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Federal Contaminated Sites Action Plan (FCSAP)

Framework for Addressing and Managing Aquatic Contaminated Sites under the Federal Contaminated Sites Action Plan (FCSAP), version 2.1

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Framework for Addressing and Managing Aquatic Contaminated Sites under the Federal Contaminated Sites Action Plan (FCSAP)

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Fisheries and Oceans Canada (DFO) Expert Support, as the lead Expert Support Department for FCSAP Aquatic Sites Framework, has revised this guidance document to reflect the 2019 changes to federal legislation and Phase IV (2020-2025) modifications to the renewed FCSAP program. Please find further details on document changes in the table below.

Document change control

Revision Number	Date of Issue	Author(s)	Brief Description of Change
2.0	June 2019	Aquatic Sites Working Group subcommittee of the Contaminated Sites Management Working Group (CSMWG)	• Corrected formatting and grammar; condensed information • Updated references • Updated definitions and terminology to align with CCME • Added biomagnification footnote to Table 1 • Improved alignment with the FCSAP Decision-Making Framework, including use of flowcharts
2.1	November 2021	Fisheries and Oceans Canada (DFO) Expert Support & Federal Contaminated Sites Action Plan (FCSAP) Secretariat	• Improved alignment with FCSAP Decision-Making Framework, Version 4.0 (in press), including use of flowcharts and updates to FCSAP Phase IV (*e.g.,* site eligibility and prioritization) • Improved alignment with updated legislation relevant to the FCSAP program, such as the *Fisheries Act* (2019) and the *Impact Assessment Act* (2019) • Updated links and citations

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Executive Summary

A common, risk-based Framework for the adaptive management of contaminated aquatic sites under federal custody is described. The original Aquatic Sites Framework, developed by Chapman (2011) and the Aquatic Sites Working Group (ASWG) subcommittee of the inter-departmental Contaminated Sites Management Working Group (CSMWG), is based on the 10-step approach for terrestrial contaminated sites described in *A Federal Approach to Contaminated Sites* (CSMWG 1999) and the *Decision-Making Framework* (DMF; FCSAP 2018). The FCSAP DMF provides a roadmap that outlines the specific approaches and key decision points to effectively address federal contaminated sites in Canada.

This Aquatic Sites Framework is iterative and sequential in both scope and decision points (the latter comprise simple “yes” or “no” criteria).

The Aquatic Sites Framework described herein is also a 10-step process, which begins with information gathering (Steps 1-2), during which aquatic sites suspected of being contaminated are identified for further assessment and aquatic sites that are not suspected of being contaminated are eliminated from further consideration. Steps 3-4 involve Screening Level Assessment (SLA), during which contaminated aquatic sites are classified as either:

a) Requiring remediation/ risk management; or,
b) Requiring further assessment; or,
c) Eliminated from further consideration.

Steps 5-6 involve Detailed Level Assessment (DLA) of sites classified for further assessment, following which these aquatic sites are either prioritized for remediation/risk management (R/RM) action(s) or eliminated from further consideration. R/RM strategies are developed and implemented for prioritized contaminated aquatic sites in Steps 7 and 8. Confirmatory sampling and long-term monitoring are conducted in Steps 9 and 10 to ensure that R/RM objectives are met.

Aquatic sites entering the 10-step process can be eliminated from further consideration at several decision points, or can be prioritized for management action(s). Contaminated aquatic sites where R/RM action(s) are necessary remain within the process until the risk has been successfully addressed. Successful risk management/remediation is defined as a condition where there are negligible residual risks to human health and the environment.

List of Abbreviations

ASWG - Aquatic Sites Working Group

BPJ - Best Professional Judgment

BMP - Best Management Practices

BSAF - Biota sediment accumulation factor

CALA - Canadian Association for Laboratory Accreditation

CCME - Canadian Council of Ministers of the Environment

CEPA - *Canadian Environmental Protection Act*

COA - The *Canada-Ontario Decision-Making Framework* (Environment Canada and Ontario Ministry of the Environment 2008; the *COA*)

COC - Contaminant of concern

COPC - Contaminant of potential concern

CSM - Conceptual site model

CSMWG - Contaminated Sites Management Working Group

DMF – Decision-Making Framework

DFO - Department of Fisheries and Oceans

DLA - Detailed level assessment

DQO - Data quality objectives

EA - Environmental assessment

ECCC - Environment and Climate Change Canada

EMP - Environmental management plan

EPP - Environmental protection plan

ERA - Ecological risk assessment

FCSI - Federal Contaminated Sites Inventory

FCSAP - Federal Contaminated Sites Action Plan

HC - Health Canada

HHRA - Human health risk assessment

IAA - *Impact Assessment Act*

ISQG - Interim Sediment Quality Guideline

LOE - Line of evidence

MNR - Monitored natural recovery

NAPL - Non-aqueous phase liquids

PEL - Probable effect level

PSPC - Public Services and Procurement Canada

QA/QC - Quality assurance/quality control

R/RM - Remediation/ Risk management

RAP/RMP - Remedial action plan/Risk Management Plan

ROC - Receptor of concern

ROPC - Receptor of potential concern

SAP - Sampling and analysis plan

SARA - *Species at Risk Act*

SLA - Screening level assessment

SeQG - Sediment quality guideline

SeQO - Sediment quality objective

TEL - Threshold effect level - equivalent to a CCME ISQG (TEL)

TRV - Toxicity reference value

WOE - Weight of evidence

W/U/A - Works, undertakings or activities

Glossary of Terms

Acute toxicity - A discernible adverse effect (lethal or sublethal) induced in test organisms with a short period of exposure in relation to the life span of the test organism (defined as less than 10% of an organism's life span by Environment and Climate Change Canada) (FCSAP ERA Module 1, 2010).

Adaptive management - A planned and systematic process for continuously improving environmental management practices by learning about their outcomes. Adaptive management involves iterative decision-making (evaluating results and adjusting on the basis of what has been learned), and emphasizes continual improvement to optimize decision-making.

Adverse effect (to an organism) - An undesirable or harmful effect to an organism, indicated by some result such as mortality, reduced growth, reduced fecundity, behavioural, or visible pathological changes.

Aquatic site - A water lot or land or part of land that is completely, partially, or occasionally submerged by water. Aquatic sites include freshwater and marine sites, and the transition zones (where shallow groundwater and surface water mix), but exclude deep-seated groundwater. Exceptions to the above definition may be established, on a case-by-case basis, using professional judgment.

Area use - The extent to which an area is used by an organism during its life cycle (*e.g.*, feeding, rearing, etc.).

Assessment endpoint - The explicit expression of the environmental value that is to be protected. An assessment endpoint must include a receptor (or receptor group – i.e., a 'thing' to be protected) and a specific property of that receptor. For example, if the receptor is a fish community, endpoint properties could include the number of species.

Benthic organisms - Refers to organisms living in, or on, the sediments of aquatic habitats.

Benthos - The sum total of organisms (including plants and animals) living in, or on, the sediments of aquatic habitats.

Best professional judgement - The thorough application of critical judgement in professional practice, in which an experiential, reflective, self-corrective, and purposeful thinking process is applied to consider knowledge, context, evidence, methods, conceptualizations, and criteria. BPJ is a means by which a practitioner can incorporate a diverse range of information without articulating a mechanical process for processing the information.

Bioaccumulation - The process by which chemical substances are accumulated by organisms from exposure to water, sediments, or soil directly or through consumption of food containing the chemicals. Most substances bioaccumulate to some extent, whereas few biomagnify (CCME ERA Guidance, 2020).

Bioassay - The use of a living organism(s) (or part of an organism) as a method for measuring or assessing the presence or biological effects of one or more substances under defined conditions. A bioassay test is used to measure a degree of response (*e.g.*, growth or death)

produced by exposure to a physical, chemical or biological variable (a toxicity test) or uptake of a chemical into an organism (a bioaccumulation test).

Bioavailability - Refers to the fraction of the total chemical in the surrounding environment which can be taken up by organisms (US National Research Council 2003). The environment may include surface water, interstitial water, soil sediment, suspended particles, and food items.

Biomagnification - A phenomenon observed as the result of bioaccumulation by which tissue concentrations increase as the chemical passes up through the food chain (i.e., two or more trophic levels (FCSAP ERA Module 1, 2010).

Biota sediment accumulation factor - A parameter describing bioaccumulation of chemicals from sediments into tissues of ecological receptors.

Chronic toxicity - A discernable adverse effect (lethal or sublethal) induced in test organisms during relatively long period of exposure, usually a substantial proportion of the life span of the organism (*i.e.,* defined as 10% or more of lifespan by Environment and Climate Change Canada) (FCSAP ERA Module 1, 2010).

Concentration - The amount of a substance (*e.g.*, a chemical) in a given environmental medium per unit mass (mg/kg) or volume (mg/L) of that medium.

Conceptual site model - A diagrammatic representation of a site and its environment that represents what is known or suspected about contaminant sources as well as the physical, chemical and biological processes that affect contaminant transport to potential environmental receptors (Appendix C).

Contaminant - Any physical, chemical, biological or radiological substance in air, soil, sediment or water whose concentration exceeds guideline and/or background concentrations or which is not naturally occurring in the environment.

Contaminant of concern - A contaminant at a site that adversely affects a human or non-human biological receptor.

Contaminant of potential concern - A suspected contaminant at a site that has the potential to adversely affect a human or non-human biological receptor.

Contaminated site - A site at which substances (*e.g.*, chemicals) (1) occur at concentrations above background levels and may pose an immediate or long-term hazard to human health or the environment, or (2) exceed concentrations specified in policies or regulations.

Data quality objectives - Qualitative and quantitative statements of the overall level of uncertainty that a decision-maker will accept in results or decisions based on environmental data. DQO provide the statistical framework for planning and managing environmental data operations consistent with user needs (Appendix B).

Ecological risk assessment - The process of defining and quantifying risks to non-human biota, *i.e.*, the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors. This definition recognizes that a risk does not exist unless:

(1) the stressor has an inherent ability to cause adverse effects; and (2) it is in contact with the ecological component at sufficient duration and intensity, to elicit the identified adverse effect(s).

Environmental management plan - Outlines the regulatory and permitting requirements specific to the site management/remediation project and identifies the potential environmental effects and how they can be mitigated. It also identifies environmental performance criteria (*e.g.*, turbidity criteria) that should not be exceeded during the work as well as the actions that should be taken in the event that they are exceeded.

Environmental protection plan - A project-specific plan that outlines roles and responsibilities of the custodial organization, the contractor's staff, the location of spill response equipment, and the specific measures that they will use to meet environmental protection requirements. Should be consistent with IAA 2019.

Expert Support - Within FCSAP program there are four expert support departments that offer technical advice to assist custodians with the management of their contaminated sites. Environment and Climate Change Canada, Health Canada and Department of Fisheries and Oceans provide science-based advice, training and guidance. They review project documentation, including site eligibility scores, to ensure that the risks posed by the sites to human health and the environment have been adequately considered in the project proposals. Public Services and Procurement Canada (formerly Public Works and Government Services Canada) provides expert support to the program through the development of project management and procurement tools and the dissemination of information on innovative technologies and best practices.

Exposure - The contact between a contaminant and a biological receptor (*i.e.*, an individual or population). Even the most toxic material does not pose risk if there is no exposure pathway.

Fish - Fish includes (*a*) parts of fish, (*b*) shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals, and (c) the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals (*Fisheries Act*, Subsection 2(1)).

Fish habitat - Water frequented by fish and any other areas, on which fish depend directly or indirectly to carry out their life processes, including spawning grounds and nursery, rearing, food supply and migration areas (*Fisheries Act*, Subsection 2(1)).

***Fisheries Act* Authorization -** An authorization granted by the Minister of Fisheries and Oceans Canada under paragraphs 34.4(2)(b) and 35(2)(b) of the *Fisheries Act* in accordance with the *Authorizations Concerning Fish and Fish Habitat Protection Regulations*. This authorization allows the carrying out of a w/u/a that results in the death of fish, other than fishing, and the harmful alteration, disruption or destruction of fish habitat in cases where, after the implementation of avoidance and mitigation measures the w/u/a still results in residual harm to fish and fish habitat. An Authorization can also act as a permit issued under the *Species at Risk Act* provided that certain conditions are met (DFO, Fish and Fish Habitat Protection Policy Statement, 2019). For further details see section 2.5.2.2 Environmental Management Plan in this Framework.

Groundwater - Subsurface water beneath the water table in fully saturated geologic formations

Guideline - A value that is recommended for the screening of environmental data, such as tissue residues or concentrations in abiotic media. A guideline usually differs from a standard in that a guideline does not convey a legal requirement or formal responsibility. Also see the definition of Sediment Quality Guideline, below.

Hazard - The possibility of an adverse effect, *e.g.*, a measure of the toxic potential of a substance.

Human health risk assessment - The process of defining and quantifying risks to human health: evaluates the likelihood that adverse human health effects may occur or are occurring as a result of exposure to one or more stressors. It is recognized that a risk does not exist unless: (1) the stressor has an inherent ability to cause adverse effects; and (2) it is coincident with or in contact with one or more humans long enough and at sufficient intensity to elicit the identified adverse effect(s).

Institutional controls - Non-engineered instruments, such as administrative and legal controls, that help minimize the potential for exposure to contamination and/or protect the integrity of a remedy. They play an important role in site remedies because they reduce exposure to contamination by limiting aquatic site or resource use and guide human behaviour at a site. For instance, zoning restrictions can prevent aquatic site uses such as dock construction, which could affect the integrity of an engineered cap.

Interim Sediment Quality Guidelines - Canadian sediment quality guidelines that are derived when data are available but limited, and information gaps are explicitly outlined.

Invertebrate - Animal lacking a dorsal column of vertebrae or a notochord.

Letter of Advice - A letter that is issued to a proponent proposing to conduct works, undertakings or activities in or near water when the DFO-Fish and Fish Habitat Protection biologists have determined that the risk posed to fish and fish habitat can be effectively managed by the implementation of the appropriate suggested avoidance and mitigation measures.

Line of Evidence - A component of weight of evidence determinations (*e.g.*, toxicity, benthos alteration, biomagnification, chemical contamination).

Measurement endpoint - An expression of an observed or measured response to a hazard; a measurable environmental characteristic that is related to the valued characteristic chosen as the assessment endpoint.

Media - The fundamental components of the environment including air, water, sediment, soil and biota.

Migration - Movement of substances or biota.

Mitigation - Actions taken to alleviate potential or actual adverse effects to humans or the environment.

Monitored Natural Recovery - a passive *in situ* remediation approach where naturally-occurring processes demonstrably contribute to declining contaminant concentrations and/or bioavailability in sediments.

Monitoring - Determining changes or trends over time in measured parameters (*e.g.*, contaminant concentrations in different media, the status of resident populations of biota).

Offsetting Plans - In conjunction with a *Fisheries Act* authorization, the offsetting plans contain measures to counterbalance unavoidable death of fish (other than fishing) and harmful alteration, disruption or destruction of fish habitat resulting from a work, undertaking or activity with the goal of protecting and conserving fish and fish habitat. Offsetting measures should support available fisheries management objectives and local restoration priorities and be conducted in a manner consistent with the department's offsetting policy (DFO, Fish and Fish Habitat Protection Policy Statement, 2019). Offsetting is an action someone can take to counterbalance residual negative effects of their project on fish and fish habitat. Offsetting is used only after residual effects remain after the implementation of avoidance and mitigation measures.

Pathway - The means by which organisms are exposed to contaminants. More generally, pathways include exposure via air, water, soil, sediments, food, and other media to which the ecological or human receptor may be exposed.

Pollution - The introduction by humans, directly or indirectly, of substances or energy into the affected area that results, or is likely to result, in (a) hazards to human health; (b) harm to living resources or ecosystems; (c) damage to amenities; or (d) interference with other legitimate uses of the environment.

Probable Effect Level - The level above which adverse effects in biota are expected to occur frequently.

Problem formulation - The first step in risk assessment, which clarifies the nature of issues associated with contamination at a site and how those issues will be addressed.

Receptor - The entity that might be adversely affected by contact with, or exposure to, a contaminant of potential concern. (*e.g.,* organism, population, community, ecosystem). The descriptor of *concern* or *potential concern* is sometimes used, depending on the stage at which a receptor was identified.

Receptor of concern - Human or non-human biota that are exposed to and may be adversely affected by contaminants or other stressors.

Receptor of potential concern - Human or non-human biota that may be exposed to and adversely affected by contaminants or other stressors.

Reference area - An unimpacted or relatively unimpacted area with physical and biological attributes similar to those of the study area, but for the release of site-related chemicals.

Remedial Action/ Risk Management Plan - The plan which details the selected strategy to be implemented for addressing contamination on site.

Remediation - The removal or destruction or containment of pollution or contaminants from media such as soil, groundwater, sediment or surface water for the general protection of human health and the environment.

Residuals - The quantity of material remaining after a process (*e.g.*, the amount of contaminated sediment remaining after remedial activities such as dredging have been undertaken).

Risk - The likelihood of an adverse effect as measured by exposure of receptors of potential concern to contaminants of potential concern.

Risk assessment - A scientific examination of the likelihood that contaminants will adversely affect humans or the environment.

Risk hypotheses - Specific assumptions about potential risk to assessment endpoints; may be based on theory and logic, empirical data, mathematical models, or probability models (Appendix D).

Risk management - The selection and implementation of a strategy to control risk. Risk management may include strategies that reduce the probability, intensity, frequency, or duration of the exposure to contamination.

Screening - An analysis to determine if further action (*e.g.*, detailed analysis or remediation) is necessary.

Sediment - Material, such as sand or mud, suspended in or settling to the bottom of surface water. Sediment input to a body of water comes from natural sources, such as erosion of soils and weathering of rock, or as the result of anthropogenic activities, such as forest or agricultural practices, or construction activities.

Sediment quality guideline - Numerical limits or narrative statements recommended to support and maintain designated uses of the aquatic environment. Sediment quality guidelines for the protection of aquatic life are derived from the available toxicological information on the biological effects of sediment-associated chemicals on aquatic organisms. The resulting guidelines provide scientific benchmarks to be used as a basis for the evaluation, protection, and enhancement of sediment quality.

Site management - The implementation of a strategy or measures to control or reduce the level of risk estimated by the risk assessment.

Site-specific - Specific to a particular site, taking into consideration the site's unique physical, chemical and biological characteristics. A site-specific guideline considers site-specific science-based factors (physical, chemical and biological), while a site-specific objective considers science and/or socio-economic and/or technological factors and/or policy factors (*e.g.*, management goals).

Stressor - Any physical, chemical or biological factor that causes constraints on the productivity of organisms and the development of ecosystems.

Surface water - Water in direct contact with the atmosphere (*e.g.*, rivers, streams, lakes, wetlands, estuaries, artificial water courses such as canals).

Threshold Effect Level - The concentration below which adverse biological effects are expected to occur rarely.

Tiered assessment - An iterative process in which the initial assessment is the simplest (*e.g.*, minimal site-specific data) and most conservative, and thus will not always provide sufficient certainty for decision-making. The initial assessment will serve to determine three possibilities: (1) risk unlikely; (2) risk potentially exists; (3) too much uncertainty present for a determination without further investigation. However, possibility 3, which typically will comprise more cases than possibilities 1 and 2, will require further assessment (*i.e*., further tiers). Successive tiers will involve more focused (*e.g.*, site-specific) investigations, informed and focused based on the results of the previous tier. Data needs are relatively low at the initial tier, but increase at successive tiers; however, uncertainty also reduces at successive tiers. Weight of evidence typically determines the tier at which uncertainty has been reduced sufficiently for informed management decision making.

Toxic Substance - A substance is toxic if it is entering or may enter the environment in a quantity or concentration or under conditions that (a) have or may have an immediate or long-term harmful effect on the environment or its biological diversity; (b) constitute or may constitute a danger to the environment on which life depends; or (c) constitute or may constitute a danger in Canada to human life or health (*Canadian Environmental Protection Act,* Part 5, S.64).

Toxicity - The observation of a chemically-induced physiological or biological response that impairs the health of an organism.

Toxicity Reference Value - An exposure concentration or dose that is not expected to cause an unacceptable level of effect in receptor(s) exposed to the contaminant of potential concern. A TRV is a specific type of *threshold*, as defined above.

Trophic level - Functional classification of organisms in a community according to feeding relationships - *e.g.*, the first trophic level includes photosynthesizers, the second level includes herbivores, etc.

Weight of evidence - A determination related to possible ecological impacts based on multiple Lines of Evidence.

1.0 Introduction

The Federal Contaminated Sites Action Plan (FCSAP) is a federal program established in 2005 with the goal of reducing environmental and human health risks from known federal contaminated sites in Canada and their associated federal financial liabilities. To achieve this objective, FCSAP provides guidance, tools and resources to federal departments, agencies and Consolidated Crown corporations (collectively referred to as "custodians") to ensure that federal contaminated sites are managed in a scientifically sound and a nationally consistent manner. The FCSAP Decision-Making Framework (DMF) is a 10-step roadmap that outlines the specific activities, requirements and key decisions to effectively address federal contaminated sites in Canada. The DMF along with other FCSAP-related resources can be found on the FCSAP website.

This *Framework for Addressing and Managing Aquatic Contaminated Sites under the FCSAP* provides a consistent and scientifically-based approach for federal custodians in identifying and addressing their aquatic contaminated sites.

1.1 Background

The inter-departmental Contaminated Sites Management Working Group (CSMWG) promotes a nationally consistent approach for the management of the thousands of contaminated sites on federal lands for which the Canadian federal government has accepted responsibility and that require attention. The CSMWG is also charged with developing guidance for assessing, classifying, and managing federal aquatic sites funded by FCSAP. Aquatic sites are defined as a water lot, or land or part of land, that is completely, partially, or occasionally submerged by water. Aquatic sites include freshwater and marine sites, and the transition zones (where shallow groundwater and surface water mix), but exclude deep-seated groundwater. Exceptions to the above definition may be established, on a case-by-case basis, using professional judgment.

The CSMWG (1999) and FCSAP (2018) DMF established a common, risk-based approach for the management of contaminated sites under federal custody. This approach incorporates a 10-step process that has proven to be an effective management tool for terrestrial contaminated sites, but which does not provide adequate guidance for aquatic contaminated sites. Aquatic sites differ from terrestrial sites in that they are often more difficult to access, have different receptors and food webs, are dominated by hydrology, and have limited interactions with aerial sources of contaminants. The guidance document has been developed to address this knowledge gap. It is based on the CSMWG (1999) 10-step process and FCSAP (2018) DMF with suitable modifications and updates, combining relevant aspects of human health risk assessment (HHRA) and ecological risk assessment (ERA) approaches. It is also based on the weight of evidence (WOE) approach in the *Canada-Ontario Decision-Making Framework* (*COA*; Environment Canada and Ontario Ministry of the Environment 2008). The *COA* is widely used and includes guidance regarding data quality objectives (DQOs: based on USEPA 2000, 2006) and contaminated sediment management options. Additional relevant and useful guidance documents include Nikl (2006), CCME (2008) and references provided in Appendix A.

FCSAP (2021b) *Guidance for Assessing and Managing Aquatic Contaminated Sites in Working Harbours* was developed to provide guidance to custodians who manage an aquatic contaminated site in a working harbour. This document complements the FCSAP 10-step process for addressing and managing an aquatic contaminated site by providing supplementary

guidance at each step of the framework to address challenges specific to working harbour sites. Custodians are encouraged to consult the guidance as required.

1.2 Purpose

The purpose of this document is to provide an objective, transparent, consistent and scientifically rigorous framework for identifying, assessing, and managing federal contaminated aquatic sites. This framework is intended to provide the CSMWG with an efficient, consistent and uniform government-wide approach to the adaptive management of contaminated aquatic sites; but is not intended as detailed guidance for conducting a risk assessment or for preparing a remediation/risk management strategy. The primary guidance for implementation of the *Framework for Addressing and Managing Aquatic Contaminated Sites under FCSAP* (hereafter, "framework") is identical to that of the *COA* (Section 2.1, p 3) - *it shall be applied within the context of best professional judgement. In other words, it will not be applied inflexibly.*

There are four other guidance "rules" for the use of this Framework (the *COA*, Section 2.1, p 3):

- Sediment chemistry data (e.g., sediment quality guidelines [SeQGs]) will not be used alone for remediation decisions except for two cases. The first case involves "simple contamination where adverse biological effects are likely… when the costs of further investigation outweigh the costs of remediation, and there is agreement to act instead of conducting further investigations." (Wenning et al. 2005). This first case is intended to apply to small sites with a limited number of contaminants present at extremely elevated concentrations (e.g., well above predicted effects levels). The second case involves sites subject to regulatory action.
- Accordingly, any remediation decisions will be based primarily on biology, not chemistry since chemical SeQGs are not clean-up numbers by themselves, and *need to* be *used in* a risk assessment Framework.
- Lines of evidence (LOE; e.g., laboratory toxicity tests, models) that contradict the results of properly conducted field surveys with appropriate power to detect changes (e.g., Chp 3.7 - Environment Canada 2012) "are clearly incorrect" (Suter 1996) to the extent that other LOE are not indicative of adverse biological effects in the field.
- If the impacts of a remedial alternative will "cause more environmental harm than leaving the contaminants in place", that alternative should not be implemented (USEPA 1998).

Although the basic framework is not expected to change over time, new knowledge is expected to follow and improve the tools available for use within the framework. The framework is most effectively applied when used in conjunction with best available science and state-of-the-art expertise in the various disciplines comprising the framework.

1.3 Intended Audience

This document is intended for both scientists and non-scientists, specifically for those conducting investigations of contaminated aquatic sites, and for those making decisions based on those investigations. Since the FCSAP program has adopted this guidance, information is geared towards FCSAP program partners (*e.g.,* custodians, expert support departments, consultants, etc.).

2.0 Approach for Addressing Contaminated Aquatic Sites

While this guidance document provides useful information for scientists and non-scientists alike, the implementation of this approach requires sound technical expertise and professional judgement. Initial steps allow for the gathering of aquatic site information necessary for effective management decision-making. At some aquatic sites it may not be necessary to complete all of Steps 1-5 before making a final management decision (*i.e*., aquatic sites that are clearly not contaminated; or aquatic sites that are clearly heavily contaminated and that, with minimal uncertainty, pose an unacceptable toxic risk to humans or the environment; figure 1). However, for most aquatic sites, all of Steps 1-5 will be necessary for final management decision-making.

Each aquatic site will, to some extent, be unique. Thus, generic approaches and/or prioritizations have to be adapted site-specifically to properly characterize and, if necessary, manage different aquatic sites. Dual terrestrial-aquatic properties may require application of both the FCSAP (2018) DMF and this framework whenever there is an impacted aquatic portion to any contaminated site.

2.1 Overview

The framework herein follows the 10-step process outlined in the CSMWG (1999) and FCSAP (2018) DMF, organized into information gathering, screening level assessment (SLA), detailed level assessment (DLA), and remediation/risk management including monitoring (Figure 1). Additional detail for each of the categories is provided in the *COA*, as noted below. The technical foundations contained in the *COA* have been widely applied, even though it was developed specifically for use in the Great Lakes. For example, the Province of Ontario has adapted it for assessing contaminated sediments province-wide (Fletcher et al. 2008) and found it to be a useful tool.

For a more comprehensive approach to investigating and managing aquatic sites, consider the CCME Volume 1: *Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment* (CCME 2016), which describes best practices for site characterization and methods to obtain the data that is required to perform an ERA. This guidance provides an overview of various sampling designs and the minimum data specifications required to achieve an appropriate level of statistical confidence. Similarly, the Canadian federal *Metal Mining Technical Guidance for Environmental Effects Monitoring* (Environment Canada, 2012) advises on the importance of implementing a statistical power analysis into the study design, which determines if the sampling program is collecting sufficient information for management decisions to be made, among numerous other study design elements to provide the basis for ‘scientifically rigorous’ investigations. Lastly, CCME (2020) *Ecological Risk Assessment Guidance* discusses the significant role of best professional judgment (BPJ) in the integrated evaluation of multiple LOEs in a WOE approach.

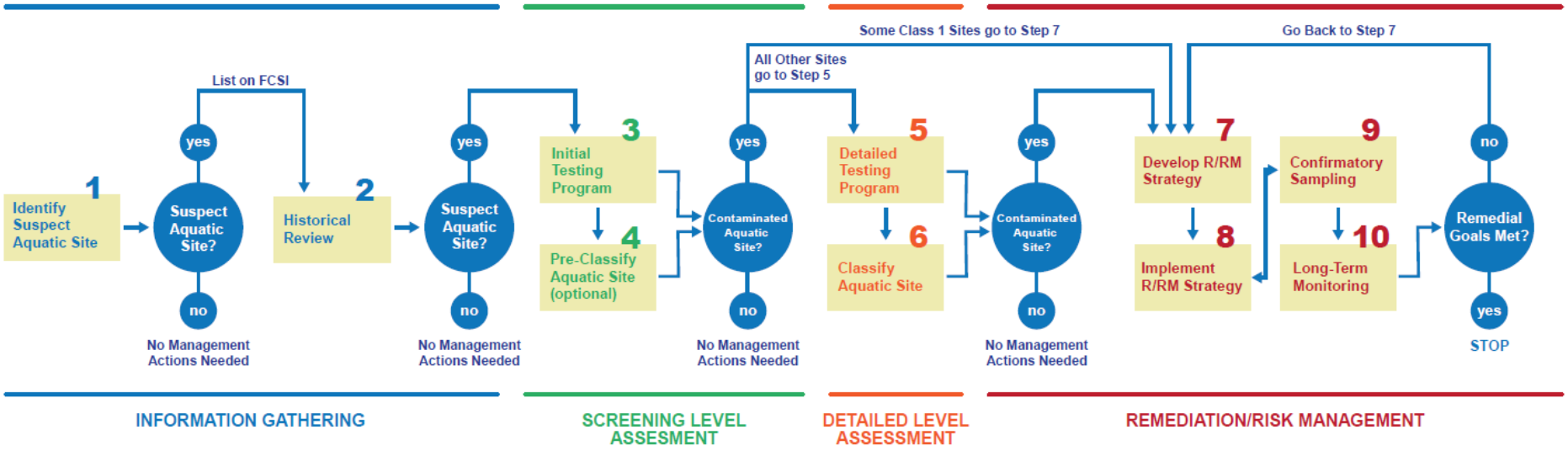
As with the *COA*, the present framework is primarily focused on ecological risk and does not address situations where potential human health concerns are associated with dermal contact to contaminated sediment (*e.g.*, swimming, wading), or by other exposure routes (*e.g.*, flooding resulting in sediments contaminating residential soils or gardens). For further information on human health considerations, please consult the Health Canada (2017) *Supplemental Guidance for Assessing Human Health Risks due to Direct Contact with Contaminated Sediments*. Additionally, this framework does not address the issue of unacceptable levels of contaminants

that do not biomagnify, such as cadmium, lead, polycyclic aromatic hydrocarbons, in fish or shellfish. In such situations, an HHRA should be considered to assess potential risks and inform the public.

As noted by Jaagumagi and Persaud (1996), “Due to the complexity involved in evaluating contaminated sediment, it is essential that scientists with strong expertise in sediment chemistry (chemical fate, transport and speciation), sediment toxicity testing, benthic community assessment, food chain effects and environmental statistics assist stakeholder groups in the interpretation of the data. This is especially important in determining differences or effects of sediment contamination compared to reference conditions.”

Useful documents specifically related to each of the DMF 10-steps, shown in Figure 1 below, are listed in Appendix A.

Figure 1: Steps for Addressing and Managing Contaminated Aquatic Sites



2.2 Information Gathering

Rationale: To initially identify suspected contaminated sites and confirm the need for further assessment.

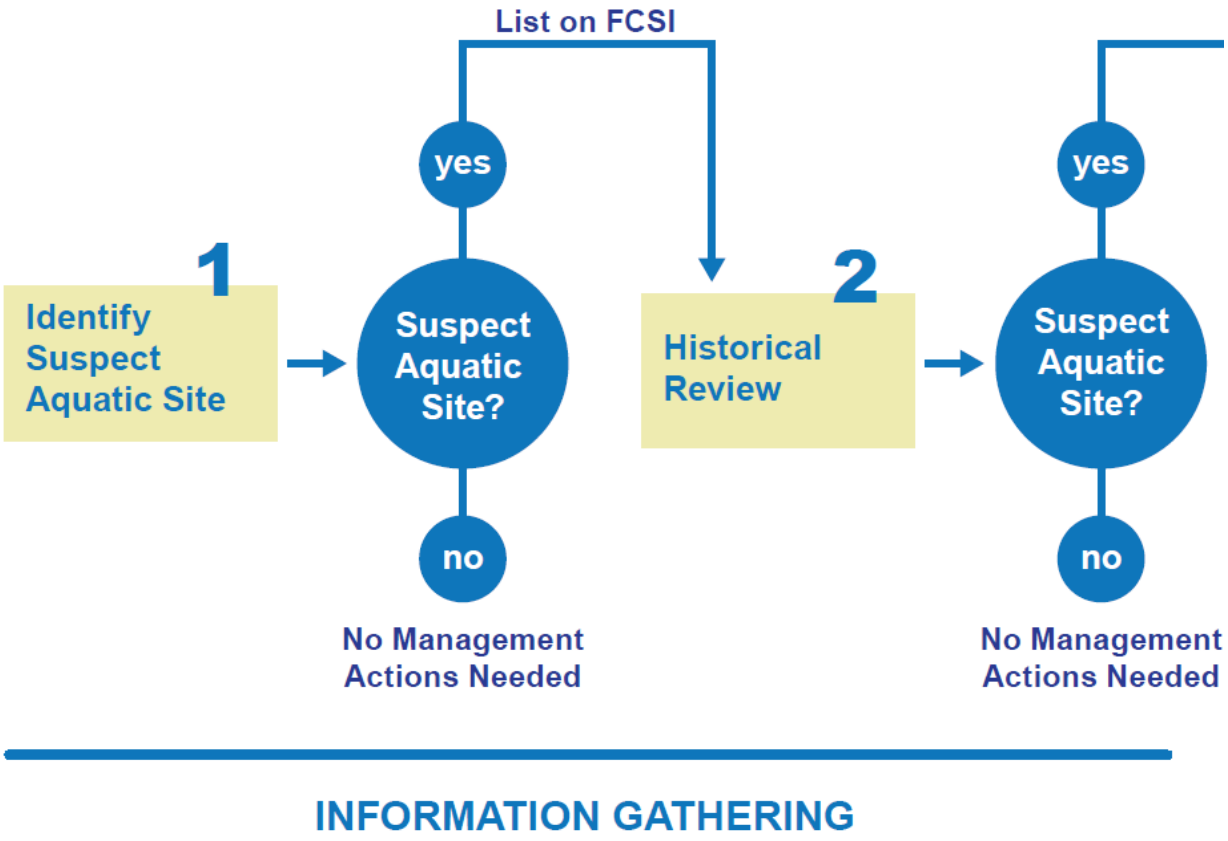
Readily available information is used to identify suspect aquatic sites (Step 1) that require further investigation and to screen out aquatic sites that, with a reasonable level of certainty, are not contaminated to levels that would cause adverse effects. Where there is insufficient information to make such a determination, further investigation (Step 2) is required. An initial conceptual site model (CSM) is developed for suspect aquatic sites, as is a Sampling and Analysis Plan (SAP) (*COA*, pp 7-8 and 25-26). The SAP is implemented in Step 3 (Section 2.3.1) at suspect aquatic sites to address data gaps identified in the historical information review and enable an update of the CSM.

Additional guidance can be found in the CCME (2016) Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment: Volume 1 and FCSAP (2019a) *ERA Module 5: Defining Background Conditions and Using Background Concentrations*.

Information gathering steps are illustrated in Figure 2.

The following two steps correspond to Step 1 of the *COA*, Examine Available Data (*COA*: p 7):

Figure 2: Steps 1-2 for Addressing and Managing Contaminated Aquatic Sites



2.2.1 Step 1: Identify Suspect Aquatic Sites

Rationale: Suspected aquatic sites are identified for further review and sites not suspected of potential risk are eliminated from further consideration. Sites that require further investigation (which are suspect) must be catalogued on the Federal Contaminated Sites Inventory (FCSI) database.

Aquatic contaminated sites are typically adjacent to active or historical commercial, industrial or waste disposal sites and have received or are receiving contaminants via direct discharges, *e.g.*, leaks or spills. For more information, please refer to FCSAP (2021b) *Guidance for Assessing and Managing Aquatic Contaminated Sites in Working Harbours*. Aquatic contaminated sites may also be located downstream of terrestrial or aquatic sources of contaminants (*e.g.*, a downstream depositional area). Hydrological factors that govern sediment movement within a watershed (*e.g.*, flow rates, channel morphology, gradient, and stream order) should also be considered when assessing aquatic sites. Custodians are encouraged to contact Expert Support for advice or input as required.

Identification of suspect aquatic sites can be based on factors including, but not limited to:

- location of the site (*e.g.*, past or current activities at or near the aquatic site);

- historical and current environmental or other records (*e.g.*, newspaper records of beach closures, fish kills, fishing restrictions);
- complaints by citizens (*e.g.*, olfactory or visual evidence of contamination in the waters overlying the sediments);
- information from local anglers (*e.g.*, fish absent from certain areas, fish tumours or deformities);
- property transfer/divestment arrangements that may initiate site investigations as part of a business due diligence initiative.

Step 1 serves to screen aquatic sites into two categories:

a) Aquatic sites that do not represent a potential risk to human health or the environment (*e.g.*, sites with no evident or suspected contamination above background or reference levels); and,
b) Aquatic sites that may represent a potential risk to human health or the environment (*e.g.*, sites with evidence of contamination above background or reference levels, or for which insufficient information is available to make a final determination).

Aquatic sites that fall under category “a” do not require further investigation and need not be reported to the FCSI. Aquatic sites that fall under category “b” should be placed on the FCSI and require further investigation. Such investigation begins with a historical review.

2.2.2 Step 2: Historical Review

Rationale: To determine that there is evidence or reason to suspect the site is contaminated and justify moving forward for further assessment. Using historical information will appropriately guide subsequent sampling and analysis (*i.e.*, new data collection), and avoid generating new data where data already exists.

This step (corresponding to a Phase I Environmental Site Assessment), comprises a desktop exercise together with a site visit (mostly nonintrusive investigation). All readily available current and historical information pertaining to the suspect aquatic site should be assembled and reviewed. The review of available information should include, but not be limited to: available reports, aerial photographs, regulatory agency records (*e.g.*, *Fisheries Act* Authorizations, inspections, Inspector's Directions, provincial or other discharge permits, spill reports, enforcement actions, offsetting [formerly known as habitat compensation] plans, records of restoration at the site or in the immediate area), information about adjacent industrial or other contaminant sources, including environmental reports and company records. In addition, a site visit should be conducted and, if possible and appropriate, informed individuals (*e.g.*, local residents, former or retired employees of adjacent facilities) should be interviewed. Federal regulatory agencies (*e.g.,* DFO and ECCC) and provincial regulatory agencies should be consulted at this step and should be appropriately involved in subsequent steps. A site history should be compiled from the above information. The site history will identify past land-use and characterize known or suspected chemicals.

Current or past land uses of the site should also be identified. This information can often be obtained from online databases, the individuals noted above, or through traditional ecological knowledge from Indigenous or non-Indigenous resource users. Especially for aquatic sites, local

resource management agency enforcement staff are likely aware of harvesting activities and areas that are in current or intermittent use.

The historical review, together with information from Step 1, will inform initial decision-making and, further assessment if required. Specifically, this review will:

- Identify Contaminants of Potential Concern (COPC)s and, depending on the available information, their concentrations at the sediment surface (<10 cm) and at depth (>10 cm);
- Identify possible historic and continuing sources of contamination (*e.g.*, discharge such as storm water or off-site migration);
- Identify ecological Receptors of Potential Concern (ROPC)s that may be affected by COPCs; (*e.g.*, fish species and fish habitat; federally- or provincially-listed species at risk; commercial, recreational or Indigenous fisheries for any species, and other receptors upon which ROPCs may depend);
- Identify human ROPC and their use of the site (including consumption of biota harvested at or near the site and use of sediments as garden soil);
- Determine exposure pathways by which COPCs may reach, and thus potentially affect, ROPCs;
- Determine appropriate assessment endpoints, such as:
    - what effects will be measured, (*e.g.*, for benthos: species diversity, abundance, dominance; for fish: bioaccumulation and/or biomagnification of contaminants, species diversity and abundance, any tumours or lesions)
- Determine physical/chemical site characteristics (*e.g.*, sediment grain size, organic carbon content, factors that could modify contaminant bioavailability), including sediment stability (evaluated in more detail in Step 5);
- Determine water type (marine, fresh, or brackish) and physical dynamics (*e.g.*, deposition, erosion, tidal cycles, wave action, ice scour);
- Determine if there is mixing of shallow groundwater and surface water within the aquatic site (*i.e*., the transitional zones), the location(s) of such, and ecological use of that mixing zone;
- Determine whether the site should be considered environmentally sensitive (based on habitat parameters) and whether contamination originates solely from off-site sources; and,
- Determine appropriate reference sample locations, if required for further assessment.

The above information is used to construct an initial CSM (Figure 3 depicts examples of bioaccumulation pathways and Figure 4 depicts biomagnification pathways; additional information is available in Appendix C). The CSM should include potential sources of contamination, their nature and location, and should incorporate the available spatial and temporal information. If possible; the CSM should also capture indicators of adverse effects compared to reference site(s) such as reduced recruitment, incidence of tumours or lesions, and reduced species abundance and richness.

The CSM (*e.g*. Figure 3 and 4) is used as the basis for determining a SAP if further site assessment is required. The SAP outlines the required samples and tests of particular environmental media and their respective DQOs (Appendix B). Based on risk hypotheses (Appendix D), sampling may be recommended across the entire suspected aquatic site or at specific locations (see Step 3 Section 2.3.1, below for further information).

Figure 3: : Example of a Pictorial Conceptual Site Model showing the Bioaccumulation Pathways for Sediment Contaminants along a Freshwater Aquatic Food Chain

Source: Golder Associates Ltd (2006). POM = particulate organic matter

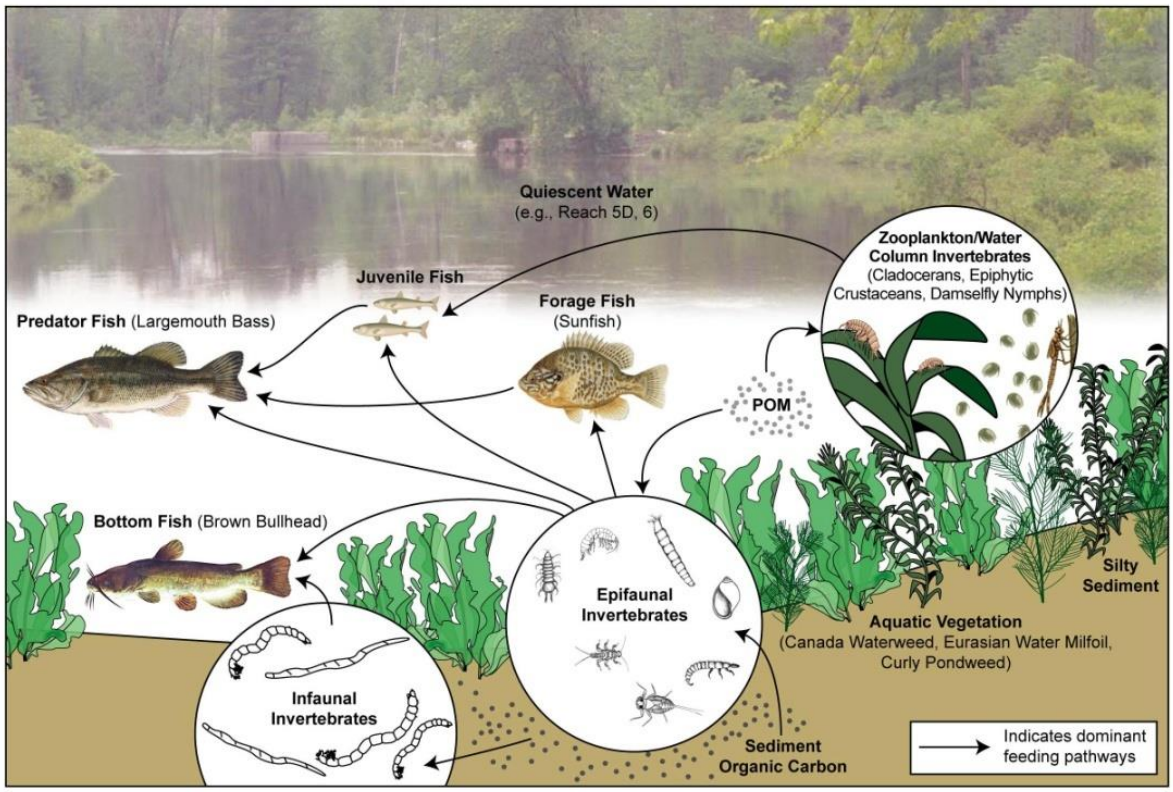


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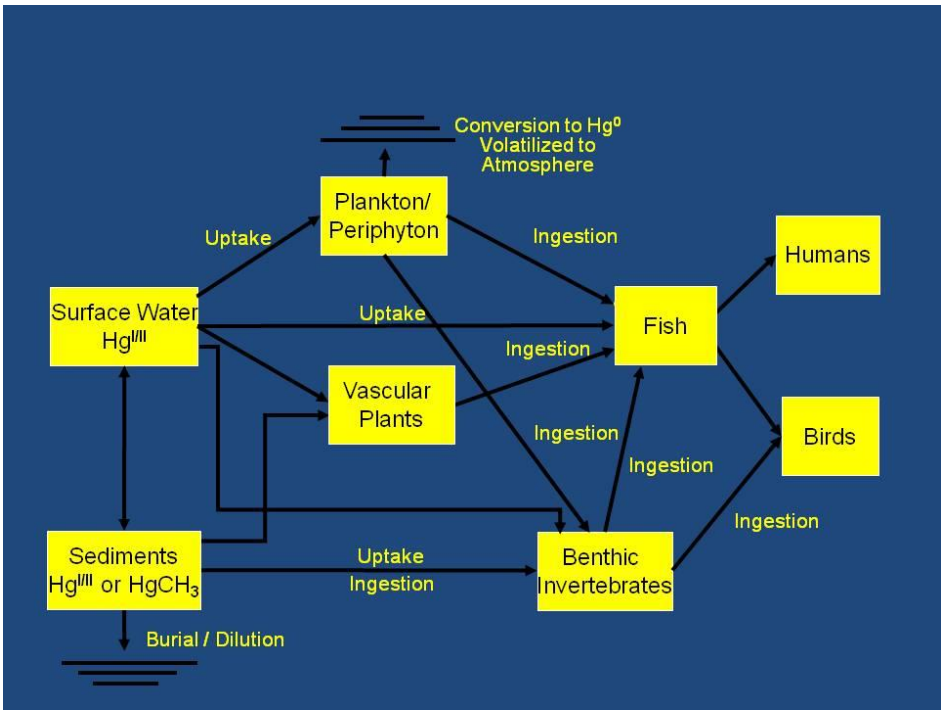
Figure 4: Example of a Simplified Diagrammatic Conceptual Site Model showing the Biomagnification Pathways for Methyl-mercury (CH_3Hg^+) from Sediment through an Aquatic Food Chain to Fish, Birds, and Humans

Source: Golder Associates Ltd (2006).



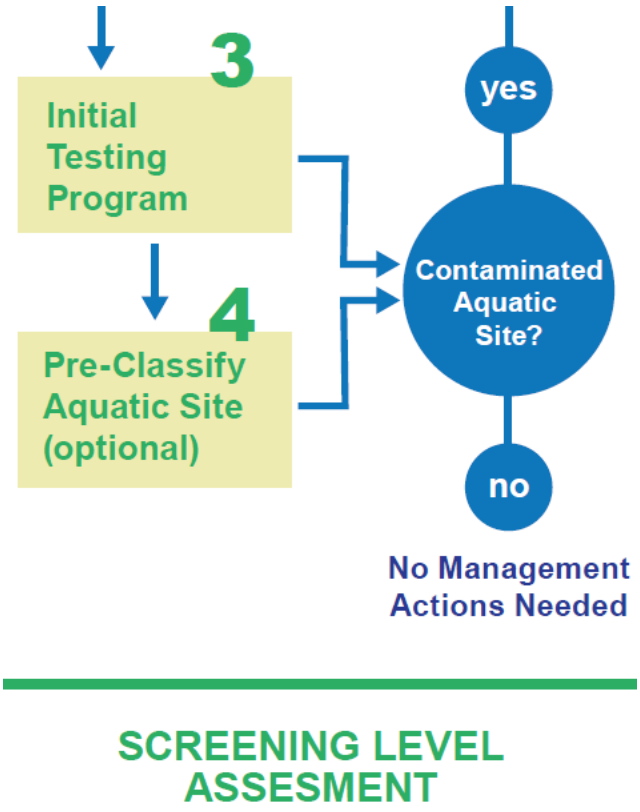
2.3 Screening Level Assessment

Rationale: Presence of contamination must be confirmed on suspect sites and prioritized for further action when found. (Further action can mean additional sampling for assessment or developing an R/RM strategy if warranted).

The third and fourth steps of the framework comprise initial testing (Step 3) of suspect aquatic sites followed by pre-classify the site (Step 4) (optional). Suspect aquatic sites are then either identified as contaminated aquatic sites or eliminated from further consideration. Contaminated aquatic sites are either flagged for “further investigation” (Step 5) or prioritized for “remediation/risk management action” (Step 7).

The SLA would benefit from additional guidance (*i.e.*, based on directed research and/or case studies) regarding different water bodies (lotic and lentic freshwaters, estuarine waters, and marine waters).

Figure 5: Screening Level Assessment: Steps 3-4 for Addressing and Managing Contaminated Aquatic Sites.



2.3.1 Step 3: Initial Testing Program

Rationale: Conduct sampling (guided by, and building upon, historic information) to provide necessary information to determine whether or not the suspect aquatic site is contaminated.

Once COPCs and ROPCs are confirmed, the available information will be assessed to determine whether the aquatic site may pose a potential risk to the environment and/or human health. This information is also used to initially pre-classify aquatic sites (Step 4; optional) and prioritize for the need to address any potential risk. Depending on the outcomes, the site can 1) be determined as not contaminated and thus not requiring further investigation; 2) contaminated and requiring some form of remediation/risk management (Step 7); or 3) insufficient information to classify the site without further investigation (Step 5) and an update to pre-classification (Step 6).

The initial scope of an assessment relies to some extent on professional judgement concerning the likely spatial boundaries of contamination (reflected in the SAP), which are confirmed later when the vertical and lateral boundaries of that contamination have been delineated (at DMF Step 5). The SAP should establish appropriate sampling techniques and equipment, sample density, sampling media (*e.g.*, water, sediments, pore water, biota), and analytical parameters (i.e., the COPCs and factors that may modify their bioavailability and toxicity). It should include both “hot spots” and, if applicable, reference areas, and should be focused on reducing uncertainties precluding informed risk management decision-making. The probability that “hot

spots" exist, whether or not they have been captured in the data set and whether or not they are likely to influence the characterization of risk, is often addressed on the basis of professional judgment. Where a more rigorous and quantitative analysis of "hot spot" delineation is warranted, some recommended approaches can be found in Gilbert (1987). Due to the practical difficulties associated with locating an ideal "reference area," multiple reference sites are often needed to aid in defining minimally impaired conditions.

It is important that a sufficient number of samples from both the suspected aquatic site, and from the reference areas, if applicable, are collected to reduce uncertainties and improve management decision making capacity. While sampling should include surficial sediments (to 10 cm depth), where the majority of sediment-dwelling organisms live, deeper sediment sampling may also be considered. The context for sampling deeper sediment includes an assessment of the risk that contaminants may be uncovered via sediment erosion (scour) and migration processes, and whether there is a risk that previously buried contaminants could migrate and affect the surrounding area, or downstream and/or downcurrent sites. The status of deeper sediments should be reconsidered as additional information becomes available.

Both the CSM and the SAP should be reviewed by regulatory agencies and the custodian should provide (where appropriate) an opportunity to other stakeholders, Indigenous peoples and Expert Support to comment. Revisions to the SAP may be required following such review. The CSM should also be reviewed and updated following this Step and Step 5 (Section 2.4.1), as more information becomes available and as uncertainties regarding CSM components are reduced. The CCME (2016) has finalized a *Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment: Volumes 1-4*, which could aid in the development of the SAP.

Please refer to FCSAP (in press) DMF for additional guidance on this step, or any others of the 10-step process.

The initial testing program (corresponding to a Phase II Environmental Site Assessment) is intended to produce data that are representative of the suspected aquatic site being investigated, and consists of the following components:

- Field and/or laboratory investigation and sampling including appropriate quality assurance/quality control (QA/QC) procedures;
- Sample analyses by accredited laboratories (*e.g.*, Canadian Association for Laboratory Accreditation (CALA)) including appropriate QA/QC procedures;
- Data interpretation and evaluation;
- CSM refinement based on the above components (*e.g.*, refining the COPCs, ROPCs and the exposure links between them); and,
- SLA based on the degree, nature (*e.g.*, bioavailability), extent and significance of contamination.

The SLA should provide answers to the following questions to allow for pre-classification in Step 4 (Section 2.3.2):

1. Are COPCs present in concentrations that exceed the generic CCME ISQG (TEL)? This comparison should involve the most recent, relevant CCME ISQG (TEL) or, in their absence, the most recent, appropriate provincial/territorial guidelines. For example, see FCSAP Advisory Bulletin on the *Use of Atlantic PIRI's petroleum hydrocarbon sediment quality criteria at federal sites - Version 1.0* (2019c). If no Canadian guidelines are available for a parameter, the most recent guidelines from international jurisdictions (*e.g.*, USEPA) can be used. Where guidelines from another jurisdiction are used, a narrative justification for their use should be provided;
2. Is there a potential for biomagnification? (based on the presence or absence of those organic chemicals that biomagnify); and,
3. Are these or other COPCs present at concentrations above reference area concentrations?

Specifically, the following comparisons and decisions (Table 1) based on the *COA* (pp 8-9) are made during this step, with advice from Expert Support when requested.

The initial comparison is a determination of any exceedances of conservative sediment quality guidelines (*i.e.*, Threshold Effects Level (TEL) or CCME ISQG; *e.g.*, CCME Environmental Quality Guidelines) and a determination as to whether or not substances that can biomagnify are present.

Where exceedances of the conservative CCME ISQG (TEL) occur and/or substances that can biomagnify are present, a subsequent comparison is to reference conditions (selection of appropriate reference sites/conditions will require expert judgment). The rationale for this second comparison is that inorganic and some organic substances occur naturally and may be naturally enriched in some areas (*e.g.*, naturally mineralized areas, oil seeps), and the fact that reference areas are often not pristine. Further guidance can be found in the FCSAP (2019a) *ERA Module 5: Defining Background Conditions and Using Background Concentrations*.

Only if concentrations of a COPC are greater than reference conditions, or there are substances present which can biomagnify, is there potential risk requiring further assessment. The results of both comparisons are considered a part of the more extensive site pre-classification conducted in Step 4 (Section 2.3.2), which also considers other concerns (*e.g.*, unexploded ordnances, non-aqueous phase liquids (NAPL), documented impacts to human health).

Table 1: Screening Level Assessment Comparisons and Decisions[1]

Comparison	Decision
All sediment COPC < CCME ISQG (TEL), **and** no substances present that can biomagnify	No further assessment or remediation/risk management required
One or more sediment COPC > CCME ISQG (TEL), **or** one or more substances present that can biomagnify	Potential risk; further action required as detailed below
[Concentrations of one or more sediment COPC > CCME ISQG (TEL) **and/or** substances present that can biomagnify] < reference conditions **or** statistically no different than reference conditions	No further assessment or remediation required
[Concentrations of one or more sediment COPC > CCME ISQG (TEL) **or** one or more substances present that can biomagnify] are statistically higher than reference conditions	Potential risk; further action required

[1] Biomagnification is a phenomenon observed as the result of bioaccumulation by which tissue concentrations increase as the chemical passes up through the food chain (i.e., two or more trophic levels (FCSAP ERA Module 1, 2010). Even at relatively low concentrations in the aquatic environment, biomagnifying substances may pose risk to upper-trophic-level receptors. There may be a need to communicate potential risks to site users as part of due diligence. For example, harvesting restrictions (e.g., fish consumption advisories) should be communicated to site users. For a list of examples, the Aquatic Sites Classification System provides a list of examples of bioaccumulating and/or biomagnifying substances for user reference.

2.3.2 Step 4: Pre-Classify the Site (optional)

Rationale: To determine if enough information on the site has been gathered to complete a site classification, to identify the site for further assessment and/or prioritize the sites for subsequent action (remediation/risk management).

At this step, pre-classification of the aquatic site is based on *FCSAP (2021a) Aquatic Sites Classification System (ASCS)*. To determine if enough information on the site has already been gathered to complete a robust site classification, the option of Step 4 can be used at the discretion of the custodians to complete a preliminary assessment of a site's classification. Similarly, if custodians need to collect more data to complete a meaningful classification (at Step 6) they can choose to proceed directly from Step 3 to Step 5. Therefore, the site is either flagged for further assessment (*i.e.,* DLA- Step 5, below), prioritized for R/RM actions, or is eliminated from further consideration under FCSAP.

FCSAP (2021a) Aquatic Sites Classification System was developed to evaluate the level of concern for aquatic contaminated sites. It provides a uniform approach to classifying such sites by providing a tool designed to screen a contaminated aquatic site with respect to the need for further action. It includes a pre-screening checklist, a site description page, a summary score sheet, and three worksheet pages for the user to complete. The ASCS delineates a grading system (from A to F) based on the level of detail available for the site. Then a contaminated aquatic site is assigned to one of the following five classes:

- **Class 1** - High Priority for Action: The available information indicates that action (further site characterization or remediation/risk management) is required to address existing concerns. Typically, Class 1 contaminated aquatic sites indicate high concern for several factors, and measured or observed impacts have been documented. Depending on site-specific information, Step 5 (adequate certainty regarding sources or causation is lacking) or Step 7 (certainty is adequate for management decision-making) would be initiated for these contaminated aquatic sites.

- **Class 2** - Medium Priority for Action: The available information indicates that there is potential for adverse impacts, although the threat to human health and the environment is generally not imminent. Additional investigative work may be carried out to confirm the site classification or determine the appropriate form of action.

- **Class 3** - Low Priority for Action: The available information indicates that these contaminated aquatic sites are currently not a high concern. However, additional investigative work may be carried out to confirm the site classification, or determine if some form of remediation/risk management action is required. Contaminated aquatic sites classified under Class 3 may or may not be further assessed under Step 5 depending on available resources; they are clearly not the contaminated aquatic sites of highest potential concern.

- **Class N** - Not a Priority for Action: The available information indicates that there is the least likelihood for significant environmental impact or human health threats. There is a low potential for risk unless new information becomes available indicating greater concerns, in which case the aquatic site should be re-examined. Note that Class N sites

can exceed CCME or other guidelines if there is no chemical bioavailability resulting in toxicity or there are no receptors or pathways from chemical contaminants to receptors.

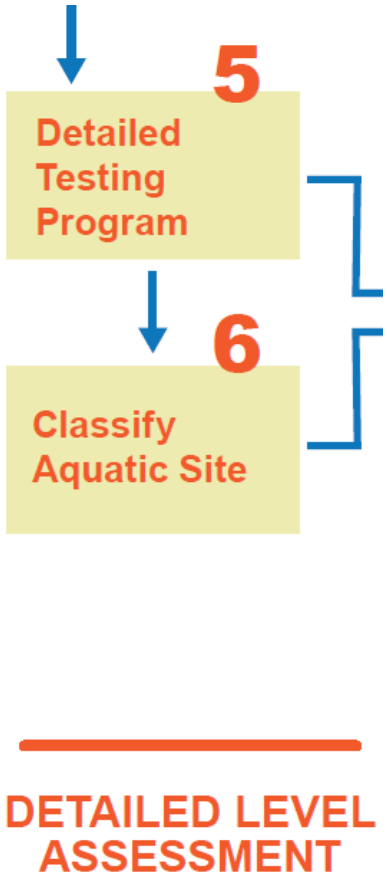
- **Class INS** - Insufficient Information: There is insufficient information to classify these contaminated aquatic sites. In this instance, additional information is required to address data gaps. Step 5 may be initiated dependent on available resources and other priorities.

2.4 Detailed Level Assessment

Rationale: Aquatic sites that could not be pre-classified in Step 4 without further information, or where custodians require more information for future decision making, are subject to further investigation (Step 5), after which a classification (or update to pre-classification) is completed (Step 6).

Steps 5 and 6 of the framework comprise the detailed level assessment. Contaminated aquatic sites are then either prioritized for management action(s) or eliminated from further consideration. DLA steps are illustrated in Figure 7, below (*COA*; pp 20-22).

Figure 6: Detailed Level Assessment: Steps 5-6 for Addressing and Managing Contaminated Aquatic Sites



2.4.1 Step 5: Detailed Testing Program

Rationale: Aquatic sites will need more detailed assessment when they cannot be properly classified, when classification would benefit from additional validation, or when it is anticipated that future work (*e.g.* developing remediation/risk management strategy) will need specific information.

The detailed testing program is applied, where required on a high priority basis, to those contaminated aquatic sites identified as Class 1 in Step 4. Those sites will be subject to management actions, but further information is required before specific management actions can be determined (*e.g.*, causation for measured or observed impacts remains to be determined). The detailed testing program may also be applied on a priority basis to contaminated aquatic sites classed as 2, 3 and INS in Step 4.

This step further defines the nature of the aquatic site contamination in measured/observed or suspected impacts to allow for classification (or update of pre-classification from Step 4) in Step 6 (Section 2.4.2). The detailed testing program will generally focus only on those issues identified in the initial testing program (Step 3, Section 2.3.1). Step 5 objectives include:

- Address key information gaps and data deficiencies identified in Step 3, the initial testing program (*i.e*., reduce identified uncertainties). For example, by collecting a greater number of samples to quantify the extent of contamination.
- Delineate of the area of contamination
- Define reference conditions;
- Refine the CSM;
- Provide information necessary for classification (Step 6) or updating pre-classification from Step 4; and,
- Provide information necessary to develop a remedial action / risk management plan (Step 7), if required, including input to specifications and tender documents.

The data collected during the detailed testing program should be sufficiently representative of the contaminated aquatic site conditions to refine the CSM and to provide adequate information for R/RM decision-making. This information, which is equivalent to a Phase III Environmental Site Assessment, can be used together with Expert Support advice to conduct a classification (or update the pre-classification) of contaminated aquatic sites.

The detailed testing program consists of the following components and is intended to produce data that is reliable and representative of the contaminated aquatic site being investigated:

- Field and/or laboratory investigation and sampling including appropriate (QA/QC) procedures;
- Sample analyses by accredited laboratories (*e.g.*, CALA following appropriate QA/QC procedures); and,
- Data interpretation and evaluation.

Sediment toxicity testing should be applied, using professional judgment, to contaminated sites containing both organic and inorganic contaminants. Bioavailability and toxicity cannot be reliably predicted for either type of contaminant based solely on chemical measurements (Hamers et al. 2010). For example, site-specific conditions will determine whether or not organic contaminants are bioavailable and toxic (Sui et al. 2010; McDonough et al. 2010).

A detailed testing program differs from the initial testing program in that the measures used will often include biological testing (*e.g.*, toxicity tests or tissue sampling) or ecological community data (*e.g.*, benthic macroinvertebrates, quantitative plant community surveys), whereas the initial testing is typically limited to comparisons with established environmental quality guidelines. The detailed testing involves a similar systematic process of sampling and analysis, evaluation, conclusions and recommendations. However, a greater number of samples are usually collected and a smaller suite of chemical substances may be analyzed, in order to delineate the contamination. As discussed further in Section 2.5.1, more emphasis should be placed on biological/ecological methods as these have greater relevance to site management objectives.

The outputs of the above components should be used to refine the CSM by re-examining, in light of the more informative data expected from a detailed testing, the COPCs, ROPCs and the exposure links between them. The scope of detailed testing should be based on initial testing and will be dictated by the degree, nature (*e.g.*, bioavailability), extent and significance of contamination.

The detailed testing should strengthen existing assessment data and answer the following question to allow for classification in Step 6 (Section 2.4.2):

- Does the contaminated aquatic site pose a potentially unacceptable human or ecological risk such that further management action is required?

A defensible CSM can then be refined based on information collected. The horizontal and vertical extent of sediment contamination, and associated human or ecological risks, need to be adequately addressed as a starting point. Surficial sediments (about 10 cm depth) should be assessed and deeper sediment should be considered if exposure could occur in the future due to natural (*e.g.*, erosional scour) or anthropogenic factors (*e.g.*, dredging, construction, anchoring). The possibility of contaminant migration via groundwater inputs and/or from surface water bodies or sediments to groundwater during periods of groundwater recharge also needs to be outlined in the CSM. The answer to the above question and the information gathered in this and previous steps should provide a sound basis not only for decisions as to whether or not R/RM actions are required, but also the priority and form that such actions should take.

Once a thorough detailed testing program has been completed, the following decisions outlined in Table 2 [based on the *COA* (pp 12-14)] can be completed with confidence, with input from Expert Support. Moreover, the development of a decision matrix for the WOE evaluation occurs at this point (as detailed in Appendix E of this document and in pages 14-18 of the *COA*).

Table 2: Detailed Level Assessment Comparisons and Decisions

Comparison[1]	Decision
There is no potential for contaminant biomagnification from the sediments through aquatic food chains	No further assessment or remediation required relative to biomagnification
There is potential for contaminant biomagnification from the sediments through aquatic food chains	Potential risk; further assessment of biomagnification potential required
All sediment toxicity endpoints < 20% difference from reference	No further assessment required relative to laboratory toxicity
One or more sediment endpoints ≥ 20% difference from reference	Potential risk; further assessment required
Results from benthic community assessments (if appropriate/possible based on the *COA*; pp 13-14) are not statistically different from reference	No further assessment required relative to the benthic community
Results from benthic community assessments (if appropriate/possible based on the *COA*; pp 13-14) are statistically different from reference	Potential risk; conduct further evaluation and examine the results
Levels of COPC in deeper sediments (>10 cm) below CCME ISQG (TEL) and no substances present that can biomagnify, **or** deeper sediments very unlikely to be uncovered under any reasonably possible set of circumstances	No further assessment or remediation required; management options for polluted surficial sediments should be determined
Levels of COPC in deeper sediments (>10 cm) above CCME ISQG (TEL) or one or more substances present that can biomagnify, **and** these sediments may be uncovered under one or more reasonably possible set of circumstances	Potential risk; further assessment may be required

[1] Note three key differences between the DLA of this framework and that of the *COA* (p 13): 1) The first comparison does not include the term “not statistically significantly different than reference” and is less than, not less than or equal, to 20%. 2) The second comparison is greater than or equal to 20%, not just greater than. 3) The possibility of future toxicity (*e.g.*, from deep groundwater emerging) needs to be considered.

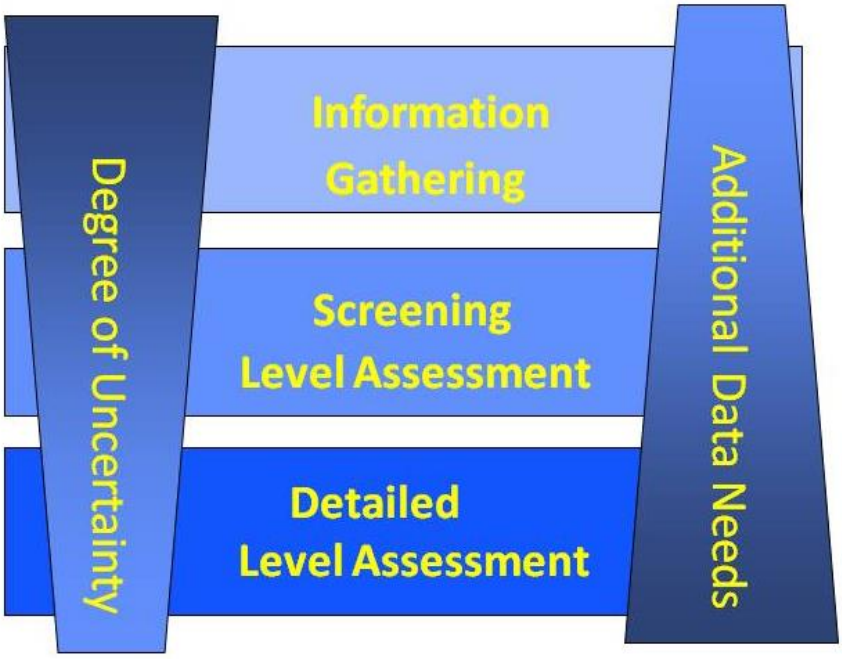
2.4.2 Step 6: Classify Site

Rationale: New information acquired and developed in Step 5 is applied in order to classify (or update the pre-classification from Step 4) aquatic sites and determine priority for action.

At this step, the *FCSAP (2021a) Aquatic Sites Classification System* is applied. The contaminated aquatic site is classified for the first time, or the pre-classification from Step 4 is updated. Sites determined not to be contaminated are eliminated from further consideration. There should be no sites classified as INS; sites with sufficient information should now have adequate information to classify and prioritize. Where information is still found lacking, activities would continue under step 5 until all data gaps are filled.

Figure 7: Tiered Approach to Assessment (Steps 1-6)

Source: Golder Associates Ltd (2006). (Information Gathering = Steps 1-2; Screening Level Assessment = Steps 3-4; Detailed Level Assessment = Steps 5-6)



2.5 Remediation/Risk Management

Rationale: Custodians must determine the best method with which to address sites with confirmed contamination.

Steps 7 and 8 of the framework involve the development and implementation of an R/RM strategy for contaminated aquatic sites prioritized for management action(s). Site-specific considerations and biological analyses form the basis for developing remedial goals at a contaminated aquatic site. Generally, site-specific numeric remediation objectives need to be

developed. Implementation of R/RM measures should include consideration of the contracting strategy and how the contractor will, on behalf of the custodian, manage health, safety, and environmental risks. RM activities would benefit from case studies regarding development, application and implementation of site-specific numeric remediation objectives.

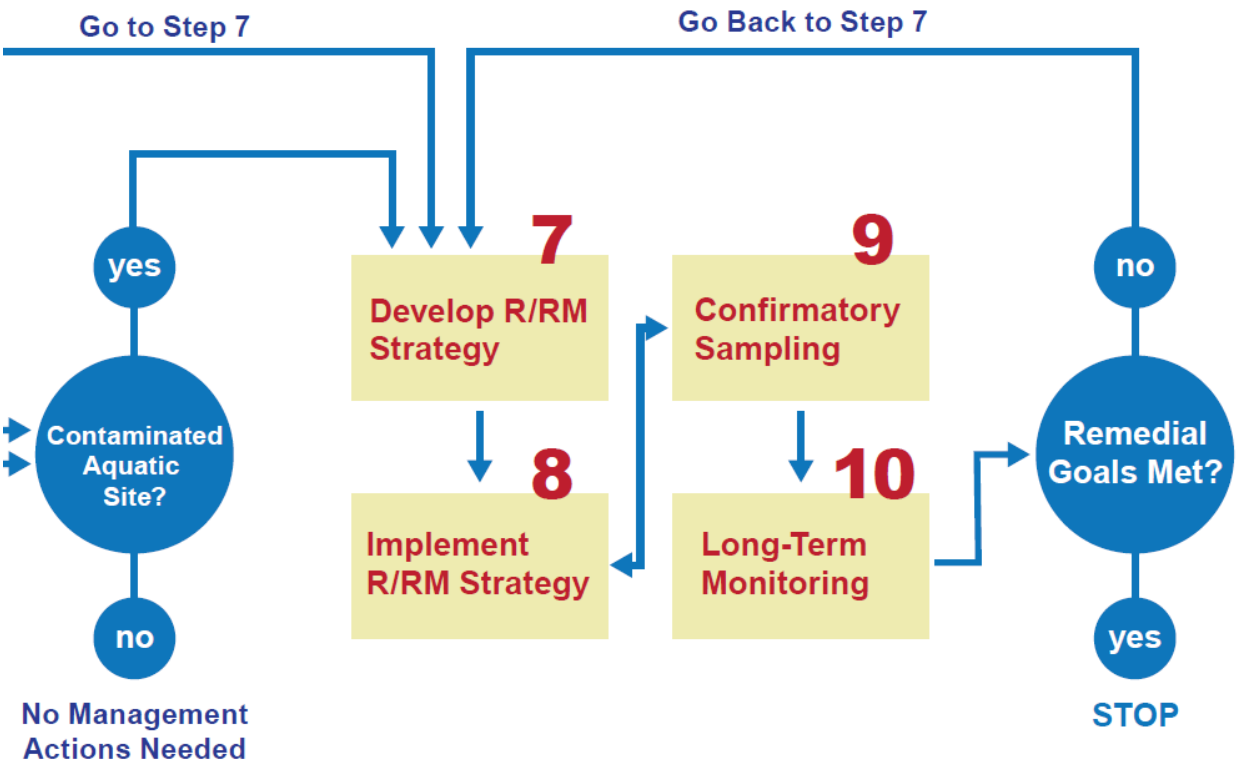
The following 11 R/RM principles [based on USEPA (2002a] should be followed:

1. Control sources of contamination early in this stage;
2. Involve the community early and often;
3. Coordinate with provinces, territories, local governments, and Indigenous peoples;
4. Develop and refine a CSM that considers sediment stability;
5. Use an iterative approach in a risk-based framework;
6. Carefully evaluate the assumptions and uncertainties associated with the site characterization data and site models;
7. Select site-specific, project-specific, and sediment-specific R/RM approaches that will achieve risk-based goals;
8. Use sediment cleanup levels that are clearly tied to R/RM goals;
9. Maximize the effectiveness of institutional controls and recognize their limitations;
10. Design remedies to minimize short-term risks while achieving long-term protection; and,
11. Monitor appropriate media (water, sediment, or tissue) during and after source control and/or sediment remediation to assess and document remedy effectiveness.

Note that remediation of some aquatic contaminated sites can be complex. Risk assessment is often conducted in order to facilitate the selection of local sustainable R/RM measures (Sparrevik and Breedveld, 2009) or justifies the need for further action. In some cases specialized site-specific geotechnical and/or bench-scale testing may be required.

Figure 8: Remediation/Risk Management Strategy (Steps 7-8), Confirmatory Sampling (Step 9), and Long-Term Monitoring (Step 10) for Addressing and Managing Contaminated Aquatic Sites

These steps follow from the SLA and DLA.



2.5.1 Step 7: Develop Remediation/Risk Management Strategy

Rationale: Custodians need to develop a site-specific R/RM strategy, which could include a risk assessment, used to address contamination found at their site. Information gathered as part of the process to classify contaminated aquatic sites is used to develop such a strategy.

The goal of Step 7 is to develop an adaptive environmental site management strategy by which the levels of, or exposure to, contaminants of concern (COCs) are reduced, so that existing or potential risks to humans and the environment have been appropriately reduced or removed. Typically sites considered in Step 7 are well characterized in terms of contaminant distribution, delineation, fate and transport, and human health and environmental risks.

Where any ongoing sources of contamination are not controlled/risk managed, the site is generally not eligible for funding. However, there may be circumstances where addressing such

sites is warranted and therefore should be further discussed with Expert Support and FCSAP Secretariat on a case-by-case basis.

Historically in the FCSAP program, R/RM funding was only available for contaminated sites where the activity that caused the contamination took place prior to April 1st, 1998. However, there are several exceptions in FCSAP Phase IV, which are outlined in the *FCSAP Directive on Phase IV Site and Costs Eligibility,* available as an appendix of the *FCSAP Phase IV Handbook* (FCSAP, in press). The prioritization rules for R/RM funding are also described in the *FCSAP Directive on Phase IV Site and Costs Eligibility* (FCSAP, 2021c).

2.5.1.1 Risk Management Considerations

Rationale: Where feasible, the exposure to contamination can be reduced such that it no longer constitutes a risk to human health or the environment.

Certain components need to be considered in developing risk management strategies. Risk management involves one or both of the following: limiting the use of the site by receptors of concern (ROCs); and/or eliminating or reducing the pathway for exposure to the contamination. Exposure relates to the links between ROCs and COCs. Key components in any risk management strategy include, but are not restricted to, the following:

- Compliance with standards, criteria, and guidance;
- Long-term effectiveness and permanence;
- Constraints on implementation (*e.g.*, navigation dredging will remove the need for capping);
- Capital and operating costs;
- Opportunities (*e.g.*, future uses);
- Overall protection of public health and the environment;
- Risk tolerance (by the public, regulators and the proponent);
- Community acceptance.

The risk management strategy needs to be based upon a clear statement of the problem requiring further action and the goals of site management. The effectiveness of any risk management decisions must then be judged against these goals.

Depending on the characteristics of the contaminants and the site, risk management might only involve terminating the source of contamination and then allowing natural recovery processes to remediate the aquatic site. The remainder of the discussion in the following section is predicated on sources having been controlled.

2.5.1.2 Aquatic Remediation Considerations

Rationale: Where feasible, contamination can be remediated from the affected media such that it no longer constitutes a risk to human health or the environment.

When deciding on an appropriate course of action, the custodian has the option to simply base remediation efforts on generic environmental quality guidelines. One scenario where this would be considered an appropriate course of action would be a relatively small, highly contaminated aquatic site pre-classified as Class 1 in Step 4 (*e.g.*, a ‘hot spot’), where all stakeholders and

Indigenous peoples agree that remediation should occur without further investigation. This approach can be taken into consideration when the costs of remediation are less than those of further investigations and remedial actions will not cause more environmental damage than they remedy or the impacts to receptors are unacceptable and contamination levels must be lowered immediately.

However, it is important to note that remediation efforts are not usually based on generic environmental quality guidelines, but rather on site-specific quantitative objectives developed by adapting generic guidelines to reflect site-specific conditions and/or based on risk assessment. The reason for this is because generic environmental quality guidelines alone may not be sufficient to guide decision-making because they are not adapted to site-specific conditions. Instead, they are used as triggers for further investigation (*e.g.*, during risk assessment problem formulation [Desrosiers *et al.* 2009]). In general, there should be sound biological information indicating that significant impairment of the aquatic ecosystem is resulting from the COCs at the site; or there should be evidence to support the potential for unacceptable human health risks. Remediation of contaminated aquatic sites based on simple, numeric exceedances of generic environmental quality guidelines could result in more disturbances to aquatic habitats. For this reason, remediation objectives would usually adhere to either modified generic guidelines based on the outcome of a DLA and/or risk assessment, or a combination of a guideline-based approach and a risk-based approach, known as the 'hybrid approach', as described in the updated FCSAP (in press) DMF.

Site-specific numeric remediation objectives should be developed to protect both human health and the environment in the manner that generic guidelines are intended to protect human health and the environment. However, as previously noted, site-specific objectives should not be based on generic environmental quality guidelines which are typically overly conservative (*e.g.*, are based on total chemical concentrations without considering site-specific bioavailability). Site-specific sediment quality guidelines or site-specific numeric remediation objectives should be utilized based on the information generated previously, adapting generic guidelines to reflect site-specific conditions, and/or based on a risk assessment.

As previously mentioned, custodians have the option of proceeding with the 'hybrid approach', which is a combined R/RM approach that uses both environmental quality guidelines and risk-based site-specific quantitative objectives. The generic and site-specific R/RM objectives are used in conjunction, based on a combination of measurements from the assessment step(s) and using best professional judgement.

Custodians are encouraged to consult FCSAP DMF (2018) to assist in selecting the most appropriate approach for developing the R/RM strategy (Step 7).

The following expanded points should be viewed as prerequisites to remedial planning:

- *It is important to determine causation of contamination before taking remedial action*. If causation is not determined, proposed remedies may not be appropriate and risks may not be reduced. Methods for determining causation are outlined in Chapman and Hollert (2006) and the *COA* (2008, p 18). Refer to the Supplemental Guidance for ERA: Module 4 (FCSAP, 2013c), which discusses the four main steps comprising causality assessment.

- *It is important that on-going sources of contamination are controlled before taking remedial action*. Remedial actions are usually ecologically intrusive and financially expensive. Source removal or control is a pre-requisite to remediation of the aquatic environment so that the disturbance associated with remedial measures will not need to be repeated.

- *It is important that remedial actions not cause more environmental damage than they remedy*. Remedial actions that offer relatively little environmental benefit compared with their associated environmental damage and financial costs should be avoided. Alternative, innovative or sustainable technologies should be considered to prevent harmful environmental impacts.

Sediment quality objectives (SeQOs) should ideally be based on ERA and HHRA, which incorporate both chemical and biological data (laboratory and field). In other words, they should be based on information generated previously with the condition that, for ERA, the results of resident benthic community analyses (if such can be conducted) outweigh the results of laboratory toxicity testing if done with sufficient power to detect change (Suter *et al.* 2002; Chapman 2007; McPherson *et al.* 2008; the *COA*; Fletcher *et al.* 2008).

Once site-specific SeQOs have been established, an R/RM strategy can be developed. This strategy will determine what specific action(s) or remedies are required to meet SeQOs (*e.g.*, to reduce or minimize exposure of ROCs to COCs). Appropriate remediation/risk management actions are influenced not only by risk reduction, but also by the technical, economic, and social factors specific to the contaminated aquatic site and its stakeholders and Indigenous peoples.

In some cases, site management may comprise monitoring rather than physical actions (*e.g.*, monitored natural recovery (Magar *et al.* 2009)). FCSAP program has developed a guidance document on MNR, “Guide to Monitored Natural Recovery (MNR) at Federal Aquatic Contaminated Sites” (FCSAP, in press). Some possible management actions are depicted in Figure 9 below, relative to both cost and site-specific risk reduction, with additional information provided in Table 3 below. Risk reduction at a contaminated aquatic site can, without proper planning and controls, result in increased risk off-site (*e.g.*, contaminated water leaching from dredged material placed on land and flowing into groundwater or surface waters). For this reason, an adaptive environmental management plan (EMP) (Section 2.5.2) should be considered an integral component of any environmental remediation activity.

There are no zero-risk options for managing contaminated sediments. Both monetary cost-benefit analysis and environmental cost-benefit analysis (*i.e.*, comparative risk: risk analysis) should be undertaken to assist in determining the optimum R/RM strategy, and where applicable, prioritizing multiple sites for remediation. Key questions to consider are:

- What will change as a result of the proposed management action(s)?

- Will such management action(s) be of overall benefit to human health and the environment?

- Are the proposed management action(s) the best option(s), or are there better alternatives?

Research may be required to assess the applicability and effectiveness of different possible remedial actions at the contaminated aquatic site. Applicable technologies should be reviewed in detail for the selected remedial action(s). Public Services and Procurement Canada (PSPC) maintains a comprehensive tool with substantial reference materials referred to as the Guidance and Orientation for the Selection of Technologies (GOST). GOST is a database and decision-making tool, created jointly by National Research Council Canada Biotechnology Research Institute and PSPC, to assist contaminated sites managers in selecting the most appropriate remediation technologies.

Figure 9: Possible Management Actions for Contaminated Aquatic Sites Following Source Control

Source: Golder 2006

Site-specific plans often combine these remedial/risk management options; however, site-specific risk-reduction may increase risk elsewhere (*e.g.*, dredged material disposal)

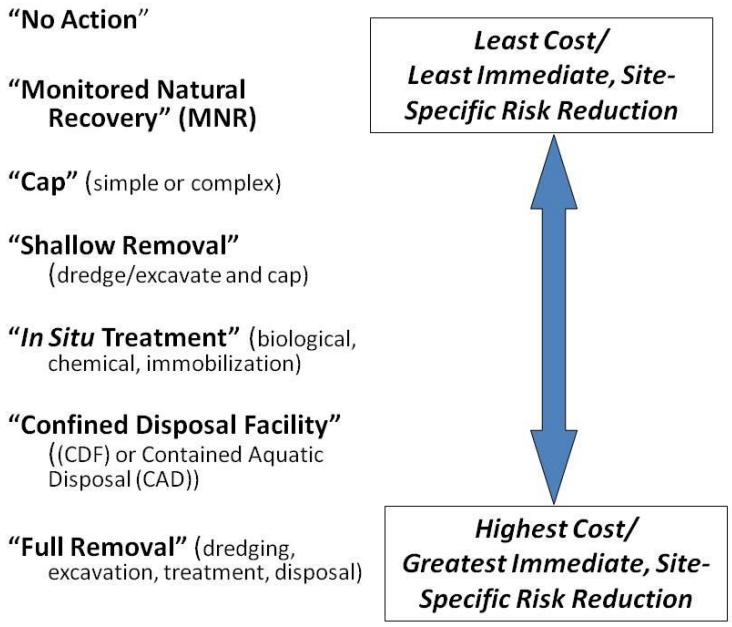


Table 3: Possible Management Actions for Contaminated Aquatic Sites: Suitability, Requirements and Implications

Useful references are provided in Appendix A. Monitoring is a required component of all of these possible management actions.

Constraints	Monitored Natural Recovery[1]	*In Situ* Treatment	Capping	Dredging and Disposal[2]
Suitable for sediment with the following characteristics	Low toxicity; benthic community impact; low concern for biomagnification; negligible human health risk	Acute toxicity; biomagnifying substances; human health risk	Acute toxicity; biomagnifying substances; possibility of future sediment disturbance and exposure of contaminated deeper sediments (>10 cm); human health risk	
Not suitable for sediment with the following characteristics	Acute toxicity, high concern for biomagnification	Unstable bottom conditions; untreatable chemicals; need for rapid removal/isolation; possibility of future sediment disturbance/ exposure of contaminated deeper sediments (>10 cm)	Unstable bottom conditions; need for rapid removal/isolation	Suitable for all sediments
Requirements	Depositional/stable area; sufficiently high depositional rate; low potential for disturbance (*i.e.*, conditions that progressively reduce exposure of ROCs to COCs)	Contaminants amenable to treatment within reasonable time frame	Relatively level bottom; low energy; short haulage distance for capping material; possible long-term maintenance plan	Minimization of sediment turbidity/ losses during removal/ handling; site engineering; disposal facility
Implications	Area use may be restricted with potential economic impact; however, no sediment resuspension, loss or disposal issues	Use of area may be restricted; treats only surface of sediment deposits; however, no sediment disposal issues	Use of area may be restricted with potential economic impact; may affect navigation (altered water depth); short-term impact on aquatic habitat	Short-term impact on aquatic habitat and navigation

[1] For information on thin-layer capping to enhance natural recovery: Merritt *et al.* (2010). Actions such as monitored natural recovery should be considered for sensitive, unique environments that could be irreversibly damaged by intrusive management actions such as capping (other than possibly thin-layer capping) or dredging.

[2] For information on dredging processes and remedy effectiveness: Bridges *et al.* (2010).

2.5.2 Step 8: Implement Remediation/Risk Management Strategy

Rationale: The R/RM strategy developed in Step 7 (Section 2.5.1) is implemented, including a RAP or RMP, an EMP, and selection of appropriate contractor(s) for the remedial works/risk management activities.

Depending on the specific contaminated aquatic site, its sensitivity or proximity to sensitive areas, and the complexity of contamination issues, R/RM can range from straightforward techniques implemented over a relatively short time-frame to a complex strategy or combination thereof implemented over a relatively long time-frame. Comprehensive evaluation of alternatives, careful planning of R/RM and controlled yet adaptable implementation (*i.e.*, adaptive management) will facilitate effective and efficient remediation of a contaminated aquatic site.

2.5.2.1 Preparation of a Remedial Action/Risk Management Plan

Rationale: The RAP/RMP considers the environmental problems as identified during the detailed testing (Step 5) and develops an R/RM plan accordingly. This includes implementation and potentially long term monitoring.

In general, the RAP should be prepared with the assistance of Expert Support. The RAP/RMP should include a separate worker health and safety plan and contractor tender documents. A qualified contractor is selected based on the level of experience and capabilities of the contracting team, tasked to provide proper documentation, QA/QC, and should communicate with stakeholders and Indigenous peoples, as appropriate, during the implementation of the RAP/RMP. Where local contractors may not have the necessary background, expertise or experience to successfully conduct highly specialized work elements, these elements should be subcontracted.

The RAP/RMP should include:

- A summary of the findings of previous site investigations (*i.e*., of Steps 1-6);
- COCs;
- ROCs;
- Identification, quantification and characterization of the sediments to be remediated/risk managed;
- A summary of the R/RM options evaluated and of the methodology used to select the preferred strategy;
- A detailed Implementation Plan including schedule and associated costs;
- Control measures to minimize human and environmental risks during implementation of the remedial option, including worker health and safety;
- A contingency plan in the event of unexpected events (*e.g.*, fuel oil spills, release of contaminants from the sediments into the water column);
- Identification of the fate of residual contaminants; and,
- A description of plans for confirmatory sampling (Step 9) and long-term monitoring (Step 10) if warranted.

Depending on the complexity and size of the project, an independent technical review of the RAP may be desirable along with input from stakeholders and Indigenous peoples, as

appropriate. Federal and provincial/territorial regulatory agencies should be consulted regarding regulatory requirements, where applicable.

2.5.2.2 Environmental Management Plan

Rationale: An EMP can be prepared as part of the remedial planning with the assistance of Expert Support. The EMP outlines the regulatory and permitting requirements specific to the remediation project and identifies the potential environmental effects and how they can be mitigated. The EMP also identifies environmental performance criteria (*e.g.*, turbidity criteria) that should not be exceeded during the work as well as the actions that should be taken in the event that they are exceeded.

Legislative requirements will vary by province. Federal legislative requirements include:

- *Impact Assessment Act (IAA), 2019* - Federal authorities are required by section 81-91 Federal Lands provisions of IAA 2019 to determine the likelihood of significant adverse environmental effects that might result from a project being carried out on federal lands. The IAA defines a project as a physical activity in relation to a physical work. To assist authorities in understanding the requirements under the IAA, the Agency has developed several resources to help explain the federal government's impact assessment process. Also note that:
    - Contaminated sites may be subject to review under a northern environmental assessment regime (*e.g.*, *Yukon Environmental and Socio-economic Assessment Act* [PDF], *Mackenzie Valley Resource Management Act*, Inuvialuit Final Agreement [PDF], Nunavut Land Claims Agreement Act) [PDF]), that is typically triggered when a project requires an approval or permit from an authorizing agency;
- *Canadian Environmental Protection Act (CEPA), 1999* - Contributes to sustainable development through pollution prevention, and to protecting the environment and human health from the risks associated with toxic substances;
- *Migratory Birds Convention Act, 1994* - Protects and conserves migratory birds and their eggs and nests from hunting, trafficking and commercialization. It also provides protection against the deposit of substances that are harmful to migratory birds;
- *Fisheries Act, 2019* - Contains, amongst others, the fish and fish habitat protection provisions (*e.g.,* subsection 34.4(1) which prohibits works, undertakings or activities that result in the death of fish, other than fishing, subsection 35(1) which prohibits works, undertakings or activities that result in the harmful alteration, disruption or destruction of fish habitat, etc.) and the pollution prevention provisions (*e.g.,* subsection 36(3) which prohibits the deposit of a deleterious substance in water frequented by fish). Also note that:
    - Physical works can result in the release of deleterious substances (*e.g.,* sediment-laden water, contaminant release during dredging) and these substances need to be controlled at their source during remediation;

- Restrictions on the timing of works/undertaking/activities (w/u/a) is one common management tool/mitigation measure to minimize potential impacts to fish or fish habitat, and may have significant impacts to the scheduling of work proposed to be carried out at a contaminated aquatic site. Measures to protect fish and fish habitat can be found on the DFO website ;
- In order to lawfully conduct a w/u/a that could result in the death of fish (other than fishing) or the harmful alteration, disruption or destruction of fish habitat, a *Fisheries Act* authorization has to be obtained by the proponent.

- *Canadian Navigable Waters Act* - Regulates work conducted on, in, upon, under, over, through or across scheduled navigable waterways;

- *Canada Water Act* - Part II deals specifically with water quality management and water pollution, where it applies; and

- *Species at Risk Act* - The purposes of the Act are to prevent wildlife species (including aquatic species) from being extirpated or becoming extinct, to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity and to manage species of special concern to prevent them from becoming endangered or threatened. The Minister of Fisheries and Oceans is responsible for the administration and enforcement of SARA with respect to listed aquatic species except for those located in or on federal lands administered by the Parks Canada Agency. These aquatic species include fish, as defined in section 2 of the *Fisheries Act*, and marine plants, as defined in section 47 of that Act. The Department is mandated to protect aquatic species listed under SARA (section 32), their residences (section 33), and their critical habitat (subsection 58(1)), as well as to provide for their recovery. Prohibitions against undertaking activities that affect aquatic species at risk target only those species listed on Schedule 1 of SARA as threatened, endangered, or extirpated. They do not apply to species listed as special concern. Aquatic species at risk found in Canadian waters and their SARA status can be accessed on the website of the Species at Risk Public Registry.
    - More information on aquatic species at risk (including aquatic species at risk maps) can be found on the DFO website. There are also a number of best management practices (BMP) documents that are available and that would provide some form of guidance for most types of work taking place in and around water (Appendix A). The EMP should identify which of these BMPs applies to the project.
    - The permitting provisions are set out in section 73 of SARA and allow for the issuance of a permit authorizing a person to engage in an activity affecting a listed wildlife species, any part of its critical habitat or the residence of its individuals. A permit may be issued, or an agreement made, provided that the conditions set out in subsections 73(2) through 73(7) are met.
    - In addition to the issuance of SARA permits, section 74 of SARA allows for an agreement, permit, licence, order or other similar document entered into, issued or made by the competent minister under another Act of Parliament to have the same effect as a SARA permit provided that the requirements of subsections 73(2) to (7) are met. This means that, for example, a *Fisheries Act* authorization may also function as a SARA permit.

It is important to note here that the above legislative processes and more specifically the related regulatory approvals/decisions may trigger the “Duty to Consult” with Indigenous groups. The

Government of Canada has a duty to consult, and where appropriate, accommodate Indigenous groups when it considers conduct that might adversely impact potential or established Aboriginal or treaty rights (CIRNAC, 2019). This can include federal government activities such as regulatory project approvals, licensing, issuance of authorizations/permits, operational decisions and policy development to name a few. Custodians are encouraged to seek legal advice if they are unsure whether there is a Duty to Consult regarding a given contaminated site.

As the contractor prepares to implement the remedial works, they should prepare a specific task analysis document for health, safety and environmental management. With respect to environmental management, many proponents require their contractor to submit a task-specific Environmental Protection Plan (EPP). The EPP is based on the EMP but is specific to the project and outlines roles and responsibilities of the contractor's staff, the location of spill response equipment, the specific measures that they will use to respond to the trigger levels in the EMP, etc.

2.5.2.3 Considerations for Contracting

Rationale: Certain components of contaminated sites may be unique and/or complex, and therefore must be taken into consideration when selecting suitable contractors for remedial/risk management activities.

The selection of a suitable contractor for R/RM activities will involve preparing detailed specifications and tender documents, which includes an evaluation component to ensure that the successful bidder is knowledgeable and experienced in applying the recommended remediation technology under similar site conditions. It should also be verified that the contractor has an effective safety and environmental management program. The specification and tender documents should contain:

- Concise descriptions and specifications outlining each component of the Implementation Plan;
- A clear statement of the RAP objectives;
- Pertinent information regarding the contaminated aquatic site including:
    - Extent and volume of contaminated materials (COCs; intervention/remediation SeQOs; horizontal and vertical footprint);
    - Site bathymetry/hydrology/hydrogeology; and,
    - Site physical/geotechnical properties (*e.g.,* deposition/scouring; extreme events such as ice thaw/scour, storms, floods; anthropogenic factors such as navigational dredging, propeller wash, future uses);
- Clearly defined reporting and documentation requirements;
- Pre-determined methods for verifying volumes of material removed (*e.g.*, bathymetry, volumes shipped by truck, etc.), if applicable;
- A request for detailed cost information and for unit rates for possible unforeseen additional work in order to amend the contract;
- The criteria on how bids will be evaluated.

When requested, the bidders should be able to visit the contaminated aquatic site. Bidders should be provided with site reports and the opportunity to ask questions/request clarification. Responses to such questions/requests for clarification must be provided equally to all bidders.

Projects where approvals are in place will generally attract more competitive bids. Package prices where a contractor must obtain agency approvals are viewed as being high risk by most contractors and that risk, usually with a premium attached, will be factored into the bids received or will decrease the numbers of bidders.

Proposals developed in response to the specification and tender documents commonly include:

- A concise description outlining each component of the implementation plan;
- A detailed work schedule;
- A health, safety and EPP or outline how that will be developed if awarded the contract;
- Identification of any proposed feasibility, pilot-scale or optimization studies;
- A site monitoring plan (addressing Steps 9 and 10, below);
- A QA/QC plan including an organized, comprehensive record-keeping and documentation system;
- Deliverables such as environmental monitoring reports, confirmation of remediation reports, etc.;
- A contingency plan; and,
- Detailed cost information.

It is important to provide the contractor with as much information as possible so that the contractor is well aware of site conditions. Changes in site conditions from those conditions expected as part of the bid process could incur additional costs and the contract may need to be amended causing delays in project milestones.

2.6 Monitoring of Remediation/Risk Management

Rationale: Confirmatory sampling (Step 9) ensures that R/RM objectives have been met during and immediately following implementation of the RAP/RMP, while long-term monitoring (Step 10) verifies that the management objectives will be met for the foreseeable future. Refer to Figure 8 for illustration of Steps 9 and 10.

Long-term monitoring (LTM) may begin after confirmatory sampling shows that the R/RM goals have been achieved. LTM is typically required at sites where the R/RM approach relied on the elimination of contamination transport pathways to receptors rather than the removal or treatment of contaminants exceeding remediation objectives. The main driver of LTM is the need to ensure that the R/RM controls remain protective of human health and the environment. Generic guidance regarding monitoring is available in Appendix A.

2.6.1 Step 9: Confirmatory Sampling

Rationale: Confirmatory sampling is conducted to ensure that R/RM objectives have been met during and immediately following implementation of the RAP/RMP.

Confirmatory sampling is required to demonstrate that the risk to humans and the environment is negligible following R/RM. In other words, either contamination has been removed (*i.e*., dredging), exposure to contamination has been eliminated (*e.g.*, *in situ* treatment, capping) or the risk to receptors has been sufficiently controlled via risk management (*e.g.,* MNR).

The remediated or risk managed areas need to be sampled to verify that the R/RM objectives have been met (*e.g.*, residuals from dredging activities do not exceed the SeQOs). If objectives have not been met, additional R/RM activities followed by additional confirmatory sampling will be required. Such additional activities may involve a change in R/RM approaches. When the objectives have been met, R/RM activities and resulting site conditions are documented in a report. Information on site conditions following management actions and acceptable confirmatory sampling will form the basis for subsequent long-term monitoring (Step 10, Section 2.6.2), if needed.

Confirmatory sampling should preferably, but not necessarily, be conducted by an independent third party qualified to carry out such work, using standardized and consistent sampling methods. Confirmatory sampling consists of the following components:

- Field sampling and/or laboratory testing including appropriate quality assurance/quality control (QA/QC) procedures;
- Sample analyses by accredited laboratories (*e.g.*, CALA) including appropriate QA/QC procedures;
- Data interpretation and evaluation; and,
- A clear answer to the question “Does the contaminated aquatic site still pose an unacceptable human or ecological risk such that further management action is required?”

The answer to the question “Does the contaminated aquatic site still pose an unacceptable human or ecological risk such that further management action is required?” will be based on whether R/RM objectives have been met. Expert Support can provide guidance in this area (*e.g.*, does one exceedance of a guideline equate to non-compliance?). FCSAP has recently updated the Site Closure Report Template (FCSAP, in press) and associated guidance (FCSAP, in press). The template includes checklists to help document whether risk at the site has been reduced to an acceptable level through implementation of the remediation or risk management actions on the site.

2.6.2 Step 10: Long-Term Monitoring (if required)

Rationale: Long-term monitoring of all R/RM actions is conducted to verify that the R/RM objectives will be met for the foreseeable future; monitoring is terminated when this has been verified.

Generic guidelines on long term monitoring are provided in Michaud (2000); however, monitoring components will be site and situation specific in design, frequency and duration (Appendix A). Such monitoring should be adaptive, based on principles outlined in Lindermayer and Likes (2009) to avoid the three major problems hindering monitoring effectiveness: 1) the wrong drivers (*e.g.*, politics rather than good science); 2) poor initial design; and, 3) lack of clarity regarding goals and components. Doing so will not only avoid unnecessary data collection and miscommunication with stakeholders (*e.g.*, “what should be monitored?”), but will also promote the assessment of the long-term effectiveness of management action(s).

Assessment and measurement endpoints forming the basis for the long-term monitoring will be site- and situation-specific based on the finalized CSM (Step 5, Section 2.4.1; Appendix C). The long-term monitoring should:

- Have clear management relevance and necessity (*i.e.*, there is no point in doing monitoring for its own sake);
- Be transparent (*e.g.*, repeatable, with all data freely available) and technically defensible (*e.g.*, appropriate QA/QC);
- Be integrative (internally, using measurement endpoints in a WOE assessment; externally, linking individual source monitoring and regional monitoring);
- Be agreed upon by all stakeholders and Indigenous peoples, where appropriate; and,
- Be conducted by qualified professionals which could include trained community partners.

Other necessary long-term monitoring components include good *a priori* statistical design, and adaptation as new knowledge becomes available (*e.g.*, iterative revisions while maintaining the integrity of the long-term data record). In addition to comparing the long-term monitoring results with the R/RM goals (*e.g.*, site-specific SeQOs), trends in contaminant concentrations and other trends (*e.g.*, changes in site conditions) should be identified. Changes in site conditions could result in an additional ROPC or exposure pathway that must be considered. A steady increase in concentrations of a contaminant over time could be indicative of contaminant migration (*e.g.*, capping or *in situ* treatment losing their effectiveness over time), or of new contamination from other sources. Guidance for non-compliance with the R/RM goals would be useful.

Long-term monitoring can be terminated when there is a clear 'no' answer to the question, "Will the contaminated aquatic site pose an unacceptable human or ecological risk in the foreseeable future, such that further management action is required?" At this point the contaminated aquatic site can be declared successfully remediated or risk managed. However, if R/RM goals are not achieved, the RAP/RMP must be re-evaluated, which may necessitate revisiting Step 7 (Section 2.5.1) and undertaking appropriate adaptive management contingency measures.

FCSAP has developed *Long-Term Monitoring Planning Guidance* for use at federal contaminated sites (FCSAP, 2013b). This guidance 1) provides a Framework for the development and implementation of scientifically defensible LTM plans; 2) facilitates consistency, as is practicable, across federal departments, regions and regulatory jurisdictions for content and implementation of LTM plans; and 3) establishes procedures for identifying decision criteria prior to LTM data collection. This guidance includes detailed case studies of aquatic long-term monitoring programs. The full guidance and Executive Summary of the document are available from the Federal Contaminated Sites program website.

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Appendix A - Useful Online References for the Framework Steps

References to websites without titles of specific documents contain multiple relevant documents which will be added to periodically. Additional references are provided in Michaud (2009).

Reference	Data Gathering (Steps 1-2)	Screening Level Assessment (Step 3)	Detailed Level Assessment (Steps 5)	Remediation/Risk Management (Steps 7-8)	Monitoring (Steps 9-10)	Comments
Environment Canada and Ontario Ministry of the Environment (2008) Assessment of Great Lakes contaminated sediment [PDF 1.20 MB]	✓	✓	✓			Primary guidance document. Steps 4 and 6 involve *FCSAP (2021a) Aquatic Sites Classification System*
US Army Corps of Engineers *et al.* (2018) Sediment evaluation framework for the Pacific Northwest	✓	✓	✓			Information on sediment sampling, testing techniques, and interpretation
CCME (2020) Ecological Risk Assessment (ERA): Guidance Document	✓	✓	✓			General guidance for conducting risk assessments in Canada

Reference	Data Gathering (Steps 1-2)	Screening Level Assessment (Step 3)	Detailed Level Assessment (Steps 5)	Remediation/Risk Management (Steps 7-8)	Monitoring (Steps 9-10)	Comments
USEPA Contaminated Sediments in Superfund	✓	✓	✓	✓	✓	Guidance documents and fact sheets for assessing and remediating contaminated aquatic sediments
Environment Canada and Ministère du Développement durable, de l'Environnement et des Parcs du Québec (2008) Sediment Quality in Quebec [PDF 1.13 MB]	✓	✓				Quebec sediment quality criteria and application frameworks
Magar *et al.* (2009) Monitored Natural Recovery				✓	✓	Technical guide for contaminated aquatic sediment monitored natural recovery
FCSAP (2010a; 2010b; 2013a; 2013c; 2019a; 2019b) Supplemental Guidance for Ecological Risk Assessment Modules 1-6			✓	✓		Supplemental Guidance to CCME (1997) with modules on toxicity test selection, TRV derivation, wildlife receptor characteristics, causality, and background conditions
FCSAP (2013b) FCSAP Long-Term Monitoring Planning Guidance					✓	This guidance presents a framework for developing and

Reference	Data Gathering (Steps 1-2)	Screening Level Assessment (Step 3)	Detailed Level Assessment (Steps 5)	Remediation/Risk Management (Steps 7-8)	Monitoring (Steps 9-10)	Comments
						implementing technically defensible LTM plans for federal contaminated sites.
FCSAP (2021b) Guidance for Assessing and Managing Aquatic Contaminated Sites in Working Harbours	✓	✓	✓	✓	✓	Complementary guidance to FCSAP 10-step process to address challenges specific to working harbour sites.
FCSAP (2021a) Aquatic Sites Classification System (Version 3.4)						Excel spreadsheet and accompanying user guidance are used as tools for site classification at Steps 4 and 6 of FCSAP 10-step process.
FCSAP (in press). Guide to Monitored Natural Recovery (MNR) at Federal Aquatic Contaminated Sites				✓	✓	Guidance to apply MNR as a remediation strategy for contaminated sediments at aquatic federal contaminated sites.
FCSAP (in press) Decision-Making Framework (DMF), Version 4.0	✓	✓	✓	✓	✓	A complementary guide to the Federal Approach to Contaminated

Reference	Data Gathering (Steps 1-2)	Screening Level Assessment (Step 3)	Detailed Level Assessment (Steps 5)	Remediation/Risk Management (Steps 7-8)	Monitoring (Steps 9-10)	Comments
						Sites (CSMWG, 1999).
US Army Engineer Waterways Experiment Station Technical Notes				✓	✓	Dredged material management, operations technologies, risk assessment and management
USEPA Contaminated Site Clean-Up Information: Sediments				✓	✓	Remediation of contaminated aquatic sediments
Sediment Management Work Group				✓	✓	Sediment assessment and management technical papers
ASTSWMO (2009) Monitoring [PDF 775 KB]					✓	Framework for long-term sediment monitoring

Appendix B - Data Quality Objectives (DQO)

The USEPA (2000, 2006) Data Quality Objectives (DQO) process provides a useful tool toward assessing what decisions must be made, what information is available toward making those decisions, what additional information is needed, and how that information will be used in decision-making. Developing a CSM (Appendix C) is one component of the first step of the DQO process.

The DQO process is a systematic planning process applicable when data are being used to select between two alternative conditions (*e.g.*, compliance or non-compliance with a guideline, determining whether or to what extent management action is needed). The process begins with a problem statement, which requires identification of the project manager/decision makers, technical team members, stakeholders and Indigenous peoples; description of the specific problem to be investigated; assessment of this problem in terms of the CSM; and determination of resources available including limitations (budget, personnel and schedule).

The principal study questions are then identified, and possible alternative actions including potential operational options are defined. A decision statement is developed and multiple possible decisions are organized.

The information needed to reach a decision is identified. Sources for this information are determined, and an Action Level above which a management action will be taken is determined (*e.g.*, the 95% confidence limits of a data distribution). Sampling and data analysis methods required to meet the data requirements are identified.

Target populations of interest are defined relative to the smallest subpopulation, area, volume, or time for which separate decisions must be made. As part of this component, the spatial boundaries of the study are specified. The time frames for collecting data and making a decision are also determined. Practical constraints on data collection are identified.

An appropriate population parameter (mean, median, percentile) is specified. Any exceedances of the Action Level are confirmed. A decision rule is developed (an “If…then” statement).

The following components of the DQO process should particularly be followed:

- Specify tolerable limits on decision errors: The range of the parameter of interest is determined, and a null hypothesis is chosen. The consequences of an incorrect decision (Type I vs. Type II error) are examined. A range of values where the consequences are relatively minor (a “gray area”) is specified. Probability values are assigned to points above and below the Action Level that reflect tolerable probabilities for potential decision errors; and,
- Optimize the design for obtaining data: The DQO outputs are reviewed and data collection design alternatives are developed. Mathematical expressions are formulated for each design. The sample size that satisfies the DQOs is selected.

Appendix C - Conceptual Site Model (CSM)

A CSM is a written description and visual representation of predicted relationships between ecological receptors and the stressors to which they may be exposed (CCME 1996, 1997; USEPA 1998, 2002b). CSMs represent many relationships. They may include ecosystem processes that influence receptor responses, or exposure scenarios that qualitatively link land-use activities to stressors. They may describe exposure pathways or co-occurrence among exposure pathways, ecological effects, and ecological receptors.

CSMs are integral to the problem formulation phase of HHRAs and ERAs. Reviews of ERA case studies have indicated many deficiencies that might have been avoided had more attention been paid to CSMs within the problem formulation (USEPA 1993). A well-constructed problem formulation reduces the likelihood that significant pathways and receptors are incorrectly excluded, improves the alignment of the technical methods with appropriate measurement and assessment endpoints, and generally improves the consistency and transparency of the risk assessment. Effort spent on the CSM is particularly important for contaminated aquatic site risk assessments given that these assessments rely on weight of evidence (WOE) approaches and robust multi-media sampling programs, and generally require considerable effort to build consensus among stakeholders and Indigenous peoples regarding appropriate decision criteria.

The CSM for aquatic sites should emphasize the type and magnitude of sediment contamination and define the pathways for contaminants to reach ROPCs. It is developed early in the Approach (Step 2, Section 2.2.2), provides the foundation upon which to obtain relevant and necessary new information (*i.e.,* to address critical data gaps) about a suspect aquatic site, and is refined as new information becomes available (*e.g.*, in Steps 3 and 5). Establishing the CSM early in the process (*i.e.,* at Step 2) allows resources and subsequent efforts to focus appropriately on COPCs, ROPCs, and the exposure pathways between them.

Conceptual models are easily modified as knowledge increases; they highlight what is and what is not known, and they can be used to plan future work. They can be a powerful communication tool, because they provide an explicit expression of the assumptions and understanding of an aquatic site for others to evaluate. They also provide a Framework for prediction and are the template for generating risk hypotheses (Appendix D).

CSMs for HHRAs and ERAs are developed from information about stressors, potential exposure, and predicted effects on an ecological entity (the assessment endpoint). Depending on why a risk assessment is initiated, one or more of these categories of information are known at the outset. The process of creating a CSM helps identify the unknown elements.

The complexity of the CSM depends on the complexity of the problem including, for example, the number of stressors, number of assessment endpoints, nature of effects, and characteristics of the aquatic site. For single stressors and single assessment endpoints, CSMs may be simple. However, when CSMs are used to describe multiple pathways and the interaction of multiple and diverse stressors and assessment endpoints (*e.g.*, assessments initiated to protect ecological values), more complex models and several sub-models will often be needed.

CSMs consist of two principal components: a set of risk hypotheses (Appendix D) that describe predicted relationships among stressor, exposure, and assessment measurement components, along with the rationale for their selection. The conceptual model also illustrates the relationships presented in the risk hypotheses (*e.g.*, Figures 4 and 5).

Appendix D - Risk Hypotheses

Hypotheses are assumptions made in order to evaluate logical or empirical consequences, or suppositions tentatively accepted to provide a basis for evaluation. Risk hypotheses are specific assumptions about potential risk to assessment endpoints and may be based on theory and logic, empirical data, mathematical models, or probability models. They are formulated using a combination of professional judgment and available information on the aquatic site, potential sources of stressors, stressor characteristics, and observed or predicted ecological effects on selected or potential assessment endpoints.

Risk hypotheses may predict the effects of a stressor before they occur, or they may postulate why observed ecological effects occurred and ultimately what caused the effect. Depending on the scope of the risk assessment, risk hypotheses may be simple or complex.

Risk hypotheses represent relationships in the CSM and are not designed to statistically test null and alternative hypotheses. However, they can be used to generate questions appropriate for investigation, and predictions generated from risk hypotheses can be tested in a variety of ways, including standard statistical approaches. Risk hypotheses clarify and articulate relationships that are asserted through the consideration of available data, information from scientific literature, and the best professional judgment of risk assessors developing the CSMs. This explicit process opens the risk assessment to peer review and evaluation to ensure the scientific validity of the work.

Although risk hypotheses are valuable even when information is limited, the amount and quality of data and information will affect the specificity and level of uncertainty associated with risk hypotheses and the CSMs. When preliminary information is conflicting, risk hypotheses can be constructed specifically to differentiate between competing predictions. The predictions can then be evaluated systematically either by using available data during the analysis phase or by collecting new data before proceeding with the risk assessment. Hypotheses and predictions set a Framework for using data to evaluate functional relationships (*e.g.*, stressor-response curves).

Early CSMs (Step 2) are normally broad, identifying as many potential relationships as possible. As more information is incorporated, the plausibility of specific hypotheses helps risk assessors sort through potentially large numbers of stressor-effect relationships, and the ecosystem processes that influence them, to identify those risk hypotheses most appropriate for the analysis phase. It is then that justifications for selecting and omitting hypotheses are documented. Examples of risk hypotheses (information that sets the problem in perspective and the proposed relationships that need evaluation) are provided below relative to contaminated aquatic sites:

- **Stressor-Initiated:** Total Hg measured in sediments is converted to methyl Hg (meHg) and biomagnifies up the food chain. Hypothesis: Hg biomagnification may be occurring in fish feeding on invertebrates living in Hg-contaminated sediments;
- **Effects-Initiated:** Benthic community structure is different for contaminated sediments than for reference sediments. Hypothesis: Differences in benthic community structure between contaminated and reference areas are due to toxic effects of one or more sediment contaminants; and,
- **Ecological Value-Initiated:** Trout are important ecological, recreational, and economic species. The effects of heavily contaminated sediments on trout populations in areas

where they breed and rear are not clearly defined. Hypothesis: Contaminants released to the water column from heavily contaminated sediments may adversely affect exposed trout population.

Appendix E - Decision Matrix
Adapted from Tables 1 and 2, pp 16-18 of the *COA* (2008)

Table E1 provides guidance on how to determine the relative significance of results from bulk sediment chemistry, toxicity, benthos alteration and biomagnification potential analyses. The findings from each of these lines of evidence are classified into to a low, medium or high category and subsequently entered into a decision matrix (Table E2) in order to determine a course of action.

Table E1: Ordinal Ranking for WOE Categorizations for Chemistry, Toxicity, Benthos and Biomagnification Potential

	●	◎	○
Bulk Chemistry (compared to CCME ISQG)	**Adverse Effects Likely:** One or more exceedances of PEL	**Adverse Effects May or May not Occur:** One or more exceedances of CCME ISQG (TEL)	**Adverse Effects Unlikely:** All contaminant concentrations below CCME ISQG (TEL)
Toxicity Endpoints (relative to reference)	**Major:** Statistically significant reduction of more than 50% in one or more toxicological endpoints	**Minor:** Statistically significant reduction of more than 20% in one or more toxicological endpoints	**Negligible:** Reduction of 20% or less in all toxicological endpoints
Overall Toxicity	**Significant**: Multiple tests/endpoints exhibit major toxicological effects	**Potential**: Multiple tests/endpoints exhibit minor toxicological effects and/or one test/endpoint exhibits major effect	**Negligible**: Minor toxicological effects observed in no more than one endpoint
Benthos Alteration (multivariate assessment, *e.g.*, ordination)	"different" or "very different" from reference stations	"possibly different" from reference stations	"equivalent" to reference stations
Biomagnification Potential (relative to reference)	**Significant**	**Possible**	**Negligible**
Overall WOE assessment	**Significant adverse effects**: elevated chemistry;	**Potential adverse effects**: elevated chemistry;	**No significant adverse effects:**

Table E1: Ordinal Ranking for WOE Categorizations for Chemistry, Toxicity, Benthos and Biomagnification Potential

	●	◘	○
	greater than a 50% reduction in one or more toxicological endpoints; benthic community structure different (from reference); **and/or** significant potential for biomagnification	greater than a 20% reduction in two or more toxicological endpoints; benthic community structure possibly different (from reference); **and/or** possible biomagnification potential	minor reduction in no more than one toxicological endpoint; benthic community structure not different from reference; **and** negligible biomagnification potential

CCME ISQG = Note that the overall definition of “no significant adverse effects” is independent of sediment chemistry.

Table E2 provides a decision matrix and suggested course of management action for 16 different combinations of test results arising from bulk sediment chemistry, toxicity, benthos alteration and biomagnification potential analyses.

Table E2: Decision Matrix for WOE Categorization

Based on Table 1; a dash means “or”. Separate endpoints can be included within each LOE (*e.g.,* metals, polycyclic aromatic hydrocarbons, polychlorinated biphenyls for chemistry; survival, growth, reproduction for toxicity; abundance, diversity, dominance for benthos).

Scenario	Bulk Sediment Chemistry	Toxicity[1]	Benthos Alteration[2]	Biomagnification Potential[3]	Assessment
1	○	○	○	○	No further actions needed
2	●-◘	○	○	○	No further actions needed
3	○	○	●-◘	○	Determine reason(s) for benthos alteration
4	○	●-◘	○	○	Determine reason(s) for sediment toxicity
5	○	○	○	◘	Fully assess risk of biomagnification

6					Determine reason(s) for sediment toxicity
7					Determine reason(s) for benthos alteration **and** fully assess risk of biomagnification
8					Determine reason(s) for benthos alteration
9					Fully assess risk of biomagnification
10					Determine reason(s) for sediment toxicity **and** fully assess risk of biomagnification
11					Determine reason(s) for benthos alteration **and** fully assess risk of biomagnification
12					Determine reason(s) for sediment toxicity **and** fully assess risk of biomagnification
13					Determine reason(s) for sediment toxicity **and** benthos alteration
14					Determine reason(s) for sediment toxicity **and** benthos alteration, **and** fully assess risk of biomagnification
15					Management actions required[4]
16					Management actions required[4]

[1] Toxicity refers to the results of laboratory sediment toxicity tests conducted with a range of test organisms and toxicity endpoints. A positive finding of sediment toxicity may suggest that elevated concentrations of COPC are adversely affecting test organisms. However, toxicity may

also occur that is not related to sediment contamination as a result of laboratory error, problems with the testing protocol, or with the test organisms used.

[2] Benthos alteration may be due to other factors, either natural (*e.g.*, competition/predation, habitat differences) or human-related (*e.g.*, water column contamination). Benthos alteration may also be related to sediment toxicity if a substance is present that was not measured in the sediment or for which no CCME ISQG (TEL) exist, or due to toxicity associated with combined exposure to multiple substances.

[3] Per Table 1, significant biomagnification (●) can typically only be determined in Step 6 of the *COA* (p 20); Step 3 of that same document only (pp 9-10) allows a determination that there either is negligible biomagnification potential or that there is possible biomagnification potential. However, there may be site-specific situations where sufficient evidence is already available from fish advisories and prior research to consider biomagnification at a site significant; this would be determined in Step 1 (examination of available data) of the *COA* (p 7). Thus, for example, if significant biomagnification were indicated in Scenario 5, above, management actions would be required. The other three LOE do allow for definitive determinations in prior Steps of this Framework.

[4] Definitive determination possible. Ideally elevated chemistry should be shown to in fact be linked to observed biological effects (*i.e*., is causal), to ensure management actions address the problem(s). For example, there is no point in removing contaminated sediment if the source of contamination has not been addressed. Ensuring causality may require additional investigations (Section 5.3 of the *COA* [pp 29-30]). If bulk sediment chemistry, toxicity and benthos alteration all indicate that adverse effects are occurring, further assessments of biomagnification should await management actions dealing with the clearly identified problem of contaminated and toxic sediments adversely affecting the organisms living in those sediments. In other words, deal with the obvious problem, which may obviate the possible problem (*e.g.*, dredging to deal with unacceptable contaminant-induced alterations to the benthos will effectively also address possible biomagnification issues).