values as delineated in Section 8.1.1.3. *Permits are required for the collection of fish and other aquatic species. Proponents are advised to contact their local office of the Department of Fisheries and Oceans and BC Environment for specific permit requirements.*

7.3.2.11.2 Methods

Refer to Appendix N for detailed methods for sampling of fish and aquatic invertebrates. List which methods were used.

☐ **List of methods attached**

7.3.2.12 Aquatic Plant Sampling

7.3.2.12.1 Number and Spatial Distribution

Sampling strategies for aquatic plants depend on the type of plant and the planned use of the data. Aquatic plants can be divided into two main types according to whether the plants are physically attached to the sediments (*i.e.*, rooted plants) or whether they float on the water (*i.e.*, floating plants). Plant tissue sampling is conducted to address risks to herbivores (animals that eat the plants), but can also be conducted to address risks to the plants themselves if the appropriate effect data are available. Therefore, be sure to collect samples from each type of plant that is an important food for animals or that is desired for its own sake. Collect stems, roots and leaves, as these parts are edible for many aquatic plants.

To properly address spatial issues, the pattern of contamination in the receiving environment (sediment or water) must contain some gradient (*i.e.*, is not homogeneous). For example, there is no benefit in sampling duckweed (a floating plant) along with water samples if no contaminant gradient exists in the water. A spatially explicit sampling program, however, should always be considered for rooted plants when addressing which areas of the aquatic portion of the site might require remediation. The number and spatial distribution of samples for a spatially explicit sampling program is driven by the scale of the contamination gradient.

7.3.2.12.2 Methods

Sampling methods for aquatic plants are the same as those described for terrestrial plants (Section 7.3.2.5).

This completes the Analysis Phase. Go to Section 8 to put all the information together into a Risk Calculation.

Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia - Chapter 8. Risk Calculation

8.0 RISK CALCULATION

Purpose: The Risk Calculation uses information from the exposure and effect analyses to determine a probability of an adverse effect to the plant or animal of concern.

Risk calculation finalizes the assessment process. This phase proceeds through three critical steps:

1. calculation of the risk estimate,
2. description of the uncertainty associated with this estimate, and
3. presentation to the risk manager (BCE) of the risk estimate and supporting information in an understandable manner.

8.1 Risk Estimate

Two means of risk integration are available to estimate risk:

a) the *quotient method*, which is based on a comparison of the exposure estimate and the toxicity threshold value
b) the *site observation method*, which is based on site-specific observed toxicological and/or ecological effects and site-specific bioassay results

Both methods will be used in this guidance, with site observations used to substantiate or refute the presumption of risk developed by the quotient method. The result of this analysis is a qualitative risk assessment that clearly identifies the following two groups of sites:

a) those sites with low environmental risk that do not need further review or remediation
b) those sites with a high environmental risk that warrant remedial action

Intermediate cases (with moderate environmental risk) may require further investigation and analysis, after consultation with BCE.

8.1.1 Introduction to the Quotient Method

The risk quotient (RQ) for each combination of contaminant and receptor (plant or animal) of concern is calculated by dividing the estimated environmental concentration (EEC) by the toxicity reference value (TRV):

$$RQ = \frac{EEC}{TRV}$$

We use this type of model as the basis for examining risk in Section 8.1.1.3. This basic equation requires two factors, the EEC and the TRV. Guidance on determining each factor is presented below.

8.1.1.1 Estimated Environmental Concentration (EEC)

The estimated environmental concentration (EEC) is determined from the values measured in the various media during the exposure assessment. Choose the appropriate values according to the following rules:

a) Preference is given to values measured in the exposure medium of the organism of concern.
b) If any or all of these measurements are missing, use the exposure modeling approach.

8.1.1.1.1 Exposure Estimate from Measured Concentrations

a) For terrestrial plants and soil invertebrates, use soil values.
b) For rooted aquatic plants, use sediment values.
c) For bottom-dwelling aquatic invertebrates, use sediment concentrations.
d) For fish, use water concentrations.
e) For livestock, use the values in feed and forage in the same ratio in which they are fed. If there is a portion of time when they eat only feed or are entirely on pasture, use the foodstuff with the highest concentration. Calculate TOTAL dietary concentration (food + water) as described below for wildlife.
For terrestrial wildlife, calculate contamination from food and drinking water using the following directions.

Food:

Calculate the dietary food concentration by adding the values in soil, plants, or animal food items in ratios that correspond to the ratio of these items in their diets (see Exposure Analysis section). The table below is an example.

organism	**% seeds**	**% other plant material**	**% soil invert.s**	**% aquatic invert.s**	**% fish**	**% other (specify)**	**% soil (assume 2%)**	**Total**
deer mouse	15	22	61	0	0	0	2	100
contaminant	**seed conc.**	**plant material conc.**	**soil invert.s conc.**	**aquatic invert.s conc.**	**fish conc.**	**other (specify) conc.**	**soil conc.**	
chemical of concern (ppm)	50	50	225	N/A	N/A	N/A	100	

Note: As a general rule, chemical concentration in seeds is approximately the same as in leaves

The chemical concentration in the food for this example is calculated as follows:

dietary food concentration = (seed chemical concentration X % seeds of diet) + (plant chemical concentration X % plant material of diet) + (soil invertebrate chemical concentration X % soil invertebrates of diet) + (soil chemical concentration X % soil of diet)

With the substitution of the numerical values this becomes:

dietary food concentration = (50 X 0.15) + (50 X 0.22) + (225 X 0.61) + (100 X 0.02)

= 158 ppm

The specifics will change depending upon the diet of the specific animal.

Drinking Water:

If a contaminated body of fresh (stream, lake, pond) or irrigation water is included in this risk assessment, assume that terrestrial wildlife use it as a drinking water source. Calculate the TOTAL dietary concentration (food plus water) using the following rules:

1. If water concentration is less than 1% of the food concentration, skip this section.
2. If water concentration is greater than 1% of food concentration then continue. Use *one* of the two methods listed below.

Method #1: Assume that the amount of water and food consumed are equal. This is a conservative assumption, as most animals drink a smaller amount than they eat.

Add the concentration in the food plus the concentration in the water for the TOTAL dietary concentration.

Example:

dietary food concentration = 158 ppm

water concentration = 10 ppm

TOTAL dietary concentration = 158 + 10 = 168 ppm

Method #2: Calculate the ratio of food to water consumption.

Step 1: Find average food and water consumption rates for the species of concern in the literature. See Appendix J and K for some suggested references.

☐ **Attach list of references used**

OR

Use the appropriate equations from the following list to estimate the amount of food and water consumed, where F = kg of food, W = Liters of water and bw = body weight (in kg). Use the average body weight of the species of concern.

Food

F = 0.621 $(bw)^{0.564}$ (*rodents*)

F = 0.577 $(bw)^{0.727}$ (*mammalian herbivores*)

F = 0.235 $(bw)^{0.822}$ (*other mammals*)

F = 0.398 $(bw)^{0.850}$ (*song birds*)

F = 0.648 $(bw)^{0.651}$ (*other birds*)

Water

W = 0.099 $(bw)^{0.90}$ (*mammals*)

W = 0.059 $(bw)^{0.67}$ (*birds*)

Food Consumption: ______________ kg

Water Consumption: _____________ Litres

Step 2: Next calculate the ratio of food and water consumption, with food always equal to 1.0:

Food (kg) : Water (L)

Example: 0.05 kg : 0.025 L Ratio = 1:0.5

Example: 0.03 kg : 0.01 L Ratio = 1:0.33

Ratio: ___1.0___ : _________

Step 3: Last, calculate the TOTAL dietary concentration by adding the Dietary Food and Water concentrations in the appropriate ratio.

Example: (Dietary Food Conc. X 1.0) + (Water Concentration X 0.5)

(158 X 1) + (10 X 0.5) = 163 ppm

Example: (Dietary Food Conc. X 1.0) + (Water Concentration X 0.33)

(158 X 1.0) + (10 X 0.33) = 161 ppm

TOTAL Dietary Concentration = __________ ppm

8.1.1.1.2 Estimating Exposure With a Simple Food chain Model

For contaminants of concern that bioaccumulate, a food chain model is used to estimate the tissue concentration of the toxic material within the organism, if the concentration of a contaminant of concern was not measured in the food of an animal of interest. A step by step description of how to use a simple food-chain model follows.

a) List the endpoint receptors. For fish, mammal and bird receptors, do b). For invertebrates, skip to c).

b) Determine the Kow for the organic contaminant(s) of concern using scientific literature or QSAR. If your organic contaminant of concern is not a methyl mercuric chloride compound and your Kow is less than 3.5, bioaccumulation is not a concern. Therefore it is not necessary to complete this worksheet. If the Kow of your contaminant is equal to or greater than 3.5, or if your contaminant is a mercuric chloride or other metal or metalloid compound, proceed to c).

Kow: ____________________________________

Reference: ________________________________

c) Using your conceptual model, outline the potential exposure pathway from the contaminated media through the food chain to the endpoint receptor. Complete a separate pathway for each endpoint receptor and each contaminant of concern.

d) Assign a number to each trophic level in the food chain (for each exposure pathway) using the following four criteria:

Level 1: autotropic organisms (e.g., plants), microinvertebrates, macroinvertebrates and zooplankton.

Level 2: organisms that feed on level 1 organisms

Level 3: organisms that feed on level 2 organisms

Level 4: organisms that feed on level 3 organisms

Attach pathway diagrams *(Hint: Use conceptual site model diagrams whenever possible). A copy of the diagram and the assumptions should be provided to BCE for review.*

e) Using information from the literature (see Appendix I for some suggested references), find BAF or BCF values for the trophic levels identified in your pathway diagram.

- The BCF is the ratio of the amount of chemical in the tissue of an organism (plant or animal) to the amount in the water in which it is exposed. It assumes that the only exposure comes from the water.

$$\text{BCF} = \frac{\text{Tissue Concentration}}{\text{Water Concentration}}$$

- The BAF is the ratio of the amount of chemical in the tissues of an organism (plant or animal) to the amount in all exposure media (water, food, soil, etc.).

$$\text{BAF} = \frac{\text{Tissue Concentration}}{\text{Food and Water Concentration}}$$

- Note that BAFs and BCFs will be different for each trophic level.

i) For level 1, the BAF for terrestrial systems will be:

concentration in plants / concentration in soil

ii) The BAF for the second tropic level, will be:

concentration in herbivore / concentration in plant = concentration in herbivore X BAF_1 etc.

for the remaining trophic levels of interest

Attach list of BAFs and BCFs for each trophic level of interest. Include references for where each value was obtained.

f) Calculate the concentration of the contaminant of concern in the food of each receptor of concern by multiplying the soil (or water) concentration by the appropriate BAFs (or BCFs). Note that if you are interested in the risk to a Level 3 organism, you need to know only the Level 1 and Level 2 BAF (or BCF). In other words, the concentration of contaminant in the food of a $Level_x$ organism = soil X BAF_1 X BAF_2 X BAF_{n-1}:

Concentration in food item (terrestrial):

(a) BAF_1 X soil concentration = estimated concentration of an herbivore (plant-eaters) diet (**Level 2 organism**)

(b) BAF_2 X plant concentration = estimated concentration in the diet of an insectivore or carnivore (**Level 3 organism**).

OR

BAF_2 X (BAF_1 X soil concentration) = estimated concentration in carnivore diets

(c) BAF_3 X concentration in Level 3 organism = estimated concentration in diet of a **Level 4 organism** (a carnivore that eats other carnivores).

OR

BAF_3 X BAF_2 X BAF_1 X soil concentration = estimated concentration in diet of secondary carnivores (Level 4 organism)

Concentration in food item (aquatic):

(d) BAF_1 X water concentration = estimated exposure concentration for small fish (**Level 2 organism**)

(e) BAF_1 X sediment concentration = estimated concentration in diet of birds and fish eating bottom dwelling invertebrates (**Level 2 organisms**)

(f) (BAF_2 X estimated small fish or aquatic invertebrate concentration) + (BAF_1 X water concentration) = estimated exposure concentration for carnivorous fish (**Level 3 organisms**)

(g) (BAF_3 X estimated carnivorous fish concentration) = estimated exposure concentration for large carnivorous fish or fish-eating birds and mammals (**Level 4 organisms**)

<u>Calculate the concentration in each food item as described above</u>

☐ **Food concentration calculations worksheet attached**

8.1.1.2 Toxicity Reference Value

Use the values developed in Sections 3.2.3, 4.2.3, 5.2.3, 6.2.3, and 7.2.3 (Toxicity Reference Values) for the species of concern on your site.

8.1.1.3 Risk Calculation

Calculate the Risk Quotient for each species of concern on the site for each of the chemicals of concern, using one of the methods described below. The methods are presented in order of preference.

8.1.1.3.1 The Curve Model

The curve model (Freshman and Menzie 1996) is used to describe the risk to wildlife that forage over the contaminated site. The model is based off of grids or areas of sampling in the site map. If the organisms are sessile, then the model reduces to the spatially distinct risk quotient calculation presented in Section 8.1.1.3.2. Freshman and Menzie (1996) present the entire derivation and an adapted step by step progression is presented below (Figure 8-1). We recommend that the calculations be conducted using a computer spreadsheet and a linked graph.

Freshman, J.S. and Menzie, C.A. 1996. Two wildlife exposure models to assess impacts at the individual and population levels and the efficacy of remedial actions. *Human Health and Ecological Risk Assessment*. 2(3):481-498.

a) Plot the first data point as the highest environmental concentration for a site (c_1) by its associated area (a_1).

b) Plot the next data point as the average concentration for the two highest contaminated areas (c_1 + c_2)/2 versus the associated area (a_1 + a_2).

c) Plot additional data points by progressively including lesser contaminated areas until the entire site is included.

d) Add to the graph horizontal lines that represent the ECx values appropriate for the particular land use and the species involved.

e) Plot the foraging area of the organism as a vertical line.

f) Compare the intersection of the area line to the line representing the average environmental concentration. If this intersection is below the horizontal line representing the EC_x , then the risk is low. If the intersection is above the EC_x line, then the risk is above the cut-off limit for effects.

An additional use of this approach is that it can be used to estimate clean up goals. A clean up would ensure that the intersection of the concentration curve is below the EC_x value for the proposed land use. As sites or concentrations are proposed for clean-up, the model can be computed to examine the intersection of the foraging area with the EC_x value. Decisions can then be made to clean up sites with a few very contaminated areas versus sites that are not as contaminated by are of a larger surface area. Such a plan can be used in the mitigation section of the final report.

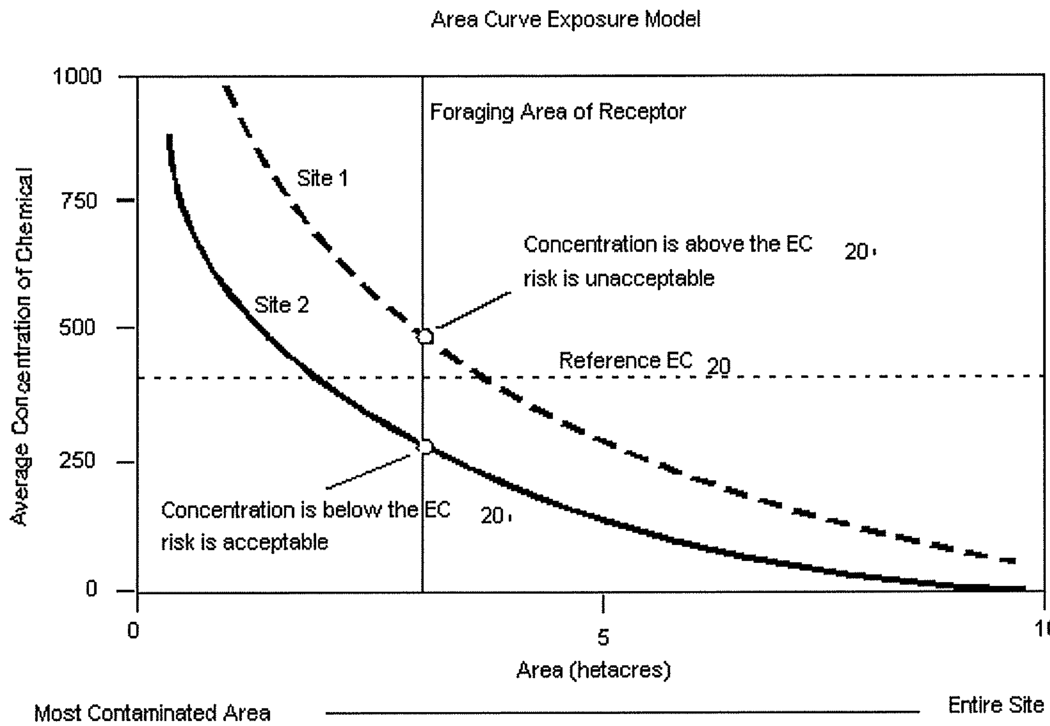

Figure 8-1. Curve Exposure Model. Site 1 exceeds the EC20. Site 2, with a slightly different average concentration curve is now below the EC20 when it crosses the size of the foraging area.

8.1.1.3.2 Spatially Distinct Risk Quotients

RQs should be calculated using the equation from 8.1.1 for each site that an environmental sample was collected, for each plant or animal species of concern. The RQs should be plotted on the site map in order to determine if there are areas where risk is high (RQ > 100), areas of low risk (RQ < 1) or areas of intermediate risk (1 < RQ < 100). If several samples were taken in close proximity to each other, use the average concentration and plot it as a single value at that location.

The *probability* of exceeding an RQ of 1 (or 100) anywhere on the site can also be estimated from this information by:

$$\frac{\text{Number of RQs} > 1 \text{ or } 100}{\text{Total number of RQs}} \times 100$$

NOTE: RQs calculated for different species should NEVER be added together, as they are not equivalent values. However, the probability of exceedence will be an approximation of overall risk.

8.1.1.3.3 Single Risk Quotient Approach

A single RQ can be calculated for the site by using the 95% upper confidence limit (UCL) of the mean for all of the measured values for each medium or the maximum measured concentration, whichever is lowest. This will result in a conservative estimate of risk, particularly for a small site with relatively few environmental sampling points or a site with one or more small areas of high contamination.

Use the following reference for formulae for calculating UCLs:

Gilbert, R.O. 1987. *Statistical Methods for Environmental Pollution Monitoring*. Van Norstrand Reinhold, New York, New York.

It is recommended that this approach be used as a screening tool. If the RQ exceeds one, it is recommended that the spatially distinct RQs be calculated. If the RQ is less than one, the site can be categorized as "low risk" and there is no need to proceed further.

8.1.2 Site Observation Method

The Site Observation Method (SOM) develops a qualitative assessment of what actually is happening on the site to support or refute the more quantitative, but less site-specific, assessment developed through use of the Risk Quotient Method. Site observations and bioassay results are reviewed to determine if plants and animals of concern actually occur onsite and whether or not these plants and animals show any obvious signs of toxicity. Bioassay results can be used to determine whether plants or animals could live and reproduce in the media (soil or water) at the current level of contamination.

8.1.2.1 Site Observations

Information compiled during the site visit on plants (brown spots, dead areas of grass, etc.), fish, and wildlife use should be reviewed according to the receptors of concern or endpoints from the conceptual model. A brief description of observations should be provided, using the following questions as a guide:

a) Is vegetation present on the site?
b) Is there any evidence of phytotoxicity? (e.g., places were grass won't grow, brown leaves on trees during the time of year when others are green, etc.).

c) Is there any evidence that earthworms or other soil invertebrates are present? Throughout the whole site or only portion of the site?

d) Are there any invertebrates in the waterbody? Are the same numbers and types present upstream and downstream from the potential source of contamination?

e) What evidence is there that animals (expected fish or wildlife receptors) are present on the site? (e.g., observations of animals, tracks, dens, runways, etc.).

f) Does the area have habitat suitable for current or projected use for the plants, animals and invertebrates typical of the biogeoclimatic zone?

g) Is the habitat marginal, but can support reproducing populations?

h) Is the habitat so marginal that organisms may be present but are unlikely to form a breeding population?

i) What kind of habitat diversity are present on the site? (large patches of habitat, lots of small patches of unsuitable habitat, small or large pools in the stream, edge of pond covered with macrophytes, flowering plants isolated to the fence rows, etc.).

8.1.2.2 Bioassay Results

Include bioassay reports with the risk assessment. Summarize the findings, with particular attention to the following items:

a) What toxicity endpoints were measured?

b) At what concentrations of soil or water were toxic effects seen (e.g., 100% site soil, 50% site soil, 25% site soil, etc.)?

c) What is the slope of the dose-response curve?

d) Are there any plateaus or other deviations from a typical dose-response curve?

e) Which one(s) of the plant or animal receptors of concern are represented by the bioassay test species?

f) What are the phylogenetic relationships (evolutionary distance) between the test species and the receptors of concern? List all factors used for extrapolation.

g) Were the effluents or soils noticeably heterogeneous in composition of other physical properties?

BCE requires full reporting of the dose-response or concentration-response curve for all bioassays in addition to the ECx value and slope.

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8.2 Uncertainty Estimate

Uncertainty exits in every risk estimation, due to natural variability in environmental processes, sampling methods, and analytical techniques. The following items must be included in the risk assessment report:

- [ ] analytical detection limits

- [ ] analytical precision

- [ ] the range of any values used in dietary estimations (e.g., body weights, food consumption rates etc.)

- [ ] representativeness of test species

- [ ] environmental or ecological effects that may confound the site-specific observations (e.g., a cold late spring, reducing the amount of vegetation present; a hot dry summer so all grass has dried up and appears "dead", etc.)

- [ ] assumptions for the BAF, BCF determinations

- [ ] range of quotients, minimum, maximum as well as the mode for the quotients in a spatially heterogenous site

- [ ] uncertainties associated with the use of the quotient method

- [ ] uncertainties associated with the spatial and temporal distribution of the assessment endpoints

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8.3 Risk Characterization

Describe the interpretation of the data and analysis. If a risk quotient suggests that there might be risk to a receptor of concern (RQ>1), but that receptor is observed on-site without obvious signs of toxicant-induced stress (or the bioassay data suggest that it can survive in 100% site soil or water), give preference to the observed effects over the RQ estimation in your conclusion of risk. Include, at a minimum, a discussion of the following questions:

a) Which species are most likely to be at risk?

b) For which portion of a year is risk likely to occur?

c) Is the risk even over the entire area or are there "hot spots" of high risk?

d) How do the pollutants move from the site of release to the plants or animals of concern (surface water run-off, groundwater movement, foodchain uptake from soil, etc.)?

e) What is known about the ecology or biology of a species that appears to be at risk that may mitigate this risk?

f) What is known about the ecology, biology or behavior of the species that appears to be at risk that may enhance this risk?

g) Are some of the life stages of the organism put at more risk than others?

h) Should some of the species be of more concern because they create habitat or are a food source for a critical species of concern?

i) Where are data lacking for making an adequate risk estimation?

For each contaminant-receptor combination, provide a qualitative estimate of risk in the following format:

Contaminant of Concern	**Receptor of Concern (Endpoint)**	**Risk Quotient**	**Site Observations (none, few, many, toxic, healthy)**	**Bioassay Results**	**Risk Characterization (low, medium, high)**

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8.4 Reiteration of the T1 EcoRA

☐ Examine the uncertainties associated with the risk assessment and ascertain if they are acceptable for decision making (Consultation with BCE is strongly advised at this time).

☐ If the uncertainties are acceptable, then proceed to the final report, Section 8.5.

If the associated uncertainties are unacceptable, then proceed to Section 8.4.1.

8.4.1 Options for the Reduction of Uncertainty, Tier 1 EcoRA

4. Return to the Tier 1 EcoRA process with a list of the factors with high uncertainty.
5. Use the preferred technique whenever possible. These techniques are ordered by their ability to reduce uncertainty and to give specific answers.
6. Obtain exposure data specific for the organism or habitat in question. Use site-specific data rather than data generated by modeling or extrapolation. Data taken from the field has primacy over other types of information.
7. Obtain custom biomonitoring or *in situ* toxicity data. A direct measurement of toxicity is always preferred and reduces uncertainty. Biomonitoring data is useful in directly measuring the toxicity of outfalls, run-off or effluents. *In situ* toxicity data should be the most relevant for judging exposure and effects given the particular environment.

If the uncertainties are acceptable, then proceed to the final report, Section 8.5.

If the associated uncertainties are unacceptable, then proceed to Section 8.4.2, Tier 2 EcoRA.

8.4.2 Options for the Reduction of Uncertainty, Tier 2 EcoRA

A Tier 2 EcoRA is outside the scope of this guidance and requires detailed knowledge of risk assessment methods and analysis. Consultation with BCE is highly recommended before progressing to a Tier 2 EcoRA. In general a Tier 2 EcoRA requires a more detailed analysis of the site using more sophisticated sampling and risk calculation techniques. The following sections list the types of analyses that are typical of a Tier 2 EcoRA.

8. Use a specific conceptual model: The conceptual models outlined in this checklist are generic and a great deal of site specific research can be conducted to detail the area.
9. Conduct a detailed field study of the site. Field research can eliminate much of the uncertainty by obtaining specific data as to chemical concentrations, types of organisms inhabiting the area, and toxicity can be measured in detail using a variety of methods. Field studies are critical in obtaining appropriate data that can later be fed into exposure and food web modeling.
10. Use a detailed food web or other exposure model. The data obtained from the field study should allow a detailed reconstruction of food web. By examining numbers of organisms and the

concentration of chemical in their tissue, the rate of transfer and bioaccumulation can be determined rather than estimated. More detailed knowledge of the interrelationships of the plants and animals at a site will significantly reduce the uncertainty associated with the risk assessment.

11. Use a Monte Carlo model. Monte Carlo modeling uses information about distributions of exposure, effects, BCFs and other factors to generate a risk distribution. A great deal of information is required to produce a Monte Carlo output and expertise is necessary to correctly interpret the output.

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8.5 Risk Communication

The information generated during this risk assessment should be compiled into a report to BCE. Use this guide as a template for the report. Include all the worksheets from this guide and all maps, photos, and other attachments that were requested. The final section of the report should summarize the risk assessment by clearly stating the current and proposed use of the site, the ecological setting, the plant and animal species of concern, and the probable risk from all current or potential contaminants. Discussion of potential management or remediation alternatives is optional.

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8.5 BCE Report Requirements for T1 EcoRa

- BCE requires by policy the a minimum of one (1) implicit calculation for exposure (EEC), typically reported as an Appendix to the report, the other compounds can be provided in a table summary provided they used the same calculation methods. For substances with unique properties it is also suggested that full disclosure of the calculations and assumptions be provided. All dose response calculations for establishing TRVs must be provided.
- Risk assessors must provide their opinion of the significance of results generated with regard to confidence, uncertainty and impact significance.
- BC Environment requires that all sites with a risk assessment approach to remediation include a monitoring program be submitted to and agreed to by the Ministry. The ERA document should make it clear that proponents should draw on the results (risk estimates, risk management works, uncertainty) and assumptions (fate and transport, exposure variable) made in the risk assessment to establish such a program.

Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia - Appendix A. Introduction to the Conceptual Models

I. Introduction

The conceptual model is critical to the risk assessment process as it determines the receptors of concern which will ultimately drive the risk estimate. Since only a few receptors are chosen, these models serve to focus the assessment and streamline the process. Once the receptors of concern are chosen, exposure pathways to these receptors can be drawn from the established conceptual models. The exposure pathway may be directly from the contaminated media or through the food chain via bioaccumulation of the chemical. The arrows in each model indicate a possible exposure pathway.

II. Aquatic Conceptual Model

The conceptual model for the aquatic environments is generic in order to represent the basic functions of an aquatic ecological structure (Figure 1). The type of aquatic environment (e.g., freshwater, brackish water, or marine water) will be the primary determinant of what receptors may be present. For example, there will be primary producers present in both freshwater and marine systems but the type or species of primary producer will be different from marine waters to freshwater. There are two principal routes of exposure, groundwater and surface run-off into water and sediment. The potential exposure pathways are shown with light gray arrows since they will not be used in every type of site. Invertebrates, vertebrates, primary producers, macrophytes (algal and vascular), fish, birds and mammals are all included. Aquatic systems all have a basic format, but the species and productivity can change, as will our assessment endpoints. Three examples, one each for marine, freshwater and estuary, are included demonstrating different aspects of the conceptual model.

In each of these examples, several items are chosen as organisms of concern, which are indicated by boldface type. Arrows that lead from the organisms of concern to the toxicant are darkened to indicate an exposure route. In this manner the conceptual model builds itself. The end result is specific to the site, although it is based on a basic aquatic framework. The first example (Figure 2) is for a PCB contaminated estuary. In this instance the great blue heron, juvenile salmon and starry flounder are the organisms of concern. If one starts at the great blue heron and darken the arrows that lead back to the contaminated sediment and repeats this process for the juvenile salmon and the starry flounder, the conceptual model is complete. The freshwater example (Figure 3) is for a PCP wood treatment site that has surface run-off and groundwater contamination. A different set of organisms are included, and a different conceptual model is produced. The last case is a marine site that has major sediment contamination and is open to use by a variety of wildlife. Essentially all of the arrows are darkened because of the large number of affected important organisms. These examples reflect the flexibility and basic simplicity of the technique.

III. Terrestrial Conceptual Model

The conceptual model for terrestrial environments is broken down by land use since the landscape of the structure is primarily determined by land use considerations and the human activities proposed at the site (Figures 5-9). As in the aquatic model, the gray arrows represent potential routes of exposure to the organisms of concern within a site. As the site becomes more open, the number of receptors increases, compare the industrial site (Figure 5) to the urban park (Figure 9).

The variation in the number and types of receptors in each of the land use classifications is an attempt to represent the changing values with each land use. In a commercial setting it is important that grass, songbirds and trees exist, but the support of important populations of wildlife is not a primary consideration. In an urban part, the populations of squirrels, a variety of bird species, and even carnivores are expected to be protected. As in the aquatic models, not all receptors may exist in a certain location and will not be included in the final conceptual model.

Determination of Biogeoclimatic Zones and Forest Districts, and Red, Blue and Yellow Listed Species

This Appendix provides information on determining the ecological (*i.e.*, biogeoclimatic) and administrative (*i.e.*, forest district) "zone" of your study site (Sections B.1 and B.2). This information is necessary for deriving lists of the species potentially at your site. It is impractical to assess risks to every organism potentially using the site (*i.e.*, receptors). The social, economic and ecological importance of receptors are all considered in determining which ones are classified as of concern. The selection of species for a risk assessment is a value judgment which often extends beyond the consideration of what we feel is important from an ecological standpoint. Cultural, political and economic values are often drivers in determining receptors of concern. The information provided in the checklist and herein focuses on ecological factors to derive regional and site-specific species lists. Consultation with the appropriate regulatory agencies and stakeholders groups may be required to discern values driven by non-ecological factors. One such factor that is addressed herein is the inclusion of species whose population status is already at risk regionally (*i.e.*, extirpated/endangered/threatened [red-listed] or sensitive/vulnerable [blue-listed] species); accessing the appropriate information is discussed in Section B.3.

This appendix provides information common to the organism groups of interest (*e.g.*, bird, mammals, etc.), while explanations on how to use these resources to obtain species lists and other resources that may be useful in making species lists are provided in Appendices C to F.

B.1 Biogeoclimatic Zone Determination

The type of plant and animal communities potentially present at the site is strongly dependent on biological, geographical and climatic (*i.e.*, biogeoclimatic) factors. Areas of the province with similar biogeoclimatic conditions generally contained similar plant and animal communities. Fourteen biogeoclimatic zones have been identified in British Columbia (Meidinger and Pojar, 1991); the spatial distribution of these zones across the province is shown in Figure

B-1. The first step in determining which plants and animals may be important at your site is to determine the biogeoclimatic zone within which your site is located.

Step One: Consult Figure A-1 or Meidinger and Pojar (1991). If the zone is difficult to define (*e.g.*, near a border between zones) continue with Step Two.

Step Two: Should your site be located near a border between zones the maps provided in Stevens (1995) may be easier as they are black and white and only include one zone per map. If the zone is still difficult to define continue with Step Three.

Step Three: To obtain a larger copy of the map in Meidinger and Pojar (1991) you may contact BC Maps at (250) 387-8688. If the zone is still difficult to define continue with Step Four.

Step Four: Each of the six (6) Forest Districts have made more detailed biogeoclimatic zones. For example, the Vancouver Forest District has five (5) maps for their region from which you may locate your site. Each district has different ways to obtain copies of these maps and each should be consulted to obtain the source. Vancouver Forest District biogeoclimatic maps can be obtained from Hugh Hamilton Ltd. (850 W. 15th Ave., North Vancouver, BC (604) 980-5061) for a cost of $30 each plus shipping and handling. Other forests districts should be contacted directly as some will ship directly at little or no cost or refer you to Victoria or other sources (Cariboo - (250) 398-4345; Kamloops - (250) 828-4131; Nelson - (250) 354-6200; Prince George (250) 565-6100; Prince Rupert (250) 847-7500).

The 14 biogeoclimatic zones are listed below:

BG	Bunchgrass	**BWBS**	Boreal White and Black Spruce
PP	Ponderosa Pine	**SWB**	Spruce - Willow - Birch
IDF	Interior Douglas-fir	**MH**	Mountain Hemlock
ICH	Interior Cedar - Hemlock	**CDF**	Coastal Douglas-fir

MS	Montane Spruce	**CWH**	Coastal Western Hemlock
SBPS	Sub-Boreal Pine - Spruce	**ESSF**	Engelmann Spruce - Subalpine Fir
SBS	Sub-Boreal Spruce	**AT**	Alpine Tundra

This information will be especially useful in determining the plant, amphibian, reptile, bird and mammal species potentially present at the site. Tables of native amphibians, reptiles, birds and mammals for each biogeoclimatic zone are provided in Meidinger and Pojar (1991) and Stevens (1995). Meidinger and Pojar (1991) tables include a selection of representative native vertebrates that can occupy the various habitats within each zone and are not meant to be exhaustive species lists.

B.2 Forest District/Subdistrict Determination

While the biogeoclimatic zones divide the province ecologically, the province is also divided administratively into forest districts and subdistricts. Determining the appropriate forest district and subdistrict is necessary to facilitate use of the provincial government's information regarding endangered (*i.e.*, red listed) or vulnerable (*i.e.*, blue listed) species. Consult Figure B-2 (also available directly on the Ministry of Forest's World Wide Web home page [http://www.for.gov.bc.ca/research/becmaps/becmaps.htm]) and use the number from this map to identify the subdistrict listed under each forest district in Table B-1.

B.3 Red, Blue and Yellow Listed Species

Red and Blue Listed Species

Red (extirpated/endangered/threatened) and Blue (sensitive/vulnerable) listed species are compiled by the BC Conservation Data Centre (CDC) which can be accessed via BC Ministry of Environment, Lands and Parks' World Wide Web home page on the Internet (http://www.elp.gov.bc.ca/rib/wis/cdc/). [Note: to reach the CDC from this web page select <site map>, then <wildlife> which is under the land box, then <Conservation Data Centre>] To date there are lists for vertebrates and vascular plants. Lists for invertebrate animals will be forthcoming for insects and eventually other groups. There are lists also for plant communities which include some non-vascular species. The vertebrate and vascular plant species lists are easily obtained from the CDC web page.

Specific requests can also be made for a particular area of interest and may be requested from:

Mailing address:
B.C. Conservation Data Centre
Wildlife Inventory Section, Resources Inventory Branch,
Ministry of Environment, Lands and Parks
P.O. Box 9344 Station Provincial Government
Victoria, BC V8W 9M1

Location/courier address:
B.C. Conservation Data Centre
Wildlife Inventory Section, Resources Inventory Branch,
Second Floor, 2975 Jutland Road
Victoria, B.C. V8T 5J9

Phone: (250) 356-0928 or Toll Free through Enquiry BC at 1-800-663-7867
Fax: (250) 387-2733
e-mail: elpcdcdata@victoria1.gov.bc.ca
ftp site: ftp://ribftp.env.gov.bc.ca/pub/outgoing/cdc_data

The CDC requires the following information to process specific requests:

- contact information from person submitting request
- location in province
  - if it can be delimited by UTM, entire 1:50000 mapsheet(s), forest district(s), ecosection(s), Regional District(s), Municipality or Indian Reservation a map is not required
  - if it is an irregular polygon that can not be identified by above then a map with boundaries clearly delineated
- type of information
  - known individual locations for: vertebrate animals
  - known individual locations for: invertebrate animals (to date only selected insects)
  - known individual locations for: vascular plants
  - known individual locations for: plant communities
  - known individual locations for: record (*i.e.*, large) trees
  - any combination of above
  - detailed information on a specific occurrence(s) of a taxa or plant community
  - details for all known occurrences of a given taxa or plant community, etc.
- reason for request
  - name of development project/proposal, conservation initiative, academic study, etc.
- name of client if you are a consultant
- desired product format/delivery
  - hard copy report, diskette, electronic file
  - by mail, email, fax, ftp

Yellow listed species

Yellow listed species (*i.e.*, common species that are "managed" in some way) are provided in "Amphibians, reptiles, birds and mammals not at risk in British Columbia: the yellow list (1994)" (BC Environment, 1995). However, this list is not subdivided by region, forest district or biogeoclimatic zone so its usefulness may be limited.

B.4 References Cited

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Figure B-1. Biogeoclimatic zones of British Columbia. (Source: Meidinger and Pojar, 1991)

Figure B-2. Reference map of Forest District names and locations. (Source: Conservation Data Centre, 1997a)

Table B-1. Forest district key for reference map of forest district locations in Figure A-1.

Forest District		Subdistrict
01	Vancouver	11 13 15 16 17 18 19 1A 1B
02	Prince Rupert	21 22 23 24 25 28 29
03		31 32 33 34 35 36 37
04		41 43 44 45 46 47 48 49
05		51 52 53 54 55 56 57
06		61 62 63 64 65

Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia - Appendix C. Plant Species List

Selecting the receptors of concern for the site is a multi-step process. First, a regional species list is compiled from available resources. The regional list of plant species should identify those species which are most representative of the site's biogeoclimatic zone. This list provides a starting point to ensure that no key species are overlooked. Second, the regional species lists are customized to the site by incorporating the results of the site visit. The objective of the site-specific species list is not to compile an exhaustive list of every plant species found at the site, but to identify which plants are ubiquitous and likely to be exposed at the site. Finally, the receptors of concern for the risk assessment are selected from the site-specific species list. Receptors of concern are the actual ecological resources addressed in the risk assessment. They are generally a single species, but may represent surrogates for other related species. Selection criteria for receptors of concern are listed below (Gaudet et *al*., 1994):

a) potentially ***sensitive*** to the stressors from the contaminated site
b) threatened or ***endangered*** (*e.g.*, Red and Blue listed species)
c) ***ecologically significant*** (*e.g.*, a migratory species that may be a significant proportion of the population; is concentrated in the vicinity of the site during specific periods; dominant within the local biological communities, or functions as keystone species within nearby ecosystems)
d) recognized as good ***indicator*** or surrogate species
e) ***aesthetic value*** to local residents
f) ***recreational*** or ***commercial*** importance

The receptors of concern must meet BCE's (and possibly other regulatory agencies) management goals for the site. Therefore, seeking agency input before implementing the risk assessment is advised.

C.1 Terrestrial Plants

There are several resources to access to compile representative terrestrial plant species lists based on the aforementioned criteria. The general approach for each is listed below:

1. To obtain endangered or vulnerable species access the BC CDC (as outlined in Appendix B.3) to obtain a list of red and blue listed species for the forest (sub)district your site is located. Query both the vascular plant and plant communities database for the district of interest.

2. To obtain yellow listed species (*e.g.*, those that are managed in BC) use the list prepared by BC Environment (1995). This list is compiled for BC rather than by zone and therefore may not be useful.

3. To obtain a representative species list of native plants use the biogeoclimatic zone information determined in Appendix B.1 and consult Meidinger and Pojar (1991) for the occurrence of trees (Table 5) and common vegetation (Figure 12) within your biogeoclimatic zone. In addition, there are figures for most biogeoclimatic zones which give vegetation for each subzone (see Figures 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, 60). These figures maybe more site specific than Table 5 or Figure 12 noted above.

4. To obtain another representative species list of native plants use the BC Ministry of Forests field guides (*e.g.*, Green and Klinka, 1994 for the Vancouver Forest Region) and biogeoclimatic unit maps (*e.g.*, Nuszdorfer et al., 1992 for the Vancouver Forest Region). There are six guides, one for each forest region. These field guides are available from BC Ministry of Forests Resource Publications (Lena Tang; 250 387-6719). They are to be used in combination with the biogeoclimatic unit maps (see Appendix A.2 for availability). In addition to giving information on biogeoclimatic zones, these maps provide further subdivision by zone and subzone. Once you have determined the zone/subzone information from the map, this code may be looked up in the appropriate Land Management Handbook (*e.g.*, Green and Klinka, 1994 for the Vancouver Forest Region) and common species from the tree, shrub, herb and moss layers can be obtained.

5. Other resources are available that detail various species distribution, habitat and seasonal range. These resources include field guidebooks and keys which may be useful in the field when confirming species lists. These resources are useful when determining which species are of importance (*e.g.*, sensitive species, indicator species, ecologically, aesthetically, recreationally and commercially significant). These are listed in the references listed in this appendix.

C.2 Aquatic Plants

Some species (*e.g.*, some macrophytes, bryophytes) may be obtained using methods/resources noted above (Section C.1). Some bryophytes species are considered aquatic and Schofield (1992) is a good resource. Other sources specific to aquatic species are available in various reference material. Various aquatic vascular plant references include: Brayshaw (1985, 1989), Johnson et al. (1995), Pojar and MacKinnon (1994), Hotchkiss (1972) and Sculthorpe (1967). Aquatic vascular plant habitat is primarily fresh or brackish water. However, there are two genera of marine plant species (*Zostera*, *Phillispadix*) along the British Columbia coast. Good references for freshwater algae and marine algae are Prescott (1964) and Scagel (1972), respectively.

C.3 References

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APPENDIX D

Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia - Appendix D. Bird Species List

Selecting the receptors of concern for the site is a multi-step process. First, a regional species list is compiled from available resources. The regional list of bird species should identify those species which are most representative of the site's biogeoclimatic zone. This list provides a starting point to ensure that no key species are overlooked. Second, the regional species lists are customized to the site by addressing several questions geared towards determining which species are likely to use the sites and are potentially exposed to contaminants. Since feeding strategy can play a significant role in exposure to contaminants the resulting site-specific species list should contain information on feeding groups. Finally, the receptors of concern for the risk assessment are selected form the site-specific species list. Receptors of concern are the actual ecological resources addressed in the risk assessment. They are generally a single species, but may represent surrogates for other related species (*e.g.*, a robin may represent insectivorous songbirds). Selection criteria for receptors of concern are listed below (Gaudet et *al.*, 1994):

- potentially ***sensitive*** to the stressors from the contaminated site
- threatened or ***endangered*** (*e.g.*, Red and Blue listed species)
- ***ecologically significant*** (*e.g.*, a migratory species that may be a significant proportion of the population; is concentrated in the vicinity of the site during specific periods; is dominant within the local biological communities, or functions as keystone species within nearby ecosystems)
- recognized as good ***indicator*** or surrogate species
- ***aesthetic value*** to local residents
- ***recreational*** or ***commercial*** importance

The receptors of concern must meet BCE's (and possibly other regulatory agencies) management goals for the site. Therefore, seeking agency input before implementing the risk assessment is advised.

There are several resources to access to compile representative bird species lists based on the aforementioned criteria. The general approach for each is listed below:

7. To obtain endangered or vulnerable species access the BC CDC (as outlined in Appendix B.3) to obtain a list of red and blue listed species for the forest (sub)district your site is located. Query the vertebrate database for the district of interest.
8. To obtain yellow listed species (*e.g.*, those that are managed in BC) use the list prepared by BC Environment (1995). This list is compiled for BC rather than by zone and therefore may not be useful.
9. To obtain a representative species list of native birds use the biogeoclimatic zone information determined in Appendix B.1 and consult Meidinger and Pojar (1991) for selected wildlife habitats and bird species. A table for the selected wildlife habitats and species are provided for each biogeoclimatic zone of BC (see Tables 11, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 35, and 36) in Meidinger and Pojar (1991). Before consulting these tables you will need to know the general habitat of your study site as species lists are provided for each habitat found in each biogeoclimatic zone.
10. Biogeoclimatic zones (as per Appendix B.1 also) and subzones are reviewed in Chapter 3 in Stevens (1995). Distribution of all birds by biogeoclimatic zone or zonal group in BC, seasonal abundance of bird species by wildlife subzone group and habitat use of taxa at risk and selected other bird species are provided in Appendices 1-3 in Stevens (1995).
11. Other resources are available that detail various species distribution, habitat and seasonal range. These resources include field guidebooks and keys which may be useful in the field when confirming species lists. These resources are useful when determining which species are of importance (*e.g.*, sensitive species, indicator species, ecologically, aesthetically, recreationally and commercially significant). These are listed below under References. Additional useful references to obtain more detailed lists include Godfrey (1986), Campbell (1990), Cannings et al. (1987), Cannings and Harcombe (1990). Information about diet can be found in many of these references, but a particularly useful one is Ehrlich et al. (1988). Detailed information about breeding habitat (*e.g.*, Grassland species, Wetland-open water species, etc.), nesting type (*e.g.*, Cavity nesting species, Open-cup nesting passerine species, etc.) and migration form groups (*e.g.*, Short distance migrants, Permanent Resident Species, etc.) can be found on the world wide web (Sauer et al., 1996). A bibliographic reference list is available should more detailed information about a particular species be required (Campbell et al., 1979, 1988).
12. Further information may be obtained from local conservation officers. Contact the Wildlife Branch in Victoria (250 387-9717) if local contacts are not given in the local telephone directory.

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Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia - Appendix E. Mammal, Amphibian and Reptile Species List

Selecting the receptors of concern for the site is a multi-step process. First, a regional species list is compiled from available resources. The regional list of mammal, amphibian, and reptile species should identify those species which are most representative of the site's biogeoclimatic zone. This list provides a starting point to ensure that no key species are overlooked. Second, the regional species lists are customized to the site by addressing several questions geared towards determining which species are likely to use the site and are potentially exposed to contaminants. Since feeding strategy can play a significant role in exposure to contaminants, the resulting site-specific species list should contain information on feeding groups. Finally, the receptors of concern for the risk assessment are selected from the site-specific species list. Receptors of concern are the actual ecological resources addressed in the risk assessment. They are generally a single species, but may represent surrogates for other related species (*e.g.*, feeding group). Selection criteria for receptors of concern are listed below (Gaudet et al., 1994):

- potentially ***sensitive*** to the stressors from the contaminated site
- threatened or ***endangered*** (*e.g.*, Red and Blue listed species)
- ***ecologically significant*** (*e.g.*, a migratory species that may be a significant proportion of the population; is concentrated in the vicinity of the site during specific periods; is dominant within the local biological communities, or functions as keystone species within nearby ecosystems)
- recognized as good ***indicator*** or surrogate species
- ***aesthetic value*** to local residents
- ***recreational*** or ***commercial*** importance

The receptors of concern must meet BCE's (and possibly other regulatory agencies) management goals for the site. Therefore, seeking agency input before implementing the risk assessment is advised.

There are several resources to access to compile representative amphibian, reptile and mammal species lists based on the aforementioned criteria. The general approach for each is listed below:

7. To obtain endangered or vulnerable species access the BC CDC (as outlined in Appendix B.3) to obtain a list of red and blue listed species for the forest (sub)district your site is located. Query the vertebrate database for the district of interest.
8. To obtain yellow listed species (*e.g.*, those that are managed in BC) use the list prepared by BC Environment (1995). This list is compiled for BC rather than by zone and therefore may not be useful.
9. To obtain a representative species list of native amphibians, reptiles and mammals use the biogeoclimatic zone information determined in Appendix B.1 and consult Meidinger and Pojar (1991) for selected wildlife habitats and bird species. A table for the selected wildlife habitats and species are provided for each biogeoclimatic zone of BC (see Tables 11, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 35, and 36) in Meidinger and Pojar (1991). Before consulting these tables you will need to know the general habitat of your study site as species lists are provided for each habitat found in each biogeoclimatic zone.

10. Biogeoclimatic zones (as per Appendix B.1 also) and subzones are reviewed in Chapter 3 in Stevens (1995). Distribution of all mammals, amphibians and reptiles by biogeoclimatic zone or zonal group in BC, seasonal abundance of mammals, amphibians and reptiles species by wildlife subzone group and habitat use of taxa at risk and selected other mammal, amphibian and reptile species are provided in Appendices 1-3 in Stevens (1995).
11. Other resources are available that detail various species distribution, habitat and seasonal range. These resources include field guidebooks and keys which may be useful in the field when confirming species lists. These resources are useful when determining which species are of importance (*e.g.*, sensitive species, indicator species, ecologically, aesthetically, recreationally and commercially significant). These are listed below under References. Additional useful references to obtain more detailed lists or information about habits include McTaggart-Cowan and Guiguet (1975), Nagorsen (1990, 1996), Nagorsen and Brigham (1993), Green and Campbell (1984) and Gregory and Campbell (1984).

12. Further information may be obtained by contacting the Wildlife Branch of the regional BCE office (see local phonebook for number), the headquarters Wildlife Branch in Victoria (250 387-9717) or Canadian Wildlife Service (604 666-0143; Delta).

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Whitaker, J.O. 1996. National Audubon Society field guide to North American mammals 2nd ed. Random House, NY

Amphibians and Reptiles

Green, D.W. and R.W. Campbell. 1984. The amphibians of British Columbia. Royal British Columbia Museum Handbook, Victoria, BC 112 pp.

Gregory, P.T. and R.W. Campbell. 1984. The reptiles of British Columbia. Royal British Columbia Museum Handbook, Victoria, BC 112 pp.

Stebbins, R.C. 1966. A field guide to western reptiles and amphibians; field marks of all species in western North America. Houghton Mifflin, Boston.

Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia - Appendix F. Fish and Invertebrate Species List

I. Fish Species List

Selecting the receptors of concern for the site is a multi-step process. First, a regional species list is compiled from available resources (see below). The regional list of fish species should identify those species most representative of the site's aquatic habitat (*e.g.*, freshwater, brackish, or marine). This list provides a starting point to ensure no key species is overlooked. Second, the regional species lists are customized to the site by addressing several questions geared toward determining species likely to use the site and have the potential of being exposed to contaminants. Because lifestyle (*e.g.*, pelagic or demersal) can play a significant role in exposure to contaminants, the resulting site-specific species list should contain such information. Finally, the receptors of concern for the risk assessment are selected from the site-specific species list. Receptors of concern are the actual ecological resources addressed in the risk assessment. They are generally a single species, but may represent surrogates for other related species (*e.g.*, a coho salmon may represent salmon in general). Selection criteria for receptors of concern are listed below (Gaudet et al., 1994):

- potentially ***sensitive*** to the stressors from the contaminated site
- threatened or ***endangered*** (*e.g.*, Red and Blue listed species)
- ***ecologically significant*** (*e.g.*, a migratory species that may be a significant proportion of the population; is concentrated in the vicinity of the site during specific periods; is dominant within the local biological communities, or functions as keystone species within nearby ecosystems)
- recognized as good ***indicator*** or surrogate species
- ***aesthetic value*** to local residents
- ***recreational*** or ***commercial*** importance

There are several resources to access to compile representative fish species lists based on the aforementioned criteria. The general approach for each is listed below:

7. To obtain endangered or vulnerable species access the BC CDC (as outlined in Appendix B.3) to obtain a list of red and blue listed species for the forest (sub)district your site is located. Query the vertebrate database for the district of interest.

8. To obtain yellow listed species (*e.g.*, those that are managed in BC) use the list prepared by BC Environment (1995). This list is compiled for BC rather than by zone and therefore may not be useful.

9. Other resources are available that detail various species distribution, habitat and seasonal range. These resources include field guidebooks and keys which may be useful in the field when confirming species lists. These resources are useful when determining which species are of importance (*e.g.*, sensitive species, indicator species, ecologically, aesthetically, recreationally and commercially significant). These are listed below under References. Carl (1977) and DFO and BC Environment (1989) are useful in determining freshwater species, while Lamb and Edgell (1986) and Williams (1989) provide detailed information on marine and brackish species. Particularly useful are Table 1 and Figure 3 in Williams (1989; Part II) which detail the various habitats used by commons coastal fish species.

10. Further information should be obtained from local fisheries officers (BCE or Department of Fisheries and Oceans, DFO). Contact the Fisheries, Wildlife and Habitat Protection Department in Victoria (250 356-0121) if local contacts are not given in the local telephone directory.

References

Carl, G.C, W.A. Clemens and C.C. Lindsey. 1977. The freshwater fishes of British Columbia. Handbook No. 5. British Columbia Provincial Museum, Victoria, BC. 192 pp.

Department of Fisheries and Oceans (DFO) and BC Ministry of Environment (BC Environment). 1989. Fish habitat inventory and information program: stream survey field guide. 33 pp.

Gaudet, EVS Environment Consultants and ESSA Environmental and Social Systems Analysts. 1994. A framework for ecological risk assessment at contaminated sites in Canada: review and recommendations. Scientific Series No. 199. Environment Canada, Ecosystem Conservation Directorate, Evaluation and Interpretation Branch, Ottawa, ON. 108 pp.

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Lamb, A. And P. Edgell. 1986. Coastal fishes of the Pacific Northwest. Harbour Publishing, Madeira Park, BC. 224 pp.

McPhail, J.D. and C.C. Lindsey. 1973. Freshwater fishes of northwestern Canada and Alaska. Bull. Fish. Res. Board Can. 173: 373 pp.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Bull. Fish. Res. Board Can. 184: 966 pp.

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II. Invertebrate Species List

The habitat list of invertebrate species should identify those species which are most representative of the site's habitat (*i.e.*, terrestrial, freshwater, brackish, marine). The objective of developing this list is not to compile an exhaustive list of every species found in a particular habitat, but to identify which invertebrates are likely to be exposed to contaminants at the site.

Rather than developing exhaustive lists which inventory all species present at and around the study site, species of importance/significance should be selected Species selection criteria are listed below (Gaudet et al., 1994):

- potentially ***sensitive*** to the stressors from the contaminated site
- threatened or ***endangered*** (*e.g.*, Red and Blue listed species)
- ***ecologically significant*** (*e.g.*, migratory species that may be a significant proportion of the population is concentrated in the vicinity of the site during specific periods, dominant within the local biological communities, functioning as keystone species within nearby ecosystems)
- recognized as good ***indicator*** or surrogate species
- ***aesthetic value*** to local residents
- ***recreational*** or ***commercial*** importance

There are several resources to access to compile representative fish species lists based on the aforementioned criteria. The general approach for each is listed below:

17. To obtain endangered or vulnerable species access the BC CDC (as outlined in Appendix B.3) to obtain a list of red and blue listed species for the forest (sub)district your site is located. A specific request will probably have to be made (see Appendix B.3) as the invertebrate database

was incomplete (*i.e.*, only some insects were beginning to be compiled) at the time this report was prepared.

18. Other resources are available that detail various species distribution, habitat and seasonal range. These resources include field guidebooks and keys which may be useful in the field when confirming species lists. These resources are useful when determining which species are of importance (*e.g.*, sensitive species, indicator species, ecologically, aesthetically, recreationally and commercially significant). These are listed below under References. However, full species lists for terrestrial, freshwater, brackish and marine invertebrates will have to be obtained from various sources. Particularly useful are Table 1 and Figure 3 in Williams (1989; Part II) which detail the various habitats used by common coastal aquatic invertebrate species.

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Butler, T.H. 1980. Shrimps of the Pacific coast of Canada. Can. Bull. Fish. Aquat. Sci. 202. 280 pp.

Carl, G.C. 1963. Guide to marine life of British Columbia. Handbook No. 21. British Columbia Provincial Museum, Victoria, BC. 135 pp.

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Scudder, G.G. and S. Cannings. 1994. British Columbia terrestrial and freshwater invertebrates: inventory priorities for and status of rare and endangered species. British Columbia Conservation Data Centre. 8 pp.

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APPENDIX G

Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia - Appendix G. EPA Terrestrial Plant Sampling Guidance

- EPA Standard Operating Proceedures (SOP) (PDF/49 KB)

Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia - Appendix H. List of Bioassay Protocols and Companies

Section I: Bioassay Protocols

Part A: Quality Assurance/Quality Control

APHA. 1992. Part 1000: Introduction. *Standard Methods for the Examination of Waters and Wastewater, 18th Edition.* American Public Health Association, American Water Works Association, and the Water Environment Federation, Washington, D.C., pp. 1-1 - 1-42.

APHA. 1995. Part 8000, Toxicity. In *Standard Methods for the Determination of Water and Wastes, 19th Edition*. American Public Health Association, American Water Works Association, and the water Environment Federation, Washington, D.C., pp. 8-1 - 8-26.

ASTM. 1994a. Standard guide for designing biological tests with sediments. *ASTM 1996 Annual Book of Standards Vol. 11.05*. E1525-94. American Society of Testing and Materials, West Conshohocken, PA. pp. 942-959.

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Method D3370: Practices for sampling water, Volume 11.01.
Method D3670: Guide for determination of precision and accuracy of methods of committee D 22, Volume 11.03.
Method D4210: Practice for interlaboratory quality control procedures and a discussion on reporting low level data, Volume 11.01.
Method D4447: Guide for the disposal of laboratory chemicals and samples, Volume 11.04.

Method D5283: Standard practice for generation of environmental data related to waste management activities: quality assurance and quality control planning and implementation, Volume 11.04. pp. 231-247.
Method E29: Practice for using significant digits in test data to determine conformance with specifications, Volume 14.02.
Method E178: Practice for dealing with outlying observations, Volume 14.02.

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BCEPD. 1996. Part A. Quality control and quality assurance. *British Columbia Field Sampling Manual For Continuous Monitoring Plus the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment, and Biological Samples, 1996 Edition*. Laboratory and Systems Management, Environmental Protection Department, Ministry of Environment, Lands and Parks, Province of British Columbia, BC, Pp. A4 - A25.

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USEPA. 1979a. *Handbook for Analytical Quality Control in Water and Wastewater Laboratories*. U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, OH, EPA-600/4-79/019.

USEPA. 1979b. *Methods for Chemical Analysis of Water and Wastes*. U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, OH, EPA-600/4-79-020, pp. xiii - xix.

USEPA. 1979c. *Quality Assurance/Quality Control Guidance for Removal Activities*. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C., Directive 9360.4-1, EPA-540/G-90/004.

USEPA. 1979d. *Soil Sampling Quality Assurance User's Guide*. U.S. Environmental Protection Agency EPA-600/4-84-043 (NTIS No. PB84198621/LL).

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ASTM. 1993b. Standard test method for determining a sorption constant (Koc) for an organic chemical in soil and sediments. *ASTM 1996 Annual Book of Standards Vol. 11.05*. E1195-87. American Society of Testing and Materials, West Conshohocken, PA. pp. 536-542.

ASTM. 1993c. Standard test method for 24-h batch-type measurement of contaminant sorption by soils and sediments. *ASTM 1994 Annual Book of Standards Vol. 11.04*. D4646-87. American Society of Testing and Materials, West Conshohocken, PA. pp. 125 - 128.

ASTM. 1994a. Standard guide for behavioral testing in aquatic toxicology. *ASTM 1996 Annual Book of Standards Vol. 11.05*. E1604-94. American Society of Testing and Materials, West Conshohocken, PA. pp. 1038 - 1045.

ASTM. 1994b. Standard guide for designing biological tests with sediments. *ASTM 1996 Annual Book of Standards Vol. 11.05*. E1525-94a. American Society of Testing and Materials, West Conshohocken, PA. pp. 942 - 959.

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ASTM. 1995c. Standard test methods for measuring the toxicity of sediment-associated contaminants with fresh water invertebrates. *ASTM 1996 Annual Book of Standards Vol. 11.05* . E1706-95b. American Society of Testing and Materials, West Conshohocken, PA. pp. 1176-1258.

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Part C: Organism Acquisition and Culture

Suppliers of Bioassay Organisms. 1996

COMPANY	PHONE	ADDRESS	CITY/STATE/ZIP
Amer. Type Tissue Cult.	(301) 881-2600	12301 Parklawn Dr	Rockville, MD 20852
Aquatic BioSystems, Inc.	(800) 331-5916	1300 Blue Spruce Dr.	Ft. Collins, CO 805
Aquatic Biotoxicity Labs	(800) 331-5916	8142 Greenwall Spr.	Baton Rouge, LA 70816
Aquatic Indicators	(904) 829-2780	710 Holmes Blvd.	St.Augustine, FL 32084

Aquatic Resources Ltd.	(707) 829-1194	2610 Meier Rd.	Sebastopol, CA 95472
Aquatox	(501) 767-9120	100 Springwd. Dr.	Hot Springs, AR 71913
Carolina Biol. Supply	(800) 334-5551	2700 York Rd.	Burlington, NC 27215
Charles River Labs.	(800) 927-1650	251 Ballardvale St.	Wilmington,MA 01887
Chesapeake Cultures	(804) 693-4046	P.O. Box 507	Hayes, VA 23072
Cosper Environ. Serv.	(516) 563-8899	83 Carlough Rd.	Bohemia, NY 11716
Culture Collect. of Algae	(512) 471-4019	Botany Dept, U.T.	Austin, TX 78713-7640
Envir. Consult. & Test.	(715) 392-6635	2231 Catlin Suite 418	Superior, WI 55880
Envir. Sci. & Engin.	(904) 332-3318	(x2328), PO Box ESE	Gainesville, FL 32602
Florida Bioassay Supply	(904) 462-4042	2809 NW 161 Ct.	Gainesville, FL 32609
Gulf Specimen Comp.	(904)984-5297	P.O. Box 237	Panacea, FL 32346
IMCO Services	(713) 561-1342	5950 N. Course Dr.	Houston, TX 77072
Integrated Research Cons.	(604) 278-7714	16-14480 River Rd.	Vancouver, BC
Kurtz Fish Hatchery	(215) 286-9250	RR 2 Box 129	Elverson, PA 19520
Marinco	(813) 377-5219	7524 Castle Dr.	Sarasota, FL 34240
Multi-Aquacult. Systems	(516) 267-3341	Bx 679 Cranbry Hle Rd	Anagansett, NY 11903
Takena Ecological. Serv.	(503) 758-8040	712 SW 3rd St.	Corvallis, OR 97333

APHA. 1995. Part 8000, Toxicity. In *Standard Methods for the Determination of Water and Wastes, 19th Edition*. American Public Health Association, American Water Works Association, and the Water Environment Federation, Washington, DC, Pp. 8-1 - 8-90. (Method specific).

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USEPA. 1989. Section 6: Test organisms. In *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms, Second Edition*. U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Office of Research and Development, Cincinnati, OH., EPA 600/4-89/001. pp. 22.

USEPA. 1991. Appendices A.1. - A.8: Systematics, ecology, life history, and culture methods. In *Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms, Fourth Edition*. U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Office of Research and Development, Cincinnati, OH., EPA/600 4-90/027. PP 131 - 262.

Appendix A.1.: Daphnid, *Ceriodaphnia dubia* pp. 131 - 147. Appendix A.2.: Daphnids, *Daphnia pulex* and *Daphnia magna* pp. 148 - 168. Appendix A.3.: Mysid, *Mysidopsis bahis*. Pp. 169 - 188. Appendix A.4.: Brine Shrimp, *Artemia salina*. Pp. 189 - 197. Appendix A.5.: Fathead Minnow, *Pimephales promelas* pp. 198 - 216. Appendix A.6.: Rainbow Trout and Brook Trout, *Oncorhynchus mykiss* and *Salvelinus fontinalis* pp. 217 - 226. Appendix A.7.: Sheepshead Minnow, *Cyprinodon variegatus* pp. 227 - 245. Appendix A.8.: Silversides: Inland Silverside, *Menidia berryllina*, Atlantic Silverside, *M. menidia*, and Tidewater Silverside, *M. peninsulae* pp. 246 - 262.

USEPA. 1993. Standard Operating Procedures for Culturing *Hyalella azteca*, (ERL-D-SOP-CTI-016), *Chironomus tentans* (ERL-D-SOP-CTI-015), and *Lumbriculus variegatus* (ERL-D-SOP-CTI-017). U.S. Environmental Protection Agency, Environmental Research Laboratory, Diluth, MN.

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Part D: Bioassay Tests

Algae / Phytoplankton

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APHA. 1995b. Part 8112, Phytoplankton. In *Standard Methods for the Determination of Water and Wastes, 19th Edition*. American Public Health Association, American Water Works Association, and the Water Environment Federation, Washington, DC, Pp. 8-39 - 8-40.

APHA. 1995b. Part 10200, Plankton. In *Standard Methods for the Determination of Water and Wastes, 19th Edition*. American Public Health Association, American Water Works Association, and the Water Environment Federation, Washington, DC, Pp. 10-2 - 10-30.

ASTM. 1990. Standard guide for conducting static 96-h toxicity tests with microalgae. *ASTM 1996 Annual Book of Standards Vol. 11.05*. E1218-90. American Society of Testing and Materials, West Conshohocken, PA. pp. 575-585.

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Appendix A: Independence, randomization, and outliers. pp. 189 - 191.
Appendix B: Validating normality and homogeneity of variance assumptions.pp. 192 - 203.
Appendix C: Dunnett's procedure. pp. 204 - 215.
Appendix D: Bonferroni's t-test. pp. 216 - 220.
Appendix E: Steel's many-one rank test. pp. 221 - 224.
Appendix F: Wilcoxon rank sum test. pp. 225 - 230.
Appendix G. Fisher's exact test. pp. 231 - 239.
Appendix H: Toxicity screening test - comparison of control with 100% effluent or instream waste concentration. pp. 240 - 243.
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Section 2. Toxicology Laboratories

Institute	Address	Contact Name and Number	Testing
	British Columbia		
BC Research Inc.	3650 Westbrook Mall Vancouver, BC V6S 2L2 CANADA	Mr. Curtis Eickhoff Ph: (604) 224-4331 Fax: (604) 224-0540	A, T
Environment Canada Pacific Env. Science Centre Pacific and Yukon Region	2645 Dollarton Highway North Vancouver, BC V7H 1V2 CANADA	Mr. Paul Kluckner Ph: (604) 924-2500 Fax: (604) 924-2555	A
EVS Environment Consultants Ltd. Laboratory Services	195 Pemberton Ave. North Vancouver, BC V7P 2R4 CANADA	Dr. Howard Bailey Ph: (604) 986-4331 Fax: (604) 662-8548	A
Integrated Resource Consultants Inc. (IRC)	160 - 14480 River Road	Don Larsen Ph: Ph. (604)278-7714	A, T

	Richmond, BC V6V 1L4 CANADA	Fax: (604)278-7741	
Northern Laboratories Ltd.	P.O. Box 1035 Prince Rupert, BC V8J 4B7 CANADA	Mr. Charles Armstrong Ph: (250) 627-1906 Fax: (752) 627-0337	
	Canada (Outside BC)		
Aquatic Sciences Inc. Biotesting Laboratory	45 Hannover Dr., #1 P.O. Box 2205, Stn. B St. Catharines, ON L2M 6P6 CANADA	Mr. John Sferrazza Ph: (905) 641-0941 Fax: (905) 641-1825	A
Aquatic Toxicology Research Centre (ATRC) Lakehead University	955 Oliver Road Thunder Bay, ON P7B 5E1 CANADA	Mr. Alasdair D. Smith Ph: (807) 343-8793 Fax: (807) 346-7749	A
B.A.R. Environmental Inc. Laboratory Services	#11 Nicholas Beaver Park R.R. #3 Guelph, ON N1H 6H9 CANADA	Mr. Keith E. Holtze Ph: (519) 763-4410 Fax: (519) 763-4419	A
Beak Consultants - Montreal Ecotoxicology Laboratory	455 Boul. Fénélon, Suite 104 Dorval, QC H9S 5T8 CANADA	Mr. Phillippe N. Riebel Ph: (514) 631-5544 Fax: (514) 631-5588	A
Beak Consultants Limited Ecotoxicology Laboratory	14 Abacus Road Brampton, ON L6T 5B7 CANADA	Mr. Guy Gilron Ph: (905) 794-2325 Fax: (905) 794-2338	A
Environment Canada, NWRI National Lab. For Environmental Testing	P.O. Box 5050 867 Lakeshore Road Burlington, ON L7R 4A6 CANADA	Mr. Robin Sampson Ph: (905) 336-4563 Fax: (905) 336-6404	A
Environment Canada Canadian Wildlife Research Centre	Bldg.#9, 100 Gamelin Bldvd. Hull, QC	Mr. Bryan Wakeford Ph: (819) 997-1412 Fax: (819) 953-6612	A

National Wildlife Research Centre Laboratory Services	K1A 0H3 CANADA		
Environment Canada Environmental Quality Laboratory - Nova Scotia	45 Alderney Drive 15th Floor, Queen Square Dartmouth NS B2Y 2N6 CANADA	Dr. Om C. Vaidya Ph: (902) 426-6195 Fax: (902) 426-8041	A
Enviro-Test Laboratories	9936 - 67 Avenue Edmonton, AB T6E 0P5 CANADA	Ms. Beth Weitzel Ph: (403) 434-9509 Fax: (403) 437-2311	A
HydroQual Laboratories Ltd.	#3, 6125 - 12th St. S.E. Calgary, AB T2H 2K1 CANADA	Ms. Mary Gregory Ph: (403) 253-7121 Fax: (403) 252-9363	A, T
Laughton Development Corporation Pollutech Environmental Limited - Sarnia	704 Mara Street Point Edward, ON N7V 1X4 CANADA	Mr. Tim Moran Ph: (519) 339-8787 Fax: (519) 336-6965)	A
Norwest Labs (Edmonton) Norwest Soil Research Ltd.	9938 - 67th Avenue Edmonton, AB T6E 0P5 CANADA	Dr. Ansar Qureshi Ph: (403) 438-5522 Fax: (403) 434-8586	A
Pollutech Environmental Limited	768 Westgate Road Oakville, ON L6L 5N2 CANADA	Mr. Richard Laughton Ph: (905) 847-0065 Fax: (905) 847-3840	A
Pollutech Enviroquatics Limited	704 Mara Street, Suite 122 Point Edward, ON N7V 1X4 CANADA	Mr. Tim Moran Ph: (519) 339-8787 Fax: (519) 336-6965	A
Prairie Biological Research Ltd.	4290 - 91A Street, Block "C"	Dr. Ram D. Mehta Ph: (403) 450-3957	A

Environmental Microbiology and Toxicology Division	Edmonton, AB T6E 5V2 CANADA	Fax: (403) 450-3960	
Saskatchewan Research Council SRC Analytical Laboratory	15 Innovation Boulevard Saskatoon, SK S7N 2X8 CANADA Also: 101 Research Drive Saskatoon, SK S7N 2X8 CANADA	Dr. Gene Smithson Ph: (306) 933-5439 Fax: (306) 933-7922	A
University of Alberta Hospitals Dept. Of Lab Medicine & Pathology Trace Elements Env. Toxicology Lab	8440 - 112 Street Edmonton, AB T6G 2B7 CANADA	Dr. Robert J. Audette Ph: (403) 492-6648 Fax: (403) 492-6267	A
Battelle Marine Sciences Laboratory	1529 W. Sequim Bay Rd. Sequim, WA 98382 USA	Mr. Eric Crecelius Ph: (360) 683-4151 Fax: (360) 683-1059	A
Bioassay Testing Services	8455 S. 19th, Suite 12A Tacoma, WA 98465 USA	Mr. Christopher Getchell Ph: (206) 565-5492)	A
Bioconsultants, Inc.	2897 - 152nd Ave. NE Redmond, WA 98052 USA	Mr. John Majnarish Ph: (206) 869-4224 Fax: (206) 869-4231	A, T
CH2M Hill Northwest -	2300 NW Walnut Blvd. Corvallis, OR 97339	Mr. Mike Stanaway Ph: (541) 752-4271	A

Corvallis	USA	Fax: (541) 752-0276	
Chadwich & Associates, Inc.	5575 S. Sycamore St., Suite 101 Littleton, CO 80120 USA	Mr. Steve Canton Ph: (303) 794-5530 Fax: (303) 794-5041	A
Coffey Laboratories, Inc.	12423 NE Whitaker Way Portland, OR 97230 USA	Mr. Victor Perry Ph: (503) 254-1794 Fax: (503) 254-1452	A
Ecological Planning and Toxicology, Inc.	5010 SE Hout St. Corvallis, OR 97333 USA	Ms. Anne Fairbrother Ph: (541) 752-3707 Fax: (541) 753-9010	T
ENSR Consulting & Engineering	4413 West LaPort Ave. Fort Collins, CO 80521 USA	Mr. David Pillard Ph: (970) 416-0916 Fax: (970) 493-8935	A
ENSR Environmental Toxicology Lab	10161 Harwin, Suite 150 Houston, TX 77036 USA	Mr. Robert Davidson Ph: (800) 677-2847 (713) 272-7444 Fax: (713) 272-7501)	A
King Country Environmental Lab	22 W. Ewing Seattle WA 98108 USA	Mr. George Parry Ph: (206) 684-2301 Mr. Jim Buckley Ph: (206) 684-2314	A
Laucks Testing Labs	940 S. Harney St. Seattle, WA 98108 USA	Mr. Harry Romberg Ph: (206) 767-5060 Fax: (206) 767-5063	A
Lott Wastewater Treatment Facility	P.O. Box 1967 Olympia, WA 98507 USA	Mr. Asha Mhatre Ph: (360) 753-8181	A
MEC Analytical Systems, Inc.	6060 Corte del Cedro Carlesbad, CA 92009 USA	Mr. F. Charles Newton Ph: (619) 931-9225 Fax: (619) 931-9251	A
Northwestern Aquatic	P.O. Box 1437	Mr. Richard Caldwell	A

Sciences	Newport, OR 97365 USA	Ph: (541) 265-7225 Fax: (541) 265-2799	
Ogden Environmental & Energy SVCS	5510 Morehouse Dr. San Diego, CA 92121 USA	Mr. Barry Snyder Ph: (619) 458-9044 Fax: (619) 458-0943	A
Parametrix, Inc., Kirkland	5808 Lake Washington Blvd., NE Kirkland, WA 98033 USA	Mr. Kevin Brix Ph: (206) 822-8880 Fax: (206) 889-8808	A

A = Aquatic Testing

T = Terrestrial Testing

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Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia - Appendix I. Toxicity Data References

Part A: General

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Part B: Bees

OEPP/EPPO. 1991. Guideline for evaluation the hazards of pesticides to honey bees, *Apis mellifera* L.

Part C: Earthworms

International Organization for Standardization. 1992. Soil quality. Effects of pollutants on earthworms (*Eisenia foetida*). Part 1: method for the determination of acute toxicity using artificial soil substrate. BSI, London. Draft International Standard ISO/DIS 11268-1.

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Part D: Plants

Alloway, B.J. 1995. *Heavy Metals in Soils*. Second Edition. Blackie Academic and Professional, London, England.

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USEPA. 1992b. Early seedling growth toxicity test. U.S. Environmental Protection Agency. Title 40 Chapter 1, subchapter R of the Code of Federal Regulations, pp. 422 - 427.

USEPA. 1993. Ecological effects test guidelines. OPPTS 850.4600 *Rhizobium*-legume toxicity. U.S. Environmental Protection Agency. EPA report 712-C-92-158.

Part E: Soil Nitrification

Nederlands Normalisatie Institute (NNI). 1988. Soil-Determination of the influence of chemicals on soil nitrification. Nederlands Normalisatie Institute, Delft, Nederlands, Dutch Standard NEN 5795.

Part F: Wildlife

Beyer, W.N., G.H. Heinz, and **A.W. Redmon-Norwood.** 1996. *Enviromental Contaminants in Wildlife: Interpreting Tissue Concentrations*. SETAC Special Publication, Lewis Publishers, Boca Raton, FL.

Edwards, C.A. and **P.J. Bohlen.** 1996. *Biology and Ecology of Earthworms*. Third Edition. Chapman & Hall, London, England.

Fairbrother, A., L.N. Locke, and **G.L. Hoff.** 1996. *Noninfectious Diseases of Wildlife, Second Edition*. Iowa State University Press, Ames, IA.

Hoffman, D.J., B.A. Rattner, G.A. Burton, and **J. Cairns Jr.** 1995. *Handbook of Ecotoxicology*. CRC Press, Boca Raton, FL.

National Research Council. 1980. *Mineral Tolerances of Domestic Animals*. National Academy of Sciences Press, Washington, D.C.

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Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia - Appendix J. Bird Foraging Area and Dietary Preferences

References

Ehrlich, P. R., D. S. Dobkin, and D. Wheye. 1988. The Birder's Handbook: A Field Guide to the Natural History of North American

Birds. Simon & Schuster, Inc., NY

This book is excellent for providing information about diet but not very good on distribution of the bird species. Therefore, it should be used AFTER you know which birds are of concern in the area of interest.

Godfrey, W. E. 1986. The Birds of Canada, revised edition. National Museum of Natural Sciences, Ottawa.

This book is an excellent reference for distribution of Canadian bird species and provides some additional natural history information. It is not very complete about dietary preferences.

Sauer, J. R., B. G. Peterjohn, S. Schwartz, and J. E. Hines. 1996. The North American Breeding Bird Survey Home Page. Version 95.1 Patuxent Wildlife Research Center, Laurel, MD

This is on the world wide web address: www.mbr.nbs.gov It contains all the breeding bird information, including maps of ranges, etc. Most important is the List of Species Groups which defines birds in Breeding Habitat Groups (e.g., Cavity nesting species, Open-cup nesting passerine species, etc.) and Migration Form Groups (e.g., Short distance migrants, Permanent Resident Species, etc.)

**Campbell, R. W., H. R. Carter, C. D. Shepard, and C. J. Guiguet. 1979. A bibliography of British Columbia Ornithology. British
Columbia Provincial Museum Heritage Record No. 7, Victoria.**

This is a good reference source if a risk assessor needs specific detailed information about a particular bird. It has a species index in the back for quickly locating information. This is, of course, simply a bibliography--once the references are identified, the actual article must be retrieved from a library. Given the ready availability of computerized databases of reference information, and the fact that this bibliography is nearly 20 years old, I would recommend that a risk assessor go to the library right away...but others may not feel comfortable doing this.

US EPA. 1993 Wildlife Exposure Factors Handbook. Vols I and II. US Environmental Protection Agency, Office of Research and Development, Washington, DC EPA/600/R-93/187.

Field Guides

The following field guide is readily available in any bookstore and contains some information about distribution, diet, and other natural history.

Peterson, R. T. 1961. A field guide to western birds: field marks of all species found in North America west of the 100th meridian, with a section on the birds of the Hawaiian Islands 2nd ed. Houghton Mifflin, Boston, MA.

Note: Information can also be obtained from the Canadian Wildlife Service (CWS), BCE Wildlife Branch.

Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia - Appendix K. Mammal Foraging Area and Dietary Preferences

References

Ingles, L. G. 1965. Mammals of the Pacific States. Stanford University Press, Palo Alto, CA.

This is **the** definitive work on mammals in the Pacific Northwest, even though it is 30 years old. It contains keys to species identification as well as narrative information about natural history, diet, etc.

Scott, M. D. and S. A. Scott. 1985. Heritage from the Wild: Familiar Land and Sea Mammals of the Northwest. Northwest Geographer Series No. 2. Northwest Panorama Publishing, Inc., Bozeman, MT.

This book has wonderful photographs of nearly all the mammals in the Pacific Northwest (notably absent are the small mice, voles, and shrews). It explains natural history information (including a good description of diets) in layman's language. A nonspecialist risk assessor may find this book much easier to read that Ingle's text. Also, it is more likely to be available at general bookstores.

US EPA. 1993 Wildlife Exposure Factors Handbook. Vols I and II. US

Field Guides

The following field guides are readily available in any bookstore and contain some information about distribution, diet, and other natural history.

Whitaker, J. O. 1996. National Audubon Society field guide to North American mammals 2nd ed. Random House, NY

Boschung, H. 1983. The Audubon Society field guide to North American fishes, whales, and dolphins Random House, NY

Peterson, R. T. 1961. A field guide to western birds: field marks of all species found in North American west of the 100th meridian, with a section on the birds of the Hawaiian Islands 2nd ed. Houghton Mifflin, Boston

Stebbins, R. C. 1966. A field guide to western reptiles and amphibians; field marks of all species in western North America. Houghton Mifflin, Boston.

Note: Information can also be obtained from the Canadian Wildlife Service (CWS), BCE Wildlife Branch.

APPENDIX L

Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia - Appendix L. Analytical Laboratories in British Columbia

For regulatory purposes under the Contaminated Sites Regulation, the ministry will only accept analytical results obtained from an accredited laboratory.

An accredited laboratory is a laboratory registered under the Environmental Data Quality Assurance (EDQA) Regulation.

To determine if a particular laboratory is registered under the EDQA regulation, visit the CAEAL Directory of Laboratories website for a list of Laboratories Registered under the EDQA Regulation and Associated Designated Characteristics under Directory of Member Lab Codes.

Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia - Appendix M. Analytical Methodology

Section A: Quality Assurance/Quality Control

APHA. 1992. Part 1000: Introduction. *Standard Methods for the Examination of Waters and Wastewater, 18th Edition.* American Public Health Association, American Water Works Association, and the Water Environment Federation, Washington, DC, Pp. 1-1 - 1-42.

ASTM. 1996. *1996 Annual Book of ASTM Standards, Section 11, Water and Environmental Technology.* American Society of Testing and Materials, West Conshohocken, PA.

Method D1192: Specification for equipment for sampling water and stream, Volume 11.01.
Method D2777: Practice for determination of precision and bias of applicable methods of committee D-19 on water, Volume 11.01.
Method D3370: Practices for sampling water, Volume 11.01.
Method D3670: Guide for determination of precision and accuracy of methods of committee D 22, Volume 11.03.
Method D4210: Practice for interlaboratory quality control procedures and a discussion on reporting low level data, Volume 11.01.
Method D4447: Guide for the disposal of laboratory chemicals and samples, Volume 11.04.
Method D5283: Standard practice for generation of environmental data related to waste management activities: quality assurance and quality control planning and implementation, Volume 11.04.
Method E29: Practice for using significant digits in test data to determine conformance with specifications, Volume 14.02.
Method E178: Practice for dealing with outlying observations, Volume 14.02.

BCEPD. 1994a. Section A. Laboratory quality assurance/quality control. *British Columbia Environmental Laboratory Manual For the Analysis of Water, Wastewater, Sediment and Biological Materials, 1994 Edition*. Laboratory Services, Environmental Protection Department, Ministry of Environment, Lands and Parks, Province of British Columbia, BC, pp. A-3 - A-22.

BCEPD. 1994b. Appendix 3: SEAM laboratory codes. *British Columbia Environmental Laboratory Manual For the Analysis of Water, Wastewater, Sediment and Biological Materials, 1994 Edition*. Laboratory Services, Environmental Protection Department, Ministry of Environment, Lands and Parks, Province of British Columbia, BC, pp. 1 - 5.

BCEPD. 1996. Part A. Quality control and quality assurance. *British Columbia Field Sampling Manual For Continuous Monitoring Plus the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment, and Biological Samples, 1996 Edition*. Laboratory and Systems Management, Environmental Protection Department, Ministry of Environment, Lands and Parks, Province of British Columbia, BC, pp. A4 - A25.

NIOSH. 1985. *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*, DSHS Publication No. 85-115. NIOSH, OSHA, USCG, EPA, (NTIS No. PB87-162855/LL). October 1985.

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Section B: Physical and Aggregate Properties

Parameter	BCEPD (1994)	USEPA (1979)	APHA (1992)
Acid Volatile Sulfides		Draft [3]	
Alkalinity, Titrimetric	0102X148	310.1	2320 B
Biochemical Oxygen Demand	0115X013	405.1	5210 B
Biomass, Gravimetric, Fixed Wt. (550° C)	0462X312		10200 I
Biomass, Gravimetric, Dry Wt. (105° C)	0460X313		10200 I
Carbon, Total Organic, (TOC)	0103X067	415 [1]	5310 B
Cation Exchange Capacity		9081[2]/Plumb [4]	
Chemical Oxygen Demand	0116X315	410.2 [1]	5220 D
Chemical Oxygen Demand	0116X315	410.2 [1]	5220 D
Chloride, Ion Chromatograph	0104X044	300.0 [1]	4110
Chlorophyll-*a* and Phaeophytin-*a*	0143X318		10200 H
Coliform, Total			9221B
Fecal			9221E
Conductivity	0011X322	120.1	2510 B
Cyanide, Total	0105X324	335.4 [1]/9012 [2]	4500-CN-D
Weak Acid Dissociable	0157x400		4500-CN- I
Ion-Selective Electrode			4500-CN-F
Hardness, Total, Titrimetric		130.2	2340 C
Fluoride, Ion Chromatograph		300.0 [1]	4110
Fluoride, Ion-Selective Electrode	1106X084	340.2	4500- F- G

Moisture Content	0025X233		
Nitrogen:Ammonia, Colorimetric, Automated	1108X326	350.1 [1]	4500-NH_3H
Ammonia, Ion Selective Electrode	1108X143	350.3	4500-NH_3G
Nitrate-Nitrite, Colorimetric, Automated	1109X328	353.2 [1]	4500-NO_3-F
Nitrate, Ion-Selective Electrode			4500-NO_3-D
Nitrite, Ion Chromatograph	1110X044	300.0 [1]	4110
Nitrite, Colorimetric	1111X327	354.1	4500-NO_2-B
Nitrite, Ion Chromatograph		300.0 [1]	4110
Total Kjeldahl, Block Digestion	0113X325	351.2 [1]	4500-NH_3H
Oxygen, Dissolved, Membrane Electrode	0014XP01	360.1	4500-O G
Azide Modification		360.2	4500-O C
Particle Size		Plumb [4]	
pH, Electrometric	0004X330	150.1	4500-H^+ B
Phosphorus: Dissolved, Colorimetric, Automated	118X157	365.1 [1]	4500-P F
Total, Colorimetric, Automated	P-TX185	365.1 [1]	4500-P F
Phosphate, Ion Chromatograph		300.0[1]	4110
Residue: Filterable (TDS) (180° C)	0007X026	160.1	2540 C
Nonfilterable (TSS) (103-105° C)	0008X332	160.2	2540 D
Settleable (Settleable Solids)	0023X050	160.5	2540 F
Total (TS) (103-105° C)	0005X333	160.3	2540 B
Fixed and Volatile, (550° C)	0032X175	160.4	2540 E
Salinity, Electrical Conductivity	0130XM09		2520-B
Sulfate, Automated Colorimetric	1121X163	375.2 [1]	4500-$SO_4 2^2$F
Sulfate, Ion Chromatograph	1121X044	300.0 [1]	4110
Sulfide, Ion-Selective Electrode	0125X340		4500-S^{2-} A
Surfactants, Sublation Extraction	0122X342		5540 B
Tannin and Lignin	0123X120		5550 B
Temperature, Thermometric		170.1	2550
Turbidity, Nephelometric	0015X164	180.1 [1]	2130 B

[1] USEPA 1993 Revision to USEPA 1979 method

[2] USEPA 1990 SW-846 method

[3] Allen, H.E., et al., 1991 USEPA draft method

[4] Plumb, R.H. 1981

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Section C: Inorganic Metals

Parameter BCEPD (1994) USEPA (1978) SW-846

Parameter	BCEPD (1994)	USEPA (1979)	SW-846
Inductively Coupled Plasma (ICP)			
Aluminum		200.7	6010
Antimony	Sb-TX352	200.7	6010
Arsenic	As-TX352	200.7	6010
Barium		200.7	6010
Beryllium		200.7	6010
Boron		200.7	6010
Cadmium	Cd-TX352	200.7	6010
Calcium		200.7	6010
Chromium	Cr-TX352	200.7	6010
Cobalt		200.7	6010
Copper	Cu-TX352	200.7	6010
Iron		200.7	6010
Lithium		200.7	6010
Magnesium		200.7	6010
Mercury		200.7	6010
Molybdenum		200.7	6010
Nickel		200.7	6010
Phosphorus		200.7	6010

Potassium		200.7	6010
Selenium	Se-TX352	200.7	6010
Silicon		200.7	6010
Silver		200.7	6010
Sodium		200.7	6010
Sulfur		200.7	6010
Thallium		200.7	6010
Tin		200.7	6010
Titanium		200.7	6010
Vanadium		200.7	6010
Yttrium		200.7	6010
Zinc		200.7	6010

Graphite Furnace Atomic Absorption Spectrometry

Antimony	Sb-TX179	204.2	7041
Arsenic		206.2	7060
Cadmium	Cd-TX179	213.2	7131
Chromium	Cr-TX179	218.2	7191
Lead	Pb-TX179	239.2	7421
Nickel	Ni-TX179	249.2	7520
Selenium	Se-TX179	270.2	7740
Silver	Ag-TX179	272.2	7760
Thalium		279.2	7841

Cold Vapor Atomic Absorption Spectrometry

Mercury, Total	HG-TX353	2445.1	7470
Dissolved	HG-TX358		

Flame Atomic Absorption Spectrometry

Aluminum	AL-TX351	202.1	7020
Barium	Ba-TX351	208.1	7080

Berylium		210.1	7090
Copper	Cu-TX351	220.1	7210
Iron	Fe-TX351	236.1	7380
Manganese	Mn-TX351	243.1	7460
Molybdenum	Mo-TX351	246.1	7480
Tin	Sn-TX351	282.1	7870
Titanium		283.1	

Sample Preparation Methods for Waters, Soils, Sediments and Solid Wastes

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Method 3005: Acid digestion of waters for total recoverable or dissolved metals foranalys is by flame atomic absorption spectroscopy or inductively coupled plasma spectroscopy.
Method 3010: Acid digestion of aqueous samples and extracts for total metals for analysis by flame atomic absorption spectroscopy or inductively coupled plasma spectroscopy.
Method 3015: Microwave assisted acid digestion of aqueous samples and extracts.
Method 3020: Acid digestion of aqueous samples and extracts for total metals for analysis by graphite furnace atomic absorption spectroscopy
Method 3040: Dissolution procedures for oils, greases, or waxes.
Method 3050: Acid digestion of sediments, sludges, and soils.
Method 3051: Microwave assisted acid digestion of sediments, sludges, soils, and oils.

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Section D: Trace Organics

Parameter	BCEPD (1994)	USEPA (1979)	SW-846
Gas Chromatograph/Mass Spectometer (GC/MS) Scans			
Base/Neutrals and Acids	EX625X362	625	8270B
Organochlorine Pesticides	EX625X362	625	8270B
Phenols	EX625X362	625	8270B
Polycyclic Aromatic Hydrocarbons	EX625X362	625	8270B
Polychlorinated Biphenyls (PCB's)	EX625X362	625	8270B
Dioxins:			
Polychlorinated Dibenzo- (PCDDs)	Unpublished		8290B
Polyclorinated Dibennzofurans (PCDFs)	Unpublished	625	8290B
2,3,7,8-Tetrachlorodibenzo-p-dioxin	Unpublished		
Volatile Halogenated Compounds	VHH-X383	625	8290B
Volatile Organic Compounds (Purgeables)	VOC-X384	624	8260A
Benzene	B020X267	624	8260A
Ethylbenzene	B021X267	624	8260A
Toluene	T001X267	624	8260A

Xylene	X001X267	624	8260A
Pesticides: Neutrals, Scan:			
Organochlorine	PESTX373	625	8270B
Organonitrogen	PESTX373	625	8270B
Organophosphorus	PESTX373	625	8270B
Herbicides	PESTX373	625	8270B
Titanium		283.1	

Gas Chromatograph Component Methods

Dioxins:			
2,3,7,8-Tetrachlorodibenzo-*p*-dioxin	Unpublished	613	8280
Polychlorinated Dibenzodioxins (PCDDs)	Unpublished	625	8290B
Polychlorinated Dibenzofurans (PCDFs)	Unpublished	625	8290B
Pesticides:			
Herbicides	AEHSX361	615	8151
Organochlorine and PCB's	OCPSX374	608/617	8080A
Organonitrogen	PESTX373	633	
Organophosphates	OPPSX375	614	8140
Phenols (GC/ECD):			
Phenols	E625X362	604	8040A
Chlorinated phenols	C020X363		
Polychlorinated Biphenyls (PCB's) by GC/ECD:			
Total, in Petroleum Products	P019X376		
Organochlorine Pesticides and PCBs	OCPSX374	608/617	
Polycyclic Aromatic Hydrocarbons:			
GC/FID, HPLC	PAH-X377	610	8100/8310
GC/MS	PAHX379	625	8270B
GC/MS	E625X362	625	8270B

Volatiles by P&T/GC:			
Purgeable Aromatics, BTEX	VOC-X384	602	8020A/8260A
Nonhalogenated Volatile Organics	H-TPX369		8015B
Purgeable Halocarbons		601	8010B
Trace Organics Analyses, Miscellaneous			
Hydrocarbons:			
Total, GC	H-TPX369		
Total, IR		418.1	9073/550F [3]
Chlorinated		612	8120A
Lipid Content	LIPIX269		
Oil and Grease:			
Combined Extraction	0003X372		
Direct Hexane	0003X055	413.1 [2]	9070A/5520 [3]
Phenolics		420.4 [4]	5530D [3]
Phenols, Colorimetric	0117X142	420.2 [2]	5530C [3]

[1] BCEPD. 1994c

[2] USEPA. 1979

[3] APHA. 1992

[4] USEPA 1993. Revision to USEPA 1979 method

Sample Extractions, Preparations and Cleanup Methods

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USEPA. 1982. Test methods. *Methods For Organic Chemical Analysis of Municipal and Industrial Wastewater*. Environmental Monitoring and Support Laboratory, Cincinnati, OH. EPA-600/4-82-057.

USEPA. 1990. Organic analytes. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846), Third Edition*. Volume One: Section B, Chapter Four. Office of Solid Waste and Emergency Response, Washington, DC, (NTIS No. PB88239223/LL).

Preparation and Extraction

Method 3500: Organic Extraction and Sample Preparation
Method 3510B: Separatory Funnel Liquid-Liquid Extraction
Method 3520B: Continuous Liquid-Liquid Extraction
Method 3540B: Soxhlet Extraction
Method 3541: Automated Soxhlet Extraction

Preparation and Extraction

Method 3550A: Ultrasonic Extraction
Method 3580A: Waste Dilution
Method 5030A: Purge and Trap

Cleanup

Method 3600: Cleanup
Method 3610A: Alumina Column Cleanup
Method 3611A: Alumina Column Cleanup and Separation of Petroleum Wastes
Method 3620A: Florisil Column Cleanup
Method 3630B: Silica Gel Cleanup
Method 3640A: Gel-Permeation Chromatography Cleanup
Method 3650A: Acid-Base Partition Cleanup
Method 3660A: Sulfur Cleanup
Method 3665: Sulfuric Acid/Permanganate Cleanup

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Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia - Appendix N. Environmental Sampling Methods

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