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WORKSHOP REPORT:

TOWARDS SELECTING BIOLOGICAL MONITORING INDICATORS UNDER THE AB-NWT BILATERAL WATER MANAGEMENT AGREEMENT

November 2018
(Final revisions by the governments of Alberta and the Northwest Territories)

Government of Northwest Territories

Alberta Government

Workshop Report:

Towards selecting biological monitoring indicators under the AB-NWT Bilateral Water Management Agreement

Prepared For:

Government of the Northwest Territories
Environment and Natural Resources
and
Government of Alberta
Environment and Parks

November 2018

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This workshop was designed and delivered by SLR Consulting (Canada) Ltd. and Sanammanga Solutions Inc., on behalf of the Government of the Northwest Territories – Water Resources Division, and the Government of Alberta – Transboundary Waters Secretariat. SLR and Sanammanga gratefully acknowledge the input and direction of the following: Annie Levasseur and Meghan Beveridge (Northwest Territories); Tim Toth, Caroline Bampfylde and Jacquie Browne (Alberta). We also acknowledge the support and feedback of Erin Kelly (Northwest Territories) throughout the duration of the workshop.

1.0 INTRODUCTION

In 1997, the *Mackenzie River Basin Transboundary Waters Master Agreement* was signed by Canada, British Columbia, Alberta (AB), Saskatchewan, Northwest Territories (NWT) and Yukon. The Agreement established common principles for the cooperative management of the water resources in the Mackenzie River Basin and made provisions for neighbouring jurisdictions to negotiate bilateral water management agreements. In 2015, the governments of Alberta and the Northwest Territories signed the *Alberta-Northwest Territories Bilateral Water Management Agreement* (BWMA).

As signatories to the BWMA, both governments are committed to improve understanding of transboundary watersheds including establishing strong metrics for transboundary water conditions in accordance with a Risk Informed Management approach. Through the BWMA, interim biological indicators and measurement methods were identified in Appendix G. These indicators are intended to track the conditions of the aquatic ecosystem and provide information to assess ecosystem health with respect to the cumulative effects of multiple substances, water withdrawals, habitat alteration and climate change, and to allow for appropriate management strategies (AB-NWT BWMA 2015)[1].

As part of a plan to fulfill the biological commitments in the BWMA and move towards the selection of final biological indicators, two workshops were organized. The first workshop was held in Edmonton, AB, on March 8, 2017 and was designed to learn about the development and use of biological indicators in existing management frameworks and to review and discuss the current BWMA interim biological indicators. Subsequently, the Government of Northwest Territories retained a consultant to conduct a literature review and prepare a synthesis and recommendations report identifying research and use of biological monitoring and biological indicators in the Hay and Slave river basins (SLR, 2017)[2].

Building on the results of the initial workshop and the synthesis and recommendations report, a second workshop was undertaken and involved representatives from both governments and external experts knowledgeable about biological monitoring of large river systems. This workshop was held in Edmonton, AB, on January 24 and 25, 2018. The overall objective of the workshop was to identify the most appropriate biological indicators for an initial biological monitoring program for two transboundary rivers, namely, the Hay and Slave rivers. Guidance was also sought about key considerations in overall biological monitoring program design. This report provides a summary of this second workshop.

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[1] Alberta-Northwest Territories Bilateral Water Management Agreement (2015). Available at http://www.enr.gov.nt.ca/sites/enr/files/ab-nwt_water_management_agreement_final_signed_2.pdf

[2] SLR (2017). Synthesis and Recommendations Report: Biological Monitoring and Biological Indicators in the Hay and Slave Rivers for the Alberta-Northwest Territories Bilateral Water Management Agreement. Prepared for Water Resources Division, Government of the Northwest Territories

2.0 WORKSHOP OBJECTIVES

The key objectives of the workshop were:

1. To gain insight from workshop participants on the characteristics of good indicators, how best to choose biological indicators and how biological monitoring should be undertaken.
2. To seek guidance from workshop participants on the design of a biological monitoring program applicable to transboundary waters.

3.0 PARTICIPANTS

Participants were invited to attend by the governments of Alberta and the NWT based on their involvement in the implementation of the BWMA, their expertise regarding biological monitoring and the use of traditional and local knowledge (TLK) in biological monitoring. The workshop was attended by 34 participants, including representatives from the following organizations:

- Government of Alberta
- Government of the Northwest Territories
- Government of British Columbia
- Government of Canada
- Northwest Territory Métis Nation
- University of Alberta
- University of Saskatchewan
- Wilfred Laurier University
- Mighty Peace Watershed Alliance

Individuals from Kátł'odeeche First Nations, Fisheries and Oceans Canada, Alberta Innovates, and University of New Brunswick were invited but were unable to attend.

The workshop was facilitated by staff from SLR Consulting (Canada) Ltd. and Sanammanga Solutions Inc.

Appendix A provides a complete list of attendees.

Photo 1: Workshop Participants (1)

Photo 2: Workshop Participants (2)

4.0 WORKSHOP AGENDA AND PROCESS

The workshop was organized as a two-day event. The agenda was modified slightly during the course of the workshop to facilitate more discussion about the design of a biological monitoring program (Appendix B).

Day 1 focused on context setting, accomplishments and learnings related to biological indicators since the signing of the BWMA, and on biological monitoring in the Mackenzie River Basin and elsewhere. This was accomplished through a series of presentations and plenary discussions. Day 1 concluded with a plenary exercise aimed at better understanding the

characteristics of good biological indicators in relation to the goals set out in Appendix G of the BWMA.

Day 2 focused on understanding the range of stressors affecting the ecological integrity of the Slave River and Hay River and monitoring program design for fish, invertebrates and aquatic mammals. This was accomplished through discussions in both small break-out groups and in plenary summary sessions. Day 2 culminated in conclusions on sampling design for fish and invertebrate programs.

5.0 PRESENTATIONS

Three "Context Setting" and five "Accomplishments and Learning" presentations were given to workshop participants. The following provide a summary of key messages and points of discussion.

5.1 Context Setting

5.1.1 The Alberta-Northwest Territories Bilateral Water Management Agreement

Presenter: Erin Kelly

This presentation outlined the main purpose and principles of the AB-NWT BWMA, its commitments with respect to the establishment of a biological monitoring program, and the interim indicators presented in Appendix G of the Agreement. The presentation also provided guidance for selecting biological indicators and monitoring methods. The importance of TLK in selecting biological indicators was highlighted.

The AB-NWT BWMA is an aquatic ecosystem agreement, where the aquatic ecosystem is considered in addition to surface and groundwater quality and quantity. Knowing that ecological integrity is best assessed using multiple indicators, four interim biological indicators were selected for the agreement: large-bodied fish, small-bodied fish, invertebrates, and aquatic mammals. The interim indicators and measurement methods were selected based on the availability of data/information and may not be the most appropriate for the BWMA.

Key messages and points of discussion included:

- There is a need to start the planning and design of a biological monitoring program and to commence the monitoring in a prudent and financially responsible manner. Program design will be imperfect at the start, but can and should evolve over time.
- The monitoring program should be specific to the features of each river. Monitoring needs may differ from one transboundary river to the next. For example, the Hay River is smaller than the Slave River and has potential for development much closer to the AB-NWT border than the Slave River.
- Environmental changes have been detected in transboundary rivers. Distinguishing effects due to upstream development and climate change is a challenge.
- The monitoring program must be capable of detecting changes and sources of effects and should assist in taking management actions as per the Risk Informed Management

Approach defined in the BWMA. There is a need to know what is causing the observed changes, whether there is a concern, and ability to address them.
- The biological indicators need to be cost effective and there needs to be similarities with other jurisdictions.
- The program should be both a scientific tool and a regulatory tool to meet the objectives of the BWMA.
- Risks need to be accounted for in the design. Risks include perceived risk by the communities.
- Indigenous people should be involved in the monitoring program design. Indigenous people are "the ears of the fish" but science is necessary to "crunch the numbers".

5.1.2 Learnings from the 2017 Workshop and Accomplishments to Date

Presenter: Caroline Bampfylde and Annie Levasseur

This presentation highlighted a number of accomplishments related to the selection of biological indicators since the signing of the BWMA. Learnings from the 2017 Alberta-NWT workshop, which focused on the use of biological indicators in existing management frameworks, were highlighted.

Key messages and points of discussion included:

- Since the signing of the BWMA, a number of activities were undertaken to inform the selection of biological indicators. Some of the activities include:
    - An annotated bibliography of relevant biological monitoring on the Slave and Hay rivers and a summary of previous biological indicators work undertaken in the Mackenzie River Basin.
    - Work related to contaminants and health measures in fish collected from the Athabasca and Slave Rivers from 2011-2015 (further analysis is underway).
    - Testing of a field program for sampling benthic macroinvertebrates on large rivers.
    - Work towards the identification of indicators for the Mackenzie River Basin Board (MRBB) State of the Aquatic Ecosystem Report (SOAER) 2018.
    - A workshop to better understand biological indicator-related activities in Alberta's lower Athabasca region and how they might relate to the Agreement.
    - A summary of available information for each of the interim biological indicators using historical and recent data to better understand the status of the interim biological indicators.

- The Biodiversity Management Framework (BMF) incorporates western science, indigenous knowledge and public input. Some of the characteristics of the BMF include:
    - Indicators primarily reflect land use (applies to both habitat and species indicators).
    - Indicators generally reflect an 'amount' rather than 'condition'.
    - BMF is very broad (100s of species; community-level monitoring).
    - Habitat is easier to monitor and is more relevant for land use.

- Lower Athabasca Surface Water Quantity Management Framework identified hydrological, ecological, and navigational indicators and triggers. Short-term ecological knowledge gaps included aquatic mammals, riparian areas, winter ecology, perched basins, and habitat connectivity.

5.1.3 Environmental Effects Monitoring: Choosing the Correct Indicators

Presenter: Kelly Munkittrick

This presentation provided background on the Environmental Effects Monitoring (EEM) programs developed for the mining and pulp and paper industries. The presentation highlighted learnings for the EEM programs with respect to the selection of indicators, how to detect change and the limitations of effects-based monitoring.

Key messages and points of discussion included:

- Fundamental to any effects monitoring program is the need to define / understand the target or desired outcome to which one is managing or to maintain the status quo. Also need to define what is unacceptable.
- Multi-stakeholder processes can help define what is "unacceptable".
- Ideal program is an integrated system with a balance of three types of indicators:
  1) stressor-based indicators
  2) values-based indicators that speak to what people care about
  3) effects-based indicators that integrate the response of organisms to accumulated stressors.
- Need to understand that every indicator has some level of compromise in terms of suitability.
- Indicators need to be ecologically relevant - statistical considerations revolve around variability, power and sensitivity.
- All effects are essentially cumulative effects.
- An EEM program should be tiered, with a spectrum of responses (i.e., from simple surveillance, confirmation of change, investigation of change, to investigations of solutions / options).
- The Joint Oil Sands Monitoring (JOSM) program was originally designed to focus on the drivers of variability - once you understand what drives variability you can transition to a more sensitive phase of performance-based monitoring.

5.2 Accomplishments and Learnings

5.2.1 Benthic Macroinvertebrate Monitoring Program

Presenter: Annie Levasseur

This presentation provided an overview of the benthic macroinvertebrate (BMI) monitoring program that took place in the Slave and Hay rivers in 2017 and described some of the challenges associated with sampling BMI in large rivers. The presentation defined the

advantages of using BMI as indicators for the BWMA and how they can help detect small changes in the ecosystem over time.

Key messages and points of discussion included:

- Benthic macroinvertebrates was selected as an interim biological indicator for the AB-NWT BWMA. Jennifer Lento (Canadian River Institute) helped initiate a pilot plan for monitoring benthic macroinvertebrates in large transboundary rivers. The objectives of the monitoring program were to test a kick sampling technique and collect baseline information. The benthic monitoring plan follows recent protocols developed for the JOSM program, which is based on the United State Environmental Protection Agency (US EPA) protocols for large rivers. It is a modified version of the nationally standardized Canadian Aquatic Biomonitoring Network (CABIN) protocol. Hester-Dendy samplers were also deployed for a one-month period. Hester-Dendy samplers are artificial substrate samplers that have been previously used by the Slave Watershed Environmental Effects Program (SWEEP) in 2013-2014.
- Lessons learned from the 2017 sampling program are that kick sampling is a suitable method for collecting BMI in the large transboundary rivers in areas where cobble and gravel can be found. Hester-Dendy samplers also seemed to have contained a diverse assemblage of BMI and would be a good option if sites cannot be sampled using a kick sampling method.
- Chironomids dominated the samples but there were also a substantial number of caddisflies, stoneflies and mayflies.
- Additional BMI samples were collected for contaminant analysis.
- It was noted that freshwater clams and mussels may be indicator species of interest to local communities.

5.2.2 Stream Invertebrate Community Sampling within the Alberta Oil Sands Region

Presenter: Nancy Glozier

This presentation provided an overview of the BMI monitoring program applied in the oil sands region. Key program design and sampling approaches were presented along with lessons learned and key recommendations.

Key messages and points of discussion included:

- The biomonitoring components of the JOSM program were designed to address ecosystem health and cumulative effects.
- Key recommendations for JOSM BMI monitoring design included using effects-based indicators and standardized sampling protocols.
- The JOSM program began routine biomonitoring of invertebrates on the Athabasca River using a large river approach, in addition to sampling tributaries focussing on clearly defined habitats.
- JOSM was focused on monitoring BMI because:

    - They are relatively sedentary, form the base of the food web for fish and water birds, show differential response to multiple stressors and integrate effects over months to years.
    - They are the most common group used for aquatic bio-assessments globally.
    - Biomonitoring of invertebrates provides a direct measure of change in biotic populations and assemblages in relation to benchmark or reference conditions, and can help identify ecological effects of cumulative stressors.
    - One can associate patterns of invertebrate biodiversity with water and sediment chemistry, and physical habitat measurements.
- JOSM used the CABIN protocols plus additional measures. The sampling is focused on erosional habitats (e.g., gravel/cobble and sand/gravel) within defined river reaches using kick sampling and net mesh size of 400 micrometers. A standardized suite of habitat and GIS measurements were taken (e.g., substrate, velocity, slope, canopy coverage, reach characteristics, etc.).
- Recommendations for overall study design included:
    - Establishing a set of core sites (both reference and test) to be measured annually so that status and trends can be measured reliably over a long time period. Sampling other sites can be on a rotational basis.
    - Increase sampling of reference area to improve ability to detect impacts (e.g., add reference sites between M0 and M2 to improve characterization of least disturbed environmental condition).
    - Improved knowledge of the natural interannual variability in benthic macroinvertebrate assemblage structure and biodiversity (or any other variable) is crucial for the ability to draw conclusions on effects.
    - Periodic adaptation of long-term monitoring network to incorporate new information (e.g., changes in natural conditions, stressor exposure, etc.).
- Recommendations for sampling design included:
    - Formalizing standard operating practices with sampling for the mainstem and tributaries focused on the cobble habitat and kick.
    - Improving understanding of contaminants source (development or natural).
    - Ensuring that sediment chemistry and Semi-Permeable Membrane Device collection is replicated as these appear to measure critical environmental variables.
- Improvements are being made regarding the direct integration of various monitoring components (e.g., water quality, benthos and fish).

5.2.3 The Slave Watershed Environmental Effects Program

Presenter: Tim Jardine

This presentation summarized the key considerations in selecting ecological indicators for the Slave Watershed Environmental Effects Program (SWEEP), highlighting the value of the concept / approach called “two-eyed seeing” and the roles played by local people, Elders, government researchers and academics.

Key messages and points of discussion included:

- The SWEEP program utilized the concept / approach called “two-eyed seeing”. This means “learning to see from one eye with the best in our Indigenous ways of knowing and from the other eye with the best of the Western (mainstream) ways of knowing…and learn to use both these eyes together for the benefit of all.”
- Best indicators are low cost, locally relevant, and provide results that are interpretable by community members. Good biological indicators should have moderate sensitivity and high local relevance.
- Indicator examples from the SWEEP program were:
    - Anomalies in fish
    - Mercury in fish
    - Abundance of furbearers.
- The SWEEP program was built on past work in the Slave River and driven by three key questions that were commonly asked by community members:
    - Is the water safe to drink?
    - Are the fish safe to eat?
    - Is the ecosystem healthy?
- Indicators are also organized as Type 1 indicators which are low cost to monitor; or Type 2 indicators which are higher cost to monitor.
- The Bayesian Belief Network can handle both qualitative and quantitative indicators and interests. It is a holistic model, but there was a certain discomfort putting TLK into a computer model; a framework was needed.

5.2.4 Traditional Knowledge and Indigenous Perspectives (1)

Presenters: Brenda Parlee and Tracy Howlett

This presentation outlined the role that traditional and local knowledge played in the MRBB State of the Aquatic Ecosystem Report (SOAER) indicators project, highlighting the value of the concept / approach called “two-eyed seeing”. The Tracking Change project was described, focusing on the manner in which biological indicators were linked to effects on livelihoods and wellbeing of communities. What makes biological indicators useful from an Indigenous perspective was discussed.

Key messages and points of discussion included:

- A SOAER Indicator Workshop took place in December 2014 bringing together Indigenous and western knowledge holders. A total of 14 recommendations were put forth from the workshop. Key recommendations out of 14 were:
    - 1: Traditional and local knowledge and western science should be ‘equal partners at the table’
    - 2: Consider traditional and local knowledge side-by-side from the start, through dialogue and working together
    - 5: Draw on and identify available information for inclusion
    - 11: Use culturally-appropriate ways of presenting information
    - 12: Identify and use indicators (signs and signals) that reflect Aboriginal values and culture.
- The 2014 workshop also focused on “two-eyed seeing” with Indigenous and scientific knowledge brought together to describe the state of the health in the Mackenzie River

Basin. It is important to clarify that traditional knowledge and western scientific knowledge should not be integrated but should be used in parallel.

- The "Tracking Change" project is a six-year collaborative community-based research project involving local and traditional knowledge and socio-economic changes in the Mackenzie, Lower Mekong and Lower Amazon river basins. The project focused on the community's role in watershed governance. The focus was on community capacity as much as it was on what to monitor. Indicators were selected to help answer four fundamental questions:
    - Can I find enough fish to meet my family's needs?
    - Can I eat the fish?
    - Can I find good water?
    - Can I drink the water?
- Overall, the program is aimed at determining management actions and policy changes that are needed to ensure sustainability of the basin.

5.2.5 Traditional Knowledge and Indigenous Perspectives (2)

Presenters: Heidi Klein and Tim Heron

This presentation provided the key findings from a review of documents regarding Traditional Knowledge and its application to biological monitoring in the Hay and Slave Rivers and Indigenous perspectives on the value and use of ecosystem indicators.

Key messages and points of discussion included:

- The GNWT identified seven documents for review regarding Traditional Knowledge and its application to biological monitoring in the Hay and Slave rivers. The majority of the documents were workshop summaries. One was a compendium of community-based research and the remainder were traditional knowledge-related summaries of research completed by others. Some of the documents reviewed come from collaborative work that GNWT did with communities in the Slave and Hay river basins.
- The documents, most particularly the workshop reports, included reference to anthropogenic drivers and stressors. Discussions in the reports were usually around the reason or cause of changes noted in the environment. The discussions focused on effects caused by certain activities.
- Key findings included:
    - Traditional knowledge reports identified a broader range of potential indicators, including insects and birds.
    - Traditional knowledge indicators tended to focus on the life cycle of the species and what would interfere with the life cycle.
    - More consideration was given to the effects of anthropogenic changes because of the link to harvesting practices. Science focused on human health.
    - Traditional knowledge included a recognition of environmental changes and trends over decades especially habitat while science knowledge tended to be limited to only a few years.
    - Traditional knowledge literature made a note of species range expansion and/or invasive species.
    - The science literature tended to be issue focused while traditional knowledge tended to be species focused. Traditional knowledge focused on livelihoods first (i.e., access to animals and ability to harvest) and health second. Science literature focused on health first and populations second.
- Mr. Heron emphasized the need for traditional knowledge to be considered side by side with western scientific knowledge. While one world view should inform the other, he wanted to make sure that scientists understood the differences in the worldviews and that the different worldviews would lead to different evaluations and outcomes. He noted that the indigenous perspective was more holistic while the scientific worldview tended to be issue focused.

5.2.6 Biological Monitoring and Biological Indicators in the Hay and Slave Rivers for the Alberta-Northwest Territories Bilateral Water Management Agreement: Synthesis and Recommendations

Presenter: Heidi Klein

This presentation provided an overview of a literature review completed regarding aquatic biological indicators and monitoring in the Slave and Hay river basins. The presentation focused on 12 indicators that could form a biological monitoring program and support the implementation of the Alberta-NWT BWMA.

Key messages and points of discussion included:

- The GNWT commissioned a literature review, followed by a synthesis and recommendations report, regarding aquatic biological indicators and monitoring in the Slave and Hay river basins to support the implementation of the Alberta-NWT BWMA.
- The literature review focused on research and monitoring of biota that are sensitive to anthropogenic changes in water quality and quantity and to other factors such as cumulative loss of aquatic habitat and climate change. Conclusions from the literature review include:
    - No programs reviewed were specific to the needs of the BWMA. No on-going program is in place for biological indicators.
    - Most monitoring has been short term (under five years); research projects are sometimes only one year in length.
    - Existing programs such as the NWT Cumulative Impacts Monitoring Program (CIMP) provide funding to external parties for monitoring, but without standardization of methods that would allow for comparison, and without the certainty of long-term funding. The CIMP program supports a variety of interests and is not exclusive to the research needs in the Mackenzie River Basin, or transboundary issues in particular.
    - Clear gaps emerged in research linking biological indicators to changes in habitat and incursion of exotic species. Insufficient attention has been paid to changes in loss of habitat or habitat degradation. Most research has concentrated on contamination.
    - There is a lack of control sites for purposes of comparison.
    - More coordination is needed between monitoring programs in the NWT and in Alberta, and greater consistency in methodology.
    - Potential new indicators include frogs and pelicans. However, additional research is required to ascertain their applicability. Migratory birds may not be suitable for monitoring contaminants, but may be suitable for monitoring habitat changes.

- There are 22 aquatic biological datasets from the Slave River and the Slave River Delta that provide useful background data for indicator development. The Hay River has received much more limited research attention – only six datasets were identified as relevant to this review. Water quality is the predominant focus of on-going aquatic monitoring program in the NWT. Programs tracking biological indicators in the NWT are limited and somewhat ad hoc, focusing on objectives not related to the BWMA. Few are specifically designed to facilitate trend detection and cumulative effects evaluation.
- Based on the literature review, the synthesis report recommended the development of 12 indicators, grouped under two criteria (summarized in the figure below). The SLR team took the extent and quality of past data records into account when selecting indicators. The recommended indicators have been implemented in other locations, providing a basis for evaluating results. The extent of local baseline data and past monitoring records necessary for trend analysis varies by indicator.

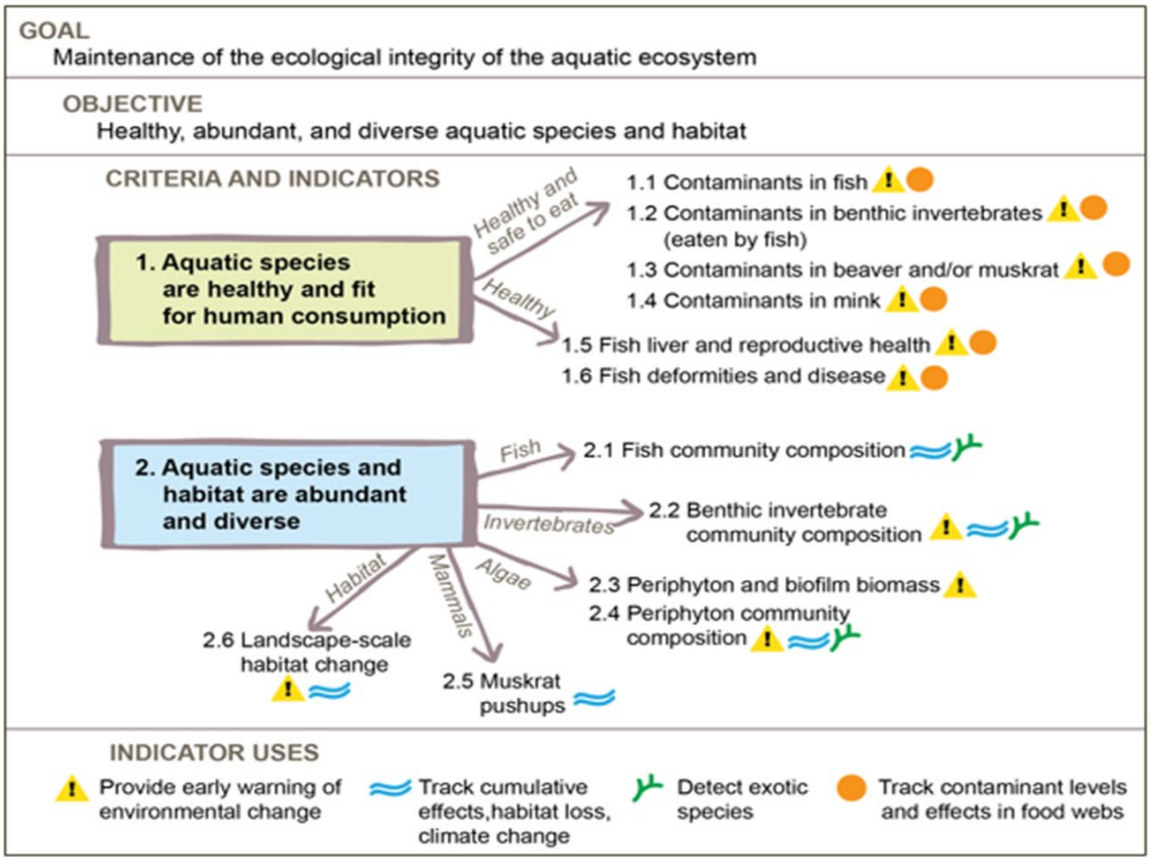

Figure 1. Potential biological indicators for ecological integrity management

6.0 DAY ONE SUMMARY

At the end of Day One, the key learnings were summarized:

- The monitoring of biological indicators is necessary to support the implementation of the Alberta-NWT BWMA. Biological indicators can:
    - Provide an early warning that a change in the environment is occurring, which allows for an adaptive response.
    - Track cumulative effects, climate change, and loss of habitat or habitat degradation.
    - Indicate the presence of exotic species that cannot be detected through water quality or quantity monitoring.
    - Track contaminant concentrations in biota before it can be detected in water.

- There is a need to move from planning and designing a biological monitoring program to its implementation. A model is needed that could be used not only for the Slave and Hay rivers but also for other transboundary waters such as those shared by BC / AB and NWT / BC.

- Key considerations in selecting biological indicators and in developing a monitoring program are:
    - Identifying a balanced set of three types of biological indicators: stressor-based, values-based, and effects-based. Different people will have a different perception of the quality, value or relevance of an indicator, based on their own experience.
    - Ensuring that the indicators are sensitive to ecological change. That means taking into account the size of the home range for the species under consideration and food web relationships.
    - Having the ability to identify effects that are beyond the range of natural variability.
    - Envisaging a longer term program that evolves over time. Not everything needs to be monitored from Day 1.
    - An ideal program would allow for the comparison of results over time and identify trends. It would indicate the need to take action in response to an identified problem. It would help define if there is a problem and help distinguish “what the problem is from what the problem is not”.
    - A “spectrum of responses” or a set of “tiered management actions” would be tied into the program. A “one size fits all” approach will not work.

- Participants discussed other aspects of monitoring program design, including considerations of: 1) sampling methods; 2) data analysis and interpretation; and 3) the concept of “two-eyed seeing”. Key points of this discussion were:
    - Sampling methods must be well tested and consistently applied over time and sampling locations. Sampling frequency should be established and may vary depending on method and location. Program managers should ensure various testing methods are undertaken in various contexts.
    - Data analysis should be based on statistically valid methods, but should also bring community standards of acceptability into the interpretation of monitoring results. In any case, evidence should be robust.
    - Traditional and local knowledge should work in parallel with science knowledge. Apply the concept of “two-eyed seeing” and engage community members in the sampling program and interpreting monitoring results. Workshop participants recognized that there will be no single, satisfactory means by which communities would be involved in the monitoring process.

- Participants stressed the need to “integrate”, and that “integration” means different things at different points in the monitoring program.
    - At the outset of program planning, “integration” tends to mean that the set of indicators selected should be “integrated” based on a holistic view of the ecosystem.
    - Any monitoring program “at the boundary” should be “integrated” with upstream and downstream monitoring programs, in terms of sampling methods, frequencies, approaches and interpretation. The use of standardized methods and protocols for sampling and data interpretation are preferred.
    - Traditional Knowledge should not be “integrated” into program design. Rather, TLK should inform program design, and a “two-eyed seeing” approach where both scientific and community-based indicators was recommended.

Photo 3: Sharing Learnings from the 2017 Workshop

7.0 EXERCISES AND GROUP DISCUSSIONS

Once the basis for the workshop had been set through presentations, a series of exercises and group discussions were initiated. The goal of the exercises was to move from the "what" to the "how" with respect to biological indicators and monitoring. With the exception of exercise 1, most discussions were held in small groups that reported to the plenary. These small groups were comprised of participants with varied experience and expertise.

7.1 Exercise One

As described in the BWMA, monitoring of biological indicators is intended to help assess ecosystem health for the cumulative effects of multiple substances or contaminants, climate change and habitat alteration, and should provide an early warning that change is occurring. In addition, biological indicators should play a role in detecting the presence of exotic species.

To better understand how to achieve these objectives, a plenary exercise was designed to identify specific characteristics that biological indicators should have to achieve the outcomes envisaged in the BWMA. Workshop participants were asked to describe the characteristics of a good indicator for: 1) early warning, 2) detecting the presence of exotic species, 3) detecting cumulative effects/changes and habitat changes, and 4) assessing ecosystem health with respect to the level of contaminants.

Below are some of the most common responses from workshop participants. There are many common characteristics of good indicators but they mean different things depending on the monitoring objective. Characteristics are not necessarily mutually exclusive; some descriptions may include aspects of more than one characteristic.

Characteristics of a good indicators for the following four monitoring objectives	Simple & Reliable	Diagnostic	Meaningful	Observable	Representative	Scalable	Actionable	Sensitive	Effective	Integrated	Reportable	Non-lethal
Provide early warning	x	x	x		x	x		x				
Detect exotic species				x			x		x			
Detect cumulative effects/changes	x		x			x	x		x	x		
Level of contaminants	x	x	x			x	x		x		x	x

Description of characteristic

Simple and Reliable - Data collection is easy to undertake using standard methods and well-tested protocols, and local community members should be able to collect good quality data. Manages for Type I errors (i.e., a "false positive" finding).

Diagnostic - Point to causes of the changes upstream of the border that might affect ecosystem health at the border and further downstream (providing early warning)

and/or

For contaminants, able to distinguish between natural/background concentrations and those resulting from human activity. Contaminants whose concentrations are linked to a particular

stressor (e.g., paper mill or agricultural discharges) or are of concern to regulators. (ecosystem health and levels of contamination).

Meaningful - Have value to community members and resource users so that they can adjust or make changes in their behaviours and activities if necessary.

Observable - Able to be seen by resource users (e.g., fish tissue quality).

Representative - Able to capture various levels of biological organization.

Scalable - Able to be applied and interpreted at various geographic scales (i.e., at individual sampling locations, individual reaches of a river and at the scale of the river itself).

Sensitive - Able to detect small changes in the ecosystem.

Actionable - Able to signal when a change exceeds an established threshold and requires management action.

Effective - Able to measure, track and distinguish between cumulative/river wide and site-specific habitat change, over short timeframes (i.e., acute changes) and longer periods (i.e., chronic changes, trends or shifts in a population or community) (cumulative effects/changes and habitat changes)

and/or

Able to detect the presence of exotic species even if present at low densities, and track whether their densities and/or geographic ranges are increasing or decreasing

and/or

Able to measure and track contaminant concentrations and distinguish between change over both short timeframes (i.e., acute changes) and over longer periods of time (ecosystem health and levels of contamination)

Integrated - Able to be part of an integrated set of indicators selected based on a holistic view of the ecosystem (i.e., integrated across media and ecosystem levels).

Non-lethal – Able to sample biota in a non-lethal manner.

Reportable – Able to assemble and report monitoring results quickly and easily, and inform multiple audiences (e.g., regulators, community members, etc.).

Photo 3: Sample Outcome from Exercise 1

7.2 Exercise Two

The second exercise explored the meaning of "transboundary river" within the context of a monitoring program. It was believed that having a common understanding of the geographic scope or physical limits of a monitoring program would be valuable when discussing potential vegetative biological indicators, as well as invertebrate monitoring. Participants acknowledged that geographic scope would affect the monitoring budget. Discussion and questions raised during this exercise included:

1) Should any effort be placed in monitoring tributaries to the Hay and Slave rivers?
2) Should smaller transboundary streams be monitored?
3) Is there value in undertaking biological monitoring in the entire watershed for the purpose of the transboundary agreement?
4) Should a transboundary biological monitoring program for wetlands and vegetation include riparian and floodplain areas?

At the plenary, it became clear that the biological monitoring program should focus on the Slave and Hay river mainstems near the border. The BWMA has specific commitments for monitoring of biological indicators for the Slave and Hay rivers, since they were classified as class three, as per the Risk Informed Management approach, due to existing and potential development and

traditional uses in the basin. The need to define (and map) the lateral extent of the mainstem (in the context of natural variability) was discussed. No specific distance upstream or downstream was discussed.

Sampling on tributaries was considered valuable where they might offer "reference points" if they are suitably similar. It was acknowledged that tributary monitoring could provide early warning of environmental change given the observable changes noted in bank vegetation conditions due to siltation or changes in water flow. Changes in vegetation on floodplains might also provide early warning of impact and could indicate potential changes in fish populations.

7.3 Exercise Three

The third exercise was to develop a common understanding of the known and potential future stressors or "drivers" of ecosystem change in the Slave and Hay rivers. The discussion of key stressors and drivers started with the diagram (see Figure 2) presented in the *Slave and Hay Rivers - Final Synthesis and Recommendations Report* (SLR, 2017). It was believed that identifying known key stressors and potential future stressors or drivers would provide good context for selecting biological indicators.

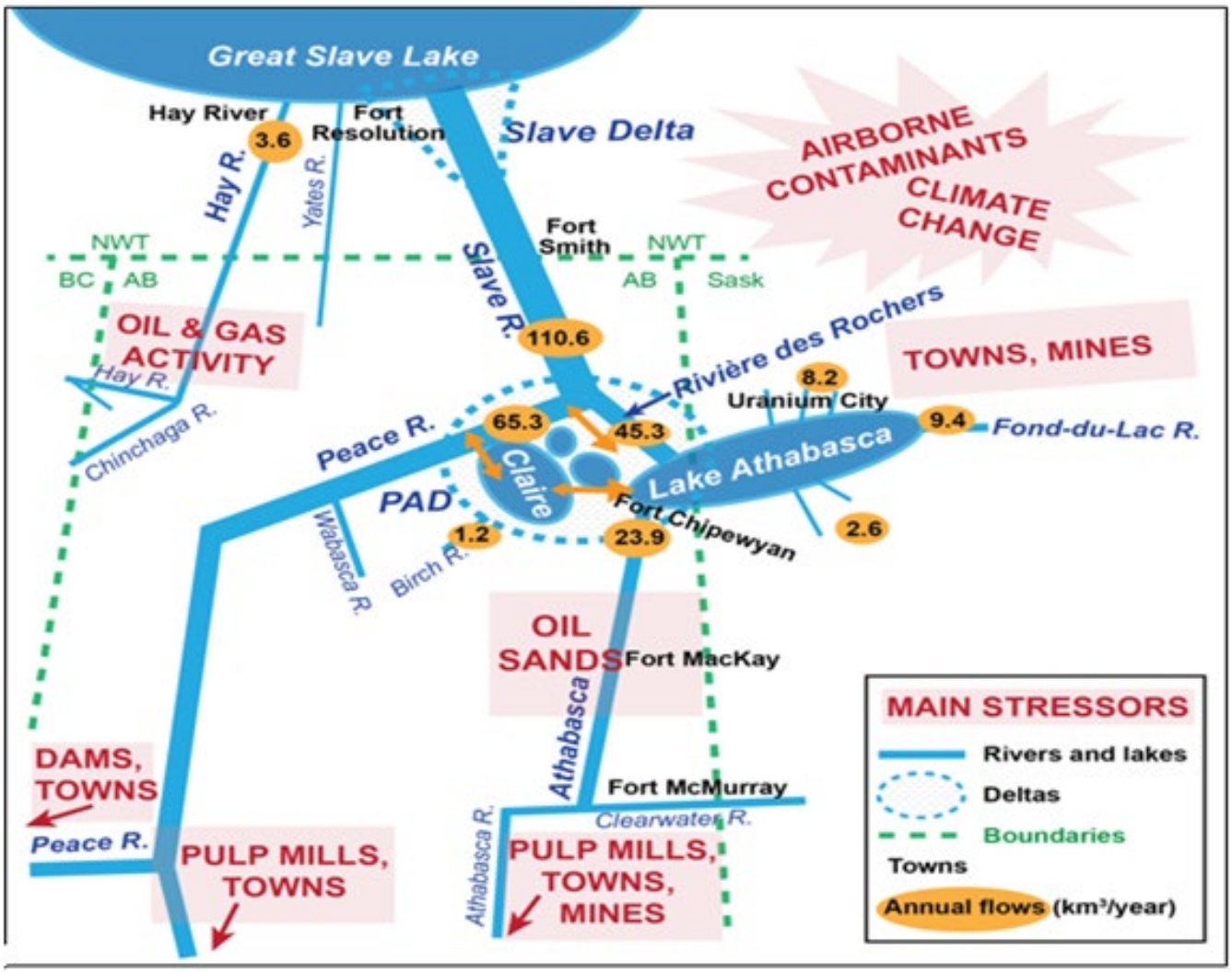

Figure 2. Stressors and drivers for the Hay and Slave River basins

Workshop participants identified a variety of activities or issues that are causing or likely to drive change in the Hay and Slave river basins (see Table 1). The conversation focused on stressors resulting from human activities, but not exclusively. Natural stressors influenced by climate change play a major role in driving current and future changes in the rivers and should therefore be factored into the monitoring design.

Table 1. List of Stressors and Drivers

Industrial Stressors	Other Anthropogenic Stressors	Natural Stressors
Existing operations, expansions and/or new operations: • Oil sands operations • Conventional oil and gas production and transmission operations (e.g., pipelines) • Mining operations • Pulp and paper mills • Hydraulic fracturing • Hydro-electric and/or water control facilities	• Human communities and population growth (including landfills, water withdrawals, sewage treatment and disposal) • Agricultural operations • Pharmaceuticals	Climate-related stressors, including: • Forest fires • Drought • Extreme weather, rapid snow and ice melt causing river pulses, ice jamming and/or lack of ice jamming)

7.4 Exercise Four

The fourth exercise focused on general program design consideration and the efficacy of specific biological indicators.

7.4.1 General Program Design Considerations

Only one of the small groups discussed general program design considerations for a biological indicators sampling program. The group recommended including the following elements:

- The primary objective of the monitoring program.
- The species to be monitored and locations for sampling with a rationale for species and locations selection.
- Sampling techniques and appropriate sampling equipment
- Scheduling and sequencing of sampling: annually, and for the life of the program
- Proposed level of effort or sampling duration.
- Sampling time of day.
- Community input for the design of the program.
- Safety and quality assurance protocols.

7.4.2 Large-bodied Fish

Workshop participants agreed that large-bodied fish should form part of a biological monitoring program because they are ubiquitous in the Hay and Slave rivers and are an essential part of

Indigenous peoples' diet. Large-bodied fish are considered to be particularly sensitive to contaminants in water and sediment and, being located at the top of the aquatic food web, they tend to accumulate contaminants (e.g., metals). Large-bodied fish health is often used as an indicator of ecosystem health, including in the JOSM program.

During the small group discussions, participants recommended avoiding designing a single program to achieve multiple purposes. Participants also suggested focusing the study on one or two key species that are an integral part the local aquatic food web.

A program concerned about contaminant concentration in fish (i.e., are the fish safe to eat?) would be designed to focus on species that:

- are resident in the river system for most or all of their life cycle and that have limited mobility,
- are long-lived species, so that contaminants accumulate longer and are measureable,
- feed on other fish and mature late, so bio-magnification is greater,
- do not spawn every year, and
- are used by people as a food source.

A program concerned about general ecosystem health would be designed to focus on species that:

- are benthic species that tend not to migrate and move less throughout the river system,
- are not targeted by anglers or used by people as a food source because this may obscure their abundance in the river, and
- mature early and are short-lived so they can provide an early warning of environmental impact.

Size-based measures (i.e., length, weight) are most common and are well accepted by scientists and intuitively understood by non-scientists as measures of fish community and general ecosystem health. "Length" may be preferred to minimize measurement error and to avoid potential seasonal variability in fish weight. Other measures (as per the EEM program) may include age, sex, gonad weight and observable abnormalities.

In general, seasonal changes in river conditions (e.g., flow, temperature) can affect the sensitivity of the monitoring program. These parameters should be noted in the monitoring program. A sampling frequency of three to five years was considered reasonable after establishing a robust baseline, with sampling across all sites staggered across years.

7.4.3 Small-bodied fish

Workshop participants agreed that small-bodied fish could form part of a biological monitoring program, but a monitoring program focused on large-bodied fish would be more valuable. Small-bodied fish could be added to the monitoring program as it evolves over time, or in the event that a change is detected in invertebrates or large-bodied fish. As such, little discussion was devoted to small-bodied fish. Nevertheless, the key points of discussion were:

- Small-bodied fish are usually more abundant than large-bodied fish and easier to capture; they represent a different level in the food chain than large-bodied fish.
- Small-bodied fish were deemed suitable for inclusion in monitoring programs focused on general ecosystem health and/or monitoring programs focused on contamination concentration in fish.

- Small-bodied fish are sensitive to environmental changes but may be better indicators of the health of a local habitat than the health of a river system.
- Using small-bodied fish will require greater attention to program design as they are more sensitive to sampling methods and timing.

7.4.4 Invertebrates

Workshop participants agreed that invertebrates should form part of a biological monitoring program. Some of the main reasons they make for a good indicator are:

- They are widespread and are sensitive to pollution and changes in their environment.
- They are generally sedentary which make them good indicators of site-specific conditions.
- As the primary food source for many fish species, invertebrates can provide early warning of changes in fish health.
- They are relatively easy to collect and identify.

The small group discussions focused on the factors that should be considered during program design. Key points of discussion were:

- Fundamentally, program design needs to consider whether sampling is to be done in depositional or erosional habitat, or both. The type(s) of habitats to be sampled will influence sampling methods, equipment and timing. Any decision about which habitat or locations to sample should be based on the specific conditions of the river or reach.
- Invertebrate sampling should be undertaken during the most ecologically relevant season, when biological diversity is highest. This is typically the fall when the majority of invertebrate species are present in sufficient numbers to be collected and lower flows in the river allow access for sampling.
- The importance of collecting geographical/site and habitat description information such as water velocity and depth, sampling depth, substrate data, etc.

7.4.5 Vegetation

Workshop participants agreed that vegetation could form part of a biological monitoring program, but monitoring fish and invertebrates is more valuable initially. Vegetation can be added to the monitoring program later. As such, little discussion was devoted to using vegetation as an indicator but some key points of discussion were:

- Vegetation is a suitable indicator for assessing habitat changes resulting from human activity and climate change.
- Changes in the vegetation community along the river can be accomplished by analyzing satellite imagery.
- Understanding changes in vegetation communities helps assess the potential for the introduction of exotic plant species.
- Changes in vegetation community may be an indicator of longer term trends in water levels and erosion.
- Algal communities are often used to measure ecosystem change in wetlands and lakes but might not be as helpful in river systems.

7.4.6 Small Aquatic Mammals

Workshop participants agreed that small, semi-aquatic mammals (e.g., beaver, muskrats) could form part of a biological monitoring program, but a monitoring program focused on fish and invertebrates would be of greater value. Small mammals can be added to the monitoring program as it evolves over time. As such, little discussion was devoted to using small mammals as indicators but some points of discussion were:

- Small mammals and their predators are appropriate indicators to assess ecosystem health and evaluate the effects of factors such as changing snow/moisture conditions, vegetation communities and other climate-related changes.
- Large year-to-year variation in population levels and long population cycles mean that very long time frames would be required to detect trends in species abundance.
- Relying on harvesting data is not sufficient to develop a picture of environmental quality because it is driven by hunter skill and value of the commodity.
- Consider occasionally sampling aquatic mammals and assessing for bioaccumulation of harmful substances to determine if they are healthy to eat.
- Focused studies could be undertaken every three years and should involve local community members. Using existing trapper information supported by GPS may be valuable.

7.5 Exercise Five

The final exercise was focused on providing specific guidance about how best to sample invertebrates and fish. Discussion took place in small groups that reported to the plenary. The composition of the small groups for this exercise was changed to allow workshop participants with similar experience, expertise and interest to discuss the topic together and provide more specific guidance.

7.5.1 Invertebrate sampling

The small group discussions were primarily focused on the Slave River, but the recommendations provided could apply to other transboundary river systems such as the Hay River. Workshop participants were reminded that the pilot monitoring program completed in 2017 under the transboundary agreement used invertebrate sampling methods modified from the Canadian Aquatic Biomonitoring Network (CABIN) protocols, as well as Hester-Dendy samplers. It was noted that CABIN is working to develop sampling protocols suitable for large river systems.

The specific guidance offered by workshop participants regarding invertebrate sampling included:

- There are a number of methods that can be used to sample macroinvertebrates in fresh waters. The most appropriate method depends upon the purpose of the sampling. Two methods were discussed:
  - "Kick sampling" involves kicking the substrate for a standardised time, while holding a mesh net downstream against the direction of flow, allowing the invertebrates to collect in the net.

    - Passive sampling using Hester-Dendy samplers typically captures fewer invertebrates and fewer species types.
- Workshop participants agreed that kick sampling is the most effective method for collecting invertebrate samples in the Slave River. Workshop participants suggested that the Hester-Dendy method be used elsewhere if it is the only option at a particular sampling location.
- The use of a modified CABIN protocol for large rivers is suitable for invertebrate sampling in the Hay and Slave rivers. This is a method similar to that used by the JOSM program on the Athabasca River.
- Participants noted the importance of being consistent in sampling similar types of habitat. Gravel/cobble areas have a better potential to provide invertebrate habitat and therefore are the ideal areas to perform kick sampling. Sampling sandy/depositional areas could be considered if clams and mussels are of interest (noted as a traditional food source).
- Considering that there are few reaches in the Slave and Hay rivers where habitat is suitable to sample on both banks of the river, the sampling should focus less on sampling both banks but extend the sampling for a greater distance along the river.
- In highly variable environments such as the Slave River, three continuous years of sampling and analysis would be sufficient to establish baseline conditions in the mainstem but four or five years would be better. Following the establishment of baseline conditions, future sampling could occur on a three to five year rotational basis among sample locations.
- In the future, collecting fewer water samples (one sample per reach) is sufficient. In general, sediment data has been found to be more relevant to BMI samples than water data.

7.5.2 Fish sampling

The small group discussions were primarily focused on the Slave River, but the guidance could also apply to other transboundary river systems such as the Hay River after gaining program experience. Consider including large-bodied fish species: whitefish, sucker, northern pike, and walleye, plus other fish consumed by communities in the basin.

Participants recommended that fish monitoring for the BWMA would be best accomplished using a method consistent with the EEM program. The EEM program could assist in identifying fish community composition and could be established using community-based methods.

The advantages of this method are:

- EEM endpoints provide an early indication of change as compared to monitoring community composition.
- EEM studies can identify potential effects caused by changes in water quality on fish, fish habitat and use of fish by humans.
- EEM studies use well-tested methods and protocols that are science-based, but there is flexibility to have TK-based indicators used alongside standard EEM indicators to promote the “two eyed seeing” approach.
- Using methods similar to those used upstream (i.e., JOSM) will ensure consistency and improve the ability to assess results.

The recommended effect indicators and endpoints of the EEM program are:

Effect Indicators	Effect Endpoints
Survival	· Age
Growth (energy use)	· Size-at-age
Reproduction (energy use)	· Gonad/body (mass)
Condition (energy storage)	· Body mass to length · Liver/body mass

Other specific guidance offered by workshop participants regarding fish sampling included:

- Three continuous years of large-bodied fish sampling and analysis would be sufficient to establish baseline conditions in the mainstem. Following the establishment of baseline conditions, future sampling could occur on a three to five year rotational basis among sample locations.
- The program should consider sampling reference sites away from the border both upstream and downstream (where possible). Reference sites from the JOSM program should be considered.
- Encourage involvement of community members in sampling and analysis. Some communities are already trained and have experience with sampling, recording and reporting protocols. A program to provide nets or repair damaged equipment could be considered.
- Use of eDNA could be considered as a research project to establish fish community composition.

8.0 SUMMARY OF GUIDANCE FROM WORKSHOP PARTICIPANTS

This workshop's objective was to identify the most appropriate biological indicators for a biological monitoring program for two transboundary rivers, the Hay and Slave rivers. Guidance was also sought for key considerations in designing an overall biological monitoring program. There were 34 participants, representing the governments of NWT, Alberta and Canada, academia, and others having expertise in biological monitoring and the use of Indigenous Traditional Knowledge in biological monitoring.

Through this workshop, participants were able to review the goals, objectives and monitoring commitments in the BWMA and share learnings and accomplishments to date related to the selection of biological indicators through implementing the BWMA and other relevant biological monitoring programs. Through a series of presentations and facilitated exercises, workshop participants shared their insights on the characteristics of good indicators, how best to choose biological indicators and how biological monitoring should be undertaken.

There was general agreement amongst participants that benthic macroinvertebrates and large-bodied fish should be the initial indicators for a transboundary biological monitoring program, and that program design can and will evolve over time. NWT and AB government representatives emphasized the need to start the planning and design of a biological monitoring

program and to commence the monitoring in a prudent and financially responsible manner. It was suggested that the initial biological monitoring program could be supplemented by focused studies involving other biological indicators. For example, occasional sampling of small semi-aquatic mammals (e.g., beaver, muskrats) for bioaccumulation could be undertaken to determine if they are healthy to eat. Such focused studies could be undertaken every three years, and should involve local community members.

There is value in designing a monitoring program that would be similar to other programs in the basin (e.g., JOSM, EEM, CABIN, etc.) such that results could be comparable. The biological monitoring program should ideally use standardized sampling methods and protocols. Monitoring of large-bodied fish would be best accomplished using a method consistent with the EEM program similar to that used in the JOSM program. For benthic macroinvertebrates, the use of the modified CABIN protocols for large rivers is suitable for invertebrate sampling in the Hay and Slave rivers.

In general, three continuous years of fish and invertebrate sampling and analysis would be sufficient to establish baseline conditions in the mainstem rivers. Following the establishment of baseline conditions, future sampling could occur on a three to five year rotational basis among sample locations.

Participants widely agreed that TLK should inform program design and participants recommended a “two-eyed seeing” approach where both scientific and community-based indicators are used. The use of community members to undertake sampling and analysis was strongly encouraged. It was noted that some communities are already trained and have experience with sampling, recording and reporting protocols.

Appendix A: Workshop Participants

NAME	ORGANIZATION	TITLE
Donald Baird	Environment and Climate Change Canada	Director, Canadian River Institute
Nathan Ballard	Government of Alberta	Regional Limnologist, Lower Athabasca Region, Operations Division
Caroline Bampfylde	Government of Alberta	Ecosystem Modeller, Policy and Planning Division
Keith Beraska	Government of Alberta	Director, Indigenous Services
Meghan Beveridge	Government of the Northwest Territories	Manager, Transboundary Waters
Lorraine Brekke	Government of the Northwest Territories	Cumulative Impact Monitoring Program Advisor
Chris Briggs	Government of Alberta	Senior Fisheries Biologist
Jacquie Browne	Government of Alberta	Transboundary Water Advisor, Strategy Division
Bob Brua	Environment and Climate Change Canada	Aquatic Ecological Sciences Biologist. Cumulative Effects and Bioassessment
Sarah Depoe	Government of Alberta	Director, Cumulative Effects Assessment, Policy and Planning Division
Nancy Glozier	Environment and Climate Change Canada	Section Manager Athabasca Arctic Basin - Aquatic Ecosystems Scientist
Queenie Gray	Parks Canada	Acting Ecologist Team Leader
Tim Heron	Northwest Territories Métis Nation	NWT Aboriginal member on the AB-NWT BWMA Bilateral Management Committee
Glynnis Hood	University of Alberta	Professor of Environmental Science, Augustana Campus
Tracy Howlett	Government of Alberta	Knowledge Translation Lead, Environmental Monitoring and Science Division
Tim Jardine	University of Saskatchewan	Assistant Professor, School of Environment and Sustainability
Paul Jones	University of Saskatchewan	Assistant Professor, School of Environment and Sustainability
Erin Kelly	Government of the Northwest Territories	ADM, Department of Environment and Natural Resources
Heidi Klein (Facilitator)	Sanammanga Solutions Inc.	President, Sanammanga Solutions Inc.
Annie Levasseur	Government of the Northwest Territories	Water Management Advisor
Gongchen Li	Government of Alberta	Transboundary Water Quantity Specialist, Strategy Division
Stuart Macmillan	Parks Canada	Manager, Resource Conservation at Wood Buffalo National Park

NAME	ORGANIZATION	TITLE
Kelly Munkittrick	Wilfred Laurier University	Executive Director of Cold Regions and Water Initiatives
Adam Norris	Mighty Peace Watershed Alliance (MPWA)	MPWA coordinator
Brenda Parlee	University of Alberta	Associate Professor, Resource Economics and Environmental Sociology
Jolene Raggett	Government of British Columbia	Aquatic Resource Biologist, Water Protection and Sustainability Branch
Garry Scrimgeour	Government of Alberta	Executive Director, Monitoring & Observation, Environmental Monitoring and Science Division
Stephanie Strachan	Environment and Climate Change Canada	Biological Monitoring and Assessment Scientist
Tim Toth	Government of Alberta	Sr. Transboundary Water Advisor, Strategy Division
Rick Walbourne	Government of the Northwest Territories	Regulatory and Science Advisor
Tomasz Wlodarczyk (Facilitator)	SLR Consulting (Canada) Ltd.	Principal Consultant, Environmental and Strategic Planning
Brian Yee	Government of Alberta	Director, Transboundary Waters Secretariat, Strategy Division
Ron Zurawell	Government of Alberta	Aquatic Scientist, Environmental Monitoring and Science Division

Appendix B: Workshop Agenda

Date of Workshop	January 24 and 25, 2018	**Time**	Registration / Coffee: 8:30 AM Commencement: 9:00 AM
Topic	**TOWARDS SELECTING BIOLOGICAL MONITORING INDICATORS UNDER THE AB-NWT BILATERAL WATER MANAGEMENT AGREEMENT**		
Location	**Main Venue:** Mountbatten Room, 10th Floor **Breakout Rooms:** On the 24th: Mountbatten/Cambridge rooms On the 25th : Mountbatten & York rooms **Address:** Federal Building, 9820 – 107 Street, Edmonton, AB		

DAY 1: Morning		***8:30 AM to Noon***
Registration and Coffee	All	8:30 – 9:00
Welcome from Government of Alberta	Brian Yee	9:00 – 9:10
Welcome, Introductions and Objectives of the Workshop • What do we want to accomplish now? • Why you were invited? • How can everyone help? • Round table introductions (name and organization)	Tim Toth Meghan Beveridge	9:10 – 9:35
Review of Workshop Agenda, Venue Safety and Workshop Materials	Heidi Klein	9:35 – 9:45
Context Setting: Goals, Objectives and Monitoring Commitments in the Alberta-Northwest Territories Bilateral Water Management Agreement (BWMA)	Erin Kelly	9:45 – 10:00
Context Setting: Learnings from the 2017 Workshop and Accomplishments to date	Caroline Bampfylde Annie Levasseur	10:00 – 10:15
Context Setting: Environmental effects monitoring: Choosing the correct indicators	Kelly Munkittrick	10:15 - 10:35
Coffee Break		***10:35 – 10:50***
Accomplishments and Learnings: 2016 / 2017 Benthic Invertebrate Studies	Annie Levasseur	10:50 - 11:10

• Overview of Benthic Invertebrate Studies on Large Rivers • How can benthic invertebrates help detect small changes over the long term? • What makes them good indicators?		
Accomplishments and Learnings: Joint Oil Sands Monitoring (JOSM). • Program Accomplishments and Status • How were indicators selected? • What makes them good indicators? • What would you change? What improvements could be made?	Nancy Glozier	11:10 - 11:35
Accomplishments and Learnings: SWEEP (The Slave Watershed Environmental Effects Program) • Program Accomplishments and Status • How were indicators selected? • What makes them good indicators? • What would you change? What improvements could be made?	Tim Jardine	11:35 – 12:00
Lunch to be Provided		***12:00 – 1:00 PM***
Day 1: Afternoon		***1:00 PM to 4:30 PM***
Introduction to Afternoon Activities	Tomasz Wlodarczyk	1:00 – 1:15
Accomplishments and Learnings: Traditional Knowledge and Indigenous Perspectives • MRBB SOAER indicators project • Linking biological indicators to effects on livelihoods and wellbeing of communities • What biological indicators best link to Indigenous livelihoods and well-being of communities? • What makes them good indicators for this purpose from an Indigenous perspective?	Tracy Howlett Brenda Parlee	1:15 – 1:35

Accomplishments and Learnings: Traditional Knowledge and Indigenous Perspectives • What Traditional Knowledge has been documented to date? • Linking biological indicators to effects on livelihoods and wellbeing of communities • What biological indicators best link to Indigenous livelihoods and well-being of communities? • What makes them good indicators for this purpose from an Indigenous perspective?	Heidi Klein Tim Heron	1:35 – 2:00
Recommendations and Monitoring Framework: Biological Monitoring and Biological Indicators in the Hay and Slave Rivers. State of knowledge for Slave River and Hay River indicators. • Literature Review and Library • Synthesis Highlights: o Small Fish o Large Fish o Aquatic Mammals o Benthic Invertebrates o Other Biological Indicators	Heidi Klein	2:30 – 3:00
Coffee Break		***3:00 – 3:15***
Exercise One: • Matching indicator features / characteristics with Appendix G objectives • Prepare for Day 2	Tomasz Wlodarczyk Heidi Klein	3:15 – 4:15
Day 1 Wrap Up	Heidi Klein	4:15 – 4:30
DAY 2: Morning		***8:30 AM to Noon***
Coffee	All	8:30 – 9:00
Exercise Two • Defining / characterizing stressors and effects	All. In break out rooms followed by plenary	9:00 – 10:00
• Plenary		10:00 – 10:30
Coffee Break		10:30 – 11:00
Exercise Three • Linking biological indicators to stressor • Sampling parameters	All. In break out rooms followed by plenary	11:00 – 11:30

• Plenary		11:30 – 12:00
Lunch to be Provided		***12:00 – 1:00 PM***
Day 2: Afternoon		***1:00 PM to 4:30 PM***
Exercise Four • SWOT analysis of biological indicators	All. In break out rooms followed by plenary	1:00 – 2:00
• Plenary		2:00 – 2:30
Coffee Break		2:30 – 3:00
Exercise Five • Monitoring program design	All. Main meeting room	3:00 – 4:00
Day 2 Wrap Up and Thank You	Tim Toth Meghan Beveridge	4:00