Guidelines for Adaptive Management - a Response Framework for Aquatic Effects Monitoring

DRAFT

Wek'èezhìi Land and Water Board

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DEFINITIONS AND ACRONYMS

This section of the Guideline provides a list of common Waste terms and their definition. Many of the terminologies and definitions are common to the land use permits and water licenses issued within the Mackenzie Valley.

Term	Definition
action level	A magnitude of environmental change which, if measured in an aquatic effects monitoring program, triggers a management action. Action levels are below that of the significance threshold, so that it will trigger management actions well below the magnitude of significant adverse effects
aquatic effects monitoring program	A monitoring program designed to determine the short and long-term effects in the receiving environment resulting from a project, to evaluate the accuracy of impact predictions, to assess the effectiveness of impact mitigation measures and to identify the need for additional impact mitigation measures to reduce or eliminate environmental effects
benchmark	A contaminant concentration that is expected to be protective of aquatic life. This value would be set below the significance threshold for a chemical parameter
Boards	Land and Water Boards of the Mackenzie Valley (Gwich'in, Sahtu, Mackenzie Valley and Wek'èezhìi Land and Water Boards)
effluent	Liquid waste discharged to the environment
effluent quality criteria (EQC)	Numerical or narrative limits on the quality of the waste discharged to the receiving environment
management action	A specific action initiated by the proponent when an aquatic effects monitoring program identifies that an action level has been reached. Management actions may include special studies, operational changes, or implementing mitigation activities, to stabilize or reverse a change in environmental conditions
mitigation	A measure to control, reduce, eliminate or avoid an adverse environmental impact
Monitoring Response Plan (MRP)	Documentation of the collection of mitigation and management actions that is prepared by the proponent in response to an action level being met as reported in the aquatic effects monitoring program.
MVRMA	Mackenzie Valley Resource Management Act

NWT	Northwest Territories
project	Any development that requires a water licence
proponent	The applicant for or holders of water licences
receiving environment	The natural environment that, directly or indirectly, receives any deposit or discharge of waste from a project
Response Framework	A systematic approach to responding when the results of an aquatic effects monitoring program indicate that an action level has been reached
Review Board	The Mackenzie Valley Environmental Impact Review Board conducts environmental assessments in the Mackenzie Valley under the MVRMA
significance threshold	A magnitude of environmental change which, if reached, would result in significant adverse effects. It is expected that this would be documented in the environmental assessment process prior to licensing
stakeholders	Includes industry, federal agencies, the territorial government, Aboriginal governments and organizations, communities, and other interested parties
waste	As defined in Section 2 of NWT Waters Act[1]
WLWB	Wek'èezhìi Land and Water Board

[1] "waste" is defined, in section 2 of the *Northwest Territories Waters Act*, as:
(a) any substance that, if added to water, would degrade or alter or form part of a process of degradation or alteration of the quality of the water to an extent that is detrimental to its use by people or by any animal, fish or plant, or
(b) water that contains a substance in such a quantity or concentration, or that has been so treated, processed or changed, by heat or other means, that it would, if added to any other water, degrade or alter or form part of a process of degradation or alteration of the quality of that water to the extent described in paragraph (a),
and, without limiting the generality of the foregoing, includes
(c) any substance or water that, for the purposes of the Canada Water Act, is deemed to be *waste*,
(d) any substance or class of substances prescribed by regulations made under subparagraph 33(1)(b)(i),
(e) water that contains any substance or class of substances in a quantity or concentration that is equal to or greater than a quantity or concentration prescribed in respect of that substance or class of substances by regulations made under subparagraph 33(1)(b)(ii), and
(f) water that has been subjected to a treatment, process or change prescribed by regulations made under subparagraph 33(1)(b)(iii)."

1 Introduction

1.1 Purpose

Projects that are licensed to deposit waste into water are often required to carry out aquatic effects monitoring to determine the nature and extent of project-related effects on the receiving environment. The Response Framework is proposed as a means to formally link the results of aquatic effects monitoring to management actions to ensure that project-related effects on the environment remain within an acceptable range. The Response Framework represents a practical and specific application of the principles of adaptive management to developments that are likely to cause environmental impacts.

The purpose of this document is to:

- Explain the WLWB's concept of the Response Framework
- Elaborate the specific components of the Response Framework
- Provide guidance on how to develop a Response Framework for a project.

The concepts put forth in this guidance document are meant to describe a series of actions that are taken to manage the environmental effects of a project to ensure that a) effects that were predicted remain within the range that informed the environmental assessment of the project and b) effects that were not predicted or foreseen are evaluated and managed to ensure that they do not become significantly adverse.

The need for these guidelines was identified during the review of two Adaptive Management Plans submitted under Type A water licences in the Wek'èezhìi Management Area in 2007-2008. Specifically, it became clear that there were differing opinions on the definition and practice of adaptive management and that there was no standard method for applying the principles of adaptive management, as described in the academic literature, to operating mines. Stakeholders at that time indicated that their primary concern was to have a transparent, inclusive, and consistent method for mining companies to respond to the results of environmental monitoring at a project site. The WLWB, with the assistance of its technical consultants, has developed this Response Framework Guideline in order to address the concerns of stakeholders.

1.2 Authority

Section 58.1 of the *Mackenzie Valley Resources Management Act* states that the "Wek'eezhii Land and Water Board shall regulate the use of land and water and the deposit of waste so as to provide for the conservation, development and utilization of land and water resources in a manner that will provide the optimum benefit generally for all Canadians and in particular for residents of its management area." The requirements of this guideline document are meant to support this mandate specifically by ensuring that project-related effects on the environment are minimized or managed to acceptable levels. The establishment of a Response Framework for Aquatic Effects Monitoring, as described in this guideline, is consistent with the powers granted to the WLWB under the *NWT Waters Act*, in particular Section 15.

1.3 Application

The requirement for the development of a Response Framework will be specified through a condition of a water licence or as a directive from the WLWB. In general, this guideline is relevant to licensees who have aquatic effect monitoring program requirements in their water licences.

1.4 Monitoring and Performance Measurement for these Guidelines

This guideline will be reviewed and revised by the WLWB periodically, and whenever there is a relevant change in technology or legislation.

1.5 Structure of this Document

The content of this document is as follows:

(a) Section 1 provides an introduction;
(b) Section 2 provides an overview for the Response Framework;
(c) Section 3 describes the components of the Response Framework in more detail;
(d) Section 4 provides a template that should be used by proponents in the development of their Response Framework;
(e) Appendix 1 presents a review of the literature on adaptive management;
(f) Appendix 2 provides a list of references on adaptive management;
(g) Appendix 3 discusses methods of assessing changes within the environment; and
(h) Appendix 4 contains a hypothetical case study to illustrate how the Response Framework might work in practice.

Wherever possible, this document was developed to minimize inconsistencies with other regulators' requirements. However, it remains the proponent's responsibility to comply with other agencies' requirements.

2 Response Framework for Aquatic Effects Monitoring- An Overview

This section of the guidelines provides an overview of the Response Framework process as well as how it fits into the context of the environmental assessment and regulatory phases of a project. This section is intended to be a plain language summary of the framework; sections 3, 4 as well as the appendices provide a more in-depth, technical description of aspects of the framework. A brief discussion of the relationship of the Response Framework to the principles of adaptive management is also provided. Details of the Response Framework components can be found in Section 3.

2.1 Background and Context

The use of water and deposit of waste into water is regulated, in the Wek'èezhìi management area, by the Wek'èezhìi Land and Water Board (WLWB). The WLWB does this through the issuance of water licences which contain terms and conditions designed to ensure that a development can proceed without adversely affecting water quality. One of the most effective means the Board uses to protect water quality is to limit the amount of waste that can be discharged from a project into the receiving environment. The Board does this by setting discharge limits, also called effluent quality criteria (EQC), in the water licence. EQC's define the maximum allowable concentrations or amounts of each potential contaminant in the effluent discharged from a project. EQC's are set on a case by case basis using the best information about the project and the receiving environment that is available to the Board at the time the licence is granted. The efficacy of the EQCs in protecting water quality is determined through aquatic effects monitoring programs which are, in turn, designed to quantify the effects of a project on both water quality and aquatic organisms.

If it is determined that a project is affecting the environment in a way that is not acceptable or was not predicted, the Board has the authority to require the licencee to perform various actions (i.e., further studies, mitigations, etc.) to avoid further environmental change. Ultimately, the Board may decide to revise the EQC. Although the Board clearly has the authority to require a company to respond appropriately to the results of aquatic effects monitoring, to date, there has been no established method to do so. The Response Framework for Aquatic Effects Monitoring has been designed to address this gap by defining the approach for each project at an early stage.

2.2 Summary of Response Framework

The Response Framework is a systematic approach to responding to the results of an aquatic effects monitoring program. The Framework requires proponents to take some action upon reaching a pre-defined level of environmental change or effect (the "action level"). Action levels are, in turn, set such that significant adverse impacts never occur. A critical requirement, therefore, of the Response Framework is defining, quantitatively or qualitatively, what is meant by "significant adverse impacts". The WLWB uses the term "significance threshold" to describe this requirement. Essentially, it is the threshold where an environmental change would be considered significantly adverse. The definition of significance threshold is meant to relate predictions and determinations made during the environmental assessment of a project to the administration of the resulting water licence. A more detailed discussion about the determination of significance thresholds and action levels can be found in Section 3.

To ensure that the significance threshold is never reached, the Response Framework involves three action levels: Low, Moderate, and High, each with a corresponding set of management actions. Typically, proponents will only be required to set the Low Action Levels in advance of actually measuring an environmental change. Each year the results from an aquatic effects monitoring program will be compared against the Low Action Levels set in the Response Framework. If a Low Action Level is reached, the proponent must submit a Monitoring Response Plan (MRP), take investigative actions, set Moderate and High Action Levels, and begin planning mitigative actions to respond to continued environmental change. If a Moderate Action Level is reached, the proponent might implement the identified mitigations and/or perform a risk assessment. High Level actions would reverse measured trends and improve environmental conditions. A summary of potential management actions for each action level is illustrated in Figure 1.

All action levels are meant to be set such that the significance threshold is never reached. The relationship between the three action levels and the significance threshold is illustrated via the fictional example in Figure 3. More detailed descriptions of the action levels and their corresponding management actions are in Section 3.2.

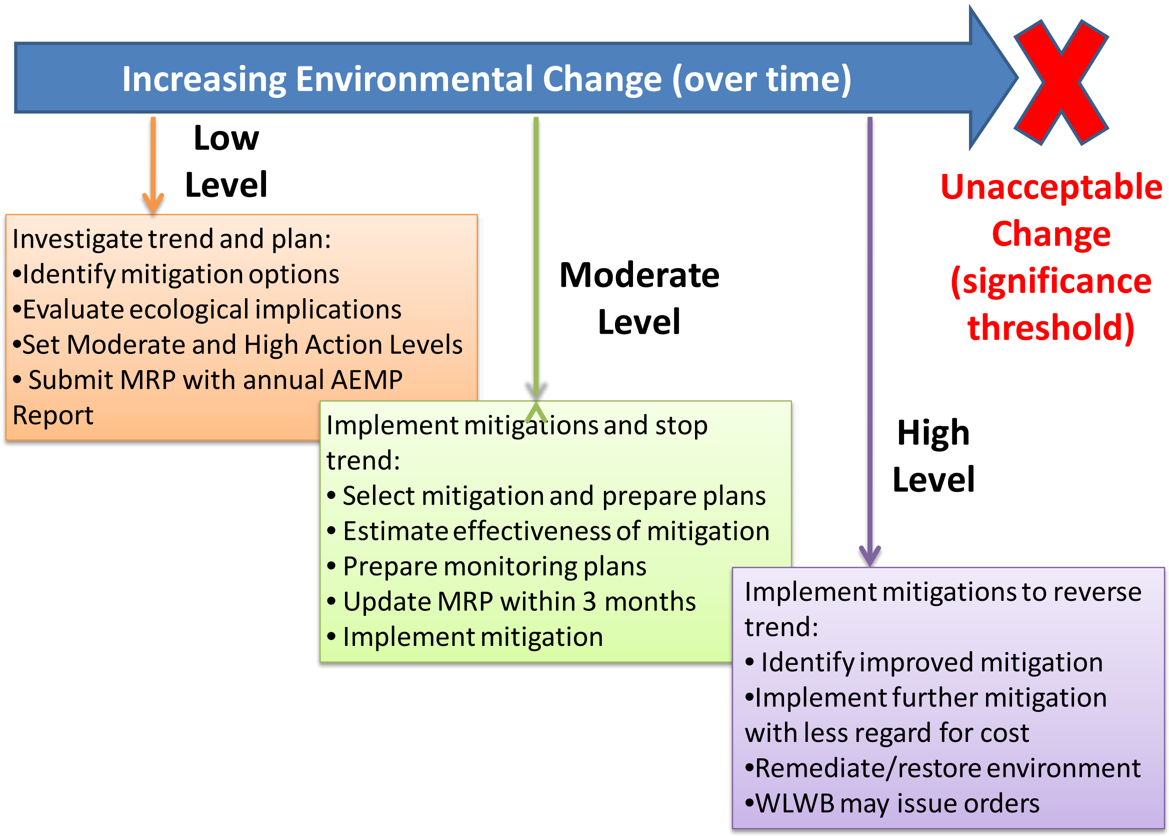


Figure 1: Potential Management Responses for Each Action Level

The requirement for the submission of a Response Framework document would be specified in a proponent's water licence. The proponent would be required to submit a Response Framework document that includes the following information (see Section 4 for more detail):

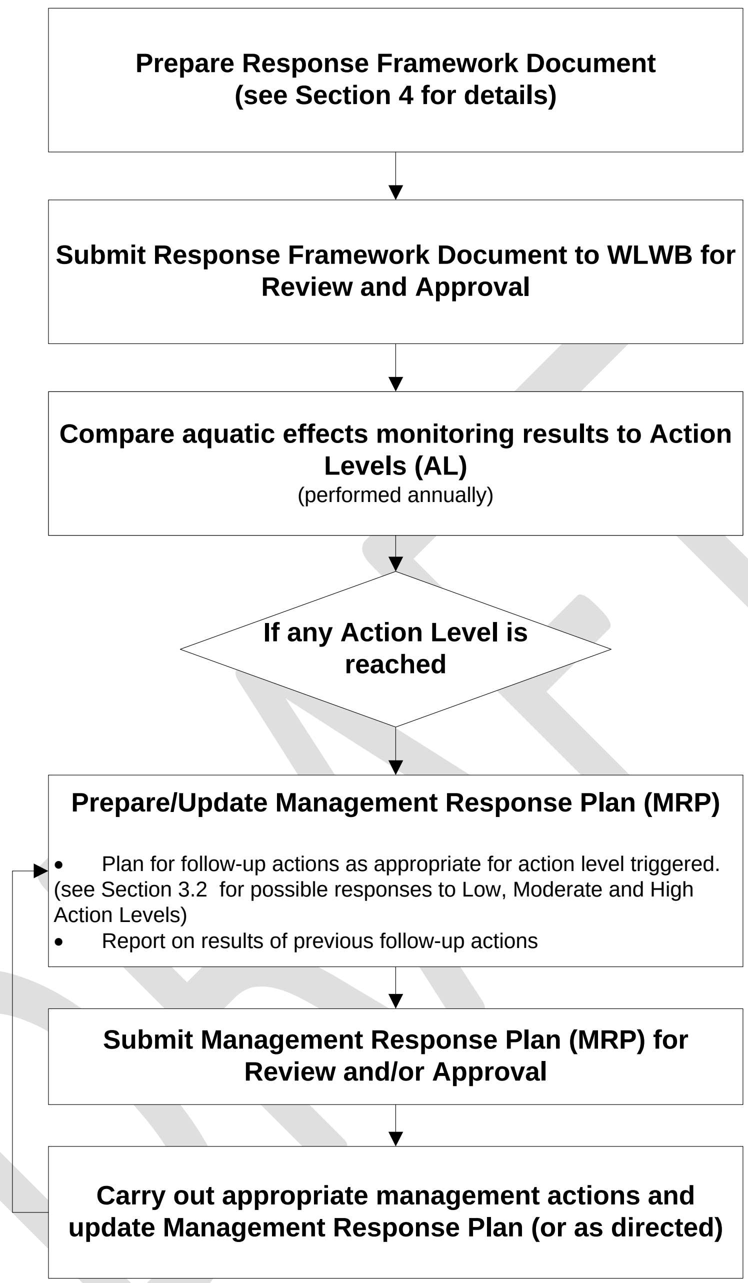
- a summary of environmental interactions and predictions of project-related effects,
- a summary of aquatic effects monitoring programs,
- a description of how environmental change will be measured and considered,
- a description of significance thresholds for valued ecosystem components and/or contaminants of potential concern,
- a description of appropriate action levels,
- a description of the format and content of Management Response Plans that will need to be submitted if action levels are reached.

This Response Framework submission will be sent to stakeholders for review and will require Board approval. Ideally, this Framework would be approved as soon as possible after a water licence is granted. Any MRP will be updated each year to describe the status of the past exceedences and report on any new exceedences. An overview of the Response Framework process is provided in Figure 2.

Overall, the Response Framework assumes that the best management actions may not be defined up front, but will be determined in response to specific changes documented by any of the environmental monitoring programs required for the project. The Response Framework will provide a clearly defined and timely process that is responsive to the results of the monitoring program. It provides the means to respond to all reasonable monitoring outcomes, without the need to develop specific management responses to all possible (i.e., theoretical) outcomes before they occur.

2.3 Relationship between the Response Framework and Adaptive Management

The term adaptive management is commonly used to describe any process where there is "learning by doing". That is, a process where management responds (or adapts) to changing conditions (regulatory, environmental, social, etc.) as those changes arise. The term therefore lends itself well to monitoring changes in the aquatic environment in response to a project and the process by which changes are managed. The review presented in Appendix 1, however, shows that the scientific literature defines adaptive management more rigorously. After reviewing all of the information, the Board has decided that the term "adaptive management" needs to be refined to meet our regulatory context. The Board has therefore proposed the concept of the Response Framework, as described here, to link monitoring results to management activities and allow management activities to be developed adaptively, in response to changes in the environment.



<u>Figure 2: Overview of Response Framework Process</u>

2.4 Relationship between the Response Framework and the Environmental Assessment

The Environmental Assessment (EA) process determines whether or not a project should proceed on the basis of whether or not the effects of the project are predicted to be significantly adverse or not. If the EA outcome allows the project to proceed then it enters the regulatory phase, which determines the specific conditions that must be included in the licence to ensure that the project-related changes remain within those that informed the EA decision.

The EA process contributes importantly to the development of a Response Framework by documenting the EA predictions of environmental change and the magnitude of change that is considered significant. In the EA, predicted impacts are assessed against criteria such as magnitude of effect, duration, geographic extent, reversibility, and timing to determine whether the project will have significant adverse effects or not. Under the legal framework of the MVRMA, after any mitigations, only projects without significant impacts are acceptable and may proceed to permitting. This is how the Act ensures that only projects with acceptable impacts (meaning without unmitigated significant adverse impacts) go forward. Specific management actions or mitigations can be defined and committed to as part of the EA process to ensure that project effects are not significantly adverse.

With a clear definition from the EA of changes that must be avoided, the Response Framework can set action levels and mitigation responses designed to ensure that such changes do not occur. However, it has been noted that the EA process does not always provide a clear description of what a significant adverse effect (i.e., the significance threshold) would be for the project. It is possible that the EA determination proceeds to a reasonable and defensible conclusion of no significant adverse effect without a clear understanding of what would make the predicted changes significantly adverse. This should not normally pose a problem – the project proceeds, changes remain within predictions and stakeholders remain confident in the outcome of the EA process.

The lack of a pre-defined threshold for a significant adverse effect becomes a problem, however, if environmental changes exceed predictions, or if changes occur that were not predicted. Does this mean that the project now has a significant adverse effect, or does it simply reflect the uncertainty inherent in predictions? To understand the appropriate management response, we must understand if the change approaches or exceeds a significance threshold, where the threshold is a measurable environmental response. Environmental measurements that reach the threshold would constitute a significant adverse effect, while measurements below the threshold would not, even if they were not predicted in the EA.

To further understand the relationship between the EA process and the Response Framework, it is helpful to look at the hierarchy of environmental changes between the pre-development baseline of a project and a significant adverse effect that is to be avoided. Within this range is the level of effect or change predicted within the EA process as well as the proposed action levels. The hierarchy is therefore:

- the baseline of chemical and biological conditions prior to the project as defined by the EA,
- the Low Action Level; normally the first trigger for management response, (development of the Monitoring Response Plan) as defined in the Response Framework,
- Moderate and High Action Levels to trigger increasing management responses, as defined by the Monitoring Response Plan,
- The EA prediction of change,
- The significance threshold; the level of change which is unacceptable to reach.

Figure 3 illustrates the hierarchical relationship between the significance threshold, EA predictions, measured environmental changes and action levels. In this example, the management actions taken in response to reaching the Moderate Action Level were successful in reversing the increasing trend in a contaminant before it exceeded EA predictions or became a significant adverse effect. The caption to Figure 3 describes the fictional example in more detail.

Note that the Response Framework does not assume that EA predictions equal the significance threshold. Rather, and as in shown in Figure 3, predictions made during the EA may fall anywhere between baseline conditions and the significance threshold. Therefore, while EA predictions always inform the setting of action levels and the significance threshold itself, exceedence of predictions will not necessarily result in a significant adverse effect. Instead it may indicate an incomplete understanding of the ecosystem. In all cases, the Response Framework is designed to ensure that environmental changes and/or effects are minimized.

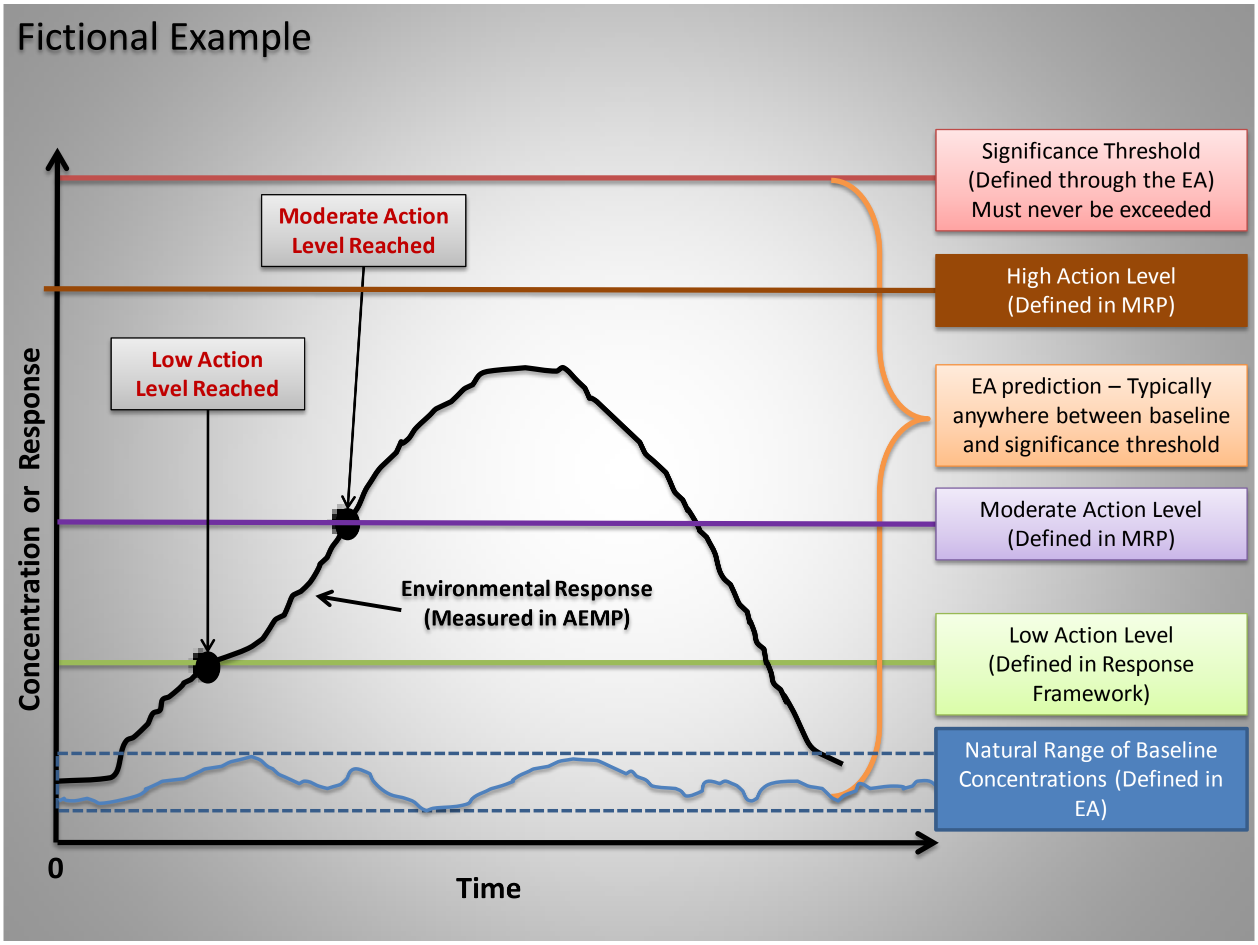


Figure 3. Hierarchy of environmental changes within the Response Framework.

This example shows the concentration (or other response), as determined by the AEMP, of a particular chemical or parameter at a fictional project. Initially, the concentration was within the natural range of baseline concentrations, but increased to the Low Action Level, which the proponent had already defined in the Response Framework. At this stage the proponent prepared and submitted a Monitoring Response Plan (MRP) for this chemical. In the MRP, the company described investigations to date, identified possible mitigations, and defined Moderate and High Action Levels. The concentration continued to rise, until it reached the Moderate Action Level, at which point the company revised the Monitoring Response Plan, and began mitigating the problem (e.g., using source control, treatment, etc.). In this case, the mitigation successfully brought the concentration back to within the range of baseline concentrations.

3 Components of the Response Framework

This section of the guidelines provides a detailed description of the main components of the Response Framework. Section 4 describes how to develop the Response Framework document (incorporating the components described here) and Appendix 4 provides an example of how the components may be used in the Response Framework.

3.1 Significance threshold

As described in Section 2.4 above, the significance threshold is most appropriately set for a project during the EA process. The definition of significance is based on traditional knowledge and scientific considerations, as informed by public consultation during the EA process.

Significance thresholds (i.e., the level of environmental change which should never occur) can be defined within a broad range of possible ecosystem change – somewhere between a departure from baseline and complete systemic collapse. They are defined in clear statements of potential environmental effects that the project must avoid. Ideally they are quantitative statements, but in practice they may take narrative form. They typically refer to biological features of the environment that must not be degraded beyond defined limits of degree, spatial extent or reversibility. They will not necessarily be based only on protective environmental quality guidelines, although such guidelines may be used as action levels to trigger management responses that will prevent reaching a significance threshold. In all cases, defining action levels and a significance threshold recognizes the fact that no development proceeds without some amount of environmental change and/or effect.

As noted in Section 2.4, the EA process may reasonably conclude that a project will not have a significant adverse effect on the environment without ever having explicitly defined what the significance threshold would have been. Since the definition of significance affects the project design and construction, we cannot return to the EA process to re-define significance after the project is built and operating. Any ambiguity in the definition of significance that remains at this stage (e.g., if changes occur that were not predicted or discussed in the EA process) must be resolved through the regulatory process.

The Response Framework, if required by the WLWB in a proponent's water licence, will be the vehicle for setting significance thresholds during the regulatory phase of a project. The Framework envisions the proponent recommending significance thresholds based on project-specific details and including information from the project's EA. Significance thresholds should be set only for those Valued Ecosystem Components (VEC) that have been identified as potentially affected by the project. The Board will seek stakeholder input on the proposed thresholds before the Response Framework document is approved.

The WLWB recognizes that setting the significance threshold, during either the EA or the regulatory phase of a project, is likely to be a difficult process. For example, many stakeholders are reluctant to define a limit of acceptable change because they fear that it will become a "pollute up to" limit or essentially an excuse not to take any mitigative action until the limit is reached. To be clear, this is not the intent of the WLWB and, in fact, goes against the guiding principle of "pollution prevention" as adopted by the Board in the Draft Water and Effluent Quality Management Policy[2]. The Policy explicitly states that water licence terms and conditions must be set both to protect water quality and minimize contaminant loadings to the environment; the Response Framework is meant to achieve the same goals.

Furthermore, although it will be challenging to pre-define significance thresholds (and associated action levels) for a project, the alternative is having the debate only after some environmental changes or effects have already been measured. In the latter case, unnecessary delays in implementing appropriate management response actions may occur, hindering our ability to minimize project-related effects in a timely and effective way. For example, it is not uncommon for stakeholders and the company to disagree (often strongly) as to the significance of measured changes in the receiving environment. Some will say that any deviation in water quality parameters from baseline is unacceptable while others will say that there is no problem as long as guideline values are not exceeded. Before making its decision, the Board must ensure it has gathered sufficient evidence from all parties as well as its own consultants before it can issue a decision on what will or will not be done in response to the results of monitoring. This can take some time and the Board believes that it is considerably more sensible to undertake that process prior to the measurement of project-related effects. Finally, although the Board already has the ability to assess monitoring results on an on-going basis and decide what action to take, a well-defined significance threshold and action levels makes the process more transparent and consistent for all parties.

3.2 Action levels and Responses

Action levels form the critical link between monitoring and response, and also establish the nature and scope of response. Action levels should be defined for any monitored parameter of potential

[2] The guiding principle of pollution prevention, as stated in the policy, reads: "The Boards believe in the use of processes, practices, materials, products or energy that avoid or minimize the creation of pollutants and waste, and reduce overall risk to human health and the environment."

environmental concern or a parameter that has clearly departed from the baseline condition and is trending toward further change. They should be set for:

- all measured ecological indicators of a Valued Ecosystem Component identified in the EA process,
- all contaminants of concern that were identified through the licensing process, i.e., any contaminant with regulated EQC in the licence,
- any environmental changes that were not predicted or foreseen to change, when evidence of a trend is documented in the aquatic effects monitoring program (AEMP).

> ***Benchmarks*** of contaminant concentration are levels above or at which biological effects could potentially be manifested in sensitive organisms.

Action levels will have an element of both degree (or severity) and spatial extent. For example, an action level may be reached if an increase in a contaminant occurs by some degree (e.g. 10%) over some spatial extent (e.g. the entire area of a small lake, or part of a large lake). The purpose of action levels, and the associated management actions, is to respond to such changes in degree or spatial extent over time (trends) that are identified by an AEMP. In this way, the Response Framework is designed to arrest environmental trends that are likely to result in negative environmental change and to reverse trends that have resulted, or will imminently result, in negative environmental change.

Although the Response Framework foresees three action levels (Low, Moderate and High) that correspond to increasing magnitude of change, it is not necessary to set numeric values for all three action levels in the first Response Framework document submitted. At a minimum, the Response Framework does require a numeric Low Action Level for each indicator, and a conceptual approach to setting Moderate and High Action Levels. If a specific Low Action Level is met, the Monitoring Response Plan (MRP) is triggered as a response. Moderate and High Action Levels can then be set numerically as part of the MRP, in response to the Low Action level being reached. The nature of each level and the corresponding response is summarized below.

3.2.1 Low Action Level and Response

A Low Action Level is meant to be pre-emptive in nature and is well below the level at which a benchmark concentration is reached or a biological effect is measured. At this point monitoring data indicate a move away from background or existing conditions and forecasting (e.g., trend analysis) suggests continuing change that is outside the range of EA prediction. Benchmark concentrations and biological effects are further discussed in Section 3.3.

Management responses on exceeding the Low Action Level are essentially investigative and planning. The actions should include investigations to identify likely sources of the change measured (or predicted) and to identify promising mitigation/abatement options. The Low Level response should also include an evaluation of the ecological implications if the benchmark value were to be exceeded, with a discussion of how the benchmark concentration relates to the significance threshold. Finally, if not already included in the Response Framework, the Moderate and High Action Levels should be set numerically at this stage. If research is required to set numerical values for these higher action levels, a plan to do so should be specified.

A Monitoring Response Plan (MRP) will be started at this stage to document the investigation and planning activities that have been initiated, the results that have been obtained, the setting of Moderate and High Action levels, and the promising mitigation/abatement options identified. The MRP will be provided to the WLWB for review and comment and there may be a formal stakeholder review process.

3.2.2 Moderate Action level and Response

The Response Framework envisions that a Moderate Action Level is activated when a benchmark exceedance or biological effect is either imminent (e.g., within 3 years as indicated by trend analysis, see textbox below) or has been measured in the near-field area. The near-field area should be defined to encompass the area where effects were predicted in the EA and where monitoring has been done in the AEMP. In the aquatic environment, normally the near-field is an area close to the point of discharge but beyond the zone of momentum-driven mixing, and large enough that receptor organisms of interest may reside there. In a chain of small lakes it is often the lake that receives the discharge. In a large receiving lake it would be a mixing zone or a portion of the lake around the discharge. In a large river it would be a zone downstream of the discharge but upstream of a major confluence.

In some cases the approved EA may have predicted a benchmark exceedence or biological effect within the near-field area, because it was not practically avoidable. Similarly, if the benchmark at the time of the EA was higher than the present day benchmark, exceedence of the latter may have been effectively approved. In such cases, if observed environmental conditions are within the predicted range, the changes may be considered acceptable, but should still be minimized [3].

Management actions on reaching the Moderate Action Level are based on the response options identified earlier as part of the Low Level response. At this stage, for example, a mitigation option will be selected, detailed plans will be prepared for the specific mitigative action(s) that are

[3] in accordance with the Draft Water and Effluent Quality Management Policy (April 2010, joint policy of all the Land and Water Boards of the Mackenzie Valley)

selected, the plans will be reviewed by the WLWB, and then (if approved) they will be implemented.

The MRP will be updated at this stage to document the mitigation plan. The plans will be quantitative in nature. The selected mitigative action(s) will be justified, which may include cost-benefit analysis. The mitigation plan will include current loadings of contaminants to the receiving environment, the reductions in loadings that are anticipated as a result of the mitigative action(s), a projection of environmental response, and monitoring plans to track that response. The plan will be submitted to the WLWB for review and approval prior to implementation. Mitigation should be implemented at this stage to stabilize the trend.

The environmental response will be reported annually to the WLWB and the effectiveness of the mitigation will be judged based on concordance of predicted and observed responses. At any time, if the mitigation appears to be ineffective, the WLWB may request additional mitigative actions.

It should be noted that if trends change following the initial development of action levels in the Response Framework and MRP, the expected time to reach a High Action level will also change. Thus, it may be appropriate to revise Moderate Action levels, if they have not been reached, based on recently observed changes in the temporal trend. Any changes in future action levels should be noted within each MRP update.

Consideration of Trends in Setting the Moderate Action level:

The Moderate Action Level is defined in part on the basis of a trend in an environmental parameter, and the expected time to reach a High Action Level or benchmark. Regression methods are well suited to extrapolation of a trend, to estimate whether parameter values are expected to reach an action level or benchmark at some defined future time. Such extrapolation assumes that processes presently responsible for the trend will continue into the future without intervention. Appendix 3 provides further advice on describing a trend and comparing a present or predicted value to an action level or benchmark. The actions defined in the MRP will vary depending on the trend in the environmental change – stronger management actions over a shorter time frame are required for trends that are likely to reach a significance threshold sooner. As such, the trend is as important as the absolute value of the measurement in determining management responses.

3.2.3 High Action Level and Response

A High Action Level is activated when benchmark exceedences or biological effects are measured outside the range of EA prediction and/or are trending toward the significance threshold. It should be noted that reaching the significance threshold is a circumstance that the WLWB believes should not be reached, and the adoption of the framework is a means to ensure that this is the case. Actions are required at this stage to reverse the measured trends and improve environmental conditions.

Management responses on meeting the High Action level will include development of new mitigative actions, with less regard to cost and the highest regard to correcting the situation. Actions at this time may include not only mitigative actions, but also some form of environmental remediation or restoration. The MRP will be updated at this stage to document the revised mitigation plan. The revised plan will include updated information on contaminant loadings and anticipated reductions, revised projections of environmental response, and monitoring plans to track that response. The plan will be submitted to the WLWB for review and approval prior to implementation. Directives may be issued by the WLWB to ensure prompt corrective action.

3.3 Benchmark concentrations and Biological Effects

Benchmark concentrations and biological effects have been referred to (Section 3.2) in setting action levels which are below the significance threshold. Benchmarks of contaminant concentration are levels above which biological effects could potentially be manifested in sensitive organisms. The CCME water quality guidelines are intended to represent this level in most Canadian surface waters. However, lower levels may be appropriate in sensitive environments if supported by evidence that CCME guideline levels are not protective in these environments, or if non-degradation is the intended policy for water quality management. Similarly, in some environments higher levels may be protective based on site-specific considerations. Some chemical parameters of interest may not have CCME guidelines. In these cases, benchmarks from other jurisdictions may be utilized, or appropriate benchmarks may be developed based on original toxicity literature. The CCME protocols for guideline derivation may be followed in developing new benchmark values.

A measured biological effect will be based on measurement endpoints as defined in the AEMP. These are usually endpoints relevant to population or community success. For example, fish growth or reproductive parameters are considered population relevant. Invertebrate community indices such as organism density and diversity are also relevant. Biological endpoints could also consider contaminant body burdens, to protect both the receptor organisms and the food web.

These biological endpoints tend to vary among fish species, invertebrate community types, ecoregions and habitats, and typically do not have generic guideline values. However, benchmarks may be defined in terms of degree of change from a suitable reference area value. For example, for benthic community evaluation, a benchmark equal to the reference area mean plus two reference area standard deviations (SD) has been used (Lowell, 1997; EC, 2002). For fish health parameters, a benchmark equal to a fixed percentage change from the reference area mean has been used (EC, 2002). The reference condition could be taken from baseline data for the monitored location, or from other locations of similar habitat type. The choice of reference areas is critical and must be justified.

A Special Case:
It should be noted that a biological benchmark defined at a baseline plus two standard deviations level is essentially at the upper limit of background. Therefore, in that case, the High Action Level (defined above as exceedence of a benchmark) might equal a Low Action Level (defined as a trend away from background) and require the strongest possible response on departure from background. If biological changes from background were predicted in the EA, it may be appropriate to set Moderate and High Action Levels for biological parameters above the upper limit of baseline. However, a biological departure from baseline is an indication that some contaminant or other stressor has exceeded its benchmark value.

3.4 Schedule for Response Planning

Monitoring results will be compared to action levels annually and reported in the AEMP Annual Report. If any of the action levels are reached, a Monitoring Response Plan will have to be prepared and submitted with the next AEMP Annual Report. The timing of subsequent updates to the MRP after reaching an action level should consider the severity of that action level. For example, if the rate of change of a parameter is known to be relatively rapid, it may be prudent to update the MRP more frequently than once a year. Situations like these will be considered on a case-by-case basis, based on the information available, and the Board will direct the process as necessary.

If a Moderate or High Action Level has been reached, the proponent should notify the Board as soon as possible after the monitoring result is obtained.

4 Developing the Response Framework

The following section is intended to provide guidance on the content for a facility-specific Response Framework consistent with the concepts introduced above, and is organized according to the expected layout. The Response Framework will be required by the WLWB early in facility life. It provides the basis for development and updating of a specific Management Response Plan (MRP) that will document the adaptive planning, implementation and evaluation of mitigative actions. To further help clarify how an MRP may evolve, a case study for a hypothetical mining project is provided in Appendix 4.

4.1 Statement of Objectives

A clear statement of the objectives of the Project's Response Framework must be provided. The Framework objectives should include:

- to define the process for early identification of project-related environmental effects and action levels,
- to define in general terms the types of mitigative actions that will be planned and implemented when (if) monitored environmental parameters reach these levels, and
- to define the process for reviewing and updating of these response plans.

4.2 Environmental Interactions and Predictions of Change

In the same manner that project-environment interactions are identified in the EA process, project-environment interactions will be documented for the purposes of the MRP, with a focus on operational effects. Plausible interactions might be direct (e.g., emissions resulting in direct exposure of a Valued Ecosystem Component [VEC] to a Contaminant of Potential Concern [COPC]) or indirect (e.g., emissions resulting in physical habitat changes). Where interactions are identified that correspond to project sources of chemical contaminants (e.g., discharge locations), the sources should be identified (noted and referenced with appropriate mapping) and characterized in terms of present day chemical loading rates.

This section of the Response Framework is meant to identify environmental parameters of concern (chemical or biological) that have changed or are likely to change as a result of project operations. Its completion will be facilitated by review of information from the project EA and/or data from routine monitoring, as well as any other relevant sources (e.g., special studies, primary or "grey" literature). It is expected that any parameters of concern will be subject to monitoring as part of the AEMP and that these same parameters will be subject to evaluation in relation to defined action levels.

This section must also include the specific predictions made in the EA process and the definition of what constitutes a significant adverse effect of the project. Significance thresholds should be defined in this section for each parameter and/or VEC that was identified in the EA or regulatory process as having the potential to be affected by the project.

4.3 Overview of Existing Environmental Monitoring Programs

As part of the Response Framework the proponent will summarize its AEMP and any other relevant environmental monitoring, with special attention paid to those environmental parameters that have been identified as parameters of potential concern. The description does not need to be exhaustive in nature (a summary table would be appropriate) but should include an indication of what is being monitored (i.e., chemical or biological measures), where samples are collected (i.e., monitoring locations) and when sampling is conducted (i.e., sampling frequency). The level of detail provided should, at a minimum, be sufficient to provide an overview indication of the data that are available to assess environmental change. Monitoring locations should be characterized based on relative exposure to project-related sources (i.e., reference, near-field, mid-field, far-field areas) consistent with the use of these terms in defining action levels (see Section 3.2).

4.4 Assessment of Environmental Change

The specific methodology that the proponent will use (or has used) to assess change in each monitored environmental parameter will be described. This will typically include methods used to define the current trend in each parameter (and to project the likely future trend), as well as methods for assessing the expected time needed for the parameter to reach an action level or benchmark based on current trends. The description should be sufficient to permit independent replication of the assessment. In the instance where the methods utilized are described in detail elsewhere (e.g., primary or “grey” literature) a brief description of the methodology and proper reference to the document(s) is sufficient for the purposes of the Response Framework.

Benchmark levels used in assessment of environmental change should be consistent with guidance provided in Section 3.3 of this document. Guidance on assessing a trend, and comparing present or future values to an action level or benchmark is provided in Appendix 3.

4.5 Environmental Action Levels and Management Responses

Proponents will define site-specific action levels for each environmental parameter (chemical and/or biological) that has been determined to be of concern or of potential concern through the screening process described in Section 4.2. It is expected that the action levels will be consistent with those described conceptually in Section 3.2 of this document. Spatial terms such as “near-field” will be given geographically explicit definitions. Environmental parameters with similar action levels may be grouped together for convenience where the same action level descriptions are applicable to the parameters within the group. This may be the case, for example, if multiple parameters share the same percent change action level.

As discussed in Section 3.2, the Response Framework foresees three action levels (Low, Moderate and High), however it is not necessary to set all three action levels in the first Response Framework document submitted. At a minimum, the Response Framework does require a numeric Low Action Level for each indicator, and a conceptual approach to setting Moderate and High Action Levels. If a specific Low Action Level is met, the Monitoring Response Plan (MRP) is triggered as a response. Moderate and High Action Levels can then be set numerically as part of the MRP, in response to the Low Action level being reached.

Proponents will define generic management responses for each instance where an action level is reached in the environment. It is expected that the management actions will be commensurate with the action level that has been reached as described conceptually in Section 3.2 of this document. As with action levels, parameters with similar management responses may be grouped together for convenience where the same responses are applicable to the parameters within the group. This may be the case, for example, if multiple parameters will be addressed by the same mitigative action(s).

Please note that in the Response Framework, management responses may be described in general terms. For example, at a Low Action Level, the response may be to identify promising mitigative actions. When this action level is reached, the mitigative actions to be investigated will be described in more detail in the Monitoring Response Plan (see Section 4.6).

4.6 Monitoring Response Plan

This section of the Response Framework will include a commitment to develop the MRP, and a description of the scope of the MRP and range of mitigation; however, the details will not be developed by the proponent until a Low Action Level is reached. The MRP will be the record of mitigative actions considered, selected for implementation, and evaluated as to success in curtailing environmental degradation. It will be a living document, subject to updates as new parameters reach pre-defined action levels (see Section 3.2 and 3.4 of this document). It is expected that the MRP will be organized by environmental parameter, so that each parameter reaching an action level can be associated with mitigative options to be considered (at the Low Action Level), or selected for implementation (at the Moderate or High Action Level). The selected abatement actions will be described in detail and reasons for their selection will be given.

The selected actions will be expected to reduce chemical loadings to the environment, and exposure concentrations in the environment, as described in Section 3.2. The proponent will make quantitative predictions (to the extent possible) about the degree of reduction expected, and will describe monitoring plans to track the environmental response. This will aid in the overall evaluation (by the proponent, the WLWB, and stakeholders) of the abatement options prior to implementation, and of their success following implementation.

When biological parameters reach action levels, the response plan will likely (and appropriately) refer to sections of the MRP associated with the chemical parameters that are suspected as causal agents. Abatement actions for these chemical parameters will be expected to reduce the biological effect and again some quantitative estimate of the anticipated reduction should be provided.

In many cases, the monitoring needed to track environmental response following mitigation will already be in place as part of routine monitoring programs. As such, the monitoring that is in place to track the reduced chemical exposures or biological effects may be noted by reference to the AEMP or other environmental monitoring programs. In some cases it may not be possible to adequately assess the success of abatement actions through routine AEMP monitoring, and in these cases additional special studies will be needed. The details of these special studies will be included in the MRP.

4.7 Review and Update of the Monitoring Response Plan

The MRP will require regular review and updating. In the Response Framework, the proponent will describe the process and timelines for reviewing and updating the MRP, consistent with Sections 3.2 and 3.4 of this guideline. This will ensure a common understanding of the process and timelines and will facilitate effective WLWB and stakeholder participation in the review process.

5 References

(for general references to Adaptive Management, please see Appendix 2)

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Appendix 1 – Adaptive Management Discussion

1.0 Introduction

The following brief discussion of adaptive management is included to inform parties that the Land and Water Boards have thoroughly investigated and considered the concepts of adaptive management, as appropriate, in their creation of this response framework guideline. Many of the philosophies and principles of adaptive management have been incorporated into the response framework.

2.0 Definition of Adaptive Management

The utilization of the "scientific method" as a management tool dates to the late 1800s, culminating with the publishing of *The Principles of Scientific Management* by Frederick Taylor in 1911 (Taylor, 1911). Taylor was one of, if not the first author to formalize the concept that efficiencies could be gained (in his case for the steel industry) by systematic observation and experimentation. In its most basic form adaptive management, as envisioned by Taylor, involves learning from experience and modifying subsequent behaviour in light of that experience. This basic adaptive management cycle is shown below in Figure 1.1.

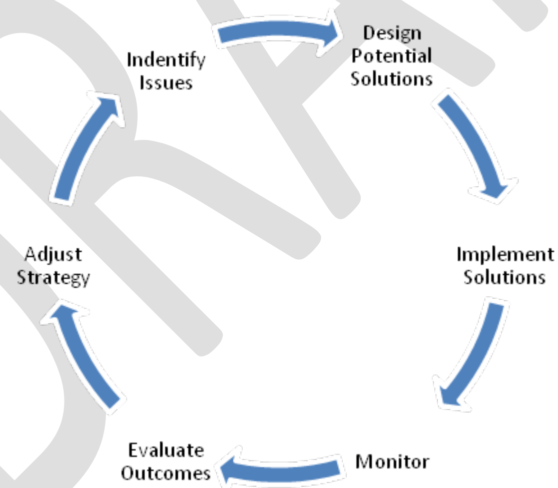

Figure 1.1: Diagram of the Adaptive Management Cycle.

The specific idea of adaptive management as a strategy for natural resource management can be traced to the work of Holling (1978), Walters (1986) and, later, Lee (1993) and has since been applied in a wide range of circumstances throughout North America and elsewhere including forest management, watershed management, fisheries resources management and others (see Bouris, 1998). A selection of examples of resource and ecosystem management contexts to which adaptive management has been applied is shown in Table 1.1.

Table 1.1: Examples of Adaptive Management Application in Various Environmental Contexts.

Area of Application	Reference
Impacts of acid rain	Andrews *et al.,* 1981
Total watershed management	CALFED, 1996
Forest management	Shindler *et al.*, 1996; BC Forest Service, 1996; ONF, 1996; CEQ, 1996
Grassland management	Allen, 1997(a); Allen, 1997(b)
Fisheries	Halbert, 1993; Hilborn and Walters, 1992
Water management	Gilmour and Geering, 1991; Walters *et al.*, 1992
Hydropower and dam flow	Wieringa and Morton 1996 Collier *et al.*, 1997

Various definitions of adaptive management have been put forward by resource managers (see examples in Table 1.2). In a recent review prepared for Fisheries and Oceans Canada (Yellowknife), ESSA (2008) suggests that most definitions of adaptive management that are used in the natural resource management context have four common themes, which include: learning in order to reduce management uncertainties; using what is learned to change policy and practice; a focus on improving management; and it is formal, structured and systematic.

Table 1.2: Sample Definitions of Adaptive Management in the Natural Resource Management Sector (adapted in part from ESSA, 2008 and Marmorek *et al.*, 2006).

Definition	Source
"Adaptive management is an approach to natural resource policy that embodies a simple imperative: policies are experiments; learn from them. In order to live we use resources of the world, but we do not understand nature well enough to know how to live harmoniously within environmental limits. Adaptive management takes that uncertainty seriously, treating human interventions in natural systems as experimental probes. Its practitioners take special care with information. First they are explicit about what they expect, so that they can design methods and apparatus to make measurements. Second, they collect and analyse information so that expectations can be compared with actuality. Finally, they transform comparison into learning – they correct errors, improve their imperfect understanding, and change action and plans".	Lee, 1993
"Adaptive management [is a decision process that] promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a 'trial and error' process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social,	National Research Council (NRC), 2004

and economic goals, increases scientific knowledge, and reduces tensions among stakeholders."	
"Adaptive management is a formal process for continually improving management policies and practices by learning from their outcomes."	Taylor *et al.*, 1997
"Adaptive management is a structured method for "learning by doing" that includes establishing clear goals, defining practices to achieve those goals, implementing the practices, monitoring the outcome of the practices, assessing how those practices are succeeding relative to the goals, and adjusting management in response to the assessments. It is designed to address questions such as: Where do we want to go? How do we get there? How do we know if we're there? If we're not there, how do we change to improve?"	Kremsater *et al.*, 2002.
"Adaptive management is "learning by doing" with the addition of an explicit, deliberate and formal dimension to framing questions and problems, undertaking experimentation and testing, critically processing results, and reassessing the policy context that originally triggered investigation in light of the newly acquired knowledge. The concept of learning is central to AM. It is a process to accelerate and enhance learning based on the results of policy implementation that mimics the scientific method: experimentation is the core of adaptive management, involving hypotheses, controls and replication. It is also irreducibly socio-political in nature".	Stankey *et al.*, 2005
"A type of natural resource management in which decisions are made as part of an ongoing science-based process. Adaptive management involves testing, monitoring, and evaluating applied strategies, and incorporating new knowledge into management approaches that are based on scientific findings and the needs of society. Results are used to modify management policy, strategies, and practices."	The Government of the United States, 2000
"Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. Its most effective form "active" adaptive management employs management programs that are designed to experimentally compare selected policies or practices, by evaluating alternative hypotheses about the system being managed."	Nyberg, 1998
"The adaptive decision-making process (ADMP) is a problem-focused, action-oriented participatory process aimed at producing use and management strategies that stakeholders agree with and feel like they "own." This process recognizes multiple stakeholders who have different values and knowledge systems and use multiple paradigms. It acknowledges the need for a dialectic decision-making process supported by rigorous single- and multidisciplinary research. Consequently, there are three themes inherent in the ADMP: (1) participatory action research, (2) the use of a user-friendly decision support system (DSS), and (3) dialectic, stakeholder-based decision making underpinned by analytical rigor."	Lal *et al.*, 2001

A bibliography of reference material regarding adaptive management, especially as it pertains to resource-based sectors, is provided in Appendix 2.

Appendix 2 – Adaptive Management Discussion References

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Appendix 3 – Statistical Considerations & Hypothesis Testing

Introduction

Two general questions are relevant to assessment of environmental change for purposes of this framework:

1. Are we seeing a trend through time in a given parameter in a given area (that is not also seen in reference areas)?
2. For a parameter showing a trend, have its values reached the defined action level (or will they do so soon)?

Statistical approaches to each of these questions are presented in the following sections, as general guidance. Readers are encouraged to consult statistical texts for detailed description of techniques, as well as the manuals for statistical software packages that are used.

Techniques may be found in standard statistical texts (Steel and Torrie, 1980; Sokal and Rolf, 1981; Gilbert, 1987; Snedecor and Cochran, 1989; Zar, 1998; Neter et al., 1999; Kutner et al., 2004; Gotelli and Ellison, 2004) and may be implemented using a number of statistical software packages (eg. SPSS, SAS, Systat, Statistica).

Detection of Trend

Regression methods are well suited to trend analysis because the independent variable (X) has time units, and expected values of the dependent variable (Y) (the environmental parameter) can be estimated for any time (X), either at present or in the near future.
Linear or non-linear models may be fit to the data. Inspection of time series plots will usually suggest appropriate candidate models, and those providing the best fit to the data (highest R^2) are generally preferred.

A second order polynomial model often provides a good fit to data with a monotonic trend, and may be written as follows:

$$Y = b_o + b_1X + b_2X^2$$

Hypothesis about trend pertain to the slope parameters of the model (b_1 and b_2). If these are statistically indistinguishable from zero, there is no time trend. Conversely, if b_1 or b_2 is distinguishable from zero, there is a time trend. The null hypothesis and alternate hypothesis are:

$$H_o = b_1 = b_2 = 0$$

$$H_a = b_1 \neq 0 \text{ or } b_2 \neq 0$$

Testing for trend in an area of the *receiving environment* (an exposure area) does not address the possibility that the same trend is occurring throughout the region due to factors other than the facility discharge. Thus, it is useful to test for a trend of the same form in one or more reference areas.

Analysis of Covariance (ANCOVA) provides a test of the hypothesis that corresponding slope parameters are the same across areas. If they are not, but there are several reference areas, we must be sure that it is the exposure area that exhibits the unique trend, not one of the reference areas. A separate comparison of trends among reference areas may be used to resolve this issue. If reference areas exhibit time trends that differ from each other, then there is uncertainty about what may be causing observed trends. On the other hand, if the exposure area exhibits a unique trend, it is likely related to the discharge. For corroboration, it may be possible to check other exposure areas closer to the discharge to see if they exhibit similar time trends. This is expected when an upstream source is driving the trend.

Consideration of mechanisms is also important in attributing an observed trend to a particular discharge. For example, an observed trend in a chemical parameter that is not released at the discharge may point to an alternate source. Professional judgement may be used in deciding whether trends are plausibly source-related and therefore relevant as triggers for abatement action.

Analysis of Variance (ANOVA) has been used to address the question of time trend across several areas. This approach underlies the Before/After – Control/Impact (BACI) study design (Green, 1979). In this approach, a time factor with different levels (time periods) represents the temporal dimension. If the time periods are short and of equal length (eg. yearly), and if time trends are first order (linear) the results may be similar to those of ANCOVA. However, regression methods are better suited to forecasting a value of Y at time X, and are preferable when there is a reasonably continuous time series of data.

Seasonality may be important in environmental measurements. If it is considered important, measurements may be made in a number of seasons throughout each year. If the environmental parameter changes on a seasonal cycle, there will be a seasonal component to variability in the data. For the purpose of detecting longer term (year to year) trends, statistical designs should specifically account for seasonal effects so that they do not obscure the longer term trend.

Parametric approaches to regression and ANCOVA make certain assumptions about the data. Specifically, the residuals from the regression model are assumed to be normally distributed and serially independent. Assumptions should be checked by inspection of residual plots and should be approximately satisfied. If assumptions are clearly violated, data transformations may be explored as a means of satisfying assumptions, or non-parametric methods may be considered.

Non-parametric regression methods are readily available, but are less powerful than parametric methods. Non-parametric ANCOVA procedures are not readily available. However, non-parametric regression models for different areas may be compared by considering their slope parameters and confidence intervals, or by visual inspection of the regression lines and data points. Gilbert (1987) describes a chi-square test for similarity of trends among stations, based on the non-parametric Mann-Kendall trend statistic.

Comparison to Action Levels or Benchmarks

An environmental parameter (Y) measured in a given area at a particular time (eg. a given downstream lake and year) may be compared to an appropriate action level or benchmark value by calculating a confidence interval (CI) on the parameter mean ($\overline{Y}$). The confidence interval on the mean may be calculated as follows:

$$CI = \overline{Y} \pm t_{\alpha/2,n-1} S_{\bar{y}}$$

where: $t_{\alpha/2,n-1}$ = Student's t (two-tailed) for a type I error rate of α and n - 1 degrees of freedom

$S_{\bar{y}}$ = standard deviation of $\overline{Y}$ = $S_y / \sqrt{n}$

S_y = standard deviation of Y

n = number of samples for the area and time of interest

For a parameter that has been increasing toward the benchmark, the benchmark will be considered to be reached when the CI includes the benchmark or exceeds the benchmark. For a parameter that has been decreasing toward the benchmark, the benchmark will be considered to be reached when the CI includes the benchmark of falls entirely below the benchmark.

The residuals are assumed to be normally distributed around the mean, for the area and time of interest. If this assumption is clearly violated, data transformations may be used to normalize the data, or less powerful non-parametric methods may be considered.

Samples sizes for a particular area and time are often small, which makes for a wide CI. If a regression (trend) model has been fit to the data, it is preferable to calculate the CI from this model, which makes use of the entire time series. Based on this model, the CI for the predicted Ŷ at a particular time X may be calculated as follows:

$$CI = \hat{Y} \pm t_{\alpha/2,n-k-1} S_{\hat{y}}$$

where: $t_{\alpha/2,n-k-1}$ = Student's t (two-tailed) for a type I error rate of α and n - k-1 degrees of freedom

$S_{\hat{y}}$ = standard deviation of $\hat{Y}$

For a second order polynomial, with two slope parameters, k=2 and $S_{\hat{y}}$ is computed as:

$$S_{\hat{y}} = S_y \text{ sqrt } (1/n + c_{11}\, x_1^2 + c_{22}\, x_2^2 + 2\, c_{12}\, x_1 x_2)$$

The x_1 and x_2 values are the deviations of X and X^2 from their mean values, and the c_{ij} elements are taken from the inverse of the matrix of sums of squares and cross-products for these two predictor variables.

The comparison of the CI to a benchmark (B), as described above, is equivalent to a one-tailed test of hypothesis about $\overline{Y}$ relative to B, or about $\hat{Y}$ relative to B. This test may be performed as a t-test. For example,

$$t = (\overline{Y} - B) / S_{\bar{y}}$$

may be compared to the critical value of t_α with n-1 degrees of freedom. For a parameter that has been increasing toward the benchmark, the null hypothesis and alternate hypothesis are:

H_o: $\mu_y < B$

H_a: $\mu_y \geq B$

The one-tailed test of hypothesis for $\hat{Y}$ takes the same form except that t_α has n-k-1 degrees of freedom.

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Appendix 4 – Hypothetical Case Study

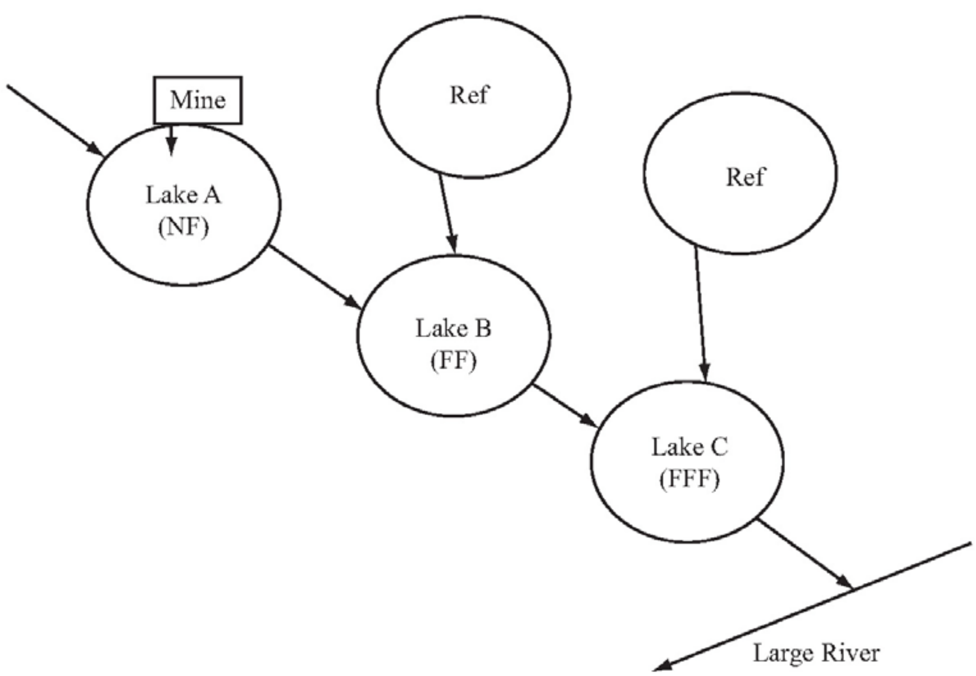
This hypothetical case study has been developed to aid in the understanding of the concepts presented in the Guidelines. The format and content of the case study below are not intended to match that described in Section 4; instead the elements of the Response Framework are presented in summary only.

The case study concerns a hypothetical diamond mine operated by Company X that has a throughput capacity of 10,000 tonnes of ore per day. Fine rejects are contained within a dammed waste management area. Water collected in the waste management area, including process water, water derived through the site run-off collection system and water produced through the de-watering of active mining areas, is discharged as effluent to the environment via an offshore diffuser at the upstream end of Lake A at an annual rate of about 2 M m^3. The case study is simplified in terms of the number of parameters of concern for which action levels are defined.

Environmental Effects Monitoring at the Mine

The mine's aquatic receiving environment comprises a series of moderately-sized lakes and streams, which together make up about 40% of the watershed area of the Large River (Figure 1). An Aquatic Environment Monitoring Program (AEMP) has been established on site and includes sampling in areas downstream of the mine discharge ("exposure areas"), as well as sampling in neighbouring sub-watersheds that are of comparable size and are within the same geological setting ("reference areas").

Figure 1: Schematic representation of the aquatic receiving environment at the Company X Diamond Mine.



The AEMP consists of:

- Water quality monitoring – suspended solids, metals, major ions, anions and nutrients are measured monthly in all exposure and reference lakes on a year-round basis and in streams during the ice free season;
- Sediment quality monitoring - metals, grain size, total organic carbon, nitrogen, and phosphorus are measured on a triennial basis in all exposure and reference lakes via coring and grab sampling.
- Benthic invertebrates – benthic invertebrate samples are collected on a triennial basis in all exposure and reference lakes and streams, to indicate the quality of the benthic community as fish habitat. Community health metrics are calculated, including organism density and diversity, and relative density of indicator species; and
- Fish – fish tissue samples (liver, fillet) are collected from a sport fish species (that is consumed by local communities) and a small forage fish species (that is known to have a relatively small home range) at exposure and reference area locations on a triennial basis. The tissues are analyzed for chemicals that could bioaccumulate in fish and affect their suitability for consumption by people or wildlife.

Baseline data exist for Lakes A, B and C, and the two reference lakes. These data provide a lake-specific baseline condition. The two reference lakes are considered to be generally comparable to the three exposure lakes in terms of geological influence and habitat conditions. The main purpose of monitoring the reference lakes is so that a trend observed in an exposure lake can be clearly attributed either to a mine influence or to some other regional influence that may be affecting all lakes. The reference lakes also provide an alternate background condition for any newly identified contaminants of concern that were not monitored in the baseline studies.

Predicted Impacts of the Mine

The significance threshold was defined in the Environmental Assessment (EA) to encompass any measurable change from reference in the quality of the benthic community in a lake, or any contamination of fish in a lake that could affect their suitability for consumption by people or wildlife.

The mine EA predicted no effects on sediment quality, benthic invertebrate communities and fish populations as a result of contaminant releases via mine effluent .

Water quality was predicted to be influenced in the near-field area (Lake A) to the extent that concentrations of Substance Y would increase from baseline levels (where the upper baseline limit is equal to 1.5 ug/L) to 4 ug/L within 5 years of the commencement of mine operations (waste management area discharge) and thereafter level off. The water quality objective (WQO) is 10 ug/L, and is intended to be protective of aquatic life.

While sediment quality was not predicted to change, the EA noted the possibility that Substance Z in sediments could be mobilized if sediment organic content in the near-field (Lake A) was increased as a result of nutrient loadings. This substance has the potential to accumulate in fish tissues and, if levels exceed consumption guidelines, to affect the suitability of fish for consumption. The advisory level for human consumption of Substance Z in fish is 0.5 ug/g fresh weight.

Action Levels Defined in the Response Framework

Action levels were defined conceptually in a Response Framework so as to ensure that significance thresholds are not reached. The approach to action levels and responses, as defined in the framework, is outlined in Table 1.

Table 1: Action Levels and General Responses

Monitoring Parameter(s)	Action Level			General Response		
	Low	Moderate	High	Low	Moderate	High
Benthic Community Metrics	NF Outside Baseline Range[1]	Near Field Outside Baseline Range	Near Field Outside Baseline Range	Identify Abatement Options	Select and Implement Action(s) (Monitor)	Further Action(s) if Needed (Monitor)
Substance Concentrations in Water	Near Field > Baseline; trend to Moderate[2]	Near Field trend to High (3yrs away)	Near Field > Water Quality Objective	Identify Abatement Options	Select and Implement Action(s) (Monitor)	Further Action(s) to Rectify (Monitor)
Substance Concentrations in Fish Tissue	Near Field > Baseline; trend to Moderate[2]	Near Field trend to High (3yrs away)	Near Field > Fish Tissue Guideline	Identify Abatement Options	Select and Implement Action(s) (Monitor)	Further Action(s) to Rectify (Monitor)
Substance Concentrations in Sediment	Near Field > Baseline; trend to Moderate[2]	Near Field trend to High (3yrs away)	Near Field > Sediment Quality Objective	Identify Abatement Options	Select and Implement Action(s) (Monitor)	Further Action(s) to Rectify (Monitor)

[1] Similar change not seen in reference lakes

[2] Trend outside the range of EA prediction, and not seen in reference lakes

According to the framework, the lake mean value for a monitored parameter will be compared to the action level. A mean that exceeds the action level will be considered to have exceeded that level. A mean that is below the action level but not statistically distinguishable from that level will be considered to have reached the action level and will trigger the associated response.

The high action levels are known in advance of post-operational monitoring because benchmark values are known. However, the moderate action levels for concentration parameters can only be defined once a trend is observed in the post-operational monitoring data. Because the EA defined a significance threshold of any measurable change from reference in the quality of the benthic community, the low and moderate action levels for benthic community metrics are the same as the high action level. Therefore, in this case, the full range of actions will proceed as quickly as possible on meeting this condition. Identification of appropriate abatement actions for the benthic community will require identification of contaminants that are likely responsible.

Low action levels were numerically defined in the Response Framework, based on the baseline data (range of annual means (M) for each lake). The low action level is generally the upper end of baseline (Mean+2SD). For parameters such as benthic invertebrate diversity, where reduced values indicate impairment, the low action level is the lower end of baseline (Mean-2SD). These baseline ranges are shown in Table 2.

Table 2: Limits[1] of Baseline for Exposure Lakes

Monitoring Parameter(s)	Exposure Lake		
	Lake A	Lake B	Lake C
Benthic Invertebrate Density (per m^2) [2]	8190	7485	8643
Benthic Invertebrate Diversity [3]	0.72	0.64	0.68
Substance Y Concentration in Water (ug/L)	1.5	1.4	1.5
Substance Z Concentration in Sport Fish Fillets (ug/g fresh weight)	0.04	0.05	0.05
Substance Z Concentration in Sediment (ug/g dry weight)	0.1	0.09	0.11

[1] Upper limit of baseline unless otherwise indicated

[2] Upper limit for density computed on a log scale and back-transformed

[3] Lower limit of baseline for Shannon diversity index

Application of the Response Framework Over 15 Years

Benthic Community

The benthic community metrics have not shown any consistent trend over time, or any statistical departure from the baseline condition. This is consistent with EA predictions. Therefore, no actions have been triggered based on the benthic community monitoring.

Water Quality

Data corresponding to 15 years of monitoring water quality monitoring data for Substance Y at near-field, far-field and far-far-field exposure areas, and at reference areas, are shown in Figure 2 as average annual values over time. Figure 2 also shows the trend predictions for Substance Y that were made in the EA, and the water quality objective.

After the first year of post-operational monitoring it is clear that the concentration of Substance Y in the near-field is greater than the baseline concentration (above the upper limit of baseline annual means) and that the concentration is increasing more rapidly than predicted in the EA (i.e., $\text{Slope}_{\text{NF-actual}} >> \text{Slope}_{\text{NF-predicted}}$). Therefore, the low action level has been reached. Based on extrapolation of the trend, a concentration of 5 ug/L is defined as the moderate action level since it would be 3 years away from the benchmark of 10 ug/L. Based on exceeding the Low action level, and the continuing trend, Company X would be required to respond as follows:

- Review the existing AEMP (specifically with respect to Substance Y) to ensure that it is sufficient for the purpose of assessing the magnitude and spatial extent of changes in Substance Y in the environment, and revise/adjust the AEMP if necessary;
- Investigate why there was a discrepancy between the EA prediction and the actual monitoring results, and revise the long-term prediction;
- Investigate mitigation strategies that could be used to slow and/or eliminate the increasing trend in concentration of Substance Y;
- Submit a Monitoring Response Plan (MRP) to the WLWB with the AEMP Annual Report outlining the numeric action levels for Substance Y (low, moderate, high), the current level, the investigation and planning activities that have been initiated, the results that have been obtained, and the promising mitigation/abatement options identified, as well as the ecological implications if the trend were to continue and exceed the benchmark concentration.

By the end of Year 3 (post-operation) the rate of change in concentration of Substance Y has not changed appreciably. Substance Y is now at concentrations which exceed the EA prediction, and are expected to reach the WQO for Substance Y within 2 more years (ie. by end of Year 5 post-operation). According to the MRP, the monitoring data for Years 1 to 3 would result in the activation of the moderate level trigger. As a result Company X would be required to respond as follows:

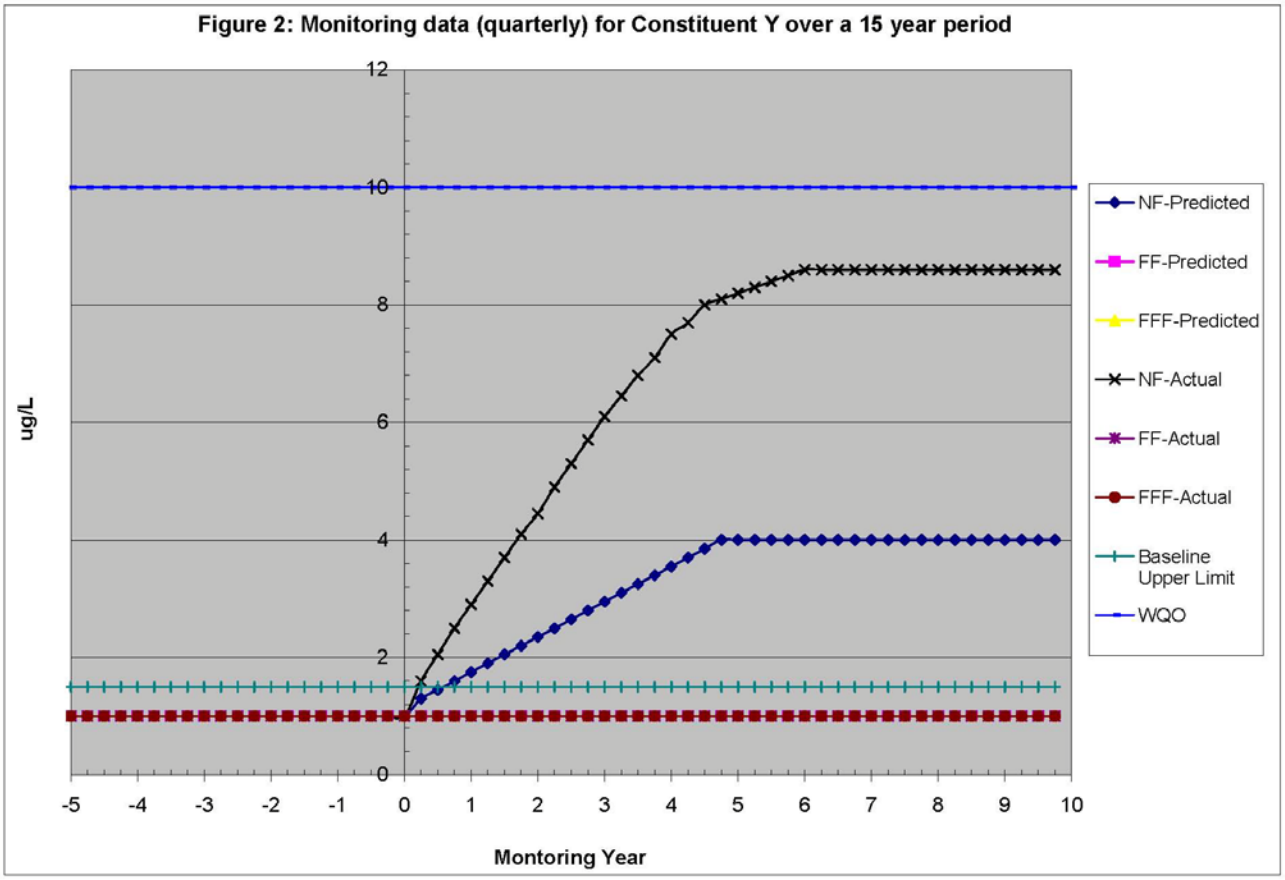
- Decide on a mitigation option;
- Submit to the WLWB an updated MRP, providing scientific justification as to why the mitigation option selected will be effective (i.e., quantitative predictions of the loading reduction and the expected environmental response), and indicating how monitoring will be undertaken to track the response;

- Complete the detailed design and implement the mitigation option that has been selected, subject to WLWB approval; and
- Report to the WLWB annually on the effectiveness of the mitigation based on the monitored environmental response

Mitigation actions triggered by the moderate action level are fully implemented by the end of Year 4 post-operation. Predictions based on the detailed design indicate that concentrations of Substance Y would level off in the range of 8 ug/L by Year 6. By the middle of Year 4 it becomes apparent that the rate of change of Substance Y has slowed considerably but concentrations are still increasing. Based on the rate of change seen in Year 4 and the first part of Year 5, it is suspected that the near-field concentrations may not level off at 8 ug/L as planned, and might reach the WQO concentration. As a result the WLWB requests that Company X consider additional mitigation technologies that would have to be implemented by the end of Year 8 if concentrations are still increasing. This action plan is to be in place not later than the middle of Year 6 (i.e., within 1 year of finding that the mitigation has been less effective than expected).

Company X develops a plan (including rationale, detailed design and schedule) for implementation of additional mitigation technology/activity. Based on the additional mitigation, assuming implementation in Year 8, it is predicted that Constituent Y will level off at or below 9 ug/L by the end of Year 10. The plan is accepted by the WLWB.

During Year 6 concentrations of Substance Y become stable at about 8.4 ug/L. No further change in Substance Y is seen through Year 7 monitoring. As a result the planned additional mitigation activity(s) are not triggered. The WLWB requests that Company X re-evaluate the long-term predictions for concentrations of Substance Y in the environment (i.e., assess the likelihood that future increases in Substance Y will occur) and continue to monitor to demonstrate that the WQO is not exceeded.



Fish Tissues

The concentrations of Substance Z in fish tissues have not shown any consistent trend over time, or any statistical departure from the baseline condition. This is consistent with EA predictions. Therefore, no actions have been triggered based on the fish tissue monitoring.

Sediment Quality

Substance Y is released with mine effluent but does not partition appreciably to sediments. Substance Z is not released with mine effluent in detectable concentrations; thus, its concentration in sediments is not expected to increase. However, it is of potential concern if mobilized as a result of increasing organic carbon and microbial activity in sediments. To date, neither Substance Y, Substance Z or total organic carbon in sediments have shown any consistent trend over time, or any statistical departure from the baseline condition. Therefore, no actions have been triggered based on sediment monitoring.