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# SCIENCE EVALUATION OF INSTREAM FLOW NEEDS (IFN) FOR THE LOWER ATHABASCA RIVER

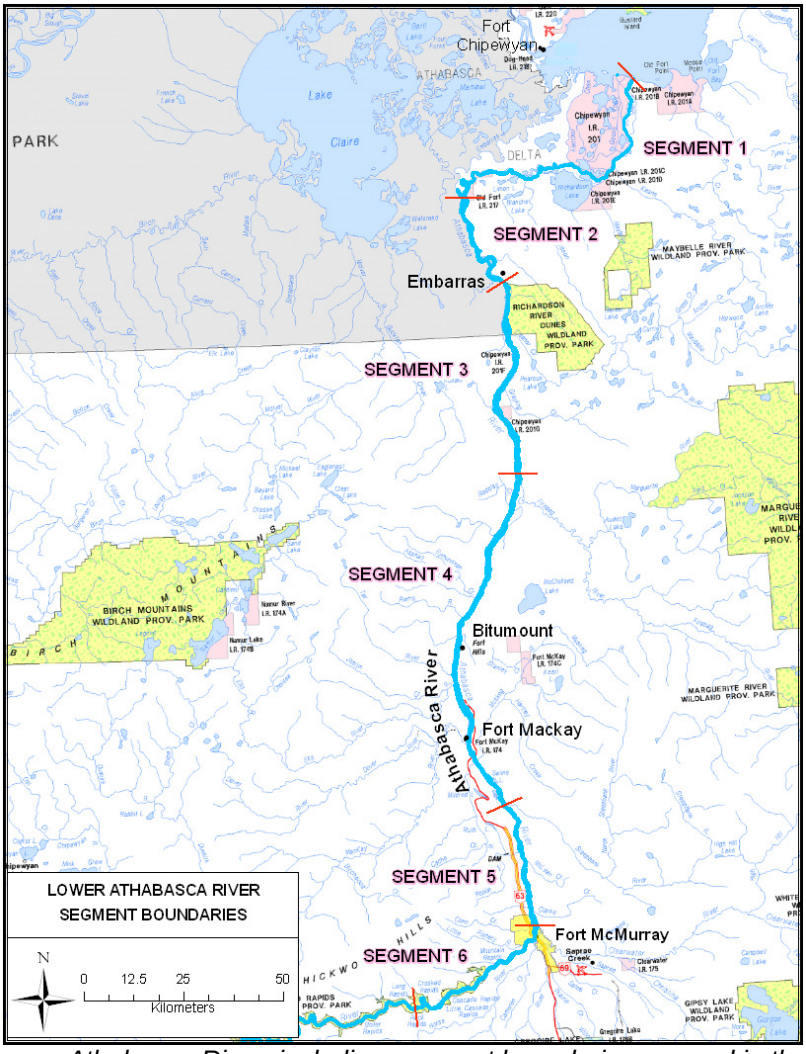


*Figure 1: Map of Lower Athabasca River, including segment boundaries as used in the technical reports. (Source: Phase 2 Framework Committee Report, 2010, Cumulative Environmental Management Association (CEMA). Image courtesy of CEMA).*

## Context :

*The extraction of oil sequestered in oil sands requires a regular supply of water. In northern Alberta, oil sands operation and development results in large scale water withdrawals from the Lower Athabasca River with potential effects on the flow regime. It is well recognized that flow regimes are critical for sustaining biodiversity and ecological integrity; thus, guidance on maintaining instream flow needs (IFN) is required to preserve ecosystem function and to limit harm to fish and fish habitat in the Lower Athabasca River (Figure 1).*

*The Cumulative Environmental Management Association (CEMA), a multi-stakeholder group including environmental organizations, First Nations, industry and regulators, has provided recommendations with respect to instream flow needs for the Lower Athabasca River. Based on input from CEMA, Fisheries and Oceans Canada (DFO) and Alberta Environment developed the Phase 1 Instream Flow Needs Water Management Framework report which was reviewed by DFO Science in 2006 and 2007. The review of Phase 1 identified information gaps with respect to fish and fish habitat; these gaps were to be addressed in subsequent studies and a second report. In response, CEMA established the Phase 2 Framework Committee (P2FC) in 2007 to develop recommendations for a Phase 2 Water Management Framework that would prescribe timing and volume of water withdrawals from the Lower Athabasca River for cumulative oil sands industry water use. The Phase 2 Instream Flow Needs P2FC recommendation report was submitted by the P2FC to the regulators and CEMA on February 1, 2010.*

*Several Canada-Alberta Joint Review Panel (JRP) Environmental Assessment Reports regarding Oil Sands Mining Projects have recommended the development of an Instream Flow Needs (IFN) assessment for the Lower Athabasca River, including one JRP Report that recommended the incorporation of an ecosystem base flow (EBF) into the final Water Management Framework for the Lower Athabasca River. As part of the Government of Canada's Response to these JRP Reports, DFO committed to establish, in cooperation with Alberta Environment, a Lower Athabasca River IFN (i.e. a Water Management Framework) and to complete and implement Phase 2 of this Framework by 2011. Part of the commitment included incorporating an EBF into the final Water Management Framework.*

*The Canadian Science Advisory Secretariat (CSAS) of DFO has been requested by the DFO Habitat Management staff to conduct a peer review of the scientific information used to develop the Evaluation Criteria reports and technical appendices of the P2FC Report.*

*This report reflects the findings of a scientific review of the aforementioned technical documents from the perspective of the mandate of DFO. It does not replace a formal environmental assessment (EA) process, nor does it constitute public consultation.*

## SUMMARY


- The Lower Athabasca River is most sensitive to water withdrawals during low flow conditions (both within and across years). Low flow conditions occur mainly during the winter season but can also occur at other times during years of low precipitation.

- While the models used within the various P2FC technical reports are generally acceptable, they are based on a large number of assumptions that cannot be validated with the presently available data on fish biology and habitat for the Lower Athabasca River. Thus, one of the principal recommendations of this scientific review is that the predictions of the various models should be field tested.

- Tributaries to the Lower Athabasca River were not within the scope of the P2FC technical analyses. While the tributaries do not constitute a large spatial area relative to the overall drainage basin and thus likely contribute relatively little to the overall flow of the Athabasca River, they likely provide important spawning and rearing habitat necessary to sustain the fish populations in the Lower Athabasca River. Thus, there is uncertainty resulting from considering the mainstem of the Lower Athabasca River in isolation from its tributaries.

- Following the conclusion of this scientific review, a recurrent error within the climate change analysis and the main P2FC report was reported. The result of this error is that the General Circulation Model (GCM) projections for changes in minimum (winter) flows are often greater than what was reviewed, and changes in mean (summer) flows are often smaller than what

was reviewed. It is recommended that the climate change analysis, and any other technical analyses using these climate change projections, be re-conducted to address this error.

- There are multiple assumptions for individual evaluation criteria (EC), and potentially compounded error both within and among the various ECs. This may lead to an overall directional bias across the various EC reports. As such, a precautionary approach to water withdrawals is recommended.

- Although uncertainty exists around what constitutes an ecosystem base flow (EBF), there was concurrence that a flow should be established for the Lower Athabasca River below which there would be no water withdrawal. Participants agreed that this flow should be established using a precautionary approach, and should consider the assumptions, uncertainties and measurement error across ECs (discussed herein).

- Despite the limitations in the biological information (along with the stated uncertainties), the information and models reviewed are the best currently available, and can thus be used to provide guidance regarding potential effects of water withdrawals to the ecosystem.

- From a hydrologic perspective, the Option H water withdrawal schedule (the non-consensus recommendation in the P2FC report) was found to be proportionally small relative to historic flow conditions during most times of the year, in most years, in the Lower Athabasca River. Given this information, it is unlikely that the hydrologic character of the river would be changed under the proposed water withdrawals. However, it is difficult to account for the uncertainty associated with climate change scenarios and their potential effects on the amount of water available in the river.

- The various technical reports examine the potential effects of various water withdrawal scenarios under different flow regimes to fish habitat in the Lower Athabasca River. Given the available information, it is impossible to assess the precise extent of potential losses to fish habitat. However, these EC reports identify the potential for loss of fish habitat under certain low flow conditions, and that these habitat losses would likely be detected in a well designed monitoring program. It is a reasonable assumption that these fish habitat losses would result in a loss of productive capacity in the Lower Athabasca River.

- Given these conclusions, participants suggested some potential habitat compensation projects. Any discussion of proposed compensation measures should consider habitat quality. Within this report, several potential compensation measures are presented for the consideration of project proponents and habitat managers.

- A monitoring and adaptive management program is essential given the various data deficiencies within the Lower Athabasca River (information on life-history, distribution, population size of different fish species, etc.). It should be recognized that adaptive management would still be subject to the uncertainty inherent throughout the assessment of IFN for the Lower Athabasca River. A well designed monitoring program would address both the need for ongoing monitoring data and important data gaps identified within this report.

- A DFO Science advisory process is recommended to provide a consistent national framework for the evaluation of instream flow needs (IFN). This advisory process should focus on ecosystem indicators of IFN and include a consideration of potential climate change effects on instream flows.

# INTRODUCTION

This DFO Science advisory workshop brought together approximately 35 experts from Fisheries and Oceans Canada (DFO), the Province of Alberta (Sustainable Resource Development and Environment), private industry, international experts, First Nations, environmental non-government organizations and academia. These experts peer reviewed the various P2FC evaluation criteria (EC) and technical reports, and examined the soundness and completeness of the scientific information and rationale that formed the basis for the P2FC recommendations. In addition, the workshop participants provided recommendations for a monitoring program for the Lower Athabasca River.

DFO Habitat Management staff requested scientific advice on the following four questions:

1. What impacts would constitute serious or irreversible harm to the ecosystem structure and function of the Lower Athabasca River as a result of modified stream flow?

2. How does the likelihood of causing serious or irreversible harm vary with stream flow in the Lower Athabasca River?

3. In respect of the scientific information used to develop the options of the P2FC report:
   (a) Are the methodologies used to assess the potential impacts to fish and fish habitat robust and sound?
   (b) Are there gaps or assumptions in the methods used that may lead to an underestimation of the impacts to fish and fish habitat?
   (c) What future monitoring or assessment requirements should be implemented to verify predictions?

4. If habitat loss is considered a likely consequence of the water extractions as outlined in the P2FC recommendations, provide science advice on the nature and extent of the potential habitat loss and the factors that should be considered when designing habitat compensation to offset these productivity losses.

In order to best respond to Question #3, participants assessed the various evaluation criteria (EC) reports and technical appendices as produced by the Instream Flow Technical Task Group (IFNTTG) which reported to P2FC. The findings of this analysis can be found within the "Assessment" section. The responses to Questions #1, 2 and 4 are addressed within the "Conclusions and Advice" section of this report.

## Technical reports reviewed:

1.0 Instream Flow Needs Technical Task Group Evaluation Criteria Reports:
- 1.1 Connectivity of Delta Distributary Channels.
- 1.2 Connectivity of Perched Basins in the Delta
- 1.3 Dissolved Oxygen in Side Channels
- 1.4 Channel Maintenance
- 1.5 Whitefish Spawning
- 1.6 Mesohabitat
- 1.7 Fish Habitat

1.8 Walleye Recruitment
2.0 Additional technical report - Climate Change Sensitivity Analysis.

# ASSESSMENT

The meeting focused on reviewing the technical reports that were used to predict the effects of various flow scenarios presented in the Phase 2 water management framework document. This review addressed questions about the robustness of the methods used to predict effects of changing flows on fish and fish habitat. For each technical report, the following questions were addressed:

**a) Are the methodologies used to assess the potential impacts to fish and fish habitat robust and sound?**
**b) Are there gaps or assumptions in the methods used that may lead to an underestimation of the impacts to fish and fish habitat?**
**c) What future monitoring or assessment requirements should be implemented to verify predictions?**

## Methods used within the various EC reports (general):

The methods (including scope and uncertainty) used to analyze the various ECs are well-described within each technical report. As such, these methods are generally acceptable but do not recognize explicitly the compounding uncertainty throughout the evaluation of instream flow needs for the Lower Athabasca River. For most metrics contained within the various EC reports, participants recognized that field validation of modeling exercises is important to test the predictions of potential effects on fish or fish habitat. There are some significant short-comings to the various technical analyses conducted, and some suggested improvements are hereby provided.

Thresholds of risk: In several instances the thresholds established for individual metrics within the EC reports are subjective, or derived from other ecosystems, and thus do not have a scientific basis within the Lower Athabasca River ecosystem.

Directional bias and/or compounded error: Given the multiple assumptions for each individual EC, there is potentially compounded error both within and among the various ECs. This may lead to an overall directional bias across the various EC reports. Statistical analyses conducted in collaboration with subject matter experts would help elucidate the magnitude and direction of error and bias in the results.

Climate change: An overall climate change analysis was conducted relative to historic flows (1957-2007) in the Lower Athabasca River, noting that the future flow regime may not be the same as the historical record. Six hydrologic scenarios were considered, although the P2FC process evaluated only three of these scenarios and only for certain evaluation criteria (fish habitat, mesohabitat, Walleye recruitment, and Lake Whitefish effective spawning habitat). Climate change sensitivity analyses were not conducted within each individual EC report. A more comprehensive approach would have considered the potential influences of all climate change scenarios on each EC.

Notwithstanding the above, if observed (actual) instream flow will be the basis for management decisions, the reasons for low flow conditions are irrelevant. Thus, the establishment of an

appropriately precautionary flow below which water withdrawals would cease would address concerns for the potential influence of climate change on the Lower Athabasca River ecosystem. However, if climate change becomes more severe, its effects on the Lower Athabasca River will need to be re-assessed.

Sources of Uncertainty and Risk (General):

i. The EC analyses were largely based on models and assumptions and included very little field validation. A precautionary approach in the decision-making process is recommended, including implementation of a comprehensive monitoring program and an adaptive management approach.
ii. The various assumptions and sources of error may have a directional bias across the various ECs.
iii. These various sources of error are compounded across and within the various EC reports.
iv. There is an inherent range of error in the Water Survey of Canada (WSC) winter discharge data.

River 2-D Presentation (hydraulic model):

The assumptions and limitations of River 2-D are already well outlined in the reports reviewed (please refer to source reports in "Sources of Information" section).

i. River 2-D sites were selected to be representative of various reaches within the Lower Athabasca River; field validation of this assumption is recommended.
ii. The uncertainty associated with the River 2-D model is greatest during the lowest low flow periods due to the errors or uncertainties associated with the traditional techniques used to extrapolate the rating curve (flow vs. stage relationship) during these low flow periods.
iii. Measured depths and velocities should be compared to those predicted by the model over a range of flows.
iv. River 2-D considers neither ice "freeze-up" nor "break-up" conditions (although an investigation of such conditions is recognized to be part of an on-going research program at the University of Alberta).

## Technical Reports Reviewed:

| **Report title: Channel Maintenance EC** |
|---|
| **Are the methodologies used to assess the potential impacts to fish and fish habitat robust and sound?**<br><br>With respect to the methodologies used to assess channel maintenance flows, the following point was identified:<br><br>-If on-stream water storage is proposed for the Lower Athabasca River, then the channel maintenance EC should be re-evaluated. |
| **Are there gaps or assumptions in the methods used that may lead to an underestimation of the impacts to fish and fish habitat?**<br><br>With respect to the analysis of channel maintenance flows, the following gaps or assumptions were identified: |

-In terms of scale, the proposed water withdrawals relative to the instantaneous flow(s) required for channel maintenance are extremely small during most times of the year (e.g. 29 $m^3$/s relative to >2000 $m^3$/s mean annual peak discharge).

-Even with existing data gaps/uncertainties, it is unlikely that the proposed withdrawals would have a significant effect on channel maintenance flows.

-This EC considered the maintenance of channel features, not how peak flows are related to fish habitat needs.

–See also sub-section on Climate Change under Assessment.

**What future monitoring or assessment requirements should be implemented to verify predictions?**

-To permit more precision and accuracy in most EC analyses, the installation of an additional water survey gauge on the mainstem downstream of Fort McMurray (and downstream of all industrial withdrawals) is recommended.

**Report title: Connectivity of Delta Distributary Channels**

**Are the methodologies used to assess the potential impacts to fish and fish habitat robust and sound?**

With respect to the methodologies used to assess connectivity of delta channels, the following methodological short-comings or comments were identified:

-Connectivity of delta channels was analyzed using “days of loss of connection” over a 50 year timeframe. However, it is possible that many of those days of loss of connectivity have occurred within single years. Other ways of representing this data would provide ecologically relevant information, such as “number of days with a particular year”, and/or a consideration of the timing of connection within a given year. This would make the analyses more directly relevant to fish and their specific life-history requirements.

-The above-noted analyses were reported to have been conducted, and should be included within the report.

-Given that only one site was evaluated, it is unknown how representative this EC is of other sites on the delta.

**Are there gaps or assumptions in the methods used that may lead to an underestimation of the impacts to fish and fish habitat?**

With respect to the analysis of connectivity of delta distributary channels, the following gaps or assumptions were identified:

-The model assumed fixed values for ice and lake levels, while these are known to vary. A sensitivity analysis of this model could provide some estimation of the importance of varying ice and lake levels to fish and fish habitat; however these were not presented within the report.

-From the methods employed, it is not possible to relate minimum water depths to the condition

of lost connectivity in distributaries.

-It is unknown how this predicted connectivity (depth, velocity, discharge) actually relates to fish ecology, particularly movements and biologically significant periods (BSP) of the different life stages of the various fish species found in the Lower Athabasca River ecosystem.

-In the absence of any other relevant thresholds, the decision thresholds for this EC were primarily based on other EC reports.

-There was no consideration of water temperature and thermal regime in relation to various ecological processes on delta.

–See also sub-section on Climate Change under Assessment.

**What future monitoring or assessment requirements should be implemented to verify predictions?**

-The high mobility of the sand substrate was noted to be an influence on the sill elevation and thus the model results (River 1D routing model). Recommend validating the predictions of connectivity (including consideration of substrate mobility and risk of freezing).

-Once validated with baseline data from the Lower Athabasca River, the decision thresholds for this EC should be confirmed or modified accordingly.

-Given that unknown representativeness of this site, survey additional sites on the delta, and include these sites within the analysis.

-Consider an analysis across different time periods (e.g., 5-year periods, “wet” years, “dry” years).

-Collect water temperature data to improve understanding of river thermal regime (freeze-up; break-up) and ecological processes.

-Evaluate how connectivity of delta channels is linked to ecosystem processes (i.e. in consideration of fish and fish habitat). The identification of which fish species require distributary connectivity during which times of the year would be particularly valuable.

**Report title: Connectivity of Perched Basins in the Delta**

**Are the methodologies used to assess the potential impacts to fish and fish habitat robust and sound?**

With respect to the methodologies used to assess connectivity of perched basins in the delta, the following methodological short-comings or comments were identified:

-There is no data to evaluate if the chosen site (Big Egg Lake) is representative of other lakes/perched basins on the delta. Additionally, Big Egg Lake has unknown ecological significance for fish populations.

- Elements of the decision thresholds for this metric are based on another jurisdiction (Florida), and may not be applicable to the Lower Athabasca River ecosystem.

-The COSEWIC/IUCN criteria used to evaluate any potential habitat reduction are derived for terrestrial species and used to examine their range and occupancy of habitat, and thus may not be applicable to aquatic species.

-Connectivity of perched basins was analyzed using “days of loss of connection” over a 50 year timeframe. However, an evaluation of the frequency and seasonality of flooding occurrence would improve confidence in this metric.

**Are there gaps or assumptions in the methods used that may lead to an underestimation of the impacts to fish and fish habitat?**

With respect to the analysis of connectivity of perched basins in the delta, the following gaps or assumptions were identified:

–See sub-section on Climate Change under Assessment.

**What future monitoring or assessment requirements should be implemented to verify predictions?**

-To better consider the range of variability between perched basins on the delta, data collection and analysis should include an examination of at least two extreme scenarios (i.e. the shallowest and highest sills on the delta).

-Field validate the biological importance of these types of perched lakes with respect to fish and fish habitat.

**Report title: Dissolved Oxygen in Side Channels**

**Are the methodologies used to assess the potential impacts to fish and fish habitat robust and sound?**

-No comments.

**Are there gaps or assumptions in the methods used that may lead to an underestimation of the impacts to fish and fish habitat?**

With respect to the analysis of dissolved oxygen in side channels, the following gaps or assumptions were identified:

-Fluctuations of dissolved oxygen in the delta environment were not considered within the analyses.

-The potential importance of "winter kill" of fishes in perched delta basins and their influence on fish populations was not considered.

–See also sub-section on Climate Change under Assessment.

**What future monitoring or assessment requirements should be implemented to verify predictions?**

-Collect additional baseline data and conduct on-going monitoring of dissolved oxygen. This would improve confidence in the analyses, both within mainstem side-channels and on the delta.

**Report title: Lake Whitefish Effective Spawning Habitat**

**Are the methodologies used to assess the potential impacts to fish and fish habitat robust and sound?**

–No comments.

**Are there gaps or assumptions in the methods used that may lead to an underestimation of the impacts to fish and fish habitat?**

With respect to the analysis of Lake Whitefish effective spawning habitat, the following gaps or assumptions were identified:

-The biological significance of Segments #2, 3 and 4 as Lake Whitefish spawning habitat is unknown.

–See also sub-section on Climate Change under Assessment.

**What future monitoring or assessment requirements should be implemented to verify predictions?**

-Suggest testing of these Habitat Suitability Criteria in Segments 4 and 5 (known Whitefish spawning areas).

**Report title: Mesohabitat**

**Are the methodologies used to assess the potential impacts to fish and fish habitat robust and sound?**

With respect to the methodologies used to assess mesohabitat, the following methodological short-comings or comments were identified:

-It is unknown if "mesohabitat" as defined in this EC report (depth, velocity, substrate) is a suitable proxy for unknown habitat niches (i.e. for those species and life-history stages which are data deficient, including adults, juveniles and eggs for some species particularly under ice-covered conditions).

-The mesohabitat analysis does not consider the spatial interaction between the various habitat components, including side channels and tributaries. For example, spatial proximity to stream mouths may be very important habitat to certain species and/or life-history stages.

-There are a variety of ways of defining mesohabitat. In this EC report, the variables considered were depth and velocity (substrate was fixed throughout). However, given the dynamic hydrologic regime within the Lower Athabasca River mainstem, it is known that substrate is not constant over time.

-In this EC, mean column velocity was used as a predictor of fish habitat. However, it is known that water velocity is not constant within the water column.

-An alternative analysis of mesohabitats could be based on channel morphology. Other quantifiable habitat characteristics (e.g. proximity to side channels, edge, thalweg, etc.) could be used as surrogates to represent various habitat types.

**Are there gaps or assumptions in the methods used that may lead to an underestimation of the impacts to fish and fish habitat?**

With respect to the analysis of mesohabitat, the following gaps or assumptions were identified:

-Assumption that substrate is constant (see above).

-Assumption that velocity is constant throughout the water column (see above).

-Assumption that fish distribution is solely related to a combination of three abiotic variables (depth, velocity, and substrate) without considerations of food availability and inter- and intra-specific interactions.

–See also sub-section on Climate Change under Assessment.

**What future monitoring or assessment requirements should be implemented to verify predictions?**

-Determine the spatial location(s) of wetted area that would be lost during the modeled flow scenarios. The spatial identification of these habitats would help identify the potential biological role(s) of these areas for the various species in the Lower Athabasca River ecosystem.

-It is recommended that river profiles (cross sections) be produced using existing information to demonstrate how various flows relate to actual channel morphology. Such river cross sections would be helpful to understand how reducing wetted area might affect fish and fish habitat.

-Examine biological linkages between mesohabitat and their importance to fish and fish habitat. This should include the priority consideration of rare mesohabitats, particularly those mesohabitats determined to be most sensitive to flow reduction.

-Monitoring efforts should be based on the prioritization of various mesohabitats in terms of fish productivity and rarity of specific habitats.

**Report title: Fish Habitat**

**Are the methodologies used to assess the potential impacts to fish and fish habitat robust and sound?**

With respect to the methodologies used to assess fish habitat, the following methodological short-comings or comments were identified:

-Many aspects of the basic life-history characteristics of many species in the Lower Athabasca River remain unknown, particularly during ice covered conditions.

-Although the models used are among the best currently available, they are heavily dependent on the appropriate selection of the fish habitat data (i.e. Habitat Suitability Criteria (HSC) curves). The reliability of these HSC curves is unknown given that they are largely derived from expert opinion and have not been field validated.

-Inter- and intra-specific interactions were not considered (although it is noted that this is an artifact of using the HSC approach).

-Within this EC, fish habitat is defined by velocity, depth, and substrate composition (with the latter fixed at any given site for all flows modeled). However, it is recognized that fish habitat also includes other components such as water temperature, water quality, cover, etc.

**Are there gaps or assumptions in the methods used that may lead to an underestimation of the impacts to fish and fish habitat?**

With respect to the analysis of fish habitat, the following gaps or assumptions were identified:

-There is an assumption of a linear relationship between habitat and population response which remains untested.
*[Note: it is acknowledged that this is an artifact of using the HSC methodology, and that this assumption may be conducive to adoption of a precautionary approach.]*

<u>Coverage of species within Lower Athabasca River ecosystem:</u>
-Fish habitat analyses were conducted for seven species, many of which were noted as relatively abundant and large-bodied. However, 31 fish species are known to occur in the Lower Athabasca River system. There are no HSC curves available for most smaller-bodied and rare species (including many juvenile life-history stages and prey species).

-With the reduction of flows, a loss of important fringe/edge habitat may occur. This could represent a significant loss to certain life-history stages in the Lower Athabasca River (juveniles, fry and eggs) and small-bodied fish. However, based on findings from other large rivers, juveniles may benefit from lower depths and lower velocities, which are noted to increase with reduced flows. It is unknown whether either (or both) of these two situations would apply to the Lower Athabasca River.
*[Note: this relationship would be highly dependant on the morphology of the channel and flows at any given location].*

-The basic life-history characteristics of many species in the Lower Athabasca River remain largely unknown, particularly during winter conditions.

-Within the EC analyses, tributaries and riparian influence were not specifically considered. These are likely to be important fish habitats, particularly given that many fish species exhibit population linkages between tributaries and mainstem rivers as part of their life-history.

-It was noted that relatively few data points were collected during fish telemetry studies.

–See also sub-section on Climate Change under Assessment.

**What future monitoring or assessment requirements should be implemented to verify predictions?**

-See comment regarding river profiles (cross sections) under mesohabitat EC.

-Determine the spatial location(s) of wetted area that would be “lost” during the modeled flow scenarios. The spatial identification of these habitats would help identify the potential biological role(s) of these areas to the various species in the Lower Athabasca River ecosystem.

-Recommend the priority field testing/validation the predictions of HSC curves for particularly sensitive life-history stages (e.g. predicted Long-nosed Sucker habitat) to provide additional confidence regarding habitat preferences for various species. Further recommend that this be conducted as an early component of the monitoring program. *[Note that this was a recommendation by the majority of participants, however, it was not a consensus recommendation.]*

-Given the importance of establishing baseline data for the Lower Athabasca River, and to establish a link between potential habitat loss and population response, on-going fish population studies in the Lower Athabasca River should be conducted. This exercise should also include data mining for existing fish data (e.g. RAMP)).

**Report title: Walleye Recruitment**

**Are the methodologies used to assess the potential impacts to fish and fish habitat robust and sound?**

With respect to the methodologies used to assess Walleye recruitment, the following methodological short-comings or comments were identified:

-Given that lake level had a stronger relationship to recruitment than did mean winter discharge, the relationship between lake level and recruitment could be further explored and assessed. The use of winter discharge was noted to represent a conservative approach to conducting the walleye recruitment analysis.

-There is an inherent range of error in the Water Survey of Canada (WSC) winter discharge data, which might affect the modeled recruitment of walleye.

**Are there gaps or assumptions in the methods used that may lead to an underestimation of the impacts to fish and fish habitat?**

With respect to the analysis of Walleye recruitment, the following gaps or assumptions were identified:

-Habitat quality and quantity were considered separately within the stock recruitment sensitivity analysis. There may be a potential interaction between these factors.
*[Note: the habitat quality assumption is more conservative than habitat quantity toward fish.]*

–See also sub-section on Climate Change under Assessment.

**What future monitoring or assessment requirements should be implemented to verify predictions?**

-Walleye recruitment data should be collected as part of a long-term monitoring program.

-Recommend the field validation of actual use of the deltaic habitat by juvenile walleye (and/or lower reaches of Lower Athabasca River) in the winter.

-Within this EC report, a period effect was noted (i.e. pre- and post- 1986) but the explanation for this effect remains unclear. Possible hypotheses include recovery from over-fishing, and/or the effects of multiple stressors.

**Presentation title: Climate Change Analysis**

**Are the methodologies used to assess the potential impacts to fish and fish habitat robust and sound?**

With respect to the methodologies used to assess climate change, the following methodological short-comings or comments were identified:

-***Important Note*:** Subsequent to the scientific peer review meeting, participants were informed of a recurring error within the Climate Change Sensitivity Analysis and associated reports. The

data presented for the modeled changes to minimum flow and mean flow were reversed. At the very least, this error affects the following data:

Climate Change Sensitivity Analysis Report:
-Figure 1
-Tables 1 and 2
-Table 1 in Appendix 2

Main P2FC report (Sections 5.6 and 8.3):
-Figures 41, 42 and 43
-Tables 3, 15 and 16
-text on page 105

Flow Calculator.
-the climate change portion(s) of the flow calculator.

-The result of this error is that the GCM projections for changes in minimum (winter) flows are often greater than what was reviewed, and changes in mean (summer) flows are often smaller than what was reviewed. It is recommended that the Climate Change Sensitivity Analysis, and any other technical analyses using these climate change projections, be re-conducted to address this error and to determine the potential import of projected changes to minimum and mean flows. A subsequent peer review is also recommended.

-As part of the trend analyses, linear trends for climate change were fitted to the data. However, the apparent trend may depend on the duration of the data set used in the analysis (considering both number and completeness of decadal oscillations). Other models might be more appropriate given the apparent oscillatory nature of the data (e.g. Pacific Decadal Oscillation).

**Are there gaps or assumptions in the methods used that may lead to an underestimation of the impacts to fish and fish habitat?**

With respect to the analysis of climate change, the following gaps or assumptions were identified:

-Relatively small changes per year may cumulatively add up to a significant change over time.

-If observed (actual) instream flow will be the basis for management decisions, the reasons for low flow conditions are irrelevant. Thus, the establishment of an appropriately precautionary flow below which water withdrawals would cease would address concerns for the potential influence of climate change on the Lower Athabasca River ecosystem. However, if climate change becomes more severe, its effects on the Lower Athabasca River will need to be re-assessed.

–See also sub-section on Climate Change under Assessment.

**What future monitoring or assessment requirements should be implemented to verify predictions?**

-Monitor water temperatures, given the linkages between the biological needs of the various life-history stages of species in the Lower Athabasca River.

-Maintain records of timing of ice “freeze-up” and “break-up” events.

*[Noted that this does occur at the Fort McMurray WSC station and is tracked annually by the Alberta River Forecast Centre.]*

-Assess air temperature, precipitation, and water temperature (where possible) over time (not just discharge).

-Given the proposed timeframe for oil sands water extractions, examine the potential influences of climate change over a longer time period (e.g. 2040 to 2069).

-In addition to the analysis of winter and summer flows, analyze trends in flow during other seasons.

**Information discussed within this meeting but not subjected to scientific peer review:**

- HSC curves (previously developed via two expert workshops).
- Proposed flow management options in P2FC report ("an acceptable balance between social, environmental and economic interests regarding water withdrawals").
- The selection of various evaluation criteria (EC) was predetermined by the Instream Flow Technical Task Group (IFNTTG) participants from a larger set of potential hypotheses.
- Although the EBF document (Appendix B) was discussed, it was not within the scope of this review (Appendix B - *Exploration of Potential Assessment Methodologies to Support the Determination of an Ecosystem Base Flow (EBF) for the Lower Athabasca River*).

**Information and/or other considerations not within the scope of this review:**

- Jurisdictional / legal considerations (e.g. water rights).
- First Nations treaty and aboriginal rights and traditional use (considered within another P2FC report not within the scope of this review).
- Socio-economic considerations.
- Human use / human needs considerations (e.g. navigation).
- Water quality / contaminants in Lower Athabasca River.
- Any ecosystem components outside of the mainstem Lower Athabasca River (e.g. tributaries, terrestrial flora and fauna dependant on Lower Athabasca River, etc.).

## CONCLUSIONS AND ADVICE

## 1. What impacts would constitute serious or irreversible harm to the ecosystem structure and function of the Lower Athabasca River as a result of modified stream flow?

For the purposes of this scientific review, participants interpreted "serious" harm to be a detectable effect on the various EC metrics used (or other ECs not yet considered) attributable to reduced flow, and therefore resulting in a "harmful alteration, disruption or destruction of fish habitat" (per S.35 of the *Fisheries Act*). The term "irreversible" was more difficult to define, given varying interpretations of what would constitute biological irreversibility and the timescale over which this would be considered.

However, several scenarios could be considered to be irreversible, including the loss of a species or genetic diversity within the Lower Athabasca River. Fixed infrastructure (e.g. dams) would be considered an irreversible change and a permanent loss of habitat, as might the

withdrawal of water from the Lower Athabasca in sufficient quantity and over a long term. There was also an acknowledgement that the cumulative effect of multiple stressors on the Lower Athabasca River ecosystem could also constitute serious or irreversible harm.

## 2. How does the likelihood of causing serious or irreversible harm vary with stream flow in the Lower Athabasca River?

With respect to the establishment of an Ecosystem Base Flow (EBF), the following guidance is provided:

Regarding the concept of an EBF:

i. Within the P2FC report, it is acknowledged that uncertainty exists around what constitutes an EBF; however, an EBF may be defined as a flow below which water withdrawals would cease to meet a stated ecosystem objective.
ii. Within the current scientific review on the Lower Athabasca River, there was no consensus on what would constitute an EBF.
iii. Given the limited biological data available for the Lower Athabasca River, it is not possible to establish an EBF at this point in time.
iv. However, there was consensus that a flow should be established below which there would be no water withdrawal. The participants agreed that this flow should be established using a precautionary approach, based on the best available science, and should consider the assumptions, uncertainties and errors within and across ECs.

Ecosystem Considerations (including potential effects and interactions of multiple stressors):

i. Assessing potential ecosystem effects of water withdrawals on the Lower Athabasca River requires an ecosystem approach. A watershed management plan, including development of a water budget and consideration of cumulative, multiple stressors should be developed.
ii. Tributaries to the Lower Athabasca River were not within the scope of the P2FC technical analyses. While the tributaries do not constitute a large spatial area relative to the overall drainage basin and thus likely contribute relatively little to the overall flow of the Athabasca River, they likely provide important spawning and rearing habitat necessary to sustain the fish populations in the Lower Athabasca River. Thus, there is uncertainty resulting from considering the mainstem of the Lower Athabasca River in isolation from its tributaries.
iii. Small changes in variables related to particular Evaluation Criteria may in some situations result in small changes to ecosystem functioning. However, these small changes may be compounded over time and/or occur during biologically sensitive time periods, either within or among ECs, potentially leading to serious adverse effects on fish or fish habitat.
iv. In the absence of other data, using wetted area as a proxy for ecosystem-level effects in the Lower Athabasca River is recommended.
[Note: Analyses of wetted area were neither included within presentations nor the technical reports reviewed, however, it is acknowledged that wetted area was considered within the overall P2FC final report.]

Recommendation for monitoring and adaptive management of aquatic resources in the Lower Athabasca River ecosystem:

i. Establish and implement a comprehensive monitoring program coupled with an adaptive management plan or strategy for the Lower Athabasca River. This plan should include the establishment of appropriate performance measures to facilitate monitoring, and should be re-evaluated regularly (e.g. every 1-2 years).
ii. A monitoring program for the Lower Athabasca River should complement the efforts of other on-going initiatives, potentially the Regional Aquatics Monitoring Program (RAMP) in Alberta, if appropriate.
iii. Establish and use an index to track ecological conditions in the Lower Athabasca River over time. This approach should include defining various attributes of the Lower Athabasca River ecosystem to serve as an effective benchmark. This reference condition approach should include the use of appropriate control sites.
iv. Given the size and spatial extent of the Lower Athabasca River ecosystem, select an "index reach(es)" to be studied annually and on a seasonal basis in a comprehensive fashion (including fish presence and movement, etc).

To permit more precision in most EC analyses, the installation of an additional water survey gauge on the mainstem downstream of Fort McMurray (and downstream of all industrial withdrawals) is recommended.

While the models used within the various technical reports are generally acceptable, they are based on a large number of assumptions that cannot be validated with the presently available data. This is detailed within the response to Question #3 (see Assessment section above). Thus, the conclusions from the technical reports must be interpreted in the context of this uncertainty, which remains unquantified. Despite the limitations in the biological information (along with the stated uncertainties), the information reviewed is the best currently available, and can thus be used to provide guidance regarding potential effects of water withdrawals to the ecosystem.

Based on the various analyses presented, it was recognized there were some components of fish habitat that might be affected.

From a hydrologic perspective, the Option H water withdrawal schedule (the non-consensus recommendation in the P2FC report) was found to be proportionally small relative to historic flow conditions during most times of the year in most years in the Lower Athabasca River. Given this information, it is unlikely that the hydrologic character of the river would be changed under the proposed water withdrawals. However, it is difficult to account for the uncertainty associated with climate change scenarios and their potential effects on the amount of water available in the river.

The Lower Athabasca River is most sensitive to water withdrawals during low flow conditions. There is a great deal of both intra- and inter-annual variability in flow in the Lower Athabasca River, with low flows occurring primarily during winter. It was noted that there is a strong correlation between seasonality and instream flow in the Lower Athabasca River. However, there is also a need to consider variation among years. Low flow conditions occur mainly during the winter season but can also occur at other times during years of low precipitation.

There is also uncertainty how actual instream flows relate to channel morphology at given points in the Lower Athabasca River and how this relates to fish habitat for the various species found there.

Those participants most familiar with the Lower Athabasca River suggested that flow alterations in Segment #4 would present a high risk to ecosystem structure and function, due to its relatively shallow nature, along with its characteristic channel braiding. This statement of the relative sensitivity of Segment #4 is based on the suggestion that its peripheral (side-channel) habitat is most important during critical periods of low flow (e.g. in the provision of juvenile rearing habitat). Delta habitats (channels and perched lakes) were also thought to be potentially at risk from low flows although very limited data are available to evaluate such a risk.

Participants discussed whether a proposed instream flow of 87 $m^3$/s during winter periods would adequately protect fish and fish habitat in most instances. As noted elsewhere within this document, there is no HSC information available for many life-history stages of most species within the Lower Athabasca River. This uncertainty is elevated in significance given that it is unknown which species use which ecological niches within the river during various times of year (i.e., basic life-history information is lacking).

A monitoring and adaptive management program is essential given the various data deficiencies within the Lower Athabasca River (information on life-history, distribution, population size of different fish species, etc.). It should be recognized that such adaptive management would still be subject to the uncertainty inherent throughout the IFN process. A well designed monitoring program would address both ongoing monitoring and important data gaps identified within this report.

## 3. In respect of the scientific information used to develop the options of the P2FC report:

**(a) Are the methodologies used to assess the potential impacts to fish and fish habitat robust and sound?**
**(b) Are there gaps or assumptions in the methods used that may lead to an underestimation of the impacts to fish and fish habitat?**
**(c) What future monitoring or assessment requirements should be implemented to verify predictions?**

Responses to each of these 3 sub-questions depended on the individual ECs evaluated; details are provided in the Assessment section.

## 4. If habitat loss is considered a likely consequence of the water extractions as outlined in the P2FC recommendations, provide science advice on the nature and extent of the potential habitat loss and the factors that should be considered when designing habitat compensation to offset these productivity losses.

The various EC reports examined the potential effects of various water withdrawal scenarios under different flow regimes to fish habitat on the Lower Athabasca River. Given the currently available information, it is impossible to assess the precise extent of potential losses to fish habitat. However, these EC reports identify the potential for loss of fish habitat under certain low flow conditions, and that these habitat losses would likely be detected in a well designed monitoring program. It is a reasonable assumption that these fish habitat losses would result in a loss of productive capacity in the Lower Athabasca River.

To assess the nature and extent of these potential habitat losses, participants recommended that an analysis of how the various flows relate to channel morphology be conducted. This exercise does not require the gathering of additional data and can be achieved using existing information for the representative reaches in each segment.

Given these conclusions, participants offered some suggested opportunities for potential habitat compensation projects. Any discussion of proposed compensation measures should consider the question of habitat quality. The following potential compensation measures were discussed and are offered for the consideration of project proponents and habitat managers:

- Improving fish access which may increase productive capacity in Lower Athabasca River (including the consideration of connectivity to side channels).
- Restoration of other degraded fish habitat(s) off-site of the Lower Athabasca River (e.g. not within the watershed).

Other ideas and suggestions regarding potential compensation measures can be found in the accompanying Proceedings document.

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## FOR MORE INFORMATION


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