PHASE 2 FRAMEWORK COMMITTEE REPORT

JANUARY 2010

Dan Ohlson, Graham Long, Compass Resource Management
Todd Hatfield, Solander Ecological Research

Executive Summary

Overview

The Phase 2 Framework Committee (P2FC) was a multi-stakeholder committee established in 2008 to develop recommendations for a Phase 2 Water Management Framework that will prescribe when, and how much, water can be withdrawn from the Lower Athabasca River for cumulative oil sands mining water use. The P2FC and its subcommittees worked through to an assigned deadline of December 2009, and its products will be the subject of consultation led by Alberta Environment and Fisheries and Oceans Canada through 2010 prior to the implementation of a Phase 2 Framework in January 2011.

The P2FC primarily sought to find a set of rules that could effectively and efficiently manage long term, cumulative oil sands mining industry water withdrawals from the Athabasca River. To thoroughly evaluate the rules under consideration with regard to future developments, the committee based its work on a reference ‘high growth’ oil sands mining future development scenario of approximately 3.5 million barrels per day of bitumen production and corresponding water withdrawal requirements from the Athabasca River. The P2FC did not discuss the merits of oil sands development *per se*, and participation in the P2FC did not imply support for any level of future oil sands development. Rather, the process outlined in this report was an attempt to find an acceptable balance between social, environmental and economic interests regarding water withdrawals from the Athabasca River within the context of the growth assumptions stated.

In overview, the P2FC achieved the following:

- Deliberated in an effective, interest-based manner that encouraged joint understanding of all interests.
- Articulated multiple interests in terms of objectives and criteria that served as the basis for quantitative analysis.
- Developed a transparent, collaborative and iterative process for identifying management alternatives.
- Defined multiple alternative management “rule sets” and assessed their consequences under multiple climate change scenarios.
- Developed a sophisticated common understanding of the relationships between potential management rule sets and their consequences for all interests, and of the relative importance that each stakeholder placed on those consequences.

- Identified an efficiency frontier, where fundamental trade-offs across alternatives exists, and narrowed the range of options under consideration toward those where a balance of interests might exist.
- Conducted detailed sensitivity analyses on the final alternative under consideration (Option H).
- Reached agreement on general principles governing an ecosystem base flow (EBF).
- Reached agreement on all major implementation requirements of the Framework to support water management rules once they are established.
- Reached agreement on the general principles and topic areas that should guide the development of an adaptive management program during 2010. The program will focus on the key ongoing uncertainties that may be reduced, which will help inform future adjustments to the management framework.

The P2FC did not achieve consensus on a final set of water management rules. The key area of disagreement revolved around issues associated with the EBF exemption specifications, which deal with withdrawal rules during rare low flow events.

Key Process Steps

A Terms of Reference and set of process guidelines were developed to initiate the planning process. Through these, participants agreed to adhere to a set of guiding principles:

- Decisions would recognize multiple objectives and the potential need for trade-offs.
- Meaningful participation would be facilitated.
- The process would strive for consensus.
- The process would not alter existing legal and constitutional rights and responsibilities.
- The best available information from all sources would be used.

A committee / technical task group structure was set up to follow a facilitated Structured Decision Making approach to planning. Highlights from the iterative steps taken by the P2FC include the following:

Objectives, Evaluation Criteria (ECs) and Modelling Approach

Objectives and evaluation criteria were developed iteratively, progressing from exploration of interest areas and objectives at the broadest level by the P2FC to detailed development of impact hypotheses and assessment of potential impacts by the task groups. The three primary interest areas and evaluation criteria that were the focus of detailed assessments were:

Interest Area	Representative Evaluation Criteria
Ecosystem Health	*Fish habitat; mesohabitat; whitefish spawning; walleye population reduction and population viability;* *off-stream storage footprint*
Traditional Use / Public Use	*Navigation in fall / spring*
Sustainable Economic Development	*Storage requirement; capital cost*

An interactive spreadsheet tool was developed to enable committee members to create flow management alternatives based on their interests, and to assess the performance of these alternatives using a number of representative evaluation criteria or proxy criteria. All alternatives were designed assuming an ultimate oil sands mining industry build out scenario that would require a combined 16 m^3/s average industry water withdrawal rate and a combined 29 m^3/s industry peak water withdrawal rate.

Evaluation Criteria models and supporting assessments, including a range of climate change sensitivity analyses, were also developed and implemented.

Alternatives, Consequences and Trade-Offs

The P2FC evaluated dozens of alternative water management rules in detail during the course of the process. These alternatives were assessed in four rounds; the nature of the alternatives explored is summarized in the table below.

Summary of the Four Rounds of Alternatives Assessment
Round 1 (Alternatives 1 to 7) These seven alternatives included extreme 'book-ends' designed to help participants learn both about technical details and about interests and trade-offs among them. This round of alternatives facilitated the development and testing of modelling tools, and enabled participants to learn how the system worked and how to better develop new alternatives based on the insights gained.
Round 2 (Alternatives 8 to 18) This refined set of alternatives represented a spectrum of approaches put forward by participants to explore interests and seek a general balance between environmental performance and industry storage requirements. Most alternatives employed rules that gradually increased protection as flows in the river decreased, and applied less restrictive withdrawal rules during the summer when flows are higher to allow filling of off-stream storage in advance of the subsequent winter period. An efficiency frontier was identified, where fundamental trade-offs exist, and alternatives are generally superior to others in terms

of environmental performance, storage or both. Participants agreed to explore a sub set of alternatives lying on or near the efficiency curve that might provide a mutually acceptable balance among objectives.

Round 3 (Alternatives 19 to 22)

These four alternatives were developed using a formal set of instream flow protection principles and targeted a notional range for off-stream storage requirements. Storage was translated into cost estimates so that the implications for industry could be better assessed, and the alternatives were rated in terms of their potential impacts on traditional use. An important outcome was the development of Option A, which demonstrated marked improvements in wetted area over the current Phase 1 Framework, while preserving performance with respect to industry interests. Participants agreed that this option was getting closer to an acceptable balance; however there remained keen interest in the establishment of an ecosystem base flow (EBF).

Round 4 (from Option A to Option H)

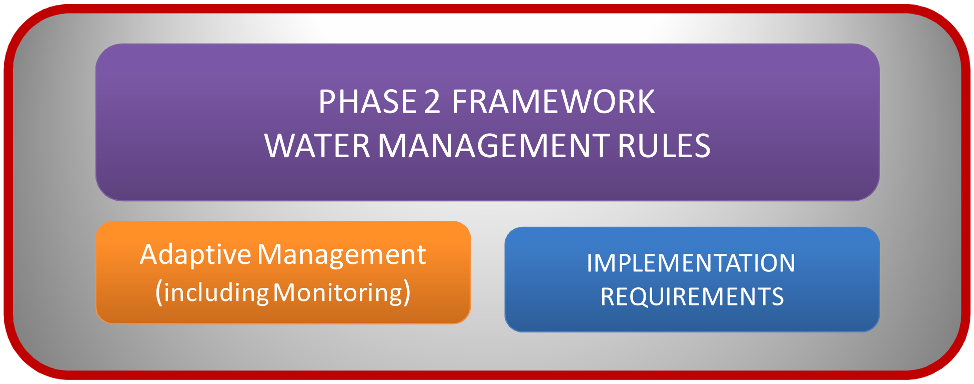
The final round focused on developing variations on Option A that provided additional protection at low flows through an EBF, while incorporating other modifications to the rules set in order to maintain the balance of interests embodied in Option A. In general, these alternatives represented a trade-off of environmental gains in average years (as achieved with Option A) for increased protection in rare low flow years (Options B through H). Option H was the final alternative proposed at this point, and an extensive set of sensitivity analyses was undertaken to provide participants with as much information as possible to take back to their constituents for review.

Key lessons and principles that emerged from this exploration, and are strongly recommended to form the basis of the final water management framework, include:

- Water withdrawal rules should generally be more restrictive as flows decrease.
- Although there is a need to provide instream flow protection throughout the entire year, there should be a hierarchy of protection across seasonal time periods: 1) mid-winter, 2) late winter/early spring, 3) fall/early winter, and 4) summer.
- A specified EBF threshold is a means of providing increased protection during low flow events and refinements to its application on the Lower Athabasca River should continue to be explored.
- Mitigation using off-stream storage (or other equivalent approach to mitigation) is a necessary means of facilitating an effective water management framework.

Final Outcomes

The results of the P2FC process are organized into three basic components – water management rules, implementation requirements and adaptive management plans.



Water Management Rules

Substantial insights were gained from detailed technical analyses and modeling which allowed increasingly sophisticated and innovative alternatives to be developed. Although it was unable to reach full agreement on a single recommended rule set, it did substantially narrow the set of alternatives that merited further consideration.

The closest the P2FC was able to get to a preferred alternative was one referred to as 'Option H'. The definition of Option H in terms of withdrawal rules (R) and thresholds (T) is presented in the table and chart below.

Week		**R1 (m^3/s) If Flow in River F > T1 allow up to:**	**T1 (m^3/s) natural flow**	**R2 (m^3/s) If Flow in River T1 > F > T2 allow up to:**	**T2 (m^3/s) natural flow**	**R3 (m^3/s) If Flow in River T2 > F > T3 allow up to:**	**T3 (m^3/s) natural flow**	**R4 (m^3/s) If Flow in River T3 > F allow up to:**
From	**To**							
1	15	16	270	6% of flow in the river	150	9	87	4.4 (*)
16	18	16	87	4.4 (*)				
19	23	20	87	4.4 (*)				
24	43	29	87	4.4 (*)				
44	52	16	200	8% of flow in the river	150	12	87	4.4 (*)

* The 4.4 m^3/s is based on an allowance of 2 m^3/s to both Suncor and Syncrude (i.e., voluntary reduction of 50 % from licensed peak instantaneous rates to their average annual allocation rates) and an allowance of 0.2 m^3/s to both Albian Muskeg River and Canadian Natural Horizon for freeze-protection of existing infrastucture.

Where:

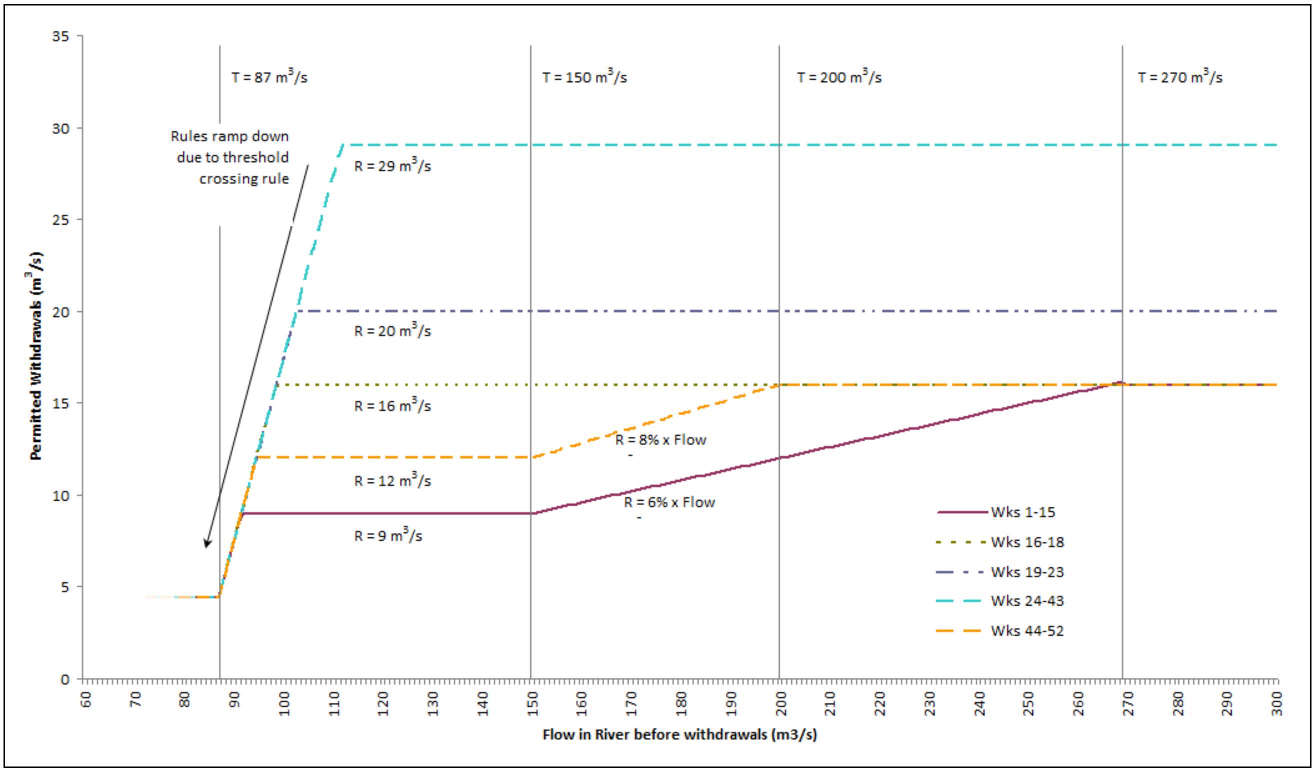
"Week From" and "To" refer to weeks of the year defining periods of applicable rules and thresholds (e.g. week 1 means January 1-7, week 2 means January 8-15 etc)

"T" = A threshold flow in the river in m^3/s, used to determine the application of rules.

"R" = A rule prescribing the maximum permitted weekly average withdrawal by the cumulative oil sands mining industry (m^3/s)

Note that there are four increasingly protective rules that apply during weeks 1 to 15 and weeks 44 to 52: R1, R2, R3 and R4. The application of each is determined by three threshold flows in the river (m^3/s): T1, T2 and T3. R1 applies when the flow in the river exceeds T1. R2 applies when the flow in the river is less than T1 but greater than T2, and so on.

During weeks 19 to 23 and 24 to 43, only one threshold, T1, is used in each case to determine the applicable rule R1 or R2.



Option H includes a Lower Athabasca River Ecosystem Base Flow (EBF) threshold to be set at $87 m^3/s$, which is based on the winter period 1 in 100 low flow statistic for mean weekly flows over the current period of record.[1] The withdrawal rule below this threshold exempts up to a maximum of 4.4 m^3/s from a full cut-off. That is, at levels of flow in the river below 87 m^3/s (i.e., at or below a 1 in 100 low flow event), industry may continue to withdraw up to a maximum of 4.4 m^3/s. This exemption recognizes voluntary withdrawal reductions from existing water license rights for the two senior companies (Suncor and Syncrude) of 50 % from licensed peak instantaneous rates to their average annual allocation rates, and provides infrastructure freeze-

---

[1] The 87 m^3/s value was calculated by averaging the weekly 1 in 100 year low flows for weeks 1 through 11. For reference, it is thought that the lowest weekly average flow in the river over the past 50 years was 88 m^3/s.

protection flows for each of two other existing operations (Albian Muskeg River and Canadian Natural Horizon). The 87 m^3/s effectively serves as a full cut-off threshold for all other water licences, although there is uncertainty regarding how any potential future water transfer application might be considered through the existing regulatory system.[2]

A detailed analysis of the anticipated performance of Option H relative to the existing Phase 1 Framework and other alternatives is presented in this document.

Implementation Requirements

To support and ensure the effective implementation of the final water management rules to be set by the regulators for the Phase 2 Framework, the P2FC developed additional recommendations in four categories:

1. Requirement and Timeline for Built Storage or Storage Equivalent
   The forecast growth in cumulative industry water storage requirements should be provided, though industry may meet the water management rules through equivalent means, including water sharing agreements, technological improvements, curtailing production, or alternate drought response measures.
2. Industry Water Management Agreement
   The annual agreement should provide details of allowable water withdrawals by operator as well as a medium term outlook on cumulative demand and storage or storage equivalent. An efficient notification process should be adopted for any departures from the annual agreement.
3. Flow & Withdrawal Notification Protocols and Compliance Reporting
   Alberta Environment should maintain responsibility to determine and notify industry of the flow rate in the Lower Athabasca River; details are provided on recommended improvements to web-based reporting.
4. Implementation / Management under the Water Act, Fisheries Act & ALSA
   A set of recommendations was developed to ensure the legal certainty in the implementation of the Phase 2 Framework.

---

[2] There are a number of initiatives underway in Alberta focused on recommending changes and improvements to the current water allocation system.

Adaptive Management

Choices made during the Phase 2 process were based on an assessment of the consequences across multiple objectives, using the best available information and knowledge of participants. Inevitably, this knowledge is imperfect, and steps should be taken to address key uncertainties.

The proposed adaptive management program is intended to serve the following purposes:

- To provide the basis for both effectiveness and compliance monitoring;
- To address the fundamental data gaps, uncertainties and competing biological hypotheses that posed a challenge during the Phase 2 analyses;
- To specify management triggers that may signal the need for a formal review prior to a regular 10-year review.

The fundamental uncertainties, knowledge gaps and competing biological hypotheses that were central to the planning process discussions and supporting analyses leading to the Water Management Framework recommendations are identified in the table below.

Hydrology and Compliance	**Biological / Social**
1. LAR Hydrology (including climate change) ▪ Install downstream gauge with winter capability (potentially at the confluence with the Firebag) ▪ Investigate opportunity to improve Fort McMurray gauge winter capability 2. Delta Hydrology (including climate change) 3. Water Use (Withdrawals)	4. Baseline Monitoring 5. Biotic Response to Low Flows ▪ EBF Threshold and Exemption ▪ Competing hypotheses 6. Delta connections 7. Mesohabitat in the Delta 8. Aquatic Mammals 9. Dissolved Oxygen 10. Navigation

Two topics that were highlighted by some stakeholders as particularly important include the biotic response to low flows and mesohabitat in the delta. Preliminary technical proposals for each topic area were developed and detailed technical monitoring plan designs will be developed in 2010.

It should also be noted that while the implementation requirements above were discussed at length during multiple meetings toward the end of the process, there was insufficient time to fully discuss all aspects of the adaptive management recommendations and thus fully reveal the level of committee agreement.

Summary of Areas of Non-Consensus

While there was agreement on the majority of challenging topics addressed in the process, by the time the process was required to end to meet regulatory deadlines, there was not yet complete consensus among the committee. Some P2FC members were of the view that the water withdrawal rules specified in Option H and the recommendations as a whole result in an acceptable balance between environmental, social and economic considerations. Some were of the view that they do not.

The key area of disagreement revolved around issues associated with the EBF exemption. While full agreement on the existence of and level of an exemption to the EBF was not reached, there was agreement on the following principles:

1. There is a low flow at which continued minimum water withdrawals could pose an unacceptable risk to the aquatic ecosystem.
2. At such a flow, it may be appropriate for all water withdrawals to cease.
3. This would require the investigation of the legal, administrative and policy options for doing this in a manner consistent with water rights granted to licensees under the Water Resources Act and preserved in the Water Act.

Despite agreement on these principles, there was disagreement on the EBF exemption and, by extension, the set of water withdrawal rules as a whole. There was also disagreement on the potential voluntary and policy actions that industry and government could or should take to seek resolution.

Based on feedback from constituent organization consultations, and stated as succinctly as possible, the disagreement can be summarized across a spectrum of differing perspectives as highlighted in the table below. Note that these perspectives are not "either / or" as some P2FC members found merit in aspects of perspectives across the spectrum.

	Range of Perspectives ↔	
Water Withdrawal Rules	The EBF threshold serves effectively as a full cut-off for all future operators, while the 4.4 m^3/s exemption is appropriate for both freeze protection and operations of existing facilities that cannot easily be adapted to maintain production without sufficient water. In the development of Option H, the EBF exemption was arrived at through a process of balancing impacts in low	Establishing an EBF threshold is a fundamental component of an IFN prescription. In principle, when flows reach the EBF threshold, there should be no withdrawal of water in order to protect the aquatic ecosystem. In the case of the Lower Athabasca River it may be appropriate for interim, minimum infrastructure freeze protection withdrawals for existing

	flow events with those under average flow conditions, and balancing aquatic impacts with industry storage requirements; any changes to the EBF exemption would require a re-evaluation of the balance of interests embedded in Option H.	operations. The constant withdrawal allowance in the Option H EBF exemption would allow the withdrawal of an increasing fraction of the water remaining in the river as flows and habitat decline to unprecedented levels. This does not represent a balance of interests.
Science & Uncertainty	Option H's 4.4m^3/s EBF exemption is a precautionary approach to managing low flow events (being significantly below the assumed 16 m^3/s demand requirement). Until compelling scientific evidence supports otherwise, however, further reductions of withdrawal are not justified.	Option H's exemption is insufficiently precautionary with respect to the EBF concept. In the absence of scientific certainty, continuing withdrawals is not justified at rare low flows when the potential for increased aquatic impacts is greatest.
Means	Considering further reductions to the EBF exemption raises legal and policy issues that are explicitly outside the scope and terms of reference for this planning process as defined in the agreed upon principles of the P2FC process. Rules governing water transfers are outside the P2FC's scope, and would be subject to government public consultation requirements.	There are voluntary and regulatory actions consistent with existing water rights that could be taken to implement a lower EBF exemption, and these were not effectively explored during the process. The potential for future water transfers could further limit the opportunity to reduce the EBF exemption in the future.

The Committee respectfully puts forward this report and the recommendations it contains, complete with the statements of principle and noted areas of agreement and disagreement, with an understanding that the regulators will take it forth as part of their consultation activities over the next year.

Table of Contents

A Evaluation Criteria Summary Tables

B Exploration of the Ecosystem Base Flow Concept and Potential Assessment Methodologies.

C Threshold Crossing Methods

D Comparing water withdrawal alternatives' effect on traditional use. Memorandum submitted to the Socio-Economic Task Group. Westland, 2009.

E Draft monitoring plan proposals

1. Introduction

1.1. Scope & Mandate of the Planning Process

Oil sands mining uses a water-based extraction process that relies on the Lower Athabasca River as a key source of its water. Water withdrawals from the Lower Athabasca River by the oil sands mining industry and their potential impacts on the aquatic ecosystem have been an issue of concern and debate for several years. On March 1, 2007, Alberta Environment and Fisheries and Oceans Canada released a Water Management Framework that put in place a Phase 1 management system that currently is in effect (AENV/DFO, 2007).

This document describes the outcomes of a multi-stakeholder process aimed at developing draft recommendations for a Phase 2 Water Management Framework for managing the water withdrawals from the Lower Athabasca River. Ultimately, the Phase 2 Water Management Framework will prescribe how much, and when, water can be withdrawn from the Lower Athabasca River for cumulative oil sands mining water use. The overall intent of the Phase 2 planning process was to seek a balance among social, economic and environmental objectives over the long term.

All efforts developed around a rigorous and inclusive planning process, centred on the activities of a multi-stakeholder committee – the Phase 2 Framework Committee (P2FC) – comprised of First Nations representatives, environmental organizations, industry, Federal and Provincial regulators. Although Fort McKay First Nation's interests were actively represented, and Métis involvement also occurred, it is unfortunate that wider active representation of other First Nations and Métis did not occur during the Phase 2 process, despite the efforts of many.

The committee was challenged to complete the development of the Phase 2 recommendation within a fixed regulatory timeline: 2011 is set as the implementation date of a Phase 2 framework, and this draft framework had to be completed a year in advance of this date to enable sufficient consultation. Given the diverse views and values of the participants in the process, this was a challenging task.

The scope of the process was entirely on Oil Sands mining water withdrawals from the Lower Athabasca River. It was recognized by the P2FC that there were numerous other interests and potential future developments that were explicitly not included within this scope, such as: 1) implications for future upstream water users, 2) the potential for other major water users, besides oil sands operations, to require water in the future, 3) water quality concerns, etc.

It is expected that the final results of the Phase 2 Water Management Framework will eventually be incorporated into the efforts on the Athabasca Watershed Planning Advisory Council (WPAC) and the Lower Athabasca Regional Plan (LARP).

1.2. Overview of planning approach

1.2.1. Principles

From the beginning, participants agreed to adhere to the following principles:

- Decisions should recognize multiple objectives and the potential need for trade-offs. The need to ‘balance’ or ‘integrate’ environmental, social, and economic interests through policy and regulatory decision-making is widely accepted. In order to achieve this balance or integration, it was recognized that there will be a need to make trade-offs as part of the decision making process.
- Meaningful participation would be facilitated. The intent was for everyone involved to participate in a meaningful way. In practice this meant:
  - allowing everyone to clearly state their interests, and participate in the search for good alternatives,
  - providing the information necessary to develop understanding,
  - committing to an open and transparent sharing of information, perspectives and values.

  A corollary of this was the expectation that all interested parties would participate in good faith, and not opt out during the process to pursue alternative courses of action.
- The process would strive for but not require a consensus recommendation among participants. Areas of consensus and non-consensus (if necessary) would be clearly documented along with the perspectives of each participating party.
- The process would not alter existing legal and constitutional rights and responsibilities.
- The best available information from all sources would be used.

Within the constraints of time and resources, every attempt was be made to:

- be systematic in the documentation of all sources;
- make all information transparent and open to peer review (with the exception of confidential or proprietary information);
- be explicit about uncertainty;
- prescribe the methods and timing of periodic reviews consistent with the nature of the issues, the degree of information uncertainty, and the opportunity for adaptive management.

1.2.2. Structured Decision Making Process

The process employed a structured decision making approach (Figure 1).

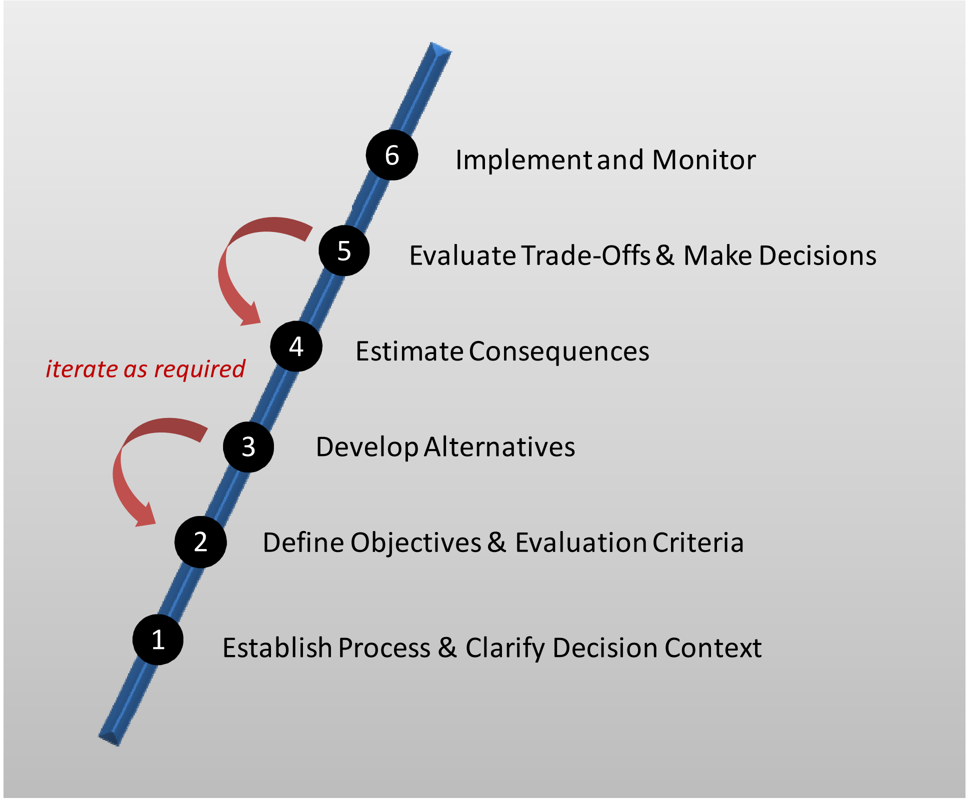


Figure 1: Steps in a Structured Decision Making Process

Structured Decision Making, or SDM, is an organized approach to identifying and evaluating alternatives and making defensible choices in difficult decision situations. SDM is designed to deliver insight to decision makers about how well their objectives may be satisfied by alternative courses of action, how risky some alternatives are relative to others, and what the core trade-offs or choices are. SDM is designed to engage stakeholders, technical experts and decision makers in a decision process that is both analytical and deliberative, using best practices in decision making.

The goal of an SDM process here was to identify and explore core trade-offs, inform committee deliberations, and ultimately to clarify where consensus could be reached and where it could not and why.

A structured decision making process is designed to make complex choices more explicit, better informed, more transparent and more efficient. It does this by:

- structuring the process – clear steps (a road map) and well defined roles for stakeholders, decision makers and technical experts help keep the decision process on track;

- structuring judgments – by decomposing and simplifying complex judgments it helps experts, stakeholders and decision makers think clearly about complex problems and make better and more transparent judgments;
- directly addressing what matters – even when what matters is hard to value using conventional economic or environmental valuation methods;
- linking analysis and consultation – by creating linkages among tasks it makes the decision process more efficient and improves the relevance of technical and stakeholder inputs to decision making;
- providing a sound technical basis for decisions – SDM is based on rigorous evaluation of the consequences of proposed alternatives and emphasizes the development of a strong decision-relevant information base including economic, environmental and socio-economic analyses;
- providing an explicit values-basis for decisions – in contrast to other approaches SDM does not purport to be objective or value-free. It explicitly incorporates the values of stakeholders and decision makers in a structured and transparent way;
- exposing trade-offs – trade-offs are at the core of difficult decisions and, again in contrast to other approaches, SDM addresses them directly;
- exploring creative solutions – by emphasizing the search for joint gains and exposing the nature and magnitude of residual trade-offs, the quality of the solutions is improved;
- clarifying risk – SDM helps people deal clearly and consistently with uncertainty, explore risk tolerance, make judgments about acceptable levels of risk and precaution, and find creative ways to manage residual risks.

This document, like the stages in the P2FC's deliberations themselves, is generally structured around the steps noted in Figure 1, with the next three sections, 2 to 4, comprising to form Step 1.

2. The Planning Context

The Athabasca River originates in Jasper National Park in Alberta, Canada, and flows north through the province draining into the Peace-Athabasca Delta in Wood Buffalo National Park at the Athabasca River terminus in Lake Athabasca. The primary area of interest for this process was the Lower Athabasca River between Fort McMurray and Lake Athabasca, which is approximately 300 km in length. This portion of the river was broken into five segments, or reaches (Figure 2) to facilitate the assessment and to allow independent assessment of different portions of the river and delta.

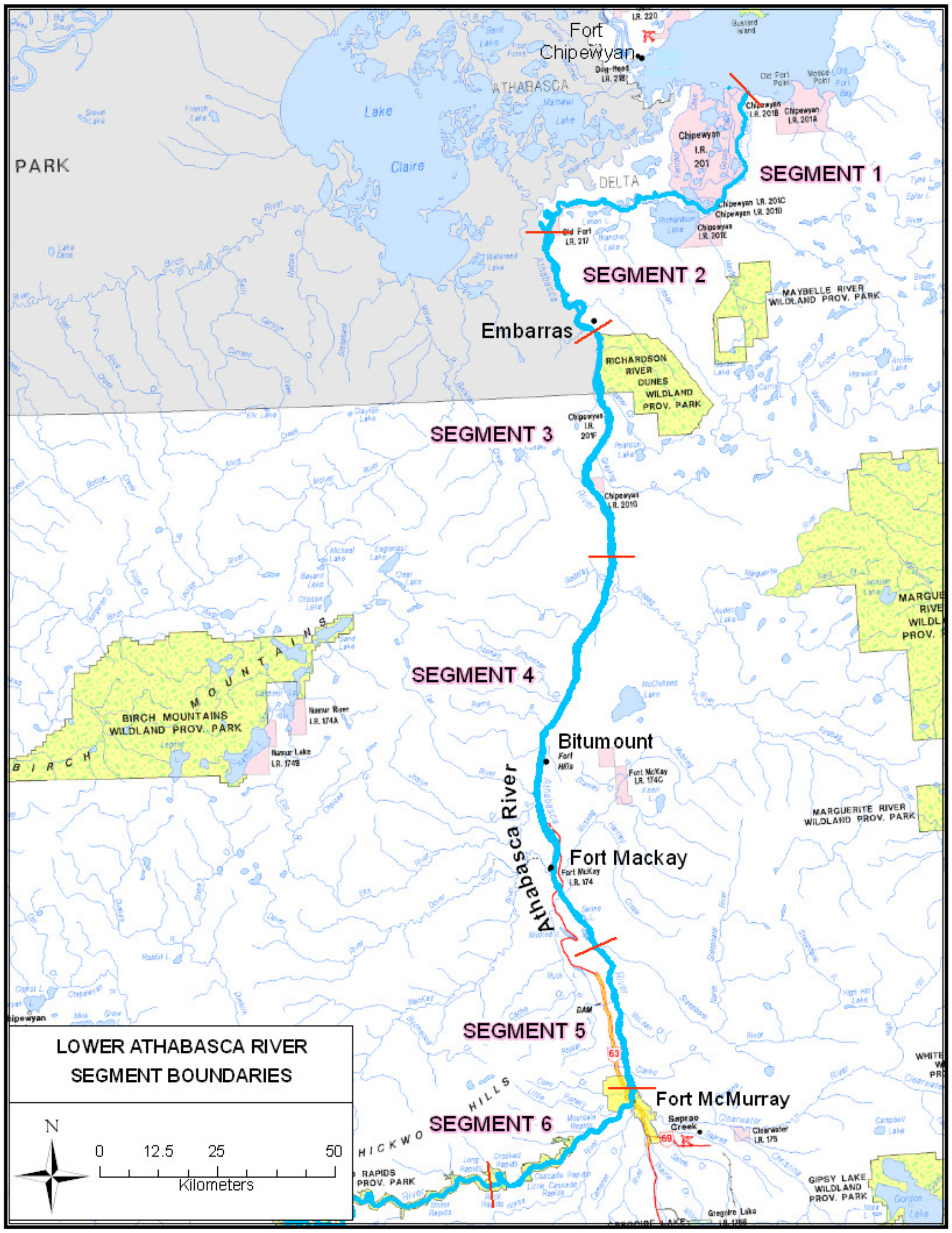


Figure 2: Lower Athabasca River Segment Boundaries

2.1. Hydrology

In this section we introduce a few basic hydrological concepts that may be helpful for some readers.

Like all rivers, the Athabasca River has flows that vary within and across years. Plotting the weekly average data for the past 50 years and taking the weekly average (mean) gives Figure 3. Each light blue line traces the change of average weekly flows of actual individual years, and the black line is the average over all the years.

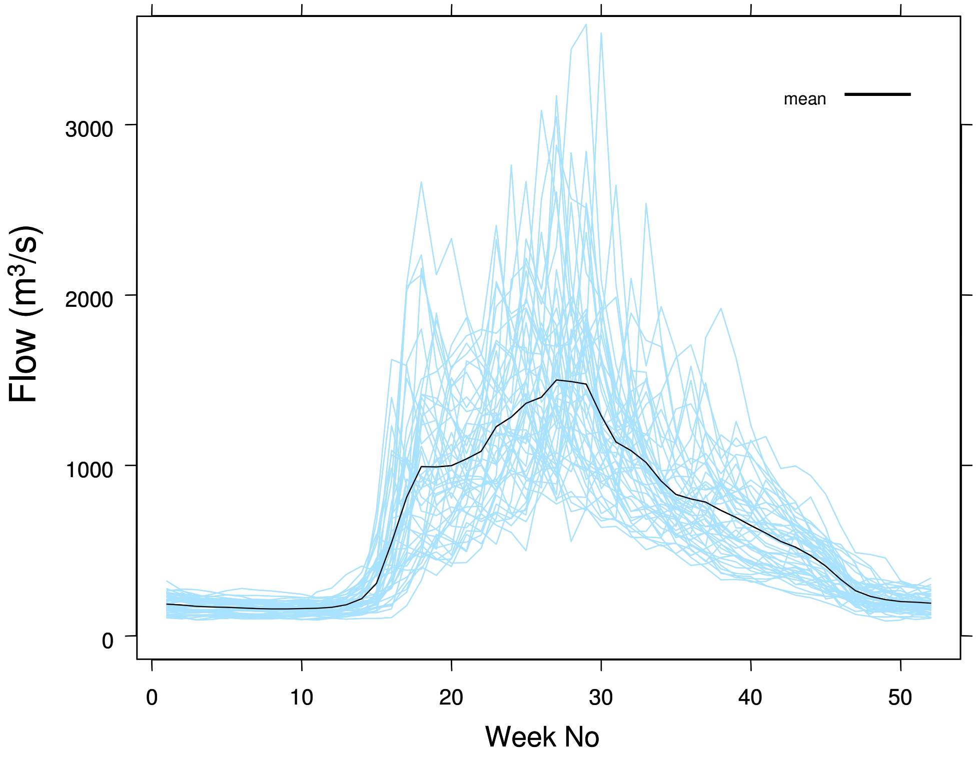


Figure 3: Athabasca River flows. (Week 1 = January 1-7, week 2 = January 8-15, etc.)

Any particular year can follow a wide range of patterns of flow, as illustrated in Figure 4. In this figure, the black line now shows a particular year. Note that some years have relatively high flows all year; some have low flows all year; some begin high but then become low later in the year and so on.

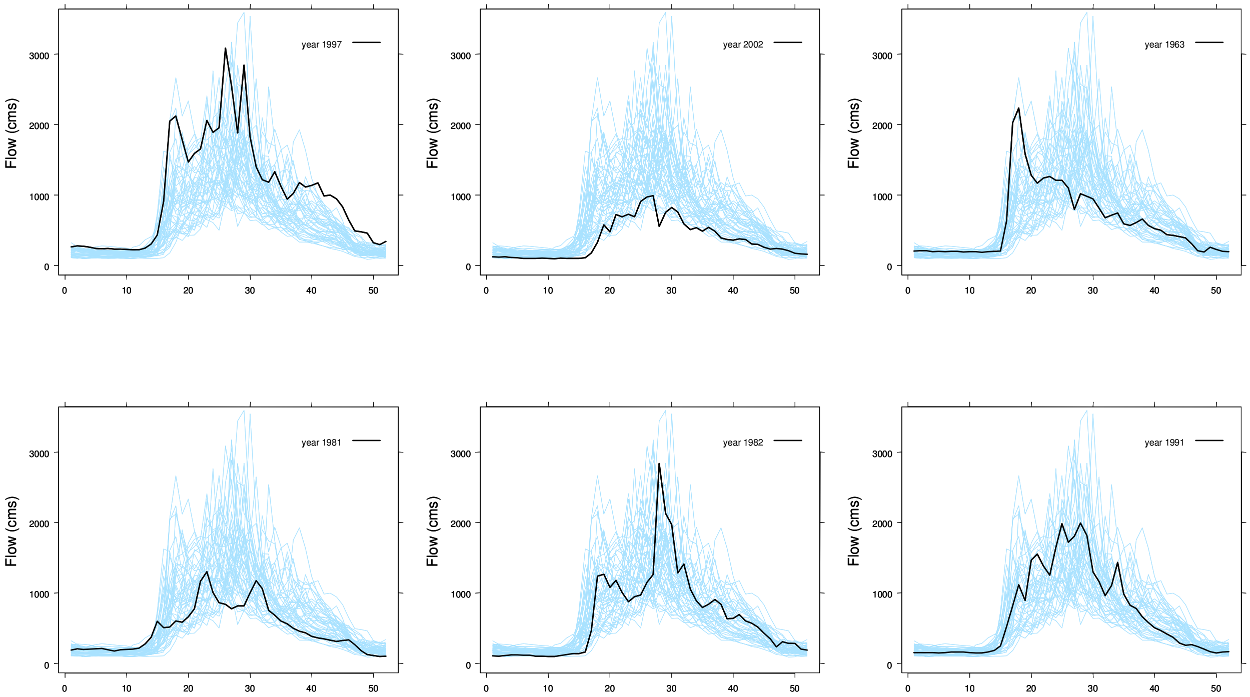


Figure 4: Sample individual years of Athabasca River flow showing within year variability

As we can see, simply taking the average of these annual figures is of limited use in most contexts. Since negative impacts associated with low flows are particularly important in river management situations, we need to have a better way of communicating the characteristics of river behavior, particularly at lower flows.

There are various ways of doing this, but the method used in this planning process was to use the concept of ‘exceedences’. An exceedence value, at least in this process, refers to a particular week of the year.[3] It is a flow in the river that is exceeded by a specified percentage of average weekly flows in the historical record, and is usually written in the form “QX for week n” where n refers to the week of the year and X refers to the percentage of time in that week at a given flow is exceeded. For example:

- Q90 in week 1 = 124 m^3/s means that 90% of the time, or 9 years out of every 10, in week 1 of the year the flow in the river is expected to be greater than 124 m^3/s. Conversely, the flow in the river is expected to be less than 124 m^3/s 10% of the time, or one year out of every ten.
- Similarly Q99 refers to the flow in any given week that is so low that we would expect actual flows in the river to exceed this value 99% of the years for this week (as a weekly average), or, conversely to be lower than this value as a weekly average only one year out of every hundred years.

---

[3] In all cases in this report Week 1 = January 1-7, Week 2 = January 8-15, …… Week 52 = December 25 -31.

Note that for this process, hydrologists were asked to create simulated sets of weekly flows that would be representative of a 1 in 100 and 1 in 200 *winter* as a whole (Also generally referred to as a "one in one hundred" or "one in two hundred" year event or "1:100" year event or "1:200" year event). These simulated years are created using complex statistical methods that capture within-year variability and across year water volumes. More information on this is presented in Section 6.2.1.

Note also that in this process the minimum time scale referred to is a weekly average. In practice, daily or hourly 'spikes' may be different, but it is the weekly average that is taken to matter for framework planning purposes.

Figure 5 illustrates the weekly exceedence concept further by showing three lines of weekly average equal exceedence value: Q10 (which is exceeded only 10% of the time), Q50 (exceeded 50% of the time) and Q90 (exceeded 90% of the time).

Clearly, the larger the number following the letter 'Q', the lower the flow in the river that is being referred to.

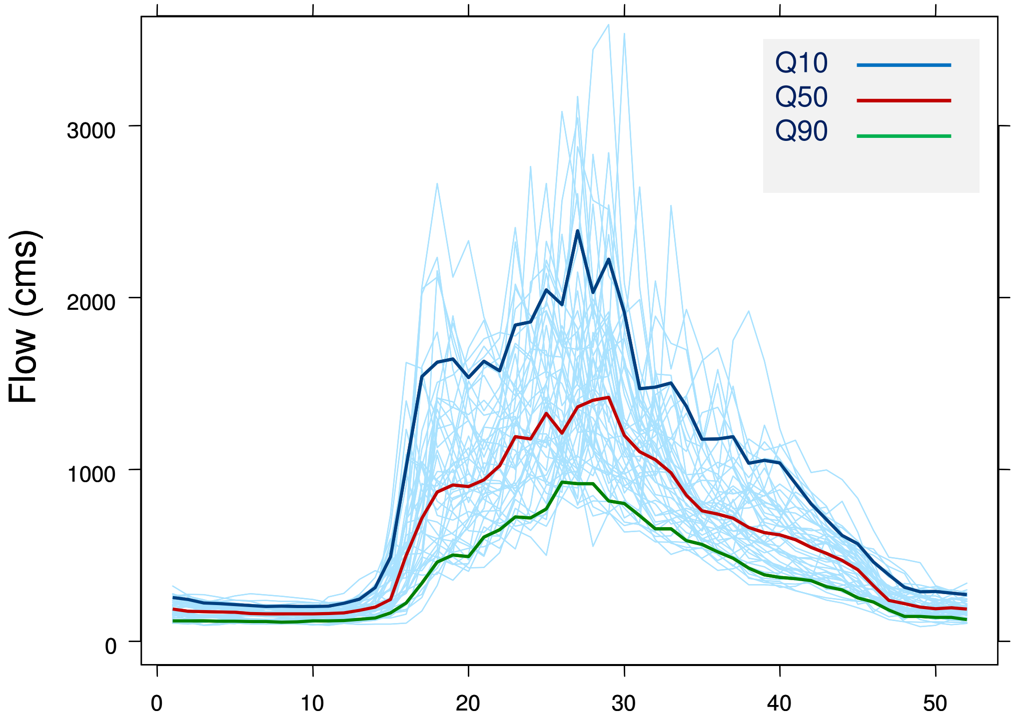


Figure 5: Lines of equal exceedence value for the Athabasca River

For reference, Figure 6 shows a broader range of exceedence values for the 50 year historical data set. In Figure 7 the Y-axis has been limited to 500 m^3/s to show more detail in the winter period.

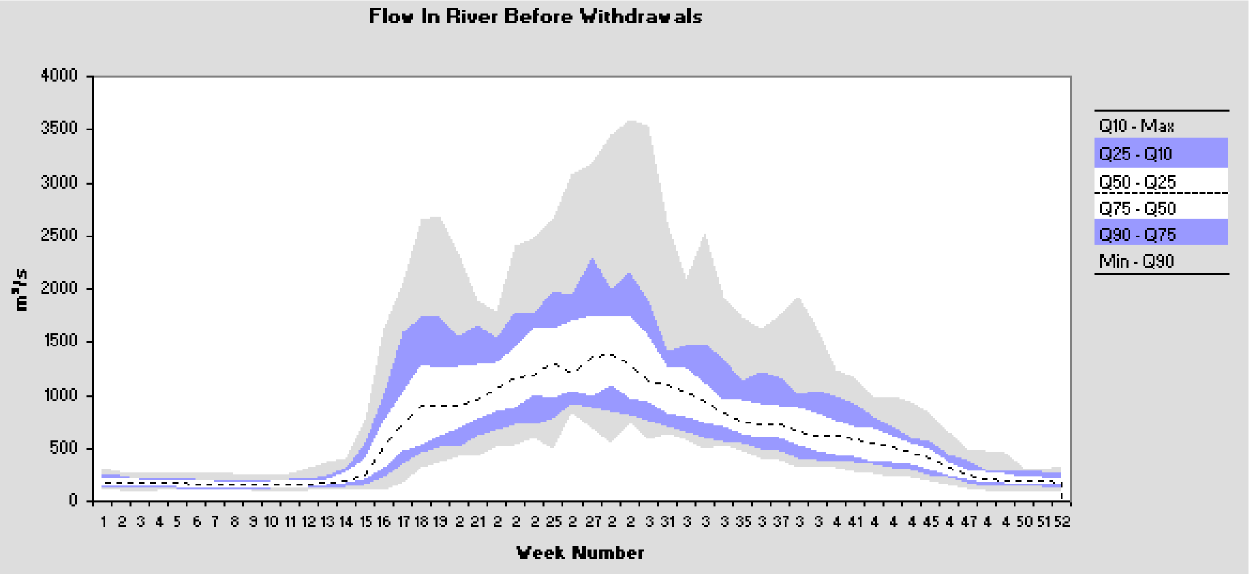


Figure 6: Historical Athabasca flows by statistical range, perspective 1

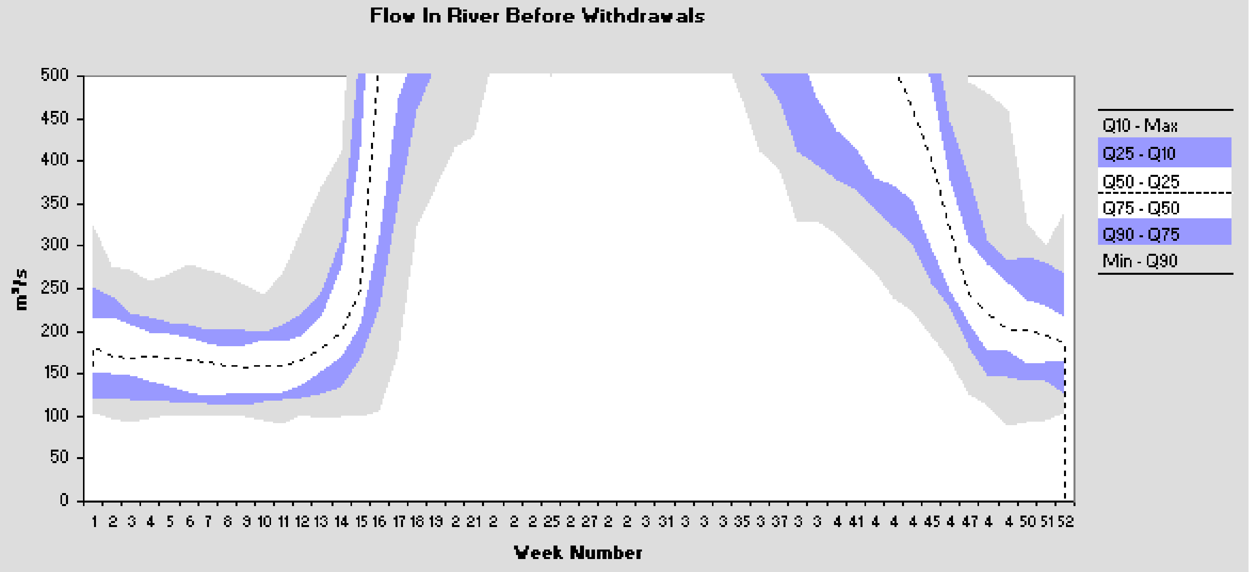


Figure 7: Historical Athabasca flows by statistical range, perspective 2

3. Oil Sands Mining Water Requirements

3.1. General description

The Alberta oil sands mining industry's need for and use of water is summarized in "Surface Oil Sands Water Management Summary Report" prepared for CEMA by Alberta Technology and Science Inc in 2006 (CEMA 2006). This report explains the role that the Athabasca River plays as one source of water required for a variety of purposes, including utilities, mining, bitumen production / extraction and in tailings settling. Water removed from the Athabasca River is not returned there, at least within the life cycle of a mine.

Figure 8 illustrates a typical mine site water balance. The majority of the water taken from the river is ultimately recycled within the plant, and mine operators have incentives to minimize the use of water from the river (e.g., there are costs associated with pumping water from the river, and long-term management implications for all water that is taken onsite). While industry's need for water varies relatively little over a typical yearly cycle, the potential for impact to the fish and aquatic values in the river resulting from that water extraction is much greater in the mid-winter months relative to the open water summer months. For that reason, as Figure 8 also indicates, water regulations that require withdrawals from the river to be limited in the winter may require water to be stored on site to supplement river water during these periods.

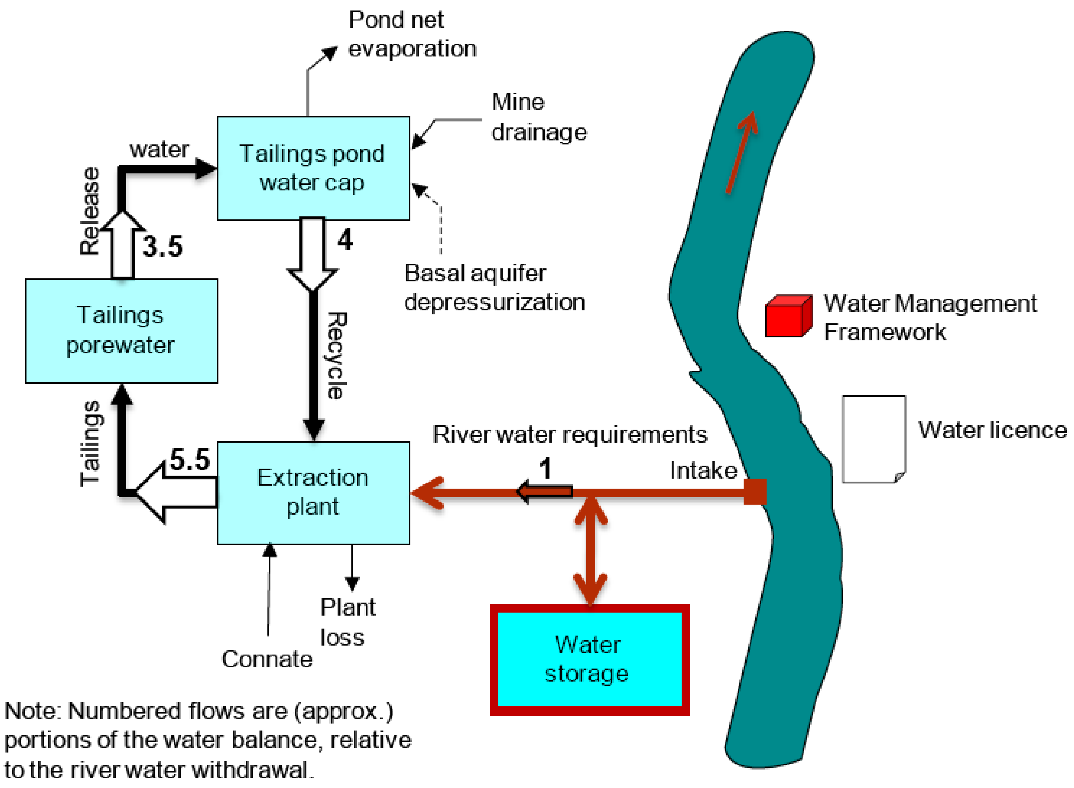


Figure 8: Typical Mine Site Water Balance Source: Golder (2009a)

3.2. Current and Future Oil Sands Water Demand from the Athabasca River

Estimating the future requirements of Athabasca River water by the oil sands mining industry is a complex task for several reasons. First, the industry comprises a number of companies, each of which needs to keep future expansion plans confidential for commercial reasons. Second, the amount of water a mine requires varies over its lifecycle, and so estimating the peak point of water requirement for the collective industry depends on the actual synchronization of mine lifecycles. Third, the oil sands development as a whole will be closely tied to global economic cycles and will be sensitive to the nature of future Canadian and global climate change regulation. Fourthly, estimates of water requirement are dependent on precipitation variability; drier periods result in a greater water requirement from the river than wetter ones.

Nevertheless, recent studies have attempted to make estimates of future average and peak withdrawal demands for the industry as a whole over the coming decades. The studies took a scenario-based approach, leading to ‘base’ and ‘high growth’ scenarios for the oil sands mining industry as a whole.

In 2007, the Athabasca Regional Issues Working Group (RIWG) – later renamed Oil Sands Developers Group (OSDG) in 2008 – developed a long term forecast for oil sands mining cumulative water use. In 2009, OSDG updated the forecast as described in OSDG (2009a), *Volume 2: Technical Appendix*. The P2FC used the forecast completed in 2007. There are only minor differences in the 2009 update.

The forecasts provided the cumulative make-up water required collectively for two scenarios, a base case “2006 Case” scenario consisting of announced or approved projects at the end of 2006, and a Growth Case scenario consisting of announced, and potential future projects considered by industry. The forecasts for the base and growth case used by P2FC are presented in Figure 9.

In these cases, annual water demand was calculated for 1 in 100 year dry conditions when low flows would prevail. Water forecasts from each of the companies were collated and the resulting cumulative demand as a function of time was calculated. The results show that the bitumen weighted average demand is 2.4 barrels of water per barrel of bitumen produced. This balance includes expected efficiency gains with increased recycle rates from tailings management with mine maturity.

In simple terms, mines with consolidated or non-segregated tailings will tend to have a river water: bitumen ratio of about four during the initial years and two or less after water from tailings consolidation is recycled back into the operation. Other tailings depositional methods, such as ‘dry tailings,’ or non-aqueous extraction technologies may improve these efficiencies in time. In the interim however, it is assumed that the current commercial extraction technologies will continue to be used to 2030. The P2FC understood that the trajectories of growth in the two scenarios were uncertain because they contained many assumptions. The recent economic downturn has already altered expectations of the timing, if not the ultimate build-out, of the industry.

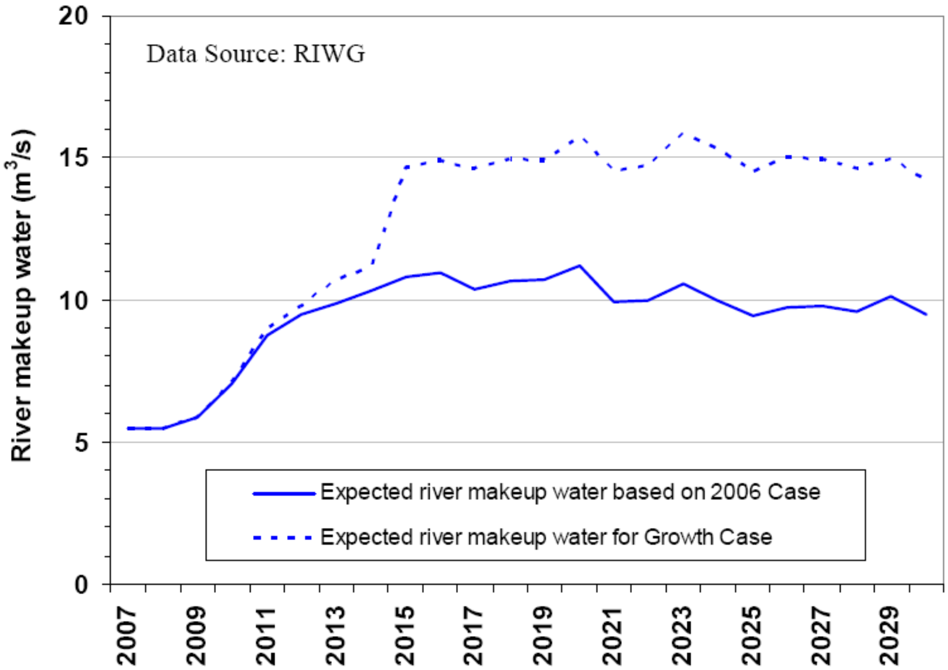
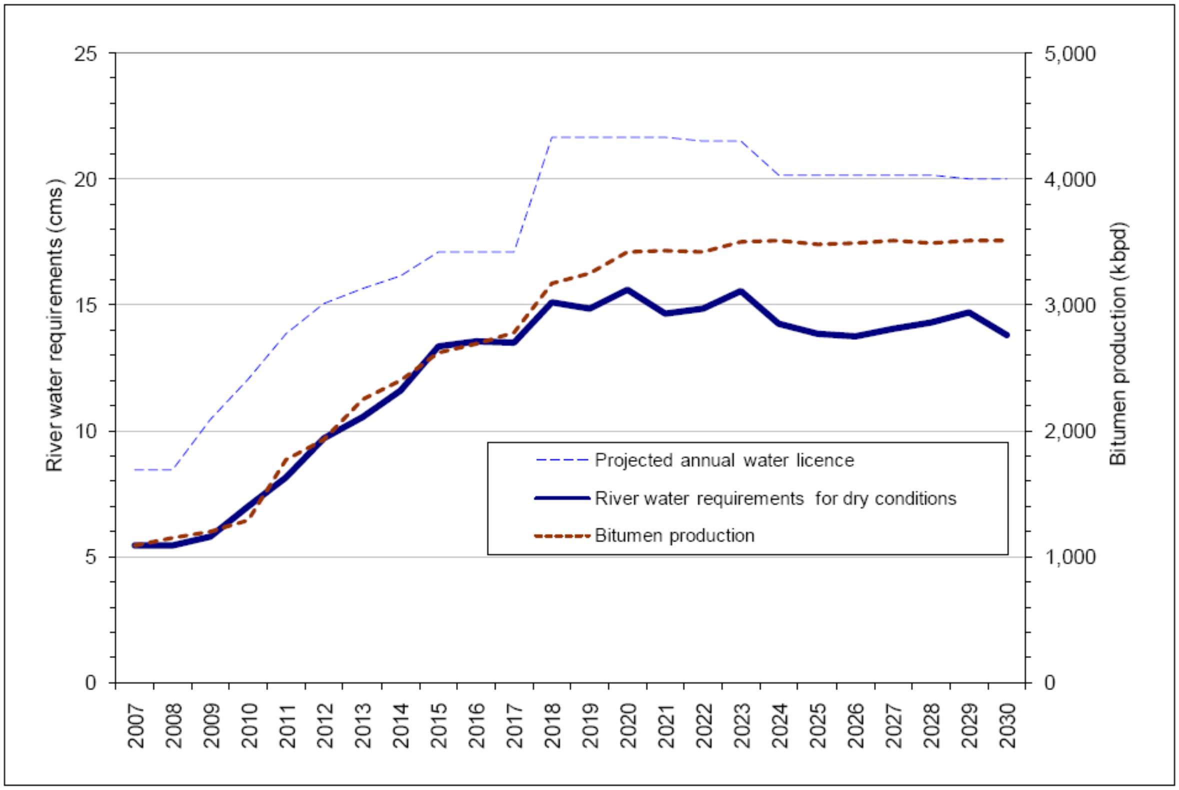


Figure 9: RIWG Forecasts of average industry Athabasca River water demand

The Growth Case scenario produced a plateau in mean water demand of 16 m^3/s. This was adopted as the basis for evaluating the environmental, social and economic performance of alternative rules to manage the amount and timing of withdrawals of water from the Athabasca River. Using the peak mean water demand for P2FC planning purposes allowed the committee to test alternative withdrawal rules against the largest projected water demand from the industry. Use of the maximum mean demand value in the planning exercise must not be misconstrued as an endorsement by all P2FC members of the pace or ultimate scale of development imagined in the Growth Case scenario.

P2FC used the upper line to define a “full build out case” of an average demand of 16 m^3/s with an associated peak demand rate of 29 m^3/s.

During the P2FC process, the forecast was updated OSDG (2009a). In the update, the base case scenario has a peak annual average demand of 11.3 m^3/s and a peak removal rate of 21.6 m^3/s. The Growth Case (Figure 10) sees an average demand of 15.6 m^3/s and a peak removal rate of 33.6 m^3/s.



Note: cms = cubic meters per second; kbpd = thousands of barrels per day of bitumen.

Figure 10 Growth Case average water requirements for the cumulative oil sands mining industry (cms = cubic metres per second) Source: Golder 2009a

These forecasts are very similar with the original projections used by P2FC, and so the P2FC continued to use the demand and peak rates of 16 m^3/s and 29 m^3/s respectively.

4. The Committee Structure, Roles & Responsibilities

4.1. Introduction

The committee / task group structure for the Phase 2 process is illustrated in Figure 11.

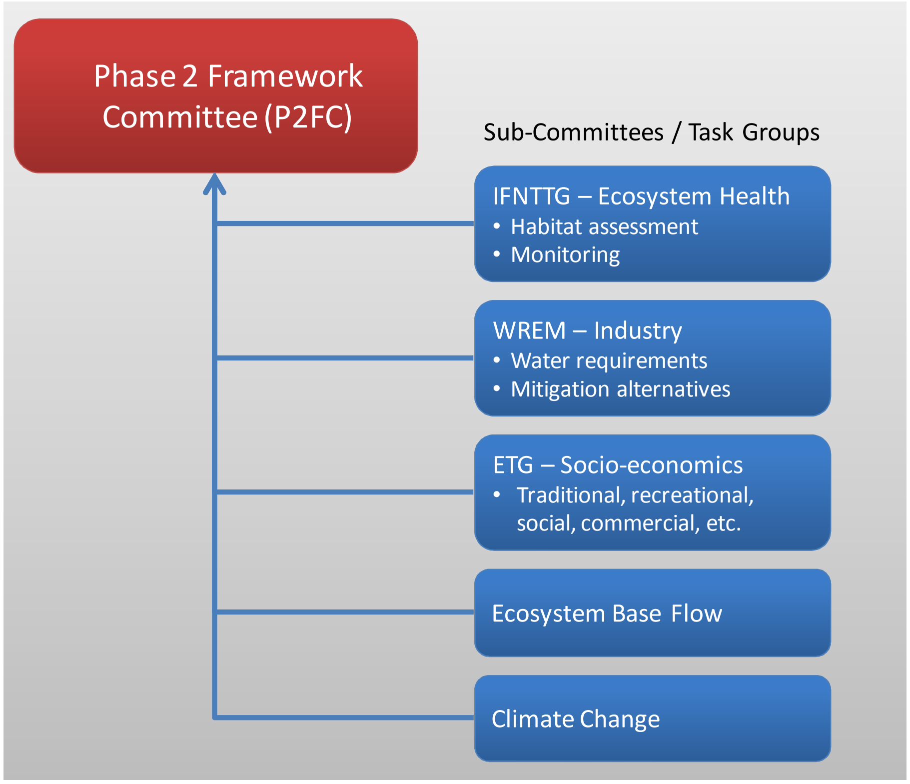


Figure 11: Committee / task group structure for the Phase 2 process

4.2. Phase 2 Framework Committee (P2FC)

The following groups and organizations were represented on the P2FC Committee:

- Alberta Environment
- Alberta Sustainable Resource Development
- Alberta Wilderness Association
- Canadian Natural Resources Limited
- Energy Resources Conservation Board
- Fisheries and Oceans Canada

- Fort Chipewyan Métis
- Fort McKay First Nation
- Imperial Oil Resources
- Parks Canada – Wood Buffalo National Park
- Petro-Canada (merged with Suncor in 2009)
- Shell Canada Energy
- South Peace Environmental Assoc.
- Suncor Energy
- Syncrude Canada
- Total E&P Canada
- World Wildlife Fund Canada

These organizations were present as observers at various times during the process:

- Fort McMurray Métis 2020
- Opti Canada
- Regional Municipality of Wood Buffalo

As regulators, Alberta Environment and Fisheries and Oceans Canada participated throughout the process providing valuable guidance along the way. They did not, however, play an active role in the development of, or agreement to, the recommendations given their ultimate role as decision makers.

The P2FC met a total of 15 times over the course of 2008 and 2009 at a wide variety of locations in Fort McMurray, Calgary and Edmonton. The P2FC acted as the central point for discussions, and delegated technical questions and other activities to the various subcommittees, which returned information for the P2FC's approval.

4.3. Instream Flow Needs Technical Task Group (IFNTTG)

The IFNTTG, sometimes referred to simply as the IFN group, provided the biological expertise that underpinned the consideration of potential impacts of water withdrawals on the aquatic ecosystem. This group considered a large number of potential impact hypotheses, developed the aquatic evaluation criteria (ECs) and conceptually designed and prioritized much of the adaptive management monitoring proposals. The group generally attempted to understand how the various flow alternatives might affect aquatic values, and to communicate this professional opinion to non-biologists on the P2FC to help them evaluate competing alternative management regimes from this perspective.

4.4. Water Requirements Engineering Mitigation Task Group (WREM)

The WREM group was a pre-existing body with the task, ongoing through the Phase 2 process, to explore and characterize possible engineering responses to future possible regulatory frameworks. WREM ’s tasks often involved collaboration with the Oil Sands Developers Group (OSDG), an oil sands industry association responsible for the analysis and compilation of proprietary information. WREM oversaw the development of cost, footprint and other estimates associated with engineering mitigation options that might be required to meet the draft Phase 2 framework as it developed.

4.5. Economics Task Group (ETG)

The ETG’s purpose was to help characterize the social and economic impacts of alternative flow withdrawal alternatives. This group’s work focused primarily in understanding the impacts on local communities, especially First Nation and Métis, that could result from the various flow withdrawal alternatives.

4.6. Ecosystem Base Flow Sub Group (EBF)

This group was convened for a short period during the Phase 2 process to tackle specific questions around the development of an Ecological Base Flow for the Lower Athabasca River.

4.7. Climate Sub Group (CSG)

Like the EBF sub-group, the climate sub group was created during the Phase 2 process to consider the means by which climate change considerations could be integrated into Phase 2 discussions.

Finally, an occasional ‘modeler’s group’ would meet to discuss issues of concern primarily to flow /withdrawal modelling development, assumptions and related issues.

5. Interests, Evaluation Criteria & Supporting Assessments

5.1. Overview

The process of developing objectives and evaluation criteria was iterative, progressing from exploration of interest areas and objectives at the broadest level by the P2FC to detailed assessment of potential impacts by the task groups. Early in the process, the P2FC developed an overall guiding objective:

> *To manage water withdrawals from the Lower Athabasca River in a manner that supports ecosystem health, traditional use, public use, and sustainable economic development, while encouraging learning and adaptation over time.*

Three primary interest areas were identified to organize detailed assessments:

- Ecosystem Health – Instream Flow
- Traditional Use / Public Use
- Sustainable Economic Development

The IFNTTG, ETG and WREM tasks groups were generally responsible for detailed planning and assessment efforts in each interest area respectively.

Specific tasks included the development and screening of:

1. Impact Hypotheses, which conceptually describe how changes in water flows affect valued ecosystem components and socio-economic /traditional use activities.
2. Evaluation Criteria, which are detailed metrics for use in comparing management alternatives accurately and consistently.

5.2. Ecosystem Health – Instream Flow

The IFNTTG coordinated all tasks related to ecosystem health and instream flow. Their approach used techniques that are common within the field of environmental impact assessment, starting with conceptual diagrams of impact pathways and progressing to detailed quantitative modeling of impacts where possible. Detailed assessments focused on aquatic biota and habitats, but assessment of terrestrial biota and habitats was completed where the IFNTTG believed there was a possibility of these being affected by water withdrawals in the mainstem.

A conceptual “means-ends” diagram is presented in Figure 12, and shows how water withdrawals can affect fish abundance and diversity in the Lower Athabasca River. The effect of water withdrawals on flow in the river depends on the timing, magnitude, frequency, duration and extent of water withdrawals. For example, a withdrawal of 10 m^3/s in the winter may reduce total flow in the river by 10% or more, whereas the same withdrawal in the summer may reduce total flow by less than 0.5%. Likewise, the effect of withdrawal during a "dry" year may be considerably different than the same withdrawal during a "wet" year. The effects of withdrawal can operate over a continuum of spatial and time scales, which are indicated in the means-ends diagram as geomorphic, mesohabitat and microhabitat scales. Effects on habitat at these scales can alter the availability of habitat, abundance of food, interactions with competitors and predators, which in turn can influence growth and survival and ultimately influence the abundance and diversity of fish in the river.

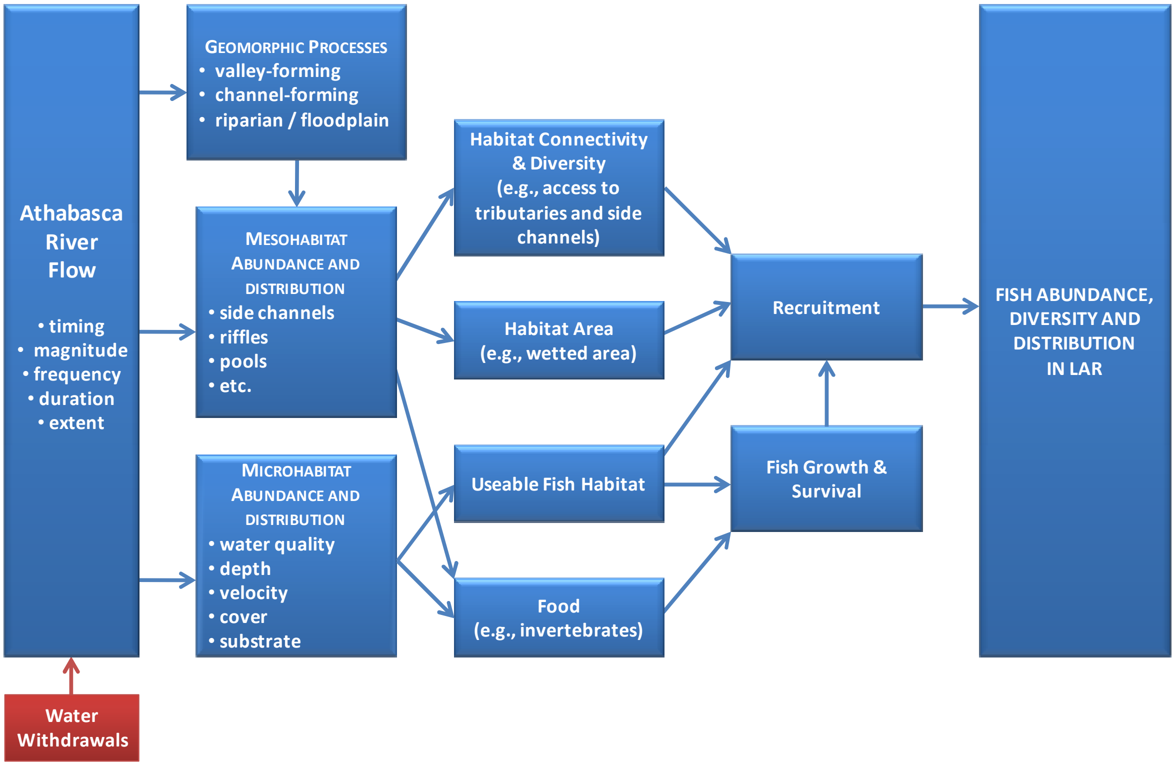


Figure 12: Example means-ends diagram that identifies conceptually how water withdrawals can influence fish abundance and diversity in the Lower Athabasca River.

5.2.1. From Impact Hypotheses to Evaluation Criteria

The first stage of the IFNTTG's assessment was a scoping exercise in which impact hypotheses were developed and evaluated. Impact hypotheses described how a particular ecological component might be affected by water withdrawals. Most of the impact hypotheses were developed at a workshop in May 2008, with a few additions and revisions completed at further meetings. The primary questions addressed were, what resources are present in the study area, and what impacts might occur to these resources from water withdrawals?

In total, 29 impact hypotheses were developed. Each impact hypothesis was screened using existing information, and rejected, accepted or categorized as not applicable or data deficient. 11 impact hypotheses were rejected or deemed not applicable, based on available information. 18 impact hypotheses were accepted or deemed to require additional assessment. The assessment of all 29 impact hypotheses is presented and discussed in Franzin (2009). It is important to understand that during this scoping exercise “acceptance” of a hypothesis implies only that this issue required further investigation and analysis.

Following initial scoping of the 29 impact hypotheses the IFNTTG then worked systematically through the 18 hypotheses that were not rejected. The hypotheses were refined and additional effort was expended in collating existing relevant data or collecting new data with which to assess each hypothesis. At this stage, some hypotheses were rewritten, combined with other hypotheses, or rejected. This additional effort led to further winnowing of the list of impact hypotheses, until 11 hypotheses remained and progressed to a process of preliminary analysis and model development (see Figure 13). Impact hypotheses led to the definition of evaluation criteria (ECs) – specific metrics that would be useful in evaluating and comparing alternatives. Once final ECs were defined, models were developed to estimate them for each alternative.

During the process of impact hypothesis refinement and EC development, candidate topics for an adaptive management program were identified when either: i) existing data gaps precluded quantitative modeling or in some cases even defining an EC, or ii) a key uncertainty was identified during the EC model development or later alternative evaluation process.

The IFNTTG worked to develop detailed models for each of the 11 “accepted” impact hypotheses. Deficiencies in the availability of relevant data, time and resources resulted in the following changes.

- Riparian Flows in Segment 2-5 was believed to be conceptually redundant to the EC developed for Channel Maintenance Flows in Segment 2-5, and was abandoned as a separate EC.
- An EC for "Riparian" Areas in the Delta was abandoned due to lack of relevant data; it was also suggested that the measure would be somewhat redundant to other measures for the delta.
- Access to Side Channels and Tributaries was believed to have similar data requirements to the EC being developed for Dissolved Oxygen, and was postponed until these data became available. At present, the hypothesis has not been addressed.
- An EC could not be developed for Aquatic Mammals in the Delta due to lack of sufficient data and expertise. A scoping study (Hood et al. 2009) was initiated during the Phase 2 Process, and was completed near the end of the process. An EC could not be developed in time for use during Phase 2 evaluations.

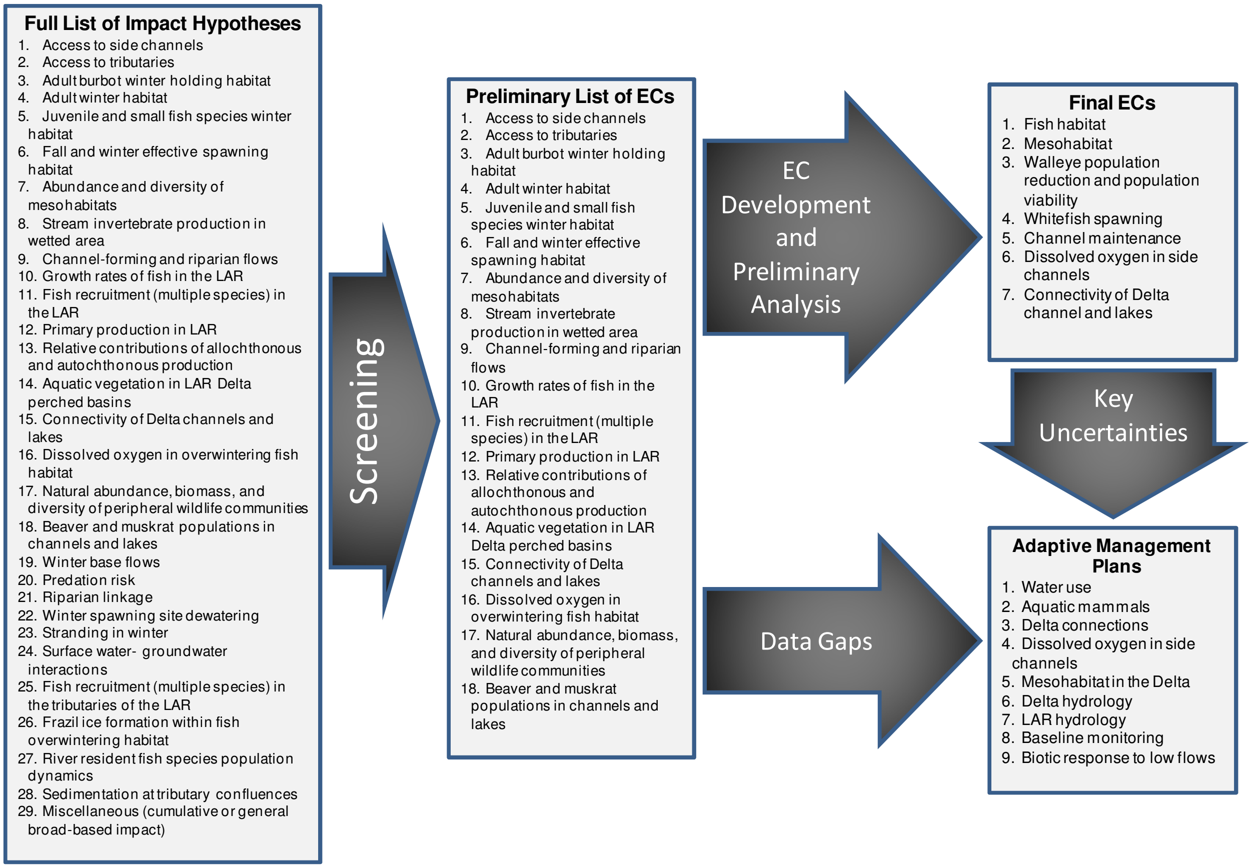


Figure 13: Summary of impact hypotheses, those that were developed into evaluation criteria, and resultant data gaps and uncertainties leading to adaptive management plans

The final list of ECs developed by the IFNTTG is as follows:

1. Fish Habitat
2. Mesohabitat
3. Walleye population reduction and population viability
4. Whitefish Spawning
5. Channel Maintenance Flows
6. Dissolve Oxygen Concentrations in Side Channels
7. Connectivity of Delta Channel and Lakes

A brief summary of these ECs that were used in the alternatives development and evaluation process is provided below. Additional summary information on each EC is contained in Appendix

A, and a full description of the technical approach and modelling details is provided in *Volume 2: Technical Appendix* (2009).

5.2.2. Fish Habitat

The fish habitat ECs addressed the following impact hypothesis: Water withdrawals influence the quantity and quality of habitat available for fish; reduction in habitat decreases individual survival or reproductive potential.

Results from the fish habitat EC are expressed as three “life-stage metrics” as follows:

> **Life-Stage Metric A** — Mean loss in habitat when habitat is in the 80-100% habitat exceedence range. This is a measure of chronic habitat loss that occurs when density-dependent interactions (e.g., competition, predation, disease transmission) are potentially elevated.
>
> **Life-Stage Metric B** — Mean loss in habitat when habitat is in the 0-80% habitat exceedence range. This measures chronic habitat loss that occurs when density-dependent interactions are less severe.
>
> **Life-Stage Metric C** — Maximum instantaneous weekly habitat loss across all habitat conditions. This is a measure of acute habitat loss across the full range of habitat conditions.

The life-stage metrics were further summarized using two fish community-level indicators.

> **Percent of life-stages affected** — The proportion of life-stages that are predicted to have a detectable decline in population abundance based on the individual life-stage metrics. The metric is broken down into ice-covered and open-water conditions and calculated for each segment. This measure provides an indication of the breadth of habitat loss across space (i.e., river segments) and fish community (i.e., number of life-stages).
>
> **Life-stage with largest habitat loss** — This measures habitat loss relative to natural conditions for the life-stage in the river segment with the greatest habitat loss. This provides an indicator of severity of impact.

The assessment of fish habitat was based on the distribution of natural habitat as the benchmark condition for different species (walleye, northern pike, longnose sucker, goldeye, burbot and flathead chub); life-stages (spawning/egg incubation, fry, juveniles and adults); water condition (open-water or ice-covered); and, river segment (segments 1 – 4) using River2D hydraulic models and habitat suitability criteria. Habitat loss relative to natural was measured using three life-stage level metrics that captured chronic or acute losses within each river segment.

The two fish-community metrics were recommended as evaluation criteria for assessing flow alternatives. Analysis during development of this EC indicated that it may be significantly affected by water withdrawals, so the EC was calculated for assessment of all alternatives.

A summary of this EC is presented in Appendix A. The fish habitat EC is described in detail in Paul and Locke (2009a), *Volume 2: Technical Appendix*.

5.2.3. Mesohabitat

A mesohabitat is defined as a discrete area of stream exhibiting relatively similar characteristics of depth, velocity, slope, substrate, and cover, and variances thereof. For example, mesohabitats may be defined as cobble-dominated riffles, bedrock pools, sandy runs, etc. Unlike the fish habitat EC, which combines modeled hydraulic measures with suitabilities for different species and life stages, the mesohabitat EC assesses only hydraulic measures. In other words, there is no explicit biological translation of the hydraulic values to a specific biological measure. There is an assumption that the different mesohabitat categories are biologically meaningful, but that meaning is not explicitly tied to fish, invertebrates, wildlife or plants. The IFNTTG has described the mesohabitat EC as a “safety net” for a variety of aquatic ecological values not captured in models for fish.

The mesohabitat ECs address the following impact hypothesis: The abundance and diversity of mesohabitats in the lower Athabasca River is a function of flow and will therefore be influenced by water withdrawals; and the natural distribution of mesohabitat types in both space and time is important to sustaining the ecological structure of the river. It is assumed that mesohabitat types can be defined by their water depth, water velocity, and substrate type and that biological communities depend upon these mesohabitat types.

Results from the mesohabitat EC are expressed as three “mesohabitat-level metrics,” which in turn were summarized as two measures of “ecosystem effect.” These are described as follows:

> **Mesohabitat-Level Metric A** — Mean change (either gain or loss) for a given mesohabitat type when habitat is in the 80-100% habitat exceedence range. This is a measure of chronic habitat change when density-dependent interactions (e.g., competition, predation, and disease transmission) are potentially elevated.
>
> **Mesohabitat-Level Metric B** — Mean change (either gain or loss) for a mesohabitat type when habitat is in the 0-80% habitat exceedence range.
>
> **Mesohabitat-Level Metric C** — Maximum instantaneous change (either gain or loss) for a mesohabitat type across all habitat conditions. This provides a measure of acute habitat change across the full range of habitat conditions.

Mesohabitat-level metrics were summarized using two indicators to capture ecosystem-level effects, as follows.

Percent of mesohabitat types impacted — The proportion of mesohabitat types that show significant changes. The metric is broken down into ice-covered and open-water conditions, and is calculated separately for each river segment. This metric provides an indication of the breadth of habitat change across river segments and mesohabitat types.

Habitat loss for most sensitive mesohabitat type — This measures habitat loss relative to natural conditions for the most sensitive mesohabitat type in the most sensitive river segment. This metric reports only the largest habitat loss because habitat loss is assumed to be of greater biological importance than habitat gain. Habitat loss for the most sensitive mesohabitat type provides an indicator of the severity of the impact on the most sensitive mesohabitat type.

The two ecosystem-level metrics were recommended as evaluation criteria for assessing flow alternatives. Analysis during development of this EC indicated that the issue may be significantly affected by water withdrawals, so the EC was calculated for assessment of all alternatives.

A summary of this EC is presented in Appendix A. The mesohabitat EC is described in detail in Paul and Locke (2009b), *Volume 2: Technical Appendix*.

During the Phase 2 Process, the mesohabitat EC as calculated for Segment 1 was very sensitive to withdrawals. The significance of this result was difficult to assess, due to the lack of explicit connection between the mesohabitat hydraulic measures and biological species or communities. The IFNTTG recommended that the necessary work to conduct the biological assessment be completed during the monitoring program. [See Section 9.5: Adaptive Management Plans]

5.2.4. Walleye Population Reduction and Population Viability

The Athabasca River Delta is an important spawning and nursery area for walleye (Sander vitreus) from Lake Athabasca. Walleye are more abundant in the Lower Athabasca River portion of the delta.

The walleye ECs address the following impact hypothesis: Recruitment of walleye is affected by low winter flow in the delta region of the Athabasca River. The EC has two separate metrics:

1. **Walleye Population Reduction** – Defined as the mean percent decrease in natural walleye population abundance caused by reduced young-of-year walleye recruitment from a flow alternative.
2. **Walleye Population Viability** – Defined as the probability of the walleye population dropping below a critical extinction threshold (20% of equilibrium abundance) within 100 years. This measure is referred to as walleye population viability.

Analysis during development of this EC indicated that the issue may be significantly affected by water withdrawals, so the EC was calculated for assessment of all alternatives.

A summary of this EC is presented in Appendix A. The walleye EC is described in detail in Paul (2009a), *Volume 2: Technical Appendix*.

5.2.5. Whitefish Spawning

Lake Whitefish (Coregonus clupeaformis) migrate from Lake Athabasca to the Athabasca River during the fall to spawn. Spawning in the Lower Athabasca River occurs almost exclusively on substrates coarser than sand (i.e., gravel, cobbles and boulders). Spawning occurs above segment 4 as coarse substrate types are more common and large numbers of migrating Lake Whitefish have been observed in these upper reaches. Spawning in segment 4 and below is also expected to occur but there is less information available. Lake Whitefish spawning in segment 6 of the river occurs through the month of October.

The whitefish spawning EC addresses the following impact hypothesis. Water withdrawals influence the quantity and quality of Lake Whitefish effective spawning habitat by potentially: a) interrupting spawning of fall spawning fishes; b) causing selection of alternate lower quality spawning sites; and, c) affecting incubation and hatching of eggs and embryos, respectively. The EC distils many complex ideas and measures into a single value that is an average across a 50 year time series. The EC is calculated as follows.

1. measure the average flow during the fall spawning season (weeks 40-43)
2. calculate suitability for spawning of each discrete 10m X 10m grid cells over the modeled River2D study space at that flow
3. measure the minimum flow during the incubation period (weeks 44-14)
4. calculate suitability for incubation of each grid cell at the minimum incubation flow (suitability for incubation is used to represent egg survival)
5. calculate effective spawning habitat across space by determining how much weighted spawning habitat survives the incubation period (multiply step 2 by step 4 and sum areas weighted by this product).

The above steps are repeated for each year in the 50 year time series, to give an effective spawning habitat time series. The loss of effective spawning habitat is calculated for each year as the difference between the natural flow series and the alternative. The EC reports the mean loss across the 50 year time series.

Analysis during development of this EC indicated that the issue may be significantly affected by water withdrawals, so the EC was calculated for assessment of all alternatives.

A summary of this EC is presented in Appendix A. The whitefish EC is described in detail in Paul (2009b), *Volume 2: Technical Appendix*.

5.2.6. Channel Maintenance

The magnitude, frequency, duration and distribution of moderate, bankfull, and overbank flows determine the stability and distribution of instream habitats for fish and other aquatic organisms. Channel maintenance flows occur relatively frequently, in the order of annually to every 2-5 years. The range of flows from about 60% to about 160% of bankfull typically account for about 80% of sediment transport and are defined here as channel maintenance flows.

The channel maintenance EC addressed the following impact hypothesis: Water withdrawal under some circumstances may limit channel maintenance flows that determine quantity and quality of available habitat in the Lower Athabasca River and thereby affect aquatic ecology.

The EC is expressed relative to natural flows in the Lower Athabasca River in a measure called Loss in Natural Channel Maintenance Range. Results from modeling indicated that this EC needs to be considered only if water withdrawals of approximately 600 m^3/s or greater are anticipated or a major on-stream storage reservoir is planned.

A summary of this EC is presented in Appendix A. The channel Maintenance EC is described in detail in Bothe and Franzin (2009), *Volume 2: Technical Appendix*.

5.2.7. Dissolved Oxygen Concentration in Side Channels

Maintenance of dissolved oxygen concentrations in the Lower Athabasca River is essential for the maintenance of suitable habitat for fish and other aquatic organisms. During winter months, when ice cover reduces re-aeration to near zero, dissolved oxygen can decline to critically low levels. Species vary in their response to low dissolved oxygen, but for most there is a lower limit below which aquatic habitat becomes unusable. The province of Alberta has established water quality guidelines for dissolved oxygen.

The dissolved oxygen EC addressed the following impact hypothesis: Water withdrawal under some circumstances may reduce flows into or disconnect side channels from flow and thus cause reduced oxygen concentrations due to biochemical oxygen demand (including sediment and loading of reduced chemical species).

Dissolved oxygen reductions were calculated from two factors: the length of time a wetted area has near zero flow and the known biochemical oxygen demand of the Lower Athabasca River. Modeling indicated that anticipated water withdrawals from the Lower Athabasca River are unlikely to have a measurable impact on dissolved oxygen. The model indicates significant areas are threatened by a potential for low DO naturally, however, losses from additional withdrawals are small.

A summary of this EC is presented in Appendix A. Details of the dissolved oxygen modeling are presented in McEachern (2009), *Volume 2: Technical Appendix*.

The modeling and analysis of DO in relation to water withdrawals could not be finalized during the Phase 2 Process. Results based on a one-dimensional hydraulic model, and initial results from a three-dimensional model, indicated a small effect of withdrawals. However, some questions remained with respect to the interactions between suitable fish habitat and the DO modeling results. Therefore, the significance of any changes in DO due to withdrawals could not be adequately assessed. The IFNTTG recommended that the necessary work to finalize this assessment be completed during the monitoring program. [See Section 9.5: Adaptive Management Plans]

5.2.8. Connectivity of Delta Channel and Perched Lakes

ECs for the connectivity of Delta channels and lakes addressed two distinct components of connectivity in the Delta: connections during winter among distributaries, and frequency of flooding of perched basins. Separate ECs were developed to address each component.

Connectivity of Delta Channels.— Connectivity of LAR Delta channels in the winter is a function of flow and ice cover. The primary assumption for this EC was that reduced connectivity would affect the quantity and quality of available habitat in the river, which in turn may affect aquatic ecology. The ecological effects could not be quantified, so the EC focused on changes in connectivity as the indicator or response to withdrawals.

The connectivity of Delta channels EC addressed the following impact hypothesis: Water withdrawal under some circumstances may limit connectivity of the LAR Delta channels and distributaries thereby impacting the free movement of fish and the quantity and quality of available habitat in the delta.

The EC was expressed in a measure based on reduction in the frequency and duration of connectivity between the main channels and distributaries in the LAR Delta. Analysis during the development of this EC indicated that the issue was not significantly affected by water withdrawals, so the EC was not calculated for all alternatives beyond the first round of analysis.

A summary of this EC is presented in Appendix A. Complete details of the EC and results of initial sensitivity analysis are described in Ghamry *et al*. (2009a), *Volume 2: Technical Appendix*.

Perched Basins.— Unpredictable, and sometimes dramatic, large flood events are characteristic of the Athabasca Delta. Flooding can occur in spring during break-up or in mid-summer during peak discharge. During floods, water spills out of the main stem into side channels and the deltas many basins. Low-lying basins are connected to the main channel every year during high flow while some perched basins may receive flood waters only once per decade. A combination of topography, ice jams, melt rates, vegetation and river discharge determines which basins are flooded in a given year. Since the delta area is extremely flat, small increases in water depth result in large increases in wetted area. The frequency and duration of floods determine the types of vegetation that can survive and flourish and in turn the type of habitat available to wildlife. The Delta provides some of the most significant waterfowl breeding and staging habitat in North America, is a major spawning site for fish migrating between delta lakes and rivers, provides habitat for wood bison, and supports moose, muskrat and other species.

The perched basins EC addressed the following impact hypothesis: Water withdrawal under some circumstances may limit connectivity of perched basins thereby affecting the quantity and quality of available habitat in the associated floodplain and thereby affecting the aquatic and terrestrial ecology of the Athabasca Delta.

The EC was expressed in a measure based on reduction in the frequency and duration of connectivity between the river and the floodplain in the LAR Delta. Analysis during the development of this EC indicated that the issue was not significantly affected by water withdrawals, so the EC was not calculated for all alternatives.

A summary of this EC is presented in Appendix A. Complete details of the EC and results of initial sensitivity analysis are described in Ghamry *et al*. (2009b), *Volume 2: Technical Appendix*.

5.2.9. Uncertainty and MSICs

It is understood by all participants that there is incomplete scientific understanding of the relationships between flow and the different environmental components (e.g., fish, geomorphology, riparian habitats, etc.) as represented by the IFN ECs described above. This means there is uncertainty in the predicted outcomes of changes in hydrology.

To the extent possible, the IFNTTG was explicit in describing the sources of uncertainty in each EC. At the same time, it is not possible to be entirely quantitative when characterizing the uncertainty because impacts on the environment interact through three types of models: 1) hydrologic measurements, 2) physical models that predict changes in abiotic conditions with changes in flow, and 3) environmental models that predict biotic changes based on changes in abiotic conditions. Although it was not possible to provide quantitative estimates of all sources of uncertainty, it was considered prudent to provide a qualitative, overall assessment of uncertainty to aid the P2FC in their decision-making.

Overall uncertainty was expressed in a measure called the Minimum Significant Increment of Change (MSIC), based on the following:

1. ***Level of Modeling Uncertainty*** — This is a judgement of the reliability of the EC to accurately reflect both direction and magnitude of environmental impacts. This measure addresses the question: *How accurately does the EC reflect the environmental impact of an alternative?*
2. ***Chance That Modeling Errors Will Change the Ranking of Alternatives*** — This is a judgement of the reliability of the EC to systematically rank (i.e., order) the alternatives. This measure addresses the question: How reliably does the EC rank an alternative

relative to other alternatives? Note that it is possible to have a fairly high degree of uncertainty without affecting the ranking of alternatives.

3. ***Critical Modeling Assumptions and Issues*** — As a guide to the primary drivers of uncertainty, a brief listing of key modeling assumptions is provided, with a description of how these assumptions contribute to uncertainty in the EC outputs.

The MSIC is a roll-up measure, a judgement of the relative change in an EC that should be considered meaningful when comparing alternatives. The MSIC allows one to answer the question: *Is the difference between two alternatives real (not an artifact of noise/inaccuracy in data and modeling) and biologically significant?*

Note that the MSIC addresses uncertainty related to data and modeling, but does not provide information on which ECs may be more important in influencing the fundamental objective of maintaining the distribution, abundance and diversity of fish and wildlife in the Athabasca River.

Table 1 provides a summary of the MSIC values for the aquatic ecosystem health ECs that were used in the evaluation of alternatives. So for example, an MSIC of 2% for Fish Habitat Metric A means that a change of 2% in the calculated value of the metric should be sufficient for participants to interpret that there is a real and potentially biologically significant effect on fish. In contrast, given the quality of data and modeling underlying Mesohabitat Metric A, a change of 5% in the calculated value is needed before participants should conclude that the calculated difference was real and of potential interest.

Table 1: Summary of MSICs for select aquatic evaluation criteria.

Evaluation Criterion	MSIC
Fish Habitat: Metric A – Mean loss in habitat when habitat is likely to be limiting.	2%
Mesohabitat: Metric A – Mean loss for a given mesohabitat type when habitat is likely to be limiting.	5%
Walleye Recruitment • Walleye Recruitment • Walleye Population Viability	 2% 0.1%
Whitefish Spawning	5%
Channel Maintenance Flows	NA [1]
Dissolved Oxygen in Side Channels	NA [2]
Delta Channels and Lakes • Connectivity of Delta Distributaries • Connectivity of Perched Basins	 5% 5%

1. This issue was dismissed as a significant concern before an MSIC was determined.
2. This EC was not completed in time to be used in the Phase 2 process, and an MSIC was not determined.

5.2.10. Measurement Scales and Reference Points

All ECs were expressed as % change relative to natural. The EC responses on their own give us four important pieces of information:

1. whether the variable of interest (e.g., fish habitat) is responsive to proposed withdrawals,
2. the direction (positive or negative) of response,
3. the magnitude of response, and
4. the form of the response (i.e., how rapid is the response and is there non-linearity in the relation to water withdrawal).

This is all important information to be considered in a decision, but for non-specialists it is difficult to address the obvious question of "What does it mean for the stated objective?" Addressing this question requires establishing or using existing reference points to gauge the "significance" of the response. The IFNTTG believed the P2FC would benefit from this additional context for the EC responses.

Reference scales were established to provide the P2FC with guidance regarding the biological significance of a response. Three levels of expected change were set for each EC using the following general categories: undetectable change, detectable change and potentially irreversible change. Conceptually, these levels are shown in Figure 14.

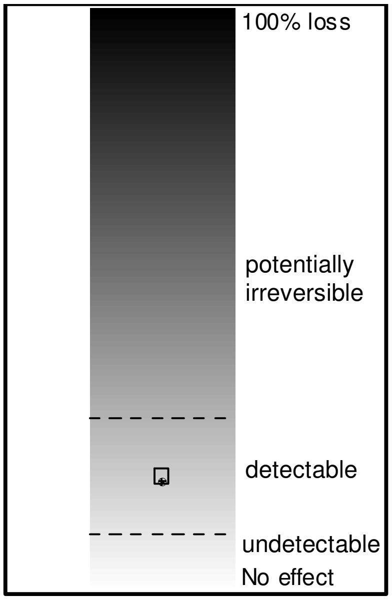


Figure 14: A conceptual diagram showing the response of a hypothetical EC in response to water withdrawals. The response varies from no effect to 100% loss. Two thresholds separate three zones of response: undetectable, detectable and potentially irreversible. The response to one or more water withdrawal alternatives can be plotted on this space along with the MSIC as a guide to biological significance.

There are two important aspects to understand regarding these zones of response and the thresholds that separate them. The first, is that the boundaries between the zones do not represent levels of discrete change. In most instances the response to water withdrawals is continuous and gradual, and the point at which one ascribes significance is a judgement based on experience, convention and past decisions. In an effort to acknowledge the different types of information supporting the thresholds, the IFNTTG used the following descriptions:

1. Benchmarked Thresholds: These are thresholds based on empirical information collected from comparable systems that document geomorphological or ecological change from natural given alterations to flow.
2. Established Provincial, Federal or International Thresholds: These are thresholds that are either government policy or well documented guidelines. Examples of this type of threshold include provincial water quality guidelines, International Union for Conservation of Nature (IUCN) or Committee on the Status of Endangered Wildlife In Canada (COSEWIC) recommendations.
3. Best Opinion Thresholds: These thresholds are based on literature and expert judgement.

From these descriptions, the boundaries between impact levels are somewhat subjective. The boundaries represent thresholds that have been used by resource managers in similar situations, based on existing information, standards and guidelines. The impact levels are provided for context when assessing EC outputs for different management alternatives.

The second point to emphasize, is that the reference scales and thresholds for all ECs were established well in advance of defining water management alternatives for consideration in the decision process. The one exception to this was the higher threshold for mesohabitat Metric A, which was established toward the end of the process. When considering thresholds for this metric there was little guidance available, and in the end a threshold was decided based on the logic used for the other ECs. Since the thresholds were established well ahead of the alternatives, they could not be adjusted or manipulated to derive a particular conclusion regarding the decision outcome.

5.2.11. Reducing the Suite of IFN ECs

During the Phase 2 Process the outputs from ECs were compiled in a consequence table to allow a comparison of the effects of different alternatives. Initial consequence tables included outputs from the full array of aquatic ecosystem ECs. Despite the IFNTTG's efforts to minimize the number of ECs, the consequence tables remained lengthy and complex. The P2FC therefore tasked the IFNTTG with further reducing the number of ECs.

The group used two primary methods to reduce the suite of environmental ECs: insensitivity and redundancy. Across a suite of 17 alternatives, several ECs were found to be insensitive. That is, they showed little variation in response to modeled water withdrawal alternatives. It was agreed that these ECs could be de-emphasized since they did not differentiate among modelled alternatives, and in a general sense offered little or no insight into the performance of different alternatives. (As a matter of process, it was agreed that all ECs would be calculated and made available, but that some would be de-emphasized during discussions at the P2FC.) The ECs in this category included: walleye population viability, % of fish life stages impacted by reduction in habitat, and % of mesohabitat types impacted.

Additional effort went into formally examining redundancy among ECs. During earlier winnowing of the impact hypotheses, the hypotheses were examined for conceptual redundancy, and the IFNTTG was satisfied with the reduced set of hypotheses (Franzin 2009) that were used as the basis for EC development. To examine statistical redundancy, ECs were calculated for 17 alternatives and plotted as scatterplot matrices, or sploms, to assess correlations among ECs. An example splom is provided in Figure 15 for the mid-winter period (weeks 1-12). Below the diagonal, sploms show pairwise comparisons of EC scores across the alternatives. Within each pairwise plot, points are identified as the result of an alternative (i.e., alternative 1 to 17). When the EC scores form a line in one of the pairwise plots, the two ECs can be said to be correlated; where the line is tightly confined, as opposed to a loose cloud of points, the two ECs are highly correlated. Pearson correlation coefficients are indicated above the diagonal. Where correlations are high, the two ECs provide the same information because the form of the response to water withdrawal is similar, although the response scale may differ.

There are several key points to be made, based on the scatterplot matrices. The first is that wetted area is highly correlated with other ECs. For example, wetted area in the winter is perfectly correlated with fish habitat and mesohabitat in the winter period, and highly correlated with the whitefish spawning EC. This means that wetted area is a good proxy for fish habitat and mesohabitat (at least as measured by those ECs), to a large extent for whitefish, and to a lesser extent for walleye. As described further in Section 6.2.3, wetted area was built into the Flow Calculator as an approximate measure of aquatic habitat, and these results indicate that this approach is reasonable, especially for exploration and initial construction of alternatives. There appears to be little risk that ecologically important detail is lost when using wetted area as a measure of ecosystem response to water withdrawals.

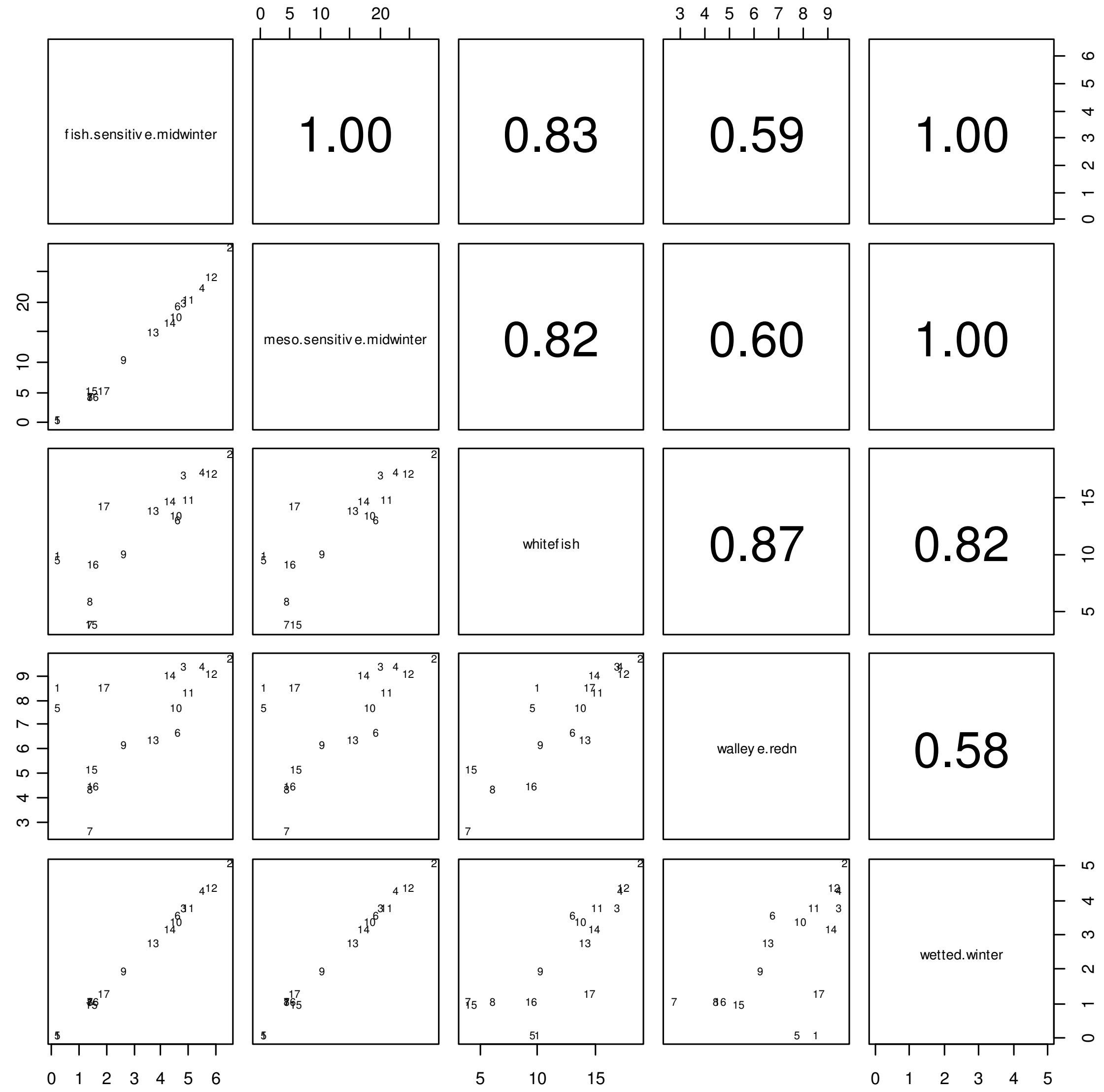


Figure 15: Scatterplot matrix of five aquatic ecosystem ECs for the mid-winter period (weeks 1-12).

Second, several ECs are highly correlated, some with correlations of 1. For example, there is a perfect correlation between fish habitat in the winter and mesohabitat in the winter. The very high, and in some cases perfect correlation between ECs was surprising because the ECs were developed independently, albeit from the same underlying data set (River2D). There was no a priori reason to expect such high correlations among ECs developed to assess different ecosystem effects. Where high correlations exist between a pair of ECs, there is redundancy in the ECs because both respond in a similar manner to water withdrawal. In other words, a reduced set of ECs will capture most of the impacts expressed by a larger set of ECs. This redundancy should make decision-making easier because multiple impacts can be expressed in a single EC. However, it is important to remember that the scale of response may nevertheless differ, even within highly correlated pairs. For example, a loss of about 5% of wetted area in the winter translates to greater than a 25% loss of the most sensitive mesohabitat.

Last, the sploms indicate a trade-off between open water and winter season measures. This is perhaps not surprising, given that storage is typically filled in the open water season for use in the winter to offset effects during the lowest flow times of year. However, the sploms indicate that this trade-off is measurable using the ECs developed for the Phase 2 process.

The IFNTTG discussed the redundancy issue in detail and recommended that the following metrics be used to evaluate water withdrawal alternatives in the Lower Athabasca:

- % loss of fish habitat for the most sensitive species in the winter period
- % loss of fish habitat for the most sensitive species in the shoulder period
- % loss of effective whitefish spawning habitat
- % loss of mesohabitat for the most sensitive mesohabitat in the winter period

This reduced set of ECs is believed to capture, either through direct measurement or correlation, the ecosystem components that are of greatest concern to fisheries managers for this river. As noted earlier, all ECs were calculated and made available, but this reduced set formed the primary basis for decision-making at the P2FC.

5.2.12. Limitations of the IFN ECs

The IFNTTG recognized that there were limitations to the use of the ECs in developing the Phase 2 Framework. In recognition of these limitations, the group developed the following guidance for use of the aquatic environment evaluation criteria (ECs) in assessing flow alternatives.

1. There is uncertainty around any of the ECs calculated. This uncertainty is captured in a measure referred to as the Minimum Significant Increment of Change (MSIC). Conceptually, this is captured in Figure 16 as a grey area around an EC calculation for an alternative.

2. Despite some uncertainty, the aquatic ECs work well in distinguishing between divergent alternatives. For example, the ECs allow one to distinguish between alternatives A and B, in Figure 16.

3. The aquatic ECs work less well when we are trying to distinguish between similar alternatives. For example, when MSICs are overlapping, as they are for alternatives X and Y in Figure 16, the alternatives likely have similar biological responses.

4. The ECs also work less well for assessing effects during extreme events, such as low flows that are not within the existing 50 year flow record. One of the main reasons for this is that the EC calculations place no special weight on events such as extreme low flows. See Section 5.3 and Appendix B for further discussion.

5. To assess differences among similar alternatives, one must use professional judgement. This judgement should be informed by the concept that sensitivity to water withdrawals

increases as flows decline (both within and among time periods). This concept leads to the following hierarchy for protection among time periods:

i. mid-winter

ii. late winter/early spring

iii. fall/early winter

iv. summer

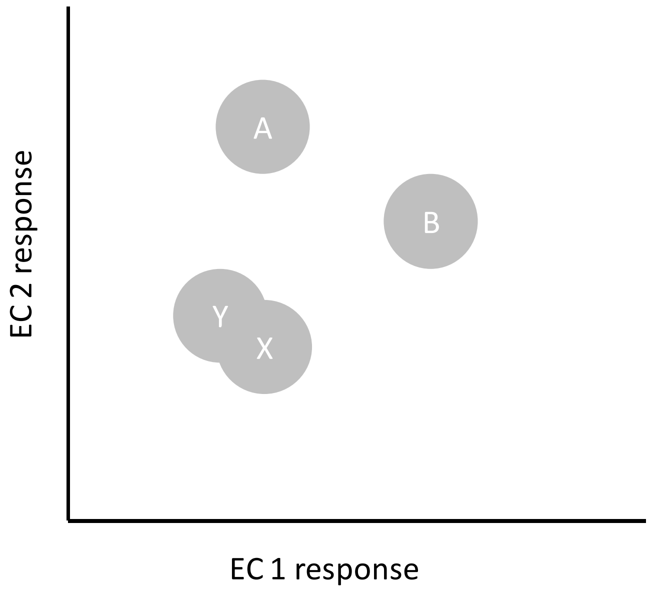


Figure 16: Conceptual diagram indicating uncertainty in environmental responses and the ability to distinguish among water management alternatives.

5.3. Ecosystem Base Flow

Low flow periods are often bottlenecks with respect to biological productivity in streams. Low flows during late summer can limit available fish rearing habitat and low flows in the fall can limit the availability of spawning habitat. During winter, low flows limit quantity and quality of over-wintering habitat for juveniles and adults, and limit incubation habitat for eggs. It is widely recognized that the potential impact from water withdrawal is greatest at low flows. In an effort to protect ecosystem values, many jurisdictions have developed and implemented water management rules that limit or preclude withdrawals at times of low flow.

5.3.1. Background

In the Lower Athabasca River context, the concept of the Ecosystem Base Flow (EBF) is often used synonymously with the term “cut-off flow”. While the exact definition and interpretation varies, the intent of an EBF is generally accepted as being a low flow at which water withdrawals may cause irreversible stress on the aquatic ecosystem.

There has been a high level of interest in the establishment of an EBF for the Lower Athabasca River. Notably, the Joint Review Panel of Imperial Oil’s Kearl Oil Sands Project recommended to Alberta Environment and the Department of Fisheries and Oceans Canada that an EBF be incorporated into the final Water Management Framework for the Athabasca River. The Government of Canada accepted this recommendation. The Phase 1 Water Management Framework made the following commitment: “Research will be directed towards addressing the definition of an EBF in Phase 2.”

The Government of Alberta recently conducted an extensive review of the EBF concept and how it has been implemented in various jurisdictions in North America and overseas. The review included examples from South Africa, Australia, New Zealand, United Kingdom, France, Norway and numerous states and provinces in the USA and Canada. The review demonstrated that the concept of a cut-off flow to protect ecosystem values during low flows is widely held throughout the world. Yet, the review also highlights that the approaches used to develop low flow cut-offs are varied and the implemented flow rules are divergent. One form of an EBF is the Alberta desktop method, which provides a full cut-off at the 80% flow exceedence. This is the most conservative value based on many site specific studies carried in Alberta where the EBF ranged from 80 to 94% exceedence.

The review is especially useful because it demonstrates that a single best approach or low flow value has not emerged as dominant. The variation in withdrawal rules is no doubt due, in part, to the highly varied social and physical contexts, but the results also imply that setting a low flow cut-off is neither straightforward nor dependent on science alone. In many cases “negotiation” was cited as an explicit part of selecting the EBF, and in no case was there evidence presented that a particular EBF was based on the discovery of a sharp ecological threshold or tipping point.

5.3.2. Explorations Undertaken During the Phase 2 Process

An EBF sub group was formed during the process and met twice to discuss the EBF issue and assessment requirements. The group reviewed a range of potential assessment tools, including:

- Application of the Fish Habitat EC Response Surface
- Sensitivity Analysis Using Wetted Area Box Plots
- Simple Fish Population Models

Details of this review can be found in Appendix B.

In parallel with this and the overall P2FC process, the regulators worked internally toward a potential proposal on the EBF. In particular, they worked toward setting an EBF threshold value based on hydrological low flow statistics.

Sections 7 and 8 provide information on how the tools and information was integrated into the deliberations of the P2FC.

5.4. Traditional Use, Public Use and Navigation

The Lower Athabasca River is an important traditional use area throughout the entire year. As noted in Westland, 2009a:

> *“The river was identified as a vital boat transportation route in spring, fall, and summer, and a snowmobile and dog sled route in winter. The river plays an important role in connecting people to traditional use areas. Food collection on and adjacent to the river occurs year-round. Moose, small game, and deer are hunted throughout the year. A range of other species is trapped in the fall and winter. Fishing occurs along the length of the river, year-round from Fort McMurray to Fort Chipewyan. Ice fishing is undertaken near known pools and riffles.”*

A conceptual “means-ends” diagram is presented in Figure 17, and shows how water withdrawals, and other factors, can affect important traditional use activities in the Lower Athabasca River region. The effect of water withdrawals on flow in the river depends on the timing, magnitude, frequency, duration and extent of water withdrawals. For example, a withdrawal of 10 m^3/s in the fall may have a greater influence on navigability than the same withdrawal in the summer. Likewise, the effect of withdrawal during a “dry” year may be considerably different than the same withdrawal during a “wet” year. Aside from hydrological influences, dredging of the river from the 1940s through to the 1990s had a significant effect on the physical characteristics; with the end of dredging, channel morphology and navigability on the Lower Athabasca River are returning to pre-1940 conditions (Westland, 2009c). It is also noted that influences on traditional use endpoints of interest (e.g., diet and health, knowledge transfer across generations, etc.) are influenced by other socio-economic factors at the community level.

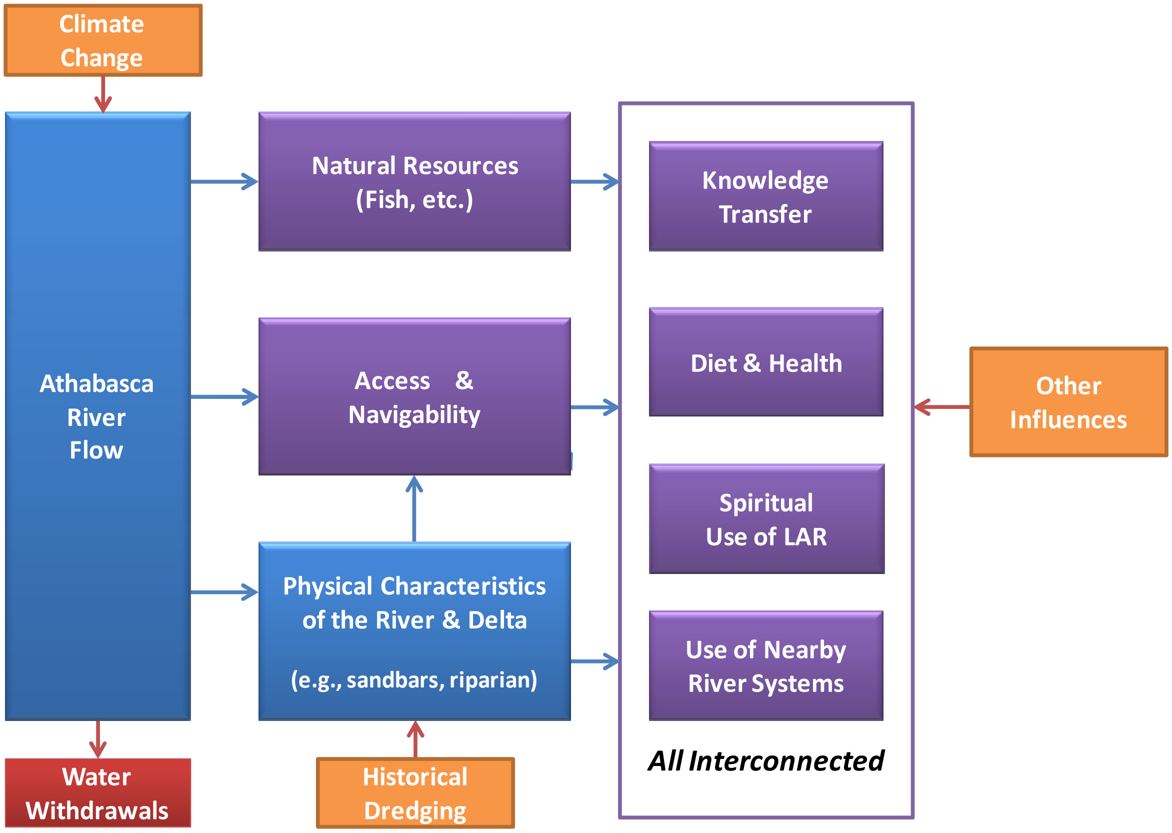


Figure 17: Means-ends diagram that identifies conceptually how water withdrawals can influence traditional use activities on the Lower Athabasca River.

The general public and visitors to the region report similar use of the Lower Athabasca River. As noted in Westland, 2009b:

> *"The river is an active year-round travel route to recreation destinations and traplines. In the spring, summer, and fall, people use the river for boating, fishing, rafting, and sightseeing. Many recreational users travel the river to access hunting, hiking, and camping locations.*
>
> *In the fall, hunters use the river to hunt bear, moose, duck, and goose. Some hunters drift down river, and are then picked up by vehicle. In the winter, the river is used for skidooing and increasingly for ice fishing."*

5.4.1. Traditional Use Study

The Socio-Economic Task Group (ETG) commissioned Westland Resource Group (Westland) to complete a Traditional Use Study (TUS). A Phase 1 TUS was completed in July 2009, which summarized existing and available information on traditional use activities in the Lower

Athabasca River region. The Phase 2 study involved collecting information from community members from eight Aboriginal groups, including Chard Métis Local 214, Conklin Métis Local 193, Fort Chipewyan Métis Local 125, Fort McKay First Nation, Fort McKay Métis Local 63, Fort McMurray Métis Local 1935, Fort McMurray Métis Local 2020, and members of CEMA's Aboriginal Round Table. Results of the study are provided in a traditional use mapping and information summary report. As reported in Westland, 2009a:

> "*The study team developed interview questions, introductory materials, and base maps prior to meeting with community members. The interviews focussed on gathering information about the seasonal traditional use activities and the specific areas that support these activities. Participants were also asked for their perspectives on the Lower Athabasca River.*
>
> *Interview participants provided their perspectives about the Lower Athabasca River. Many participants described the changes they witnessed, including lower water levels, and the resulting effects on traditional use activities. Participants spoke about river access challenges and safety concerns, changes in traditional use harvesting opportunities, barriers to knowledge transfer, and concerns about the health of the Lower Athabasca River.*
>
> *Most of the study participants have a long history of use on the river. Many spoke of the changes in a holistic manner, discussing water extraction for oil sands production, but also change caused by population growth in Fort McMurray, the Bennett Dam on the Peace River, climate change, and altered muskeg adjacent to the river as a result of industrial development*."

The Phase 2 study, also included the development of assessment of traditional use impact hypotheses related to water withdrawals from the Lower Athabasca River. An overview of the results is provided below, and the full report is contained in Westland (2009c), *Volume 2: Technical Appendix*.

Six hypotheses associated with water level effects on traditional uses and activities in the Lower Athabasca River area were developed by Westland as:

1. Water withdrawal, in some circumstances, contributes to limitations on river access to traditional use sites and traditional use activities during late summer, fall, and winter.
2. Water withdrawal, under some circumstances, contributes to decreased opportunities for harvesting resources important to Aboriginal people in the study area.
3. Water withdrawal may contribute to the decline of the transfer of traditional knowledge in Aboriginal communities in the Lower Athabasca River area.
4. Water withdrawal contributes to decreased ability to use rivers close to the mainstem of the Lower Athabasca River for traditional Aboriginal purposes.

5. Water withdrawal, under some circumstances, contributes to the decline of traditional diet and health of Aboriginal people in the Lower Athabasca River area.
6. Water withdrawal, under some circumstances, may physically alter spiritually important areas in the Lower Athabasca River area.

These hypotheses were assessed based on the potential for impact caused by oil sands water withdrawals using technical information provided by the process, as well as information and holistic perceptions gathered during interviews in the field portion of the study. The assessments also took into account other factors affecting the potential impact of river flows, such as climate change, historical dredging, etc.

The primary conclusion of the study was that the first three hypotheses listed above – access to traditional use sites, availability of traditional resources, and traditional knowledge transfer opportunities – were considered to be sensitive to water withdrawal, and these hypotheses should be considered in the examination of flow management alternatives.

Based on this conclusion, and in conjunction with a further review of technical studies generated throughout the planning process, Westland was requested to rate the potential for impact on alternatives being considered by the P2FC. These findings are presented in Section 7.3.2.

5.4.2. Navigation

Navigation of the river is of key importance to both traditional use activities as described above, and general recreation use of the river.

As a first step toward developing an understanding of the potential for water withdrawals to impact on navigation, the Socio-Economic Task Group (ETG) commissioned AECOM to evaluate the potential impact on water depths in the river for a range of book-end alternatives (see Section 7.1). AECOM used the results from River2D modelling to assess water depths at a single worst case flow value at various locations in the test segments of river segments 2, 3 and 4. Their report is provided in AECOM (2009), *Volume 2: Technical Appendix*.

This initial investigation concluded that the range of water management alternatives proposed in Phase 2 of the Athabasca River Water Management Framework will have insignificant impact on the navigation on the Lower Athabasca River.

Despite this finding, continued interest with the P2FC process led to the further development of a navigation EC for use in evaluating flow alternatives.

The navigation EC addresses the following impact hypothesis: water withdrawals have a significant and negative effect on water-based recreation and navigational uses of the Athabasca River. Two areas approaches were pursued to explore this hypothesis.

The first approach used the sections of River 2D models (discussed above) to see whether flow withdrawals could create a situation in which the river could no longer be navigated by various river craft. After establishing the depth of water required for various water craft, a water depth visualization tool was developed to show whether navigability within these sections could be affected by water withdrawals. No major navigational issues were found using this technique on these particular modeled sections, but it is recognized that other non-modelled sections of the river could well have areas for which some kind of navigational impediment could be created or exacerbated by flow withdrawals. Further, given the highly variable nature of channel morphology in the river, new areas of reduced navigability could arise or disappear periodically. However, no EC could be constructed to capture this effect in a way that might help distinguish between alternatives.

The second approach to characterizing possible navigational impacts involved the development of navigational area suitability criteria curves. A suitability curve links changes in the river to a dimensionless index of suitability for a particular purpose. Using modeling, it is then possible to describe the quantity of available navigational water through flow versus suitability-adjusted area relationships for each modeled time-unit. When conditions in the river for any given week are less than the Q80 for that week, the change in suitable navigational area relative to natural is calculated and averaged over the 50 year time series for three time periods in segments 2 to 4. The changes for three periods were calculated:

- Period 1 - “Spring” - weeks 16-20
- Period 2 - “Summer” - weeks 21-32
- Period 3 - “Fall” – weeks 33-43

Using this technique, differences were notable across alternatives and these were presented in the consequence tables in the latter rounds of alternatives assessment by the committee. The relative changes to natural were in the range of just a few percent, and though a formal estimation of the Minimum Significant Increment of Change (MSIC) was not made (a placeholder value of 2% was used), it is doubtful whether this technique indicates a significant difference across flow alternatives.

A summary of this EC is presented in Appendix A.

5.5. Storage and ECs derived from storage requirement: Cost and Mitigation Technology Footprint

As discussed in Section 3.2, a base assumption for the P2FC process was that at some point in its future, oil sands mining industry cumulatively may require up to approximately an average of 16 m^3/s of fresh ‘make-up’ water on a continuous basis. This make-up water is assumed to come entirely from the Lower Athabasca River. Assuming that instream flow rules would limit withdrawal during the winter months to a number less than 16 m^3/s, then the balance would need to be made up from water storage. Additionally, a peak rate of greater than this average would then be required to refill the storage when water was more plentiful.

In early rounds of the creation and evaluation of alternative flow rules the P2FC considered storage at an entirely hypothetical level. As explained in Section 7, the storage required by industry to meet various flow regulation alternatives can simply be calculated by recording the maximum cumulative deficit of water availability minus water demand over a simulated 50 years of flow records.

However, the P2FC soon found that it needed more information to understand the real implications of storage. If an alternative results in 100 million m^3 storage requirement, what would that actually imply? Would industry build 100 million m^3 in on-site ponds? If so, what impacts on the landscape might this suggest? How much might this cost, and how significant might this cost be to industry? Would new land area need to be disturbed? What other options, other than ponds, might there be to provide this water, and what might the advantages and disadvantages of these options be?

Fortunately, prior to the initiation of this process, the Oil Sands Development Group (OSDG), an industry association, had commissioned Golder Associates to investigate the options open to industry for providing water for oil sands mining use if Lower Athabasca River withdrawals were limited.

OSDG (2009b), *Volume 2: Technical Appendix*, describes how the company created a long list of possible mitigation options, which it screened according to various criteria. Engineering mitigation options were identified and organized into the following categories:

- best practices;
- water conservation measures;
- water treatment options;
- tailings technology options;
- compensation of potential impacts;
- water storage (on-site or off-site locations); and
- other water sources.

As this activity overlapped with the P2FC processes, WREM was also invited to provide comments and suggestions on this long list.[4] Golder subsequently narrowed down this list to the following approaches:

- treatment of tailings pond process-affected water for seasonal plant water supply, treatment sludge returned to the pond;
- treatment of tailings pond process-affected water for seasonal plant water supply, mechanical evaporation and deposition of effluent solids in a landfill;
- off-site water storage at Lesser Slave Lake, by managing existing lake levels for additional winter release;
- off-site water storage at McMillan Lake, by expanding the existing lake to store Athabasca River water for release in winter;
- fresh water ponds constructed on or adjacent to mine leases, supplying fresh water when Athabasca River water is not available;
- tailings pond storage of process-affected water in addition to the required tailings water cap, to supply additional recycle water in winter;
- decommissioned tailings pond water storage and reuse, delayed reclamation of the tailings area;
- pit lake water storage and reuse, delayed closure certification of the pit lake; and
- Wiau Channel water supply from an existing groundwater Pleistocene aquifer.

Table 2 summarizes the performance of these technologies on a number of criteria on a per unit basis.

---

[4] OSDG managed the options evaluation process largely outside of the process. As a result, the short-list should not be viewed as having full WREM or P2FC support.

Table 2: Summary Comparison of Short-Listed Options Source: OSDG 2009b

Options		Evaluation Criteria										
		Capital cost	Storage	Storage unit cost	Key issues	Annual operating costs	Footprint	Intake capacity requirements (summer)	Energy requirements	Green-house-gas emissions	Water losses (e.g. evaporation)	Provincial royalty losses
		(M$)	(Mm^3)	($\$/m^3$)	(~)	(M$)	(km^2)	(m^3/s)	(kW)	(T/yr)	(Mm^3)	(M$)
1. Water treatment												
1.1	Sludge to pond	$ 201	5	$ 40	0.5	$ 11	1	0.3	3,000	9,198	0.0	$ 50
1.2	Solids to landfill	$ 383	5	$ 77	0.5	$ 20	1	0.3	3,000	9,198	0.8	$ 96
2. Off-site water storage												
2.1	Lesser Slave Lake	$ 195	58	$ 3	0.8	$ 10	1.5	0.0	0	0	0.0	$ 49
2.2	McMillan Lake	$ 635	100	$ 6	0.8	$ 39	60	4.0	16,000	49,056	1.5	$159
3. On-site water storage												
3.1	Fresh water ponds	$ 128	8	$ 16	0.1	$ 7	4	0.5	1,600	4,906	0.3	$ 32
3.2	Tailings pond	$ 126	8	$ 16	0.4	$ 7	0.5	0.5	2,400	7,358	0.0	$ 32
3.3	Decommissioned tailings pond	$ 182	8	$ 23	0.8	$ 10	2.5	0.5	1,320	4,047	0.4	$ 46
3.4	Pit lake storage	$ 62	5	$ 12	0.8	$ 4	2.5	0.3	930	2,851	0.0	$ 16
4. Groundwater												
4.1	Wiau Channel	$ 56	4	$ 14	0.5	$ 3	6.5	0.0	290	889	0.0	$ 14

Notes:

1 Not including power supply generation/transmission upgrade costs (if necessary).
2 200 Mm^3 storage is equivalent to 30+ m^3/s summer withdrawal, approximately equal to the summer red zone withdrawal limit.
3 Alternative Athabasca River dam, for large equivalent storage of 200 Mm^3 or more, expected to cost several billion dollars.
4 Capital costs estimated from industry typical costs, based on the stated design concept for each option.
5 Annual operating and maintenance costs (OPEX) assumed to be 5% of capital cost plus power costs of $0.1 per kW of installed capacity, assumed to account for replacement costs.
6 Storage capacity based on the stated design concept for each option, assuming a typical mine river water requirement of 1 m^3/s, typical pond size of 5 km^2.
7 Disturbance footprint is approx. equivalent of disturbance to natural ground, assuming 50% equivalent for delayed reclamation, closure, 150% for off-site disturbances.
8 Intake capacity requirements assume that river intakes must be redesigned to provide capacity for summer refill.
9 Energy requirement is the total installed capacity for pumping requirements.
10 Green-house-gas emissions assumed to be 0.7 tonne per MWh, based on thermal power generation and transmission.
11 Provincial royalty losses assumed to be 25% of capital cost.

The actual use of these or other technologies, whether singularly or in portfolios, would depend on multiple factors. Moreover, decisions would be made by individual companies with differing access to capital and different risk tolerances. The P2FC was also sympathetic to the view that regulation should not prescribe one technology over another but should instead remain flexible to changes in technological innovation, economics, environmental science and stakeholder values over time.

However, it was recognized that it would be helpful to understand how the use of these technologies might likely unfold under differing storage requirements. To help understand this Golder was asked to invent a typical, illustrative 'storage mitigation technology curve' that would show how different technologies *might* be bundled together for differing levels of storage requirement. The result is illustrated in Figure 18, in which only two of the technologies shortlisted by Golder are notionally deployed up to a storage requirement of 200 million m^3. To understand why only combinations of on-site fresh water ponds and on-site tailings ponds were used, see OSDG (2009b).

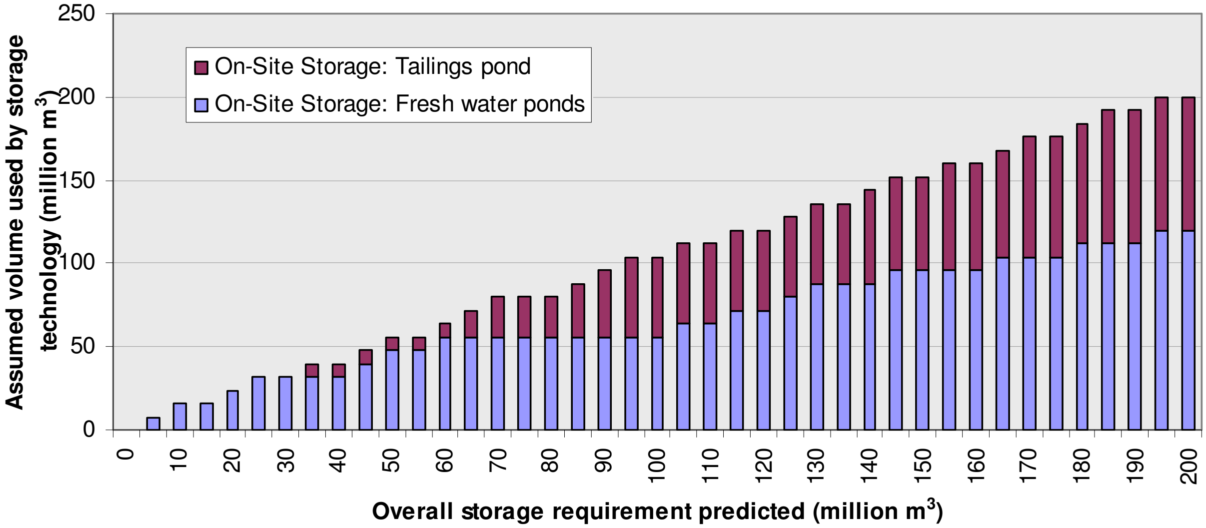


Figure 18: One possible use of storage mitigation technologies for different levels of storage requirement Source: Adapted from OSDG 2009b

Note that conflicts may or may not exist between the use of tailings ponds for storage and ERCB Tailings Directive 074, which is intended to ensure that tailings ponds are decommissioned in a timely manner. If Tailings Directive 074 were to prevent industry from using tailings ponds for storage purposes then other technologies for storage would be required.

The relationship in Figure 18 can then be used to estimate the values a number of evaluation criteria may take for any given level of storage requirement predicted by the flow calculator (See Section 6 for more information on the flow calculator).

For example, suppose the flow calculator predicted a requirement for 100 million m^3 of storage. From Figure 18 we can see that volume could come from the use of 56 million m^3 of fresh water ponds (at 8 million m^3 per unit, this is 7 ponds) and 48 million m^3 of tailings ponds (at 8 million m^3 of tailings ponds, this is 6 tailings ponds).

From Table 2 we can therefore calculate the approximate cost of providing 100 million m^3 to be 7 * 128 + 6 * 126 = $1,652 million.

Similarly, we can estimate the footprint area required to meet this storage requirement as 7 * 4 + 6 * 0.5 = 31 km^2.

Although these estimates are somewhat coarse, they at least provide some kind of order of magnitude estimate of the kinds of impacts in question. While this technique may not be accurate in terms of absolute numbers, it is helpful in assisting understanding of the *differences between* alternatives, since all alternatives' values are calculated using the same technique.

A summary of these ECs are presented in Appendix A.

5.5.1. Absolute versus relative values for cost and footprint ECs

One of the challenges in structuring a multiple account of impacts of alternatives in any process is the specific selection and definition of ECs. ECs can, of course, be developed in multiple ways, and each can offer different but equally valid perspectives on performance.

One common dilemma in these cases is whether ECs should be presented in absolute units (e.g. hectares of habitat affected) or in relative units (percent of hectares affected relative to some reference area). The decision theory literature does not give clear guidance on this point; all else being equal so called natural units are preferred (e.g. hectares or dollars), but the literature also emphasizes the importance of ECs being 'meaningful' to people. Presenting information in multiple ways is also one approach, but this comes at the expense of increased complexity and, if misused, the potential for double-counting an impact.

In this case, participants on all sides noted the asymmetry of aquatic ecosystem and navigation ECs being presented in relative units (percent change in *X* from no-withdrawals condition), while ECs for cost and footprint were presented in natural units (dollars, km^2). Some considered this unbalanced, since absolute metrics may seem more significant than relative ones.

This discussion was identified as important towards the end of the EC development stage, and approaches were developed to convert cost and footprint ECs to relative figures (and in parallel, fish habitat ECs to absolute numbers). Although these methods were not reviewed in detail by the relevant subcommittees, they were reviewed directly with the P2FC.[5]

Values using these techniques were calculated for all alternatives toward the end of the process as the committee narrowed in on preferred alternatives (see Section 7.4). They were also included in a comprehensive presentation package provided to participants to take to their constituents with appropriate caveats.

5.5.1.1. *Proposed method for calculating relative costs*

Many methods for converting cost impacts to a relative basis can be imagined, but the method put forward by the Alberta Wilderness Association representative was to calculate the estimated percent increase in a typical project cost. It was proposed to calculate this figure through the following formula:

% increase in typical project cost = A / B / C, where:

A = Estimated capital cost of storage ($ millions) as estimated using the techniques described above

B = 3.5 million barrels per day production

C = $82,000[6] ($ / barrel / day of production), average capital cost of a oil sands mine without upgrader

Using this method, most alternatives' storage capital cost as a percentage of total capital cost are in the 0.25% to 1% range.

5.5.1.2. *Proposed method for calculating relative mitigation footprint area impacts*

In parallel to the relative cost calculation is this one for calculating relative mitigation footprint as a percent of total mine footprint. This is calculated through the formula:

% of mitigation footprint area = Mitigation footprint area (km^2) / 2,300 (km^2)[7]

---

[5] Although there were outstanding questions regarding the best way to approach relative calculations for the mitigation footprint EC, the WREM group did not convene to discuss further.

[6] Source: 2009 CERI report: Oil Sands Industry Update: Production Outlook and Supply Costs 2009-2039.

[7] The figure of 2300 km2 is taken from an ERCB spreadsheet that was presented to the P2FC in October 2009, in which a figure of 230,000 hectares was noted as a combined mineable oil sands current and projected tailings and footprint area summary.

Using this method, most alternatives' storage footprint as a percentage of total mining footprint are in the 0.7% to 2.3% range.

5.6. Climate Change

The P2FC indicated an interest in testing proposed water management alternatives under a range of hydrological scenarios in order to help seek out a preferred water management framework that is robust to potential climate change effects. The P2FC formed a Climate Sub-Group (CSG) that was tasked with examining the potential impacts of climate change on Athabasca River flows in order to develop an approach that could be used to test the sensitivity of water management alternatives to different hydrological scenarios. This work is described in full in "Climate Change Sensitivity Analysis" prepared for the P2FC by Lebel *et al.* (2009), *Volume 2: Technical Appendix*.

In summary, the climate sub-group developed a range of hydrological scenarios that were used to explore possible climate impacts through the use of a sensitivity analysis using the Flow Calculator (see below). The group employed both main approaches found in the literature for predicting river flows under climate change: (1) extrapolation of historic trends, and (2) modeling through global circulation models (GCMs) and hydrologic models.

The scenarios put forward are summarized in Table 3. For more information on how climate change scenarios were used in the Flow Calculator, see Section 6.2.1.

Table 3: Summary of Climate Change Scenarios developed by the Climate Sub-group

Scenario Name	Basis	% change winter	% change summer
Base Case	No change[1]	0	0
Global Climate Model 1	Mid-range scenario (CGCM2 / A2)	-3.5 %	-12.2 %
Global Climate Model 2	Extreme scenario (CSIRO / B2)	-18.3 %	-40.2 %
Global Climate Model 3	Extreme scenario (NCAR / A2)	+8.5 %	+5.3 %
Trend 1	50-year trend[2]	-10.8 %	-12.1 %
Trend 2	30-year trend[2]	-38.4 %	-28.9 %

1 The Base Case of no change is equivalent to the long term (90-100 year) trends of annual flow for the Athabasca River at the town of Athabasca (Rood and Stupple, 2009) (Alberta Environment, 2004).

2 It should be noted that trend analyses are very sensitive to the duration chosen.

The effects of climate change on the hydrology of the Athabasca River have been considered conceptually by the CSG as a potential impact, regardless of direction or magnitude, as they would represent a departure from current conditions. However, it was also noted by some P2FC members that the effects of climate change on Athabasca River hydrology could conceivably be considered as a new hydrologic equilibrium. Under this approach, water management alternatives would be tested against departures from the climate change hydrologic equilibrium (although projected climate changes and the hydrologic response may not represent a true equilibrium), rather than the current hydrologic equilibrium.

6. Methodology for Creating and Evaluating Alternatives

6.1. Overview

In this section we introduce the methods used for creating and evaluating alternatives at the P2FC.

6.2. The Modelling Approach: The Flow Calculator

The consequences of different flow rules were estimated using a custom-built MS Excel spreadsheet application referred to as the Flow Calculator. The calculator was designed and developed by Compass Resource Management, though its basic approach to water balance calculations were consolidated from two pre-existing spreadsheets used for the same purpose. The calculator evolved continuously over the period of the P2FC process to adapt to the analytical needs of the process. Essentially, the Flow Calculator allowed users to immediately assess the consequences of alternative flow rules on a number of representative evaluation criteria or proxy criteria. The calculator was used extensively by many process participants and enabled the development and exploration of alternatives in real time during P2FC meetings. The flow calculator is illustrated conceptually in Figure 19.

6.2.1. Inputs

The flow calculator takes as inputs the following:

- The fifty year historical flow data set developed by AENV
- Low flow exceedence values
- Synthetic 1 in 100 year and 1 in 200 year data sets
- Climate change scenarios
- Flow Withdrawal Rules alternatives
- Threshold crossing rules

These are discussed below. The flow calculator also takes as inputs the following industry build assumptions, as discussed in Section 3.

- Average weekly demand in m^3/s and
- Peak intake capacity in m^3/s
- An optional actual industry storage build override (in millions m^3)

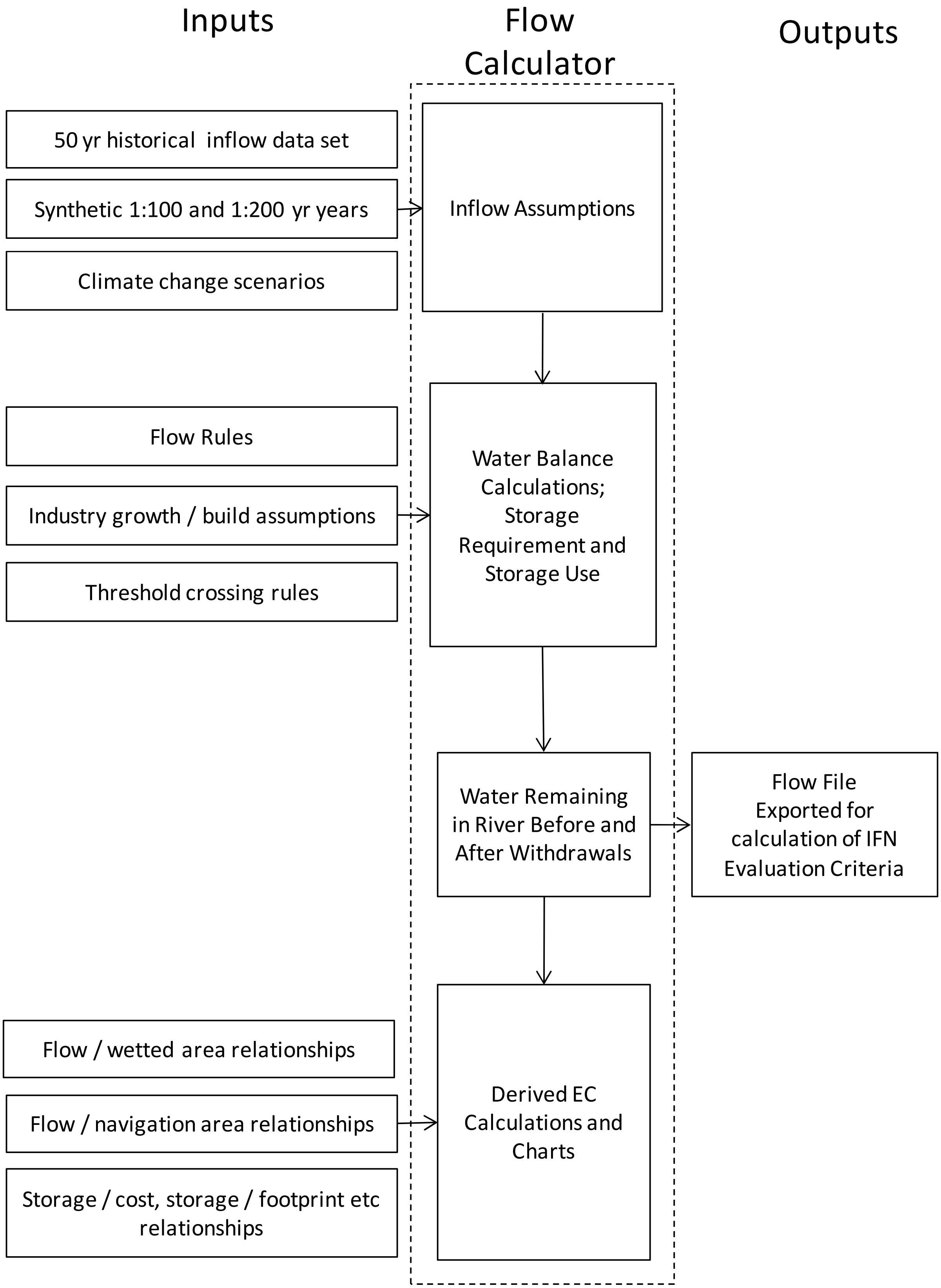


Figure 19: Flow Calculator Conceptual Design

6.2.1.1. Fifty year historical flow data set

A key input to the Flow Calculator was a 50-year weekly average flow data set developed by Alberta Environment, Northern Region (Okyere, 2009). This 2600-point (52 weeks x 50 years) set was taken to be the weekly average flows that would occur in the river before withdrawals.

The basic methodology involved using the recorded data from the Fort McMurray gauge station, with modelling adjustments used to incorporate the effect of all major tributary inflows from that point downstream (Okyere, 2009). The output provided was weekly average flow data for Segments 5 through 2 on the Lower Athabasca River.

The Flow Calculator performed calculations directly on data for Segment 4. Once water removed from Segment 4 was calculated, water remaining in segments 3 and 2 were calculated by simply subtracting these volumes from the 'no withdrawals' data sets for these segments.

6.2.1.2. Low flow exceedence values

In the first versions of the Flow Calculator, low flow exceedence values were calculated using linear interpolation methods. Since there are only 50 years of data, exceedence values up to Q98 can be calculated this way. However, given the interest in very low flows, it was considered important to have estimates of exceedence values of Q99 or lower.

A request made to hydrologists at Alberta Environment, who then provided a full range of weekly flow quantiles – from Q50 through to Q99.99 – for use in the Flow Calculator. The methodology used in developing the quantiles was based on the Pearson III distribution, with skew limits, fitted with L-moments for reaches. Flow rates used in the analysis are described above, and in Okyere, 2009.

6.2.1.3. Synthetic 1 in 100 and 1 in 200 year data

Also due to the interest in exploring the implications of low flow events, Alberta Environment was asked to develop 1-year data sets that would simulate 1 in 100 year and 1 in 200 year low flow events. The synthetic average weekly low flow datasets that were provided were based on annual and winter season statistical analysis of historic flows in the Athabasca River using the Pearson III distribution, with adjustments to i) simulate the historical winter flow recession curve developed by Alberta Environment, and ii) incorporate a low flow dip in early December that matches the minimum weekly low based on statistical analysis of historic flows in the Athabasca River.

Within the Flow Calculator, the user can simulate the effect of a 1 in 100 year or 1 in 200 year low flow event by selecting to substitute either of these two data sets, split over one winter event, over the actual data used for the next driest winter in the 50-year dataset, 2002.

6.2.1.4. Climate change scenarios

As discussed in Section 0, the flow calculator was configured to allow the user to apply any of a number of climate change scenarios. It did this simply by multiplying the fifty-year data set by % modifiers for winter and summer. For example, if the user wished to simulate the impacts of a climate change scenario that reduced winter flows by 3% and summer flows by 12%, then the flow calculator simply deducted 3% from each winter flow data point and 12% from each summer flow data point. The rest of the calculator's logic remained otherwise unchanged.

6.2.1.5. Flow Withdrawal Rules

The calculator was designed to be flexible as possible in terms of how alternatives might be designed. An interface on the calculator allows the input of flow rules in the format illustrated by these three example alternatives. The user types the numbers required into an input template:

Example 1	Start	End	R1	T1	R2	T2	R3
Period 1	1	52	29	150	8		

Example 2	Start	End	R1	T1	R2	T2	R3
Period 1	1	52	F15	Q80	0		

Example 3	Start	End	R1	T1	R2	T2	R3
Period 1	1	15	F15	Q90	12	Q95	9
Period 2	16	43	F15	Q90	34		
Period 3	44	52	F15	Q90	12	Q95	9

Where:

Start and End refer to week numbers of the year

T1 and T2 are Threshold flows in the river before withdrawals.

- A number prefixed by the letter 'Q' means that the corresponding weekly exceedence value should be used. E.g. Q95 refers to the weekly 95% exceedence value
- A number alone refers to a flow in m^3/s
- P1 means that the 'hired-wired' threshold values in m^3/s from the Phase 1 Framework are applied. These vary from week to week.

R1, R2 and R3 are the Rules that describe permitted withdrawals from the river when flow in the river before withdrawals are greater than T1, between T2 and T1, and less than T2 respectively.

- A number prefixed by the letter ‘F’ means that the permitted withdrawal is a percentage of flow in the river e.g. F15 means that up to 15% of flow in the river may be withdrawn.
- A number alone refers to a flow in m^3/s
- P1 means that the ‘hired-wired’ withdrawal allowances values in m^3/s from the Phase 1 Framework are applied. These vary from week to week.

Example 1 above uses one time period for the entire year (weeks 1-52). The rule set here is entirely defined in absolute flow values (m^3/s). When the river is above a threshold T1 of 150 m^3/s, R1 applies, meaning that up to 29 m^3/s may be removed. When the river is below T1, R2 applies, meaning that up to 8 m^3/s may be removed.

Example 2 also uses one time period for the entire year (weeks 1-52). It states that when the flow in the river before withdrawals is above the weekly 80% exceedence value (entered in the calculator by typing the characters “Q80” in the T1 column), then up to 15% of flow from the river may be removed (entered into the calculator as “F15”) in the R1 column (R stands for “Rule”). Below the Q80 threshold, 0 m^3/s or nothing may be removed.

Example 3 uses three time periods (though actually only two rules) – one for the winter (periods 1 and 3) and one for the summer. In winter periods 1 and 3, if the flow in the river is above the weekly Q90 level, then up to 15% of flow from the river may be removed. If the flow in the river is between Q90 and Q95, then up to 12 m^3/s may be removed. Below Q95, 9 m^3/s may be removed.

6.2.1.6. Threshold Crossing Methods

In situations where the withdrawal of water from one rule is greater than the amount required to cross the threshold into another rule, a ‘threshold crossing method’ needs to be applied. The flow calculator was programmed to allow the user to select one of two methods, simply called Method A and Method B.

Method A states that if a withdrawal would take the river below a threshold, then either: the proportion of the allowed rule above the threshold; or, the rule from below the threshold, whichever is greater, applies. This is the commonly held method to regulate instream flow prescriptions.

Method B states that if a withdrawal would leave the river below a threshold, then the proportion of the allowed rule above the threshold plus the rule from below the threshold (up to a maximum of the upper rule) can be taken. Method B was proposed early in the process and was set as the default in the flow calculator.

For some of the alternatives considered in detail during the process, there was no distinction between the two methods. That was because if rules on either side of a threshold were similar, or if the lower rule allowed no withdrawal at all, then Method A and Method B produced the same result. For other alternatives, the methods resulted in different amounts of water being permitted for withdrawal and hence different resultant flows in the river and storage volumes required.

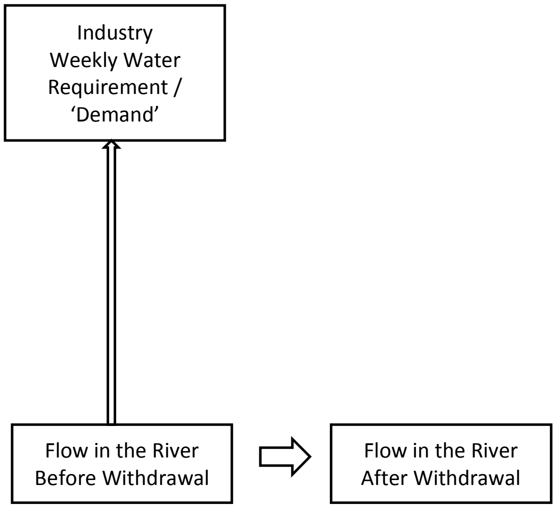
The differences between the two methods became more important late in the process when a low flow threshold (i.e., an Ecosystem Base Flow), was considered in detail by the committee. Because Method B was set as the default, most committee members explored alternatives with low flow thresholds and various exemptions below the threshold using this method. For a more detailed discussion on threshold crossing rules and the differences between the two methods, see Appendix C.

6.2.2. Water Balance Calculation Methodology

In this section we present a conceptual overview of the flow calculator water balance calculations.

At its most basic, the flow calculator calculates the flow in the river before and after weekly industry withdrawals are made.

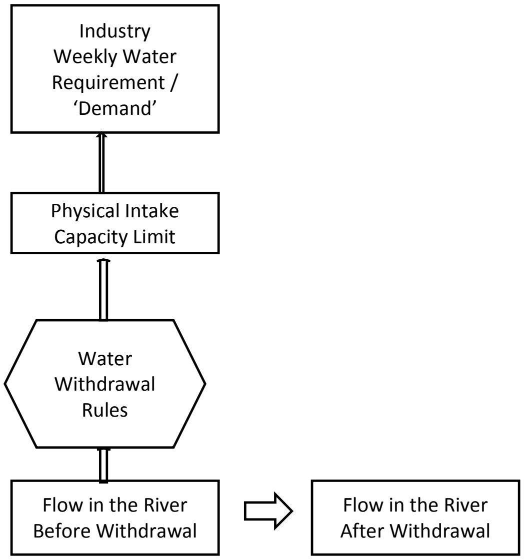
Water Requirements = Demand



The amount of water industry can withdraw from the river in order to meet demand is limited by two things:

The first is the physical intake capacity – the size of the pipes. For most of the process, this was assumed to be 29 m3/s, one forecast of the full build out case.

The second limit on the amount of water industry can withdraw is determined by the Water Withdrawal Rules.



If in any given week, if industry is unable to meet water demand using withdrawals from the river, the calculator accounts for this as a water deficit. Once water becomes more plentiful, the deficit is replenished within the available water withdrawal limits.

This is best illustrated by example:

For example suppose there is a future situation where industry demand is 16 m^3/s and intake capacity is 29 m^3/s. Suppose the rule in Week 1 says that industry can withdraw up to 8 m^3/s. The calculator takes 8 m^3/s from the river and notes a deficit of 8 m^3/s.

Suppose in following week, the rule says 10 m^3/s is the maximum withdrawal. The calculator takes 10 m^3/s out of the river (6 m^3/s short of demand) and notes a cumulative deficit of 8 + 6 = 14 m^3/s.

If, in the third week the rule increases to 40 m^3/s, the calculator takes 16 m^3/s for that week's demand and also (29-16 =) 13 m^3/s to replenish almost all the deficit. Note that the calculator treats any number greater than 29 m^3/s as 29 m^3/s, since the water cannot physically be removed faster than this rate[8].

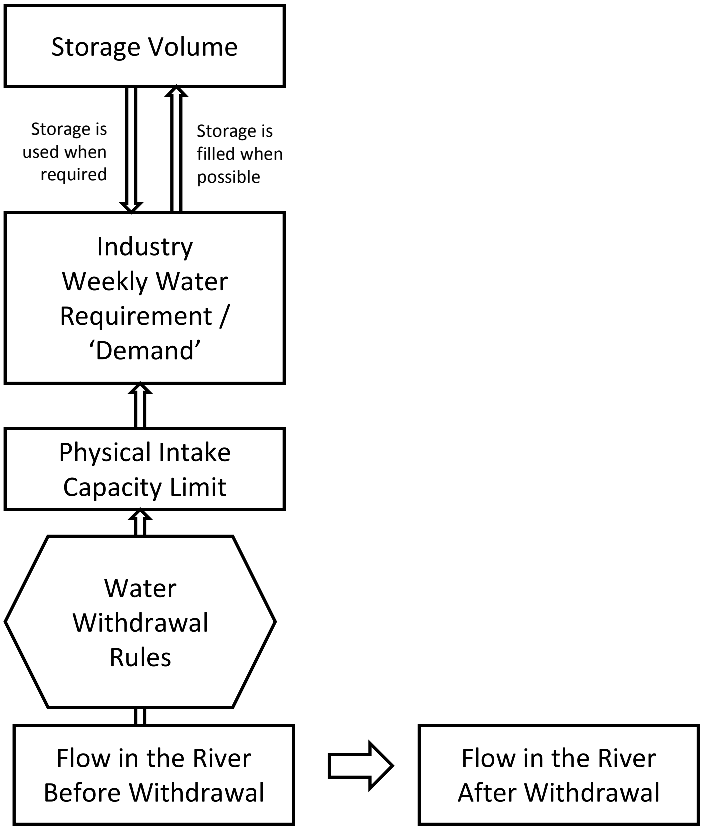
---

[8] Note that 29m^3/s is an input assumption that can be changed to any amount by the user.

To simulate the need for and use of storage, the calculator performs two steps:

First, it calculates the worst cumulative water deficit over the flow period (1958 – 2007) for the proposed rules.

Second, it assumes this deficit volume is available as storage and re-runs all the calculations as if storage of that volume were available for use.



6.2.3. Outputs

A screenshot of the Flow Calculator user interface is shown in Figure 20.

The calculator is able to incorporate up to 30 alternatives at a time. Changing the definition of the active alternative in the input box shown at the foot of Figure 20 results in immediate recalculation of the water balance and update of a number of charts and ECs.

Within the calculator itself, the following data is calculated.

Charts:

- Storage used over the 50 year flow period
- Flow remaining in the river before and after withdrawals for the 50 yr period
- % Reduction in Winter Wetted Area When Natural Flow <=Q80 for the 50 yr period
- The pattern of predicted withdrawals versus permitted withdrawals over the 50 yr period
- The statistical range of flow remaining in the river before and after withdrawals

- The statistical range of wetted area before and after withdrawals
- The statistical range of % reduction in winter wetted area when natural flow <=Q80 and >Q80.

ECs and Proxy ECs:

- Storage or storage equivalent required to meet the rules
- Predictions of storage shortfall statistics that would be expected if less than the predicted storage were built
- % Reduction in Winter Wetted Area When Natural Flow <=Q80
- % Reduction in suitable navigational area when natural flow <=Q80
- Costs of storage (see Section 5.5)
- Storage mitigation footprint area (see 5.5)

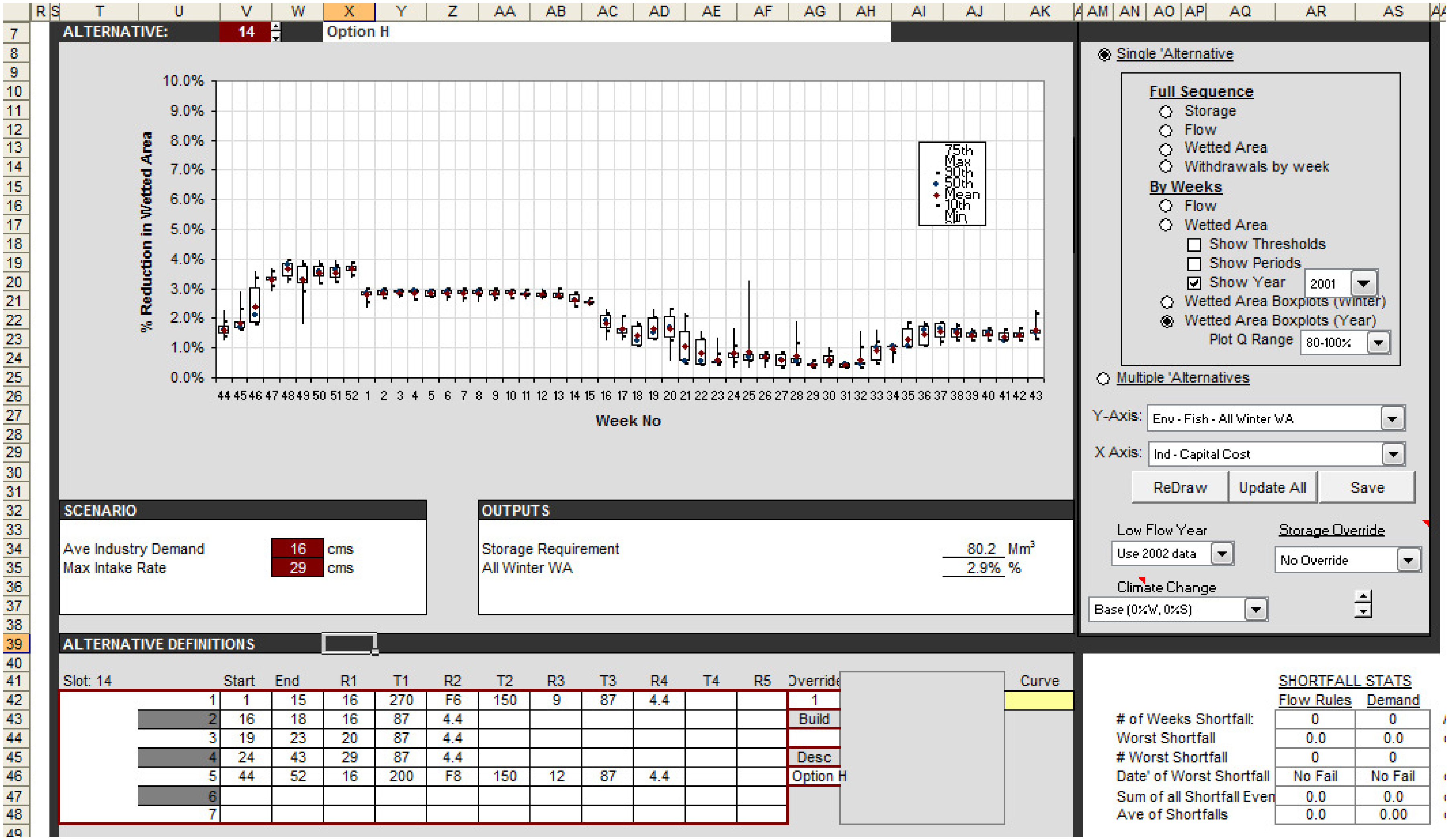
See Figure 21 for a sample of the type of output developed and presented for each alternative.

Further, the Flow Calculator could export a ‘flow file’ of the water remaining in the river for Segments 2 to 4. This flow files was used to calculate the instream flow ECs as described in Section 5.2.

The flow – wetted area relationships used by the Flow Calculator were provided by AENV based on River 2-D modelling. Because wetted area was often used as a real-time proxy for the more sophisticated instream flow EC calculations (e.g., fish habitat), statistical tests were performed which indicated a generally strong degree of correlation of the instream flow ECs with winter wetted area (see Section 5.2.11). Therefore, while the full suite of instream flow ECs continued to be calculated for all formal alternatives considered by the committee, there was confidence in the use of wetted area as a proxy measure of overall environmental performance when real-time feedback was required.

6.2.4. Quality Assurance

As an application based on Microsoft Excel, the Flow Calculator could be operated by anyone with a computer and was freely distributed. Early iterations of the Flow Calculator were audited in detail by P2FC participants familiar with modeling techniques. Over the course of the 18 months of use with the Flow Calculator, many participants tested and probed the flow calculator thoroughly through continued, often daily use. When counter-intuitive results were found, participants could examine line by line calculations to understand why. As a result of this process, participants developed a strong degree of comfort that the Flow Calculator was performing as intended.



ALTERNATIVE: 14 Option H

● Single 'Alternative

Full Sequence
- ○ Storage
- ○ Flow
- ○ Wetted Area
- ○ Withdrawals by week

By Weeks
- ○ Flow
- ○ Wetted Area
  - ☐ Show Thresholds
  - ☐ Show Periods
  - ☑ Show Year 2001
- ○ Wetted Area Boxplots (Winter)
- ● Wetted Area Boxplots (Year)
  - Plot Q Range 80-100%

○ Multiple 'Alternatives

Y-Axis: Env - Fish - All Winter WA
X Axis: Ind - Capital Cost

Low Flow Year: Use 2002 data
Storage Override: No Override
Climate Change: Base (0%W, 0%S)

SCENARIO

Ave Industry Demand	16	cms
Max Intake Rate	29	cms

OUTPUTS

Storage Requirement	80.2	Mm^3
All Winter WA	2.9%	%

ALTERNATIVE DEFINITIONS

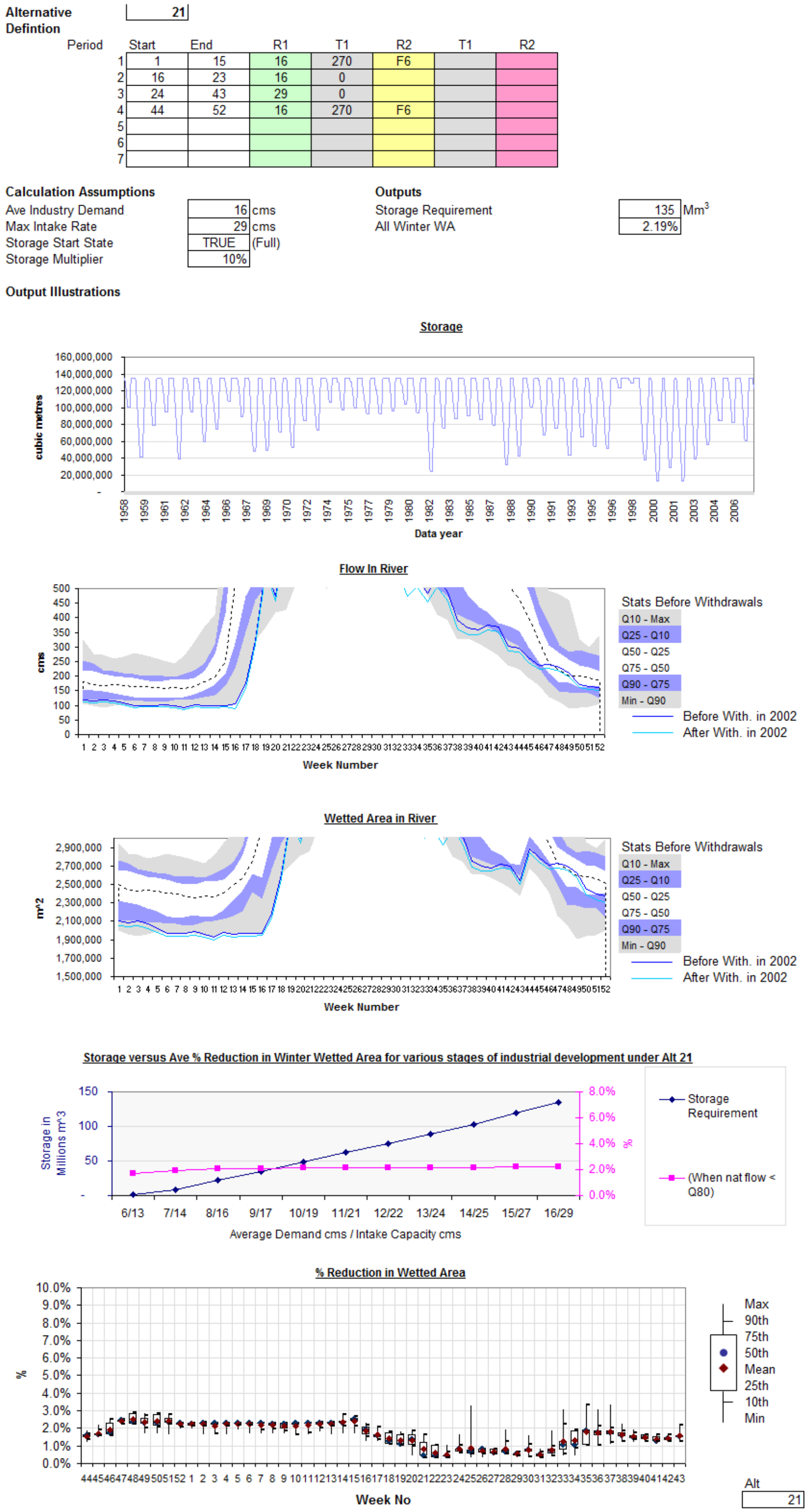
Slot: 14	Start	End	R1	T1	R2	T2	R3	T3	R4	T4	R5	Override
1	1	15	16	270	F6	150	9	87	4.4			1
2	16	18	16	87	4.4							Build
3	19	23	20	87	4.4							
4	24	43	29	87	4.4							Desc
5	44	52	16	200	F8	150	12	87	4.4			Option H
6												
7												

Curve

SHORTFALL STATS

	Flow Rules	Demand
# of Weeks Shortfall:	0	0
Worst Shortfall	0.0	0.0
# Worst Shortfall	0	0
Date' of Worst Shortfall	No Fail	No Fail
Sum of all Shortfall Even	0.0	0.0
Ave of Shortfalls	0.0	0.00

Figure 20: Flow Calculator User Interface Screenshot



Alternative Defintion 21

Period	Start	End	R1	T1	R2	T1	R2
1	1	15	16	270	F6		
2	16	23	16	0			
3	24	43	29	0			
4	44	52	16	270	F6		
5							
6							
7							

Calculation Assumptions

Ave Industry Demand	16	cms
Max Intake Rate	29	cms
Storage Start State	TRUE	(Full)
Storage Multiplier	10%	

Outputs

Storage Requirement	135	Mm^3
All Winter WA	2.19%	

Output Illustrations

Figure 21: Example outputs from the Flow Calculator

7. Alternatives Development & Consequence Assessment

In this section we summarize how the iterative process of designing and evaluating alternatives using the flow calculator, EC results, other supporting analyses and committee deliberations ultimately led to the development of a final alternative.

Note that unless indicated otherwise, all of the data presented here assume the industry conditions of 16 m^3/s weekly average demand and a 29m^3/s peak withdrawal rate. See Section 3.2 for further information on these assumptions.

7.1. Round 1 Alternatives (Alts 1-7)

In the first round of alternative definitions, the P2FC was encouraged to design and consider so-called 'bookend' alternatives. These are alternatives that are extreme versions of a particular design theme, such as "the best that could be done to protect aquatic values" or "the lowest cost" and so on. These bookends are helpful for several reasons:

- Because they are typically simple and do not embed compromises, the dynamics of the response of the bookend alternatives are readily understood and this helps participants to develop a feel for cause and effect, and also to test that the assessment tools (e.g., Flow Calculator outputs and EC results) match common sense and independent calculations.
- Bookends help test and therefore constrain consideration of alternatives to what is physically possible.
- Bookends help test the sensitivity of ECs. If an EC does not vary significantly across the range of extremely diverse bookend alternatives, then it is very unlikely they will begin to vary significantly when later considering more subtly different, balanced alternatives.

Table 4 presents the rule set definitions of alternatives 1 through 7 in terms of thresholds and water withdrawal rules.

Alternative 1 was developed as the most environmentally protective bookend and was referred to both as the 'fully protected case' and the 'Alberta Desktop method'. It states that when flows in the river exceed the weekly 80% exceedence value (Q80) then up to 15% of the river's flow may be withdrawn; below this threshold, no water can be withdrawn[9]. This method is

---

[9] If 15% of flow removal seems high, recall that the peak removal rate is limited to 29 m^3/s, and the average removal rate is assumed to be 16 m^3/s – for much of the year the river flows are in the many hundreds of m^3/s and so withdrawals are often limited by this assumed infrastructure maximum even if the rule might suggest something much greater.

sometimes used in Alberta as a default method for regulating withdrawals from smaller rivers when information that would help define a more sophisticated regime is unavailable.

Table 4: Round 1 Alternative Rule Set Definitions

		Start	End	R1	T1	R2	T2	R3
Alt 1	Period 1	1	52	F15	Q80	0		

		Start	End	R1	T1	R2	T2	R3
Alt 2	Period 1	1	52	29	0			

		Start	End	R1	T1	R2	T2	R3
Alt 3	Period 1	1	52	P1	P1	P1	P1	P1

		Start	End	R1	T1	R2	T2	R3
Alt 4	Period 1	1	15	F15	Q90	12	Q95	9
	Period 2	16	43	F15	Q90	34		
	Period 3	44	52	F15	Q90	12	Q95	9

		Start	End	R1	T1	R2	T2	R3
Alt 5	Period 1	1	15	F15	Q80	0		
	Period 2	16	43	29	0			
	Period 3	44	52	F15	Q80	0		

		Start	End	R1	T1	R2	T2	R3
Alt 6	Period 1	1	15	11	0			
	Period 2	16	43	29	0			
	Period 3	44	52	11	0			

		Start	End	R1	T1	R2	T2	R3
Alt 7	Period 1	1	15	4	Q95	0		
	Period 2	16	43	29	0			
	Period 3	44	52	4	Q95	0		

Alternative 2 represents the opposite bookend: a ‘no withdrawal constraints’ case. Above the threshold of zero, industry may withdraw up to its peak requirement of 29 m^3/s at any time. In essence this would allow demand to be met at all times, and would result in a constant ongoing withdrawal of 16 m^3/s.

Alternative 3 uses the 'hardwired' values in m^3/s from the Phase 1 framework [for details see AENV/DFO (2007), *Volume 2: Technical Appendix*].

Alternative 4 was an attempt to represent the Phase 1 framework using the input constraints of the Flow Calculator. The actual Phase 1 framework has rules that refer to other factors, including wetted area values. Although Alternative 4 does not refer to the wetted area component and makes numerous simplifications from the actual Phase 1 rules, its performance was in fact quite close to that of Alternative 3. Alternative 4 was included in case there was an interest in making discreet modifications to the Phase 1 rules.

Alternative 5 was referred to as the 'modified Alberta desktop method'. It has the same protection of fish values over the winter months, but during the open water season reverts to 'no constraints' (i.e., the maximum build peak intake of 29 m^3/s)

Alternative 6 was an attempt to define a very simple alternative. It simply states that 11 m^3/s may be withdrawn over the winter. There are essentially no constraints over the summer.

Alternative 7 has a winter allowance of 4 m^3/s when river flows exceed the weekly Q95 levels; below this threshold, no withdrawals are permitted. During the summer, there are essentially no constraints.

7.1.1. Consequence Table Summary

The consequence table developed at the time for these alternatives is presented in Table 4.

Note that later iterations of the consequence table for the same alternative and EC may show different results. This is because the methodology for calculating ECs was under ongoing review and development within the IFNTTG, WREM and ETG task groups.

Table 4: Round 1 Consequence Table

OBJECTIVES	Evaluation Criteria	Pref. Direction	MSIC	ALT 1	ALT 2	ALT 3	ALT 4	ALT 5	ALT 6	ALT 7
1 Ecosystem Health										
1.1 Delta (Reach 1)										
Delta Connectivity - Channels	**% decrease in days of no connection**	**lower**	**5%**	0.8	3.3	2.9	3.2	0.8	2.2	0.5
Walleye 1	**Population reduction (% loss)**	**lower**	**2%**	8.4	9.5	9.2	9.3	7.7	6.7	2.9
Walleye 2	**Population viability (extinction probability; %)**	**lower**	**0.2%**	0.0	0.1	0.3	0.1	0.0	0.0	0.0
1.2 Athbasca River (Reaches 4 to 2)										
Whitefish Spawning Habitat	**% loss effective spawning habitat**	**lower**	**5%**	12.2	18.7	17.4	17.8	11.5	12.8	4.1
Fish Habitat 1	**% impacted (N=9), ice cover**	**lower**	**10%**	0.0	55.6	44.4	44.4	0.0	44.4	0.0
Fish Habitat 2	**mean % loss of most sensitive, ice cover**	**lower**	**2%**	0.4	5.2	4.0	4.3	0.5	3.6	1.0
Fish Habitat 3	**% impacted (N=30), open water**	**lower**	**3%**	0.0	43.3	43.3	43.3	43.3	43.3	46.7
Fish Habitat 4	**mean % loss of most sensitive, open water**	**lower**	**2%**	0.6	2.8	3.3	3.2	3.8	4.5	4.3
Mesohabitat 1	**% impacted (N=16), ice cover**	**lower**	**6.3%**	18.8	43.8	37.5	37.5	18.8	12.5	0.0
Mesohabitat 2	**mean % loss of most sensitive, ice cover**	**lower**	**2%**	7.9	22.7	21.7	22.2	9.4	16.7	6.8
Mesohabitat 3	**% impacted (N=21), open water**	**lower**	**4.8%**	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mesohabitat 4	**mean % loss of most sensitive, open water**	**lower**	**2%**	1.5	4.4	4.7	4.6	6.0	5.9	7.9
Water Quality- Dissolved Oxygen	**% reduction in fish habitat due to DO decline**	**lower**	**5%**	6.5	7.7	5.9	6.3	6	5.2	1.4
Channel Maintenance Flows	**Frequency & Duration**	**lower**	**?**	<5	<5	<5	<5	<5	<5	<5
2 Social - Traditional and Public Use										
3 Economy - Industry										
Storage Requirements	**Volume**			1600	0	72	74	242	73	210

ECs expressed in the form of percentages show the percent reductions from natural flow in years where the weekly flow in the river is below the Q80 exceedence level (i.e. the 20% of lowest flow years).

For all ECs, the lower the number, the better.

By the time the P2FC was considering this first round of alternatives, IFNTTG Evaluation Criteria development was at a reasonably advanced, but not yet complete stage.

As previously mentioned, one helpful outcome of using ‘bookend’ alternatives is to help rule out particular issues that, while certainly of interest and value to the P2FC, do not change significantly across flow alternatives. As an example, the first row of this table shows the impact of the various alternatives on the EC for Delta Channel connectivity. Whilst there are differences across these bookend alternatives, these differences are within the Minimum Significant Increment of Change (MSIC) value of 5% for this measure, suggesting that the differences are within the uncertainty range of the model used to develop them. As another example, channel maintenance flow impact differences across alternatives were considered to be too small to be significant. As described in Section 5.2, these early analyses helped enable the IFNTTG to continually refine the ECs and focus attention on those results that were both sensitive to flow changes across alternatives and significant from an ecosystem health perspective.

Throughout the Phase 2 process, some participants expressed difficulty in understanding the true significance of the instream flow ECs on fish and other aquatic values. While the often highly complex technical details of their calculation were communicated clearly, it was an ongoing challenge to provide context to help understand how important EC variations across alternatives actually were to instream flow values. In response to these challenges, the IFNTTG developed reference scales for each EC to provide the P2FC with guidance regarding the biological significance of a response (see Section 5.2.10). Three levels of expected change were set for each EC using the following general categories: undetectable change, detectable change and potentially irreversible change. These reference scales began to be presented in Round 2 as described below.

The storage EC, while still somewhat ambiguous in nature, was nevertheless a little more tangible to participants. To understand the nature of one million m^3 of storage, it is helpful to think of a square pond one kilometer on each side by one metre deep. Alternatives 2 to 6 have storage requirements in the 0 to 300 million m^3 range. (Figure 22 shows the storage use of Alternative 3, for example). Note that each year, the reservoir is allowed to refill to the storage limit before being withdrawn again the following year.

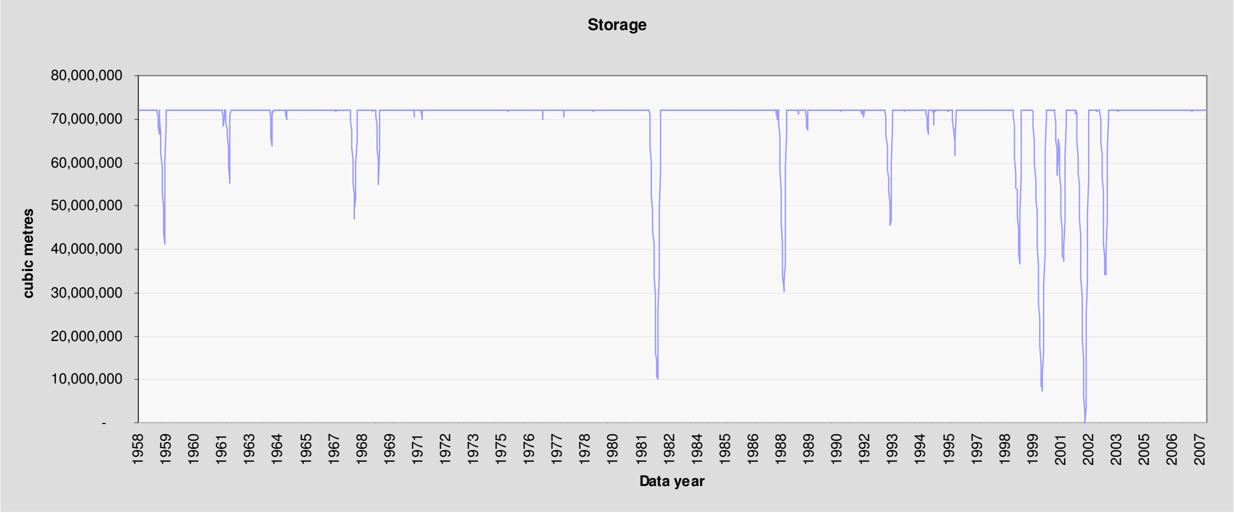


Figure 22: Storage Use of Alternative 3

Note that the cluster of more active use of water from storage in the years 1999 to 2003 is because flows in this period were relatively dry. The 2002 year was usually the one that defined the storage need.

Alternative 1, the fully protective case, by contrast does not always provide enough water during the summer to completely refill the storage (due to the 0 m^3/s allowance in weeks that are drier than the 20% driest years on record throughout the year, including the summer). In this case, the dry sequence of years in the early 2000s forces storage to be built to handle a *sequence of multi-year events* as shown in Figure 23.

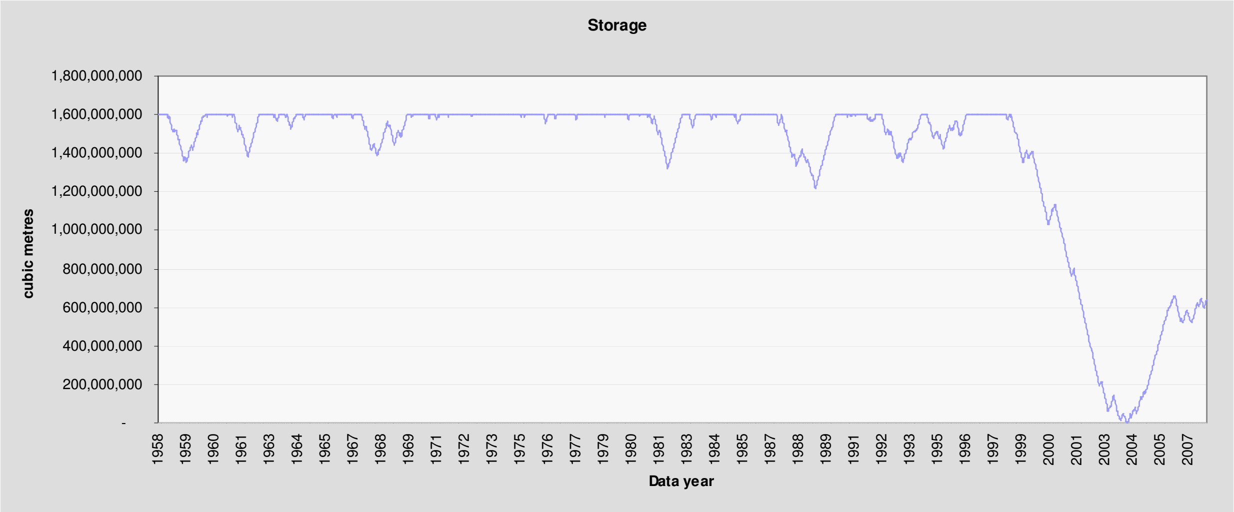


Figure 23: Storage Use of Alternative 1

Limiting storage refilling in the summer drives storage requirement to the huge level of 1,600 million m^3. The likely means of supplying this amount of storage would be to construct a major dam on the mainstem of the Athabasca River. If this was not feasible, the other alternative would be to limit oil sands mining development to the water availability below the established projections used in this analysis. Since the question of limiting the scale of oil sands mining development was outside the scope of the P2FC's mandate, it quickly became clear that economic, environmental and social impacts associated with the actual means of providing required storage would need to be addressed by the process. This task was given to WREM (see Section 5.5) and the findings first used in Round 3 deliberations.

7.1.2. Key Trade-offs, Lessons and Outcomes

Using the average percent reduction of winter wetted area in Q80- Q100 flow range as an approximate proxy for impacts to aquatic ecosystem health, and storage requirement as a proxy for the overall cost and implications for industry, and we can illustrate the key trade-off on a scatterplot as presented in Figure 24.

On this chart, a perfect solution would be at the origin, since lower values are better for both wetted area (Y-axis) and storage requirement (X-axis). Alternative 2, the 'no constraints' approach, requires no storage but is the worst performer on the wetted area proxy. Alternatives 1 and 5 perform the opposite way. The only improvement in fish protection of Alternative 1 over Alternative 5 is during the summer open water period when impacts are minimal at given withdrawal assumptions; furthermore, the additional protection provided by Alternative 1 cannot feasibly be achieved, even with a complete mainstem dam, if the 16/29 m^3/s demand assumption is maintained.

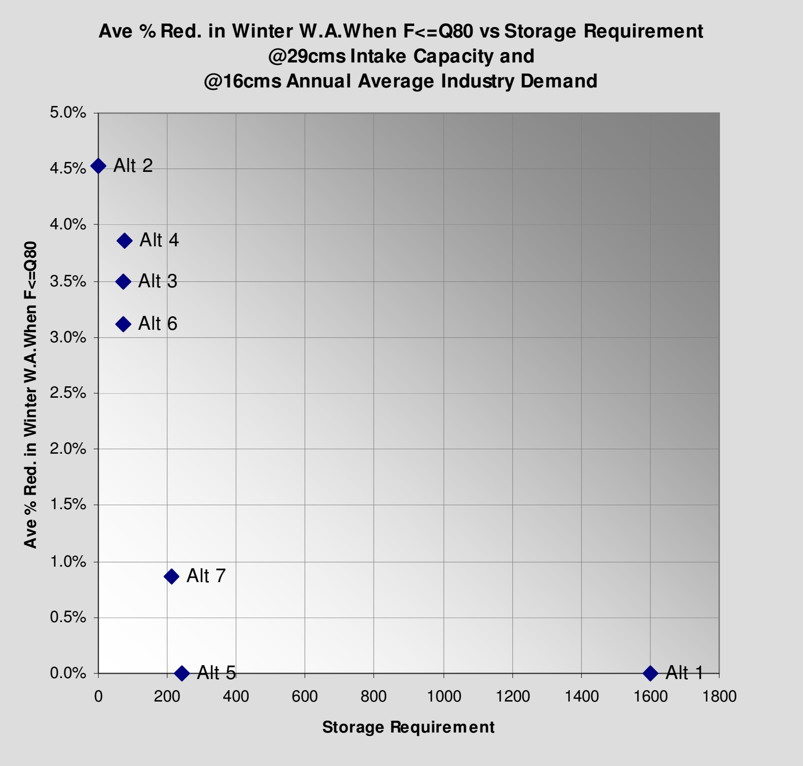


Figure 24: Loss of Average Winter Wetted Area versus Storage for Alts 1 to 7

Figure 24 demonstrates that there is a fundamental trade-off to be considered between impacts to aquatic ecosystem health and the costs of mitigation of those impacts to industry (through the proxy indicator of storage).

Through discussions of the key trade-offs and lessons from this first round of alternatives assessment, and upon reflection on the principles set out for the planning process (i.e., to seek a balance across multiple objectives, etc.), the committee agreed to move beyond the most extreme alternatives of Round 1.

Over the weeks and months that followed, many participants, in the P2FC as well as IFNTTG and WREM task groups, actively began creating and testing new alternatives, while simultaneously supporting the development of ECs and related assessment methods.

7.2. Round 2 Alternatives (Alts 8-18)

Of the many hundreds of alternatives that had been considered in the meantime, 11 more were put forward to the P2FC for the Round 2 consideration. These were chosen as being representative of the kinds of alternatives being explored by participants. These are presented in Table 5 below.

These new alternatives employ various strategies to seek a balance between environmental performance and industry cost. Participants quickly learned that summer flows need to be relatively unrestricted, i.e. at or near 29 m^3/s, in order to avoid the multi-year storage problem found with Alternative 1. These withdrawal rates in the summer were found to not be a significant problem for instream flow values using the IFN ECs, which isn't surprising given 29 m^3/s is a small percentage of river flow during much of the open-water season. Less restricted withdrawals in summer allows storage to fill fully in advance of the subsequent winter period, when tighter restrictions can reduce to below the assumed average weekly demand of 16 m^3/s as storage is used to make up the difference.

Many of the alternatives in this round employ rules that gradually increase protection as flows in the river decrease, parallel to the green, yellow and red rules of the Phase 1 Framework. Some alternatives employ weekly exceedence (Q) values to define thresholds; others preferred to use absolute flows in m^3/s instead.

Table 5: Round 2 Alternative Rule Set Definitions (Alternatives 8 to 17)

		Start	End	R1	T1	R2	T2	R3
Alt 8	Period 1	1	13	4	Q95	0		
	Period 2	14	18	F10	0			
	Period 3	19	43	29	0			
	Period 4	44	49	F7	0			
	Period 5	50	52	4	Q95	0		

		Start	End	R1	T1	R2	T2	R3
Alt 9	Period 1	1	13	6	0			
	Period 2	14	18	16	Q95	F10		
	Period 3	19	43	29	0			
	Period 4	44	49	16	Q95	F10		
	Period 5	50	52	16	Q95	F10		

		Start	End	R1	T1	R2	T2	R3
Alt 10	Period 1	1	15	11	Q95	8		
	Period 2	16	43	29	0			
	Period 3	44	46	16	0			
	Period 4	47	52	15	Q95	12		

		Start	End	R1	T1	R2	T2	R3
Alt 11	Period 1	1	15	12	Q96	F10		
	Period 2	16	43	29	0			
	Period 3	44	46	16	0			
	Period 4	47	52	16	Q96	12		

		Start	End	R1	T1	R2	T2	R3
Alt 12	Period 1	1	10	14	Q96	10		
	Period 2	11	15	16	Q96	12		
	Period 3	16	45	29	0			
	Period 4	46	49	16	Q96	14		
	Period 5	50	52	16	Q96	12		

Alt 13

	Start	End	R1	T1	R2	T2	R3
Period 1	1	10	7	0			
Period 2	11	15	16	0			
Period 3	16	45	29	0			
Period 4	46	49	14	0			
Period 5	50	52	8	0			

Alt 14

	Start	End	R1	T1	R2	T2	R3
Period 1	1	10	29	130	10	90	0
Period 2	11	15	29	170	10	90	0
Period 3	16	20	29	250	25		
Period 4	21	45	29	0			
Period 5	46	49	29	170	10	90	0
Period 6	50	52	29	145	10	90	0

Alt 15

	Start	End	R1	T1	R2	T2	R3
Period 1	1	10	29	500	16	200	3
Period 2	11	15	29	500	16	200	3
Period 3	16	20	29	500	20		
Period 4	21	45	29	0			
Period 5	46	49	29	500	16	200	3
Period 6	50	52	29	500	16	200	3

Alt 16

	Start	End	R1	T1	R2	T2	R3
Period 1	1	13	4	Q95	0		
Period 2	14	18	29	Q95	F15		
Period 3	19	43	29				
Period 4	44	49	29	Q95	F15		
Period 5	50	52	4	Q95	0		

Alt 17

	Start	End	R1	T1	R2	T2	R3
Period 1	1	13	16	Q80	5	Q95	0
Period 2	14	18	29	Q80	F15		
Period 3	19	43	29				
Period 4	44	49	29	Q80	F15		
Period 5	50	52	16	Q80	7	Q95	0

Note: Alternative 18 had a different design concept in which rules were defined by ‘dragging’ curves on a plot of flow versus permitted withdrawals. The approach was not pursued, though the functionality is retained in the Flow Calculator.

7.2.1. Consequence Table Summary

The consequences for all Round 1 and Round 2 alternatives are presented in Table 6 below. Alternatives 1 and 4 are not shown here to conserve space; by this time it was clear that neither of these alternatives would satisfy the P2FC's collective needs.

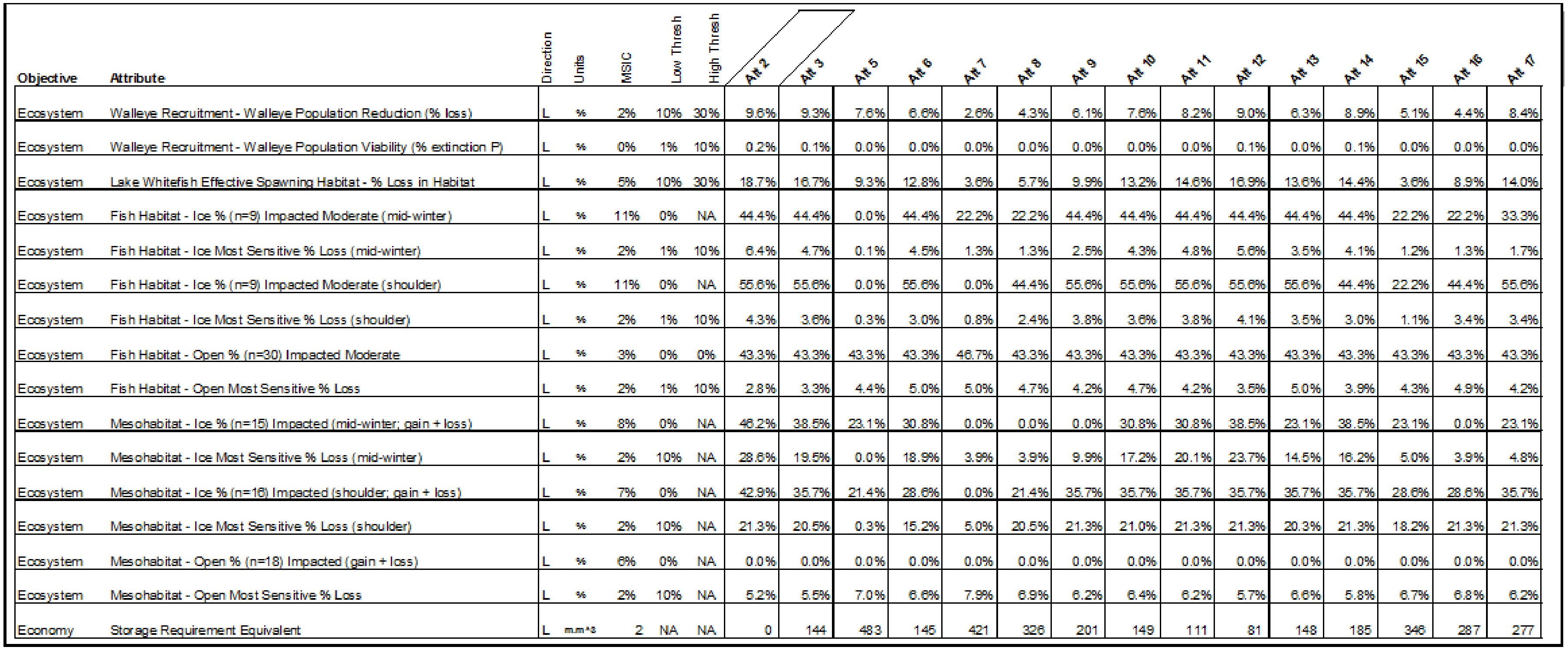
A new addition to the consequence table in this round was the addition of reference scales in the form of lower and higher thresholds for the various instream flow ECs. While technical definitions vary across ECs, in general terms the concept is that impacts below the lower threshold are considered to be 'undetectable' and are not considered to be of tangible impact to fish and other aquatic values. Impacts that lie between the lower and upper threshold are considered to be 'detectable yet reversible' and are therefore important for consideration. Impacts above the upper threshold are considered to be significant and 'potentially irreversible' (e.g., fish population declines that may be permanent).

The Walleye Population Reduction EC is one example of an EC that varied across alternatives slightly, but was always below the lower threshold. Impacts across this range of alternatives should therefore be considered to be below (yet approaching) the detectable range for walleye. Loss of whitefish spawning habitat lies fairly consistently between the lower and upper thresholds for that EC.

Fish habitat ECs are presented in pairs in Table 6: the percent of habitat types affected to at least a moderate degree (showing the breadth of impact) and the percent loss of the most sensitive habitat type (showing the intensity of impact on at least one area of concern). Of the fish habitat ECs, the ones of greatest focus for the IFNTTG were the indicators for the most sensitive impact in the mid winter and shoulder seasons. Again, these impacts are considered to be between the thresholds of concern, in the detectable zone.

The mesohabitat indicators of greatest interest were similarly the ones that measured the most sensitive impact in the mid-winter and shoulder seasons. While these indicators were often above threshold 1, the IFNTTG had not yet proposed a higher threshold at which impacts might be considered to be of more serious concern (see Section 5.2.10 for more detail).

Table 6: Round 2 Consequence Table (without colours)



Objective	Attribute	Direction	Units	MSIC	Low Thresh	High Thresh	Alt 2	Alt 3	Alt 5	Alt 6	Alt 7	Alt 8	Alt 9	Alt 10	Alt 11	Alt 12	Alt 13	Alt 14	Alt 15	Alt 16	Alt 17
Ecosystem	Walleye Recruitment - Walleye Population Reduction (% loss)	L	%	2%	10%	30%	9.6%	9.3%	7.6%	6.6%	2.6%	4.3%	6.1%	7.6%	8.2%	9.0%	6.3%	8.9%	5.1%	4.4%	8.4%
Ecosystem	Walleye Recruitment - Walleye Population Viability (% extinction P)	L	%	0%	1%	10%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%
Ecosystem	Lake Whitefish Effective Spawning Habitat - % Loss in Habitat	L	%	5%	10%	30%	18.7%	16.7%	9.3%	12.8%	3.6%	5.7%	9.9%	13.2%	14.6%	16.9%	13.6%	14.4%	3.6%	8.9%	14.0%
Ecosystem	Fish Habitat - Ice % (n=9) Impacted Moderate (mid-winter)	L	%	11%	0%	NA	44.4%	44.4%	0.0%	44.4%	22.2%	22.2%	44.4%	44.4%	44.4%	44.4%	44.4%	44.4%	22.2%	22.2%	33.3%
Ecosystem	Fish Habitat - Ice Most Sensitive % Loss (mid-winter)	L	%	2%	1%	10%	6.4%	4.7%	0.1%	4.5%	1.3%	1.3%	2.5%	4.3%	4.8%	5.6%	3.5%	4.1%	1.2%	1.3%	1.7%
Ecosystem	Fish Habitat - Ice % (n=9) Impacted Moderate (shoulder)	L	%	11%	0%	NA	55.6%	55.6%	0.0%	55.6%	0.0%	44.4%	55.6%	55.6%	55.6%	55.6%	55.6%	44.4%	22.2%	44.4%	55.6%
Ecosystem	Fish Habitat - Ice Most Sensitive % Loss (shoulder)	L	%	2%	1%	10%	4.3%	3.6%	0.3%	3.0%	0.8%	2.4%	3.8%	3.6%	3.8%	4.1%	3.5%	3.0%	1.1%	3.4%	3.4%
Ecosystem	Fish Habitat - Open % (n=30) Impacted Moderate	L	%	3%	0%	0%	43.3%	43.3%	43.3%	43.3%	46.7%	43.3%	43.3%	43.3%	43.3%	43.3%	43.3%	43.3%	43.3%	43.3%	43.3%
Ecosystem	Fish Habitat - Open Most Sensitive % Loss	L	%	2%	1%	10%	2.8%	3.3%	4.4%	5.0%	5.0%	4.7%	4.2%	4.7%	4.2%	3.5%	5.0%	3.9%	4.3%	4.9%	4.2%
Ecosystem	Mesohabitat - Ice % (n=15) Impacted (mid-winter; gain + loss)	L	%	8%	0%	NA	46.2%	38.5%	23.1%	30.8%	0.0%	0.0%	0.0%	30.8%	30.8%	38.5%	23.1%	38.5%	23.1%	0.0%	23.1%
Ecosystem	Mesohabitat - Ice Most Sensitive % Loss (mid-winter)	L	%	2%	10%	NA	28.6%	19.5%	0.0%	18.9%	3.9%	3.9%	9.9%	17.2%	20.1%	23.7%	14.5%	16.2%	5.0%	3.9%	4.8%
Ecosystem	Mesohabitat - Ice % (n=16) Impacted (shoulder; gain + loss)	L	%	7%	0%	NA	42.9%	35.7%	21.4%	28.6%	0.0%	21.4%	35.7%	35.7%	35.7%	35.7%	35.7%	35.7%	28.6%	28.6%	35.7%
Ecosystem	Mesohabitat - Ice Most Sensitive % Loss (shoulder)	L	%	2%	10%	NA	21.3%	20.5%	0.3%	15.2%	5.0%	20.5%	21.3%	21.0%	21.3%	21.3%	20.3%	21.3%	18.2%	21.3%	21.3%
Ecosystem	Mesohabitat - Open % (n=18) Impacted (gain + loss)	L	%	6%	0%	NA	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Ecosystem	Mesohabitat - Open Most Sensitive % Loss	L	%	2%	10%	NA	5.2%	5.5%	7.0%	6.6%	7.9%	6.9%	6.2%	6.4%	6.2%	5.7%	6.6%	5.8%	6.7%	6.8%	6.2%
Economy	Storage Requirement Equivalent	L	m.m^3	2	NA	NA	0	144	483	145	421	326	201	149	111	81	148	185	346	287	277

Note: Storage requirements in this table are exactly double than in the previous Round. This was due to the use of a 100% 'storage adder'.

ECs expressed in the form of percentages show the percent reductions from natural flow in years where the weekly flow in the river is below the Q80 exceedence level (i.e. the 20% of lowest flow years).

For all ECs, the lower the number, the better.

The storage figures presented at this stage were double those presented in the previous round. This reflected industry's concern that the storage indicator was assuming 'perfect' distribution of water across the multiple mine locations, and no losses to evaporation, etc. As a first attempt to represent the actual inefficiency of storage deployment, a conservative 100% 'adder' or 'multiplier' was proposed. By Round 3 a somewhat more sophisticated means of understanding the mitigation build out had been developed, and the adder was consequently reduced to 10%. When even this figure caused calculation inconsistencies during later analysis, the use of the storage adder was dropped entirely. However, it should be noted that there are expected inefficiencies in the distribution of water across mines and so the storage value predicted by the calculator does not explicitly account for this issue.

Table 6 is intended to compress the fundamental trade-offs embedded across a large number of alternatives on multiple interests on one piece of paper. To help explore the performance of one alternative relative to another, the facilitators made use of a separate spreadsheet tool that shows these differences through the use of colour coding (Table 7).

With this tool, the user may select any alternative to compare it to the others. The colour coding is as follows:

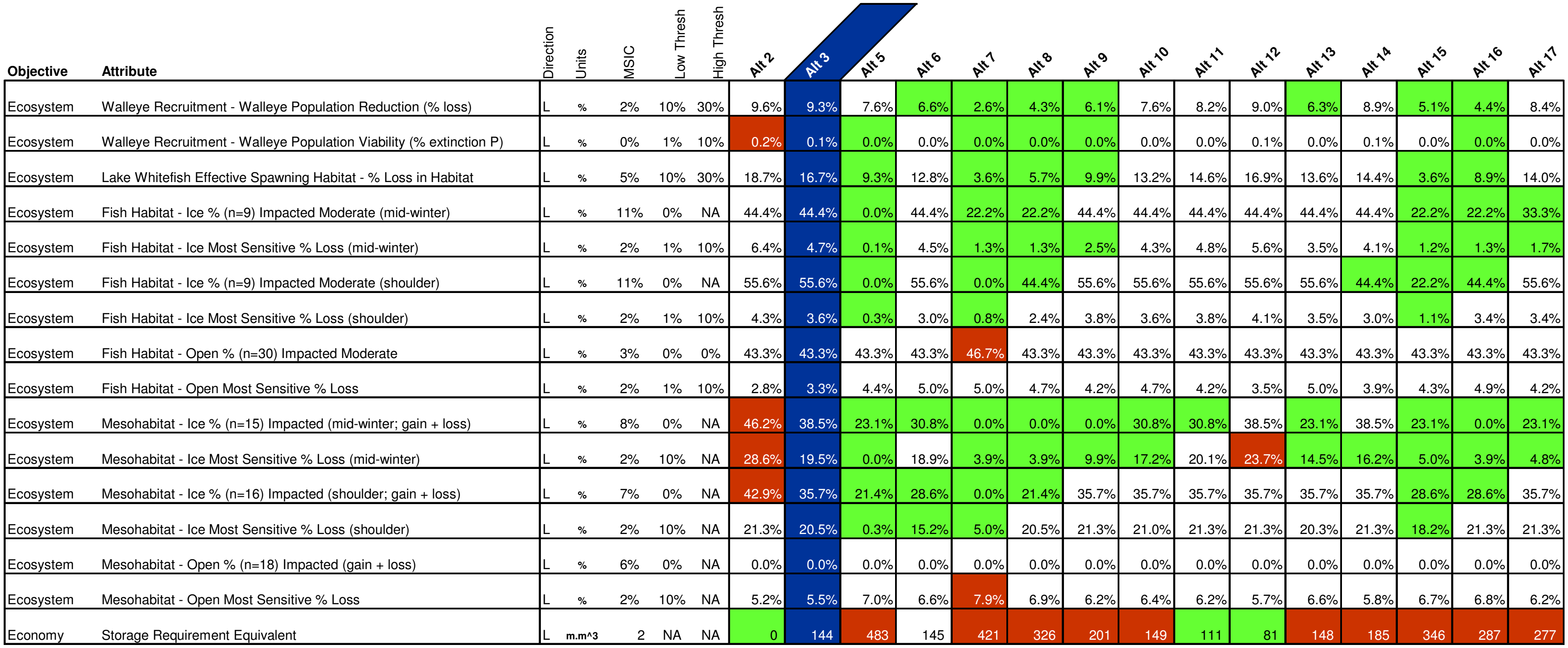
- Blue – Indicates that the alternative has been selected by the user to compare to others
- Red – Indicates that the an alternative is performing worse than the selected alternative
- Green – Indicates that an alternative is performing better than the selected alternative
- White – indicates that the performance difference between that alternative on that EC is too similar for that difference to be considered significant (i.e. within the MSIC)

In Table 7, Alternative 3 (i.e., the Phase 1 Framework) has been selected as a basis for comparison. Alternative 2 significantly outperforms it on only one criterion: storage. Otherwise it performs worse than or effectively the same as Alternative 3 on all other criteria. Because of this one criterion, however, we cannot say that Alternative 3 outperforms Alternative 2.

There are, however, several alternatives in the table that either outperform, or at least perform similarly, on all criteria. Alternatives 6 and 11, for example, appear, on the basis of the ECs, to dominate Alternative 3 across the full range of ECs.

For some people, the strength of Alternatives 6 and 11 was counter-intuitive. Both these alternatives have fixed lowest withdrawal rates (11 m^3/s and 12 m^3/s respectively), meaning that at lower flows in the river, the percentage of water removed relative to that remaining would progressively increase. There was agreement that this should generally be avoided where possible, and concern that impacts at very low flow were not being captured effectively in the ECs. From this point onwards, the identification of impacts to fish and aquatic values at rare low flows was flagged as an important issue. As the process proceeded, this concern took on greater importance.

Table 7: Round 2 Consequence Table (with colours, Alternative 3 selected)



Objective	Attribute	Direction	Units	MSIC	Low Thresh	High Thresh	Alt 2	Alt 3	Alt 5	Alt 6	Alt 7	Alt 8	Alt 9	Alt 10	Alt 11	Alt 12	Alt 13	Alt 14	Alt 15	Alt 16	Alt 17
Ecosystem	Walleye Recruitment - Walleye Population Reduction (% loss)	L	%	2%	10%	30%	9.6%	9.3%	7.6%	6.6%	2.6%	4.3%	6.1%	7.6%	8.2%	9.0%	6.3%	8.9%	5.1%	4.4%	8.4%
Ecosystem	Walleye Recruitment - Walleye Population Viability (% extinction P)	L	%	0%	1%	10%	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%
Ecosystem	Lake Whitefish Effective Spawning Habitat - % Loss in Habitat	L	%	5%	10%	30%	18.7%	16.7%	9.3%	12.8%	3.6%	5.7%	9.9%	13.2%	14.6%	16.9%	13.6%	14.4%	3.6%	8.9%	14.0%
Ecosystem	Fish Habitat - Ice % (n=9) Impacted Moderate (mid-winter)	L	%	11%	0%	NA	44.4%	44.4%	0.0%	44.4%	22.2%	22.2%	44.4%	44.4%	44.4%	44.4%	44.4%	44.4%	22.2%	22.2%	33.3%
Ecosystem	Fish Habitat - Ice Most Sensitive % Loss (mid-winter)	L	%	2%	1%	10%	6.4%	4.7%	0.1%	4.5%	1.3%	1.3%	2.5%	4.3%	4.8%	5.6%	3.5%	4.1%	1.2%	1.3%	1.7%
Ecosystem	Fish Habitat - Ice % (n=9) Impacted Moderate (shoulder)	L	%	11%	0%	NA	55.6%	55.6%	0.0%	55.6%	0.0%	44.4%	55.6%	55.6%	55.6%	55.6%	55.6%	44.4%	22.2%	44.4%	55.6%
Ecosystem	Fish Habitat - Ice Most Sensitive % Loss (shoulder)	L	%	2%	1%	10%	4.3%	3.6%	0.3%	3.0%	0.8%	2.4%	3.8%	3.6%	3.8%	4.1%	3.5%	3.0%	1.1%	3.4%	3.4%
Ecosystem	Fish Habitat - Open % (n=30) Impacted Moderate	L	%	3%	0%	0%	43.3%	43.3%	43.3%	43.3%	46.7%	43.3%	43.3%	43.3%	43.3%	43.3%	43.3%	43.3%	43.3%	43.3%	43.3%
Ecosystem	Fish Habitat - Open Most Sensitive % Loss	L	%	2%	1%	10%	2.8%	3.3%	4.4%	5.0%	5.0%	4.7%	4.2%	4.7%	4.2%	3.5%	5.0%	3.9%	4.3%	4.9%	4.2%
Ecosystem	Mesohabitat - Ice % (n=15) Impacted (mid-winter; gain + loss)	L	%	8%	0%	NA	46.2%	38.5%	23.1%	30.8%	0.0%	0.0%	0.0%	30.8%	30.8%	38.5%	23.1%	38.5%	23.1%	0.0%	23.1%
Ecosystem	Mesohabitat - Ice Most Sensitive % Loss (mid-winter)	L	%	2%	10%	NA	28.6%	19.5%	0.0%	18.9%	3.9%	3.9%	9.9%	17.2%	20.1%	23.7%	14.5%	16.2%	5.0%	3.9%	4.8%
Ecosystem	Mesohabitat - Ice % (n=16) Impacted (shoulder; gain + loss)	L	%	7%	0%	NA	42.9%	35.7%	21.4%	28.6%	0.0%	21.4%	35.7%	35.7%	35.7%	35.7%	35.7%	35.7%	28.6%	28.6%	35.7%
Ecosystem	Mesohabitat - Ice Most Sensitive % Loss (shoulder)	L	%	2%	10%	NA	21.3%	20.5%	0.3%	15.2%	5.0%	20.5%	21.3%	21.0%	21.3%	21.3%	20.3%	21.3%	18.2%	21.3%	21.3%
Ecosystem	Mesohabitat - Open % (n=18) Impacted (gain + loss)	L	%	6%	0%	NA	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Ecosystem	Mesohabitat - Open Most Sensitive % Loss	L	%	2%	10%	NA	5.2%	5.5%	7.0%	6.6%	7.9%	6.9%	6.2%	6.4%	6.2%	5.7%	6.6%	5.8%	6.7%	6.8%	6.2%
Economy	Storage Requirement Equivalent	L	m.m^3	2	NA	NA	0	144	483	145	421	326	201	149	111	81	148	185	346	287	277

Colour key:

Blue – indicates that the alternative has been selected by the user to compare to others

Red – Indicates that the an alternative is performing worse than the selected alternative

Green – Indicates that an alternative is performing better than the selected alternative

White – indicates that the performance difference between that alternative on that EC is too similar for that difference to be considered significant (i.e. within the MSIC)

Also flagged as an issue at this point was concern that the ECs alone might not reveal some important negative aspects of the performance of some alternatives. For example, consider the wetted area boxplot for Alternative 16 in Figure 25 below (note that the X-axis week numbers are arranged to ensure that an entire winter can be seen as one continuous group). The boxplot 'whiskers' show the maximum and minimum range of percent winter wetted area reduction in <Q80 years (that is, weeks that are in the driest 20% for that week number in the 50 year data set). The tags on the whiskers are the 10th and 90th percentile markers, and the boxes themselves capture the two central quartiles of the statistical range (i.e. 50% of the values appear in the white boxes). The blue marker is the median value and the red marker is the mean value.

In this case, by quirk of the definition of the alternative, various periods of the year are not protected in a way that the IFNTTG agreed would be sensible. An obvious example is the impact on weeks 14 and 15 in this case, but the disjointed increase in protection from weeks 49 to 50 is also undesirable. Common sense suggests the transitions of impacts across weeks should be smooth. For this reason, all subsequent alternatives were designed and evaluated through the use of wetted area boxplots such as these as well as via the ECs themselves.

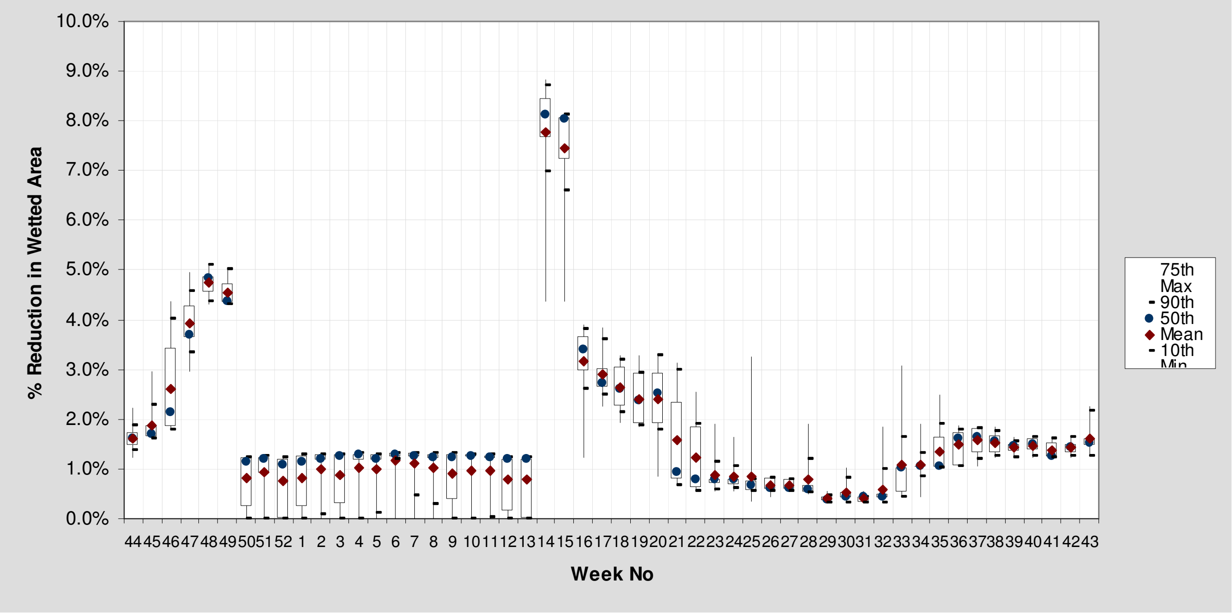


Figure 25: Reduction in winter wetted area for the <Q80 years for Alternative 1

Using the technique illustrated in Table 7 for Alternative 3, the performance of each alternative in turn relative to the others was similarly explored.

Looking now at Alternatives 2-18 on the two-way trade off chart introduced in Round 1, the P2FC could see that the alternatives were creating what was referred to as an 'efficiency frontier'. In Figure 26 below, with sufficient alternatives, we might expect that a relatively straight line could be drawn connecting 4.5% on the Y-axis and ~250 million m^3 on the X-axis. Could anything to the left of this line be created? And how might the group move forward in choosing an alternative on the line, any of which could be argued to be just as efficient as another?

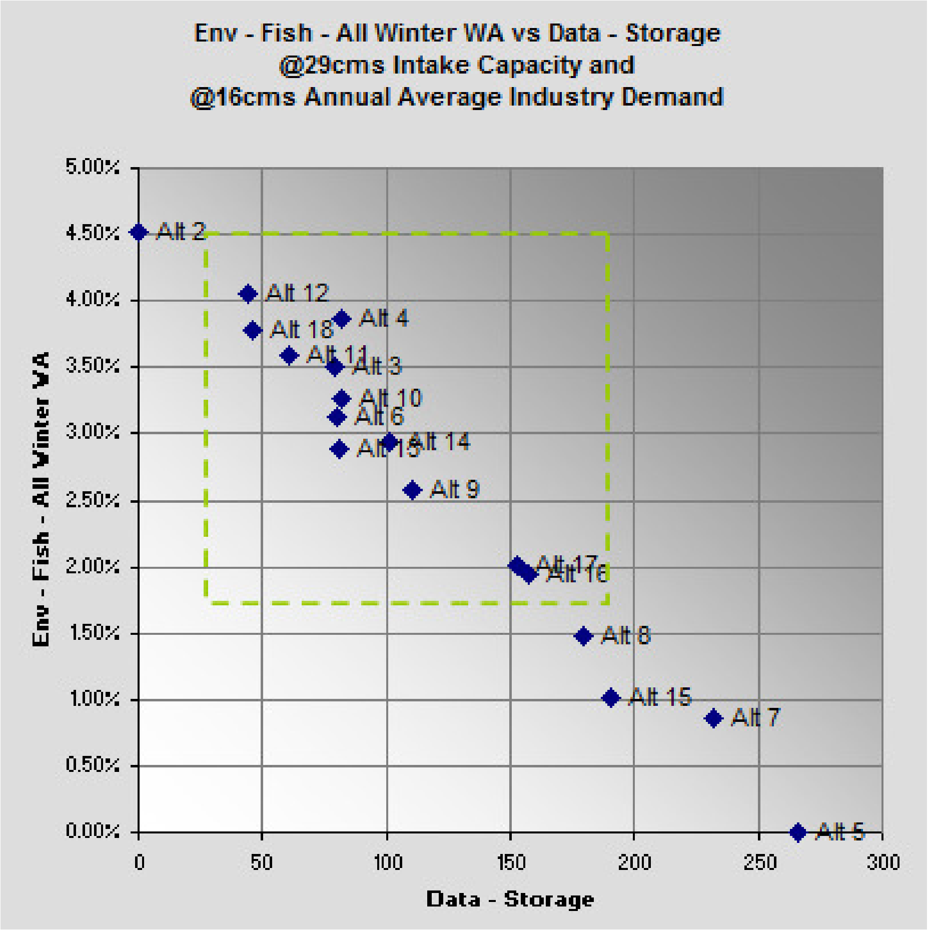


Figure 26: Round 2 Efficiency Frontier. The dotted green square denotes the range agreed to for further alternative development in the next round.

7.2.2. Key Trade-offs, Lessons & Outcomes

Having established to participants' satisfaction that the alternatives available were forming a line, the P2FC decided it would be helpful to consolidate the best ideas from these alternatives and the learning from the P2FC. There was also a desire to focus attention on a more realistic and narrow range of tradeoffs.

The group agreed that the range encompassed by the dotted square in Figure 26 was an appropriate area in which to focus. This range explicitly excluded the bookend alternatives, as well as alternatives that were considered too much of a burden on industry relative to the biological benefits possible as demonstrated by the ECs. The dotted-lined area was referred to as the “1 to 4 month storage range”, and the IFNTTG group was tasked with creating four alternatives, 19 through 22, that could most efficiently protect biological values with a ‘budget’ of one, two, three and four months’ storage respectively. The area also encompasses the water withdrawal ranges that were expected to be reasonable to consider that would avoid potentially irreversible impacts.

Note that “one month of storage” is a notional figure that is calculated as the water used collectively by industry for one month. It is simply calculated, in the full build out case, as 16 m^3/s * 60 (seconds)* 60 (minutes)* 24 (hours)* 365 (days)/ 12 (months) = 42 million m^3. Thus the storage ‘budgets’ suggested were, approximately, 40 million m^3, 80 million m^3, 120 million m^3 and 160 million m^3.

A final task posed to the IFNTTG, WREM and ETG task groups for future meetings was to try to reduce the volume of information required to communicate trade-offs in the consequence table. While it was recognized to be important to calculate all the ECs, only those that most effectively communicate the differences between alternatives should be presented as a summary to P2FC (see Section 5.2.11.).

7.3. Round 3 Alternatives (Alts 19-22)

After several weeks of exploring the dynamics of alternative definitions and their impacts, the IFNTTG developed several guiding principles for developing alternatives:

1. Minimize impacts to aquatic ecosystem, based on ECs
2. Recognizing that there are limitations to the sensitivity of ECs, the withdrawal rules should be more restrictive as flows decrease (both within and among time periods)
3. Flow rules should perform adequately on extreme events not observed in the current 50 year time series

Principle #2 leads to a hierarchy for protection among time periods:

1. mid-winter
2. late winter/early spring
3. fall/early winter
4. summer

It is important to note that the hierarchy does not imply zero protection for summer months. When developing alternatives the duration of these periods may need to be adjusted to meet a particular storage target, and additional periods may be used to help ramp storage filling (i.e., to spread storage filling across a broad period).

The following alternatives are consistent with the above principles. Alternatives 19-22 are defined in Table 8 and illustrated graphically for the important mid-winter period in Figure 27.

Table 8: Round 3 Alternative Rule Set Definitions (Alternatives 19 to 22)

		Start	End	R1	T1	R2	T2	R3
Alt 19	Period 1	1	15	16	140	F11.5		
	Period 2	16	18	16	0			
	Period 3	19	45	29	0			
	Period 4	46	49	16	0			
	Period 5	50	52	16	110	F11.5		

		Start	End	R1	T1	R2	T2	R3
Alt 20	Period 1	1	15	16	185	F8.5		
	Period 2	16	23	16	0			
	Period 3	24	43	29	0			
	Period 4	44	52	16	185	F8.5		

		Start	End	R1	T1	R2	T2	R3
Alt 21	Period 1	1	15	16	270	F6		
	Period 2	16	23	16	0			
	Period 3	24	43	29	0			
	Period 4	44	52	16	270	F6		

		Start	End	R1	T1	R2	T2	R3
Alt 22	Period 1	1	18	16	355	F4.5		
	Period 2	19	23	16	0			
	Period 3	24	43	29	0			
	Period 4	44	52	16	355	F4.5		

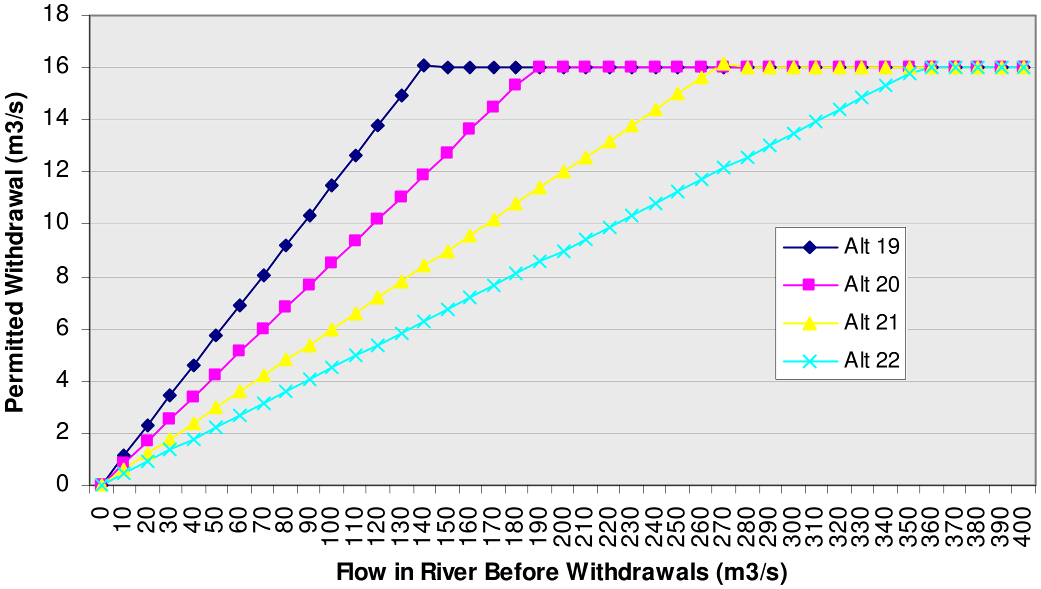
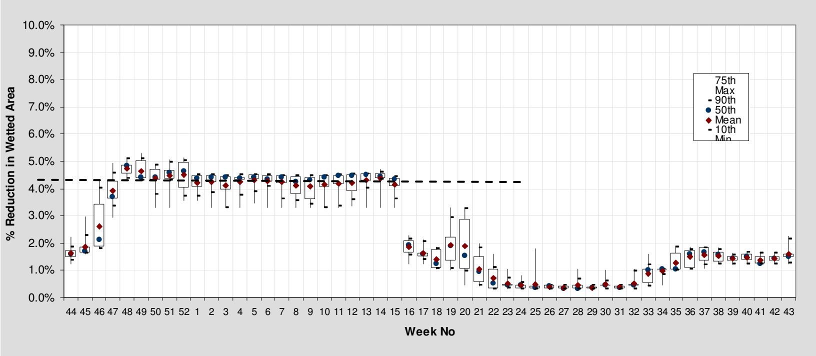


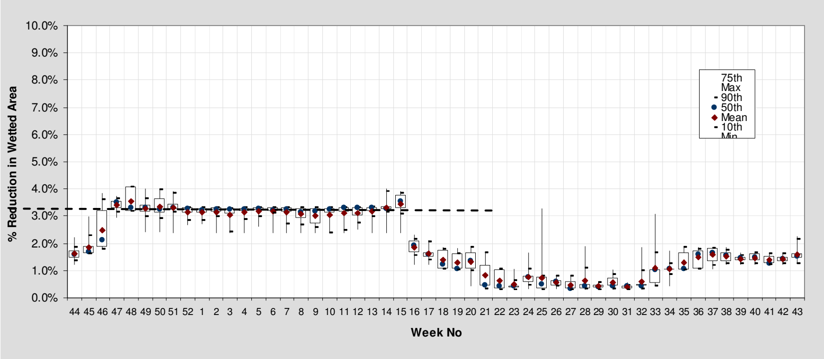
Figure 27: Graphical depiction of the mid-winter flow rules for Alternatives 19-22

Note that these four alternatives all have increasing protection as flows in the river decrease. Wetted area boxplots for these alternatives are shown in Figure 28. To the extent possible within the designed storage 'budgets', the IFNTTG attempted to ensure smooth transitions between time periods.



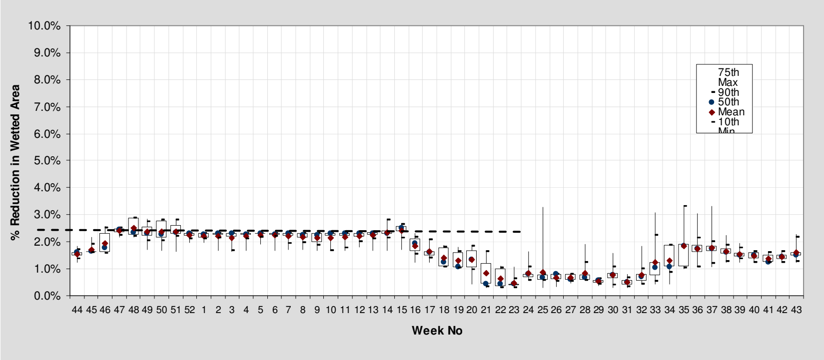
Alternative 19:

With a storage 'budget' of around 40 million m^3, only limited protection of the mid-winter and shoulder periods is possible.



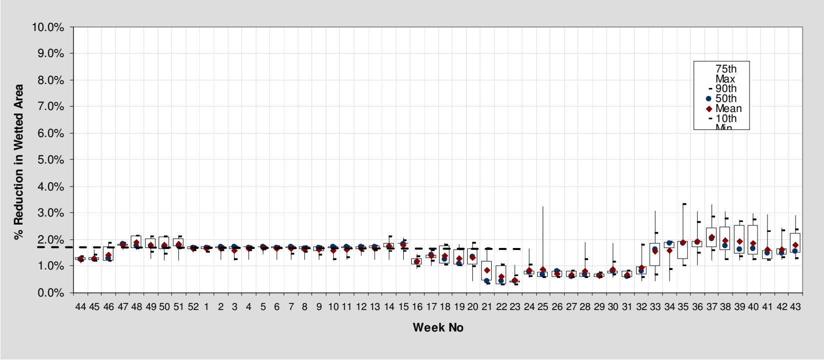
Alternative 20:

With a storage 'budget' of around 80 million m^3, the mid-winter average reduction can be reduced. Shoulder periods are not quite as protected.



Alternative 21:

With a storage 'budget' of around 120 million m^3, significant gains can be achieved for both mid-winter and shoulder periods



Alternative 22:

With a storage 'budget' of around 160 million m^3, further gains become more modest. Greater variation in fall impacts can be seen.

Figure 28: Percent reduction in wetted area in <Q80 years for alternatives 19-22.

7.3.1. Consequence Table Summary

As requested by the P2FC in the previous round, the consequence table presented to the P2FC during this round was simpler than in previous rounds (Table 9). Note that by this Round, first attempts to convert storage to costs and mitigation footprint areas were also presented (see Section 5.5), and the navigation EC was ready for use (see Section 5.4.2).

Table 9 and Figure 29 show clearly the fact that at this stage the alternatives reside along an efficiency frontier. A linear increase in protection for fish and aquatic values, as well as to a lesser degree, navigational suitability, can be achieved only by a linear increase in storage (and, more fundamentally, in cost and mitigation footprint). Note at this stage, the Flow Calculator was using a 10% storage adder.

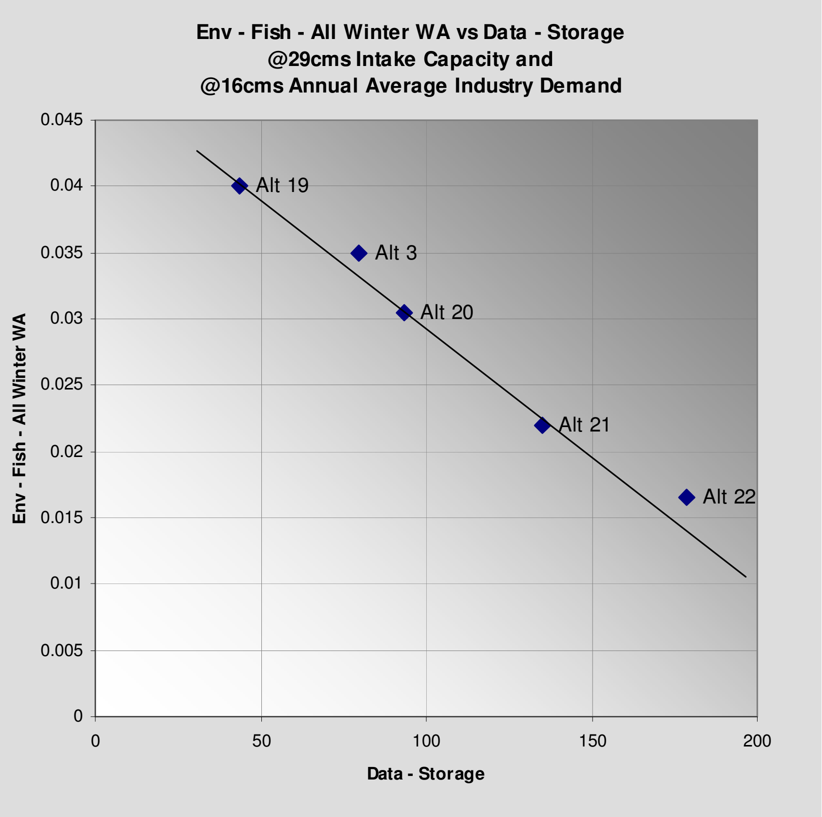


Figure 29: Efficiency frontier for alternatives 19-22, with alternative 3 shown for reference.

Table 9: Round 3 Consequence Table

Objective	Attribute	Direction	Units	MSIC Type	MSIC Val	Threshold 1	Threshold 2	Alt 19	Alt 20	Alt 21	Alt 22
Ecosystem Health	Fish Habitat - Ice Most Sensitive % Loss (mid-winter)	L	%	A	2%	0%	10%	5.9%	4.6%	3.4%	2.6%
Ecosystem Health	Fish Habitat - Ice Most Sensitive % Loss (shoulder)	L	%	A	2%	0%	10%	5.4%	4.2%	3.0%	2.2%
Ecosystem Health	Mesohabitat - Ice Most Sensitive % Loss (mid-winter)	L	%	A	2%	10%	NA	24%	18%	13%	10%
Ecosystem Health	Lake Whitefish Effective Spawning Habitat - % Loss in Habitat	L	%	A	5%	10%	30%	18%	14%	10%	7%
Ecosystem Health	Mitigation Footprint	L	km^2	R	10%	NA	NA	19	31	47	59
Navigation	Segment 4, Spring, % loss of suitability	L	%	A	2%	NA	NA	2.7%	2.4%	2.4%	2.0%
Cost	Capital Cost	L	$M	R	2%	NA	NA	$ 797	$ 1,712	$ 2,334	$ 3,098

ECs expressed in the form of percentages show the percent reductions from natural flow in years where the weekly flow in the river is below the Q80 exceedence level (i.e. the 20% of lowest flow years).

For all ECs, the lower the number, the better.

7.3.2. Assessment of Potential Impacts on Traditional Use

By this stage of the process, the assessments into the potential impacts on Traditional Use activities as reported by Westland Resource Group were complete, and they were asked to rate Alternatives 19 through 22 based on their findings coupled with available technical information. The results were presented in a technical memo (Appendix D) and are summarized in Table 10.

Westland developed a rating scale for traditional use indicators based on the six potential impact hypotheses described in Section 5.4.1. The rating scale compared the alternatives at the full build out 16 m^3/s demand to a base condition of the current state at a demand of 6 m^3/s under the Phase 1 framework.

The summary result is that all four alternatives were shown to have potentially higher impact on traditional use activities in the future compared to current conditions. The potential impact on the different indicators varied across alternatives. For example, Alternative 22 is shown to have the least potential impact on resource harvesting opportunities, consistent with the lower aquatic impacts for that alternative; however Alternative 22 is also shown to have the highest potential impact on navigation and access, due to the additional water withdrawals that extend into the late summer and fall period to fill the required storage.

Table 10: Ratings of potential effect on traditional use indicators for Alternatives 19 to 22 (Source: Westland, 2009 – Appendix D)

Level of influence of water withdrawal:	Traditional use indicators:	Alt 19 (1 mo storage)	Alt 20 (2 mo storage)	Alt 21 (3 mo storage)	Alt 22 (4 mo storage)
Moderate influence	Access to traditional use sites and activities[10]	-1	-1	-2	-3
	Fish abundance (resource harvesting opportunities)[11]	-2	-2	-1	0
	Traditional knowledge transfer[12]	-3	-3	-3	-3
Limited influence[13]	Use of nearby rivers	0	0	0	0
	Diet and health effects				
	Effects on spiritual sites				

Ratings express the extent and direction of change attributable to industrial water demand by 2050 under the withdrawal rules for each alternative at 16 m^3/s average demand, compared to future conditions without increased level of withdrawals over present conditions (i.e., Phase 1 rules, 6 m^3/s average demand)[14]:

Increasingly negative ←			No effect[15]	Increasingly positive →		
-3	-2	-1	0	+1	+2	+3

---

[10] Assumes that most of the adverse effects of water withdrawal on navigability and access for traditional use purposes would occur during late summer and fall (weeks 33 to 43).

[11] Only the alternatives' effects on fish were considered. No information is available to identify relative effects of the alternatives on other resources (plants, animals). The scores assume that fisheries impacts decline as amounts of storage increase.

[12] This indicator is a composite of access, resource availability, and inherent value of the river, so the score is the sum of the scores for access to traditional use sites and resource harvesting opportunities.

[13] None of the water storage alternatives would have a material effect on any of these indicators.

[14] Ratings consider the effects of water withdrawals in combination with other factors affecting the river, particularly climate change, which is likely to result in reduced flows and water levels.

[15] No effect means that withdrawals for industry, in combination with other external influences on the river, are unlikely to measurably affect the indicator when compared with flows that include continued withdrawal of 6 cms as allowed under Phase 1 rules.

7.3.3. Sensitivity Analyses

On top of the clear trade-offs exposed by the EC results for Alternatives 19 to 22 in Table 9, additional roundtable discussion revealed that there were additional challenges to face before attempts could be made to close in on an optimal alternative that represented the best balance across all objectives.

The issues were:

- Performance of alternatives at very low flows (e.g., a 1 in 200 year low flow event)
- The rationale and performance of an Ecological Base Flow
- The treatment of existing water rights and infrastructure protection requirements, which appeared to be in contradiction to the use of an EBF
- An evaluation of the performance of alternatives under various climate change scenarios.

An extensive sensitivity analysis was performed on alternatives 19-22 to help inform these discussions. Some findings from this process are presented below.

7.3.3.1. Low Flow Events

The considerations of the P2FC to this point had focused almost exclusively on use of the existing 50 year flow data set described in Section 6.2.1.1. However, there was an interest in understanding the impacts associated with rare low flow events. Using the synthetic 1 in 100 and 1 in 200 year event years as described in Section 6.2.1.3, the P2FC was able to explore the implications of such events.[16]

The impacts on storage are shown in Figure 30. Here, storage is shown on the Y-axis in million m^3. The low flow events 1, 2 and 3 are the standard data set low year, the 1 in 100 year and the 1 in 200 year events respectively.

In this view, the assumption is being made that Industry would build sufficient storage to meet the flow rules in each case. While all four alternatives would require more storage in the rarer events, the relative percent increase in Alternatives 19 and 20 are greater than those that would be needed for Alternatives 21 and 22. For this reason, it could be argued that Alternatives 21 and 22 are more ‘robust’ to low flow events than the other two. However, it was also pointed out that if industry were to build to the 1 in 200 year case as required by Alternative 19, then

---

[16] At this point, there was little discussion on how impacts to aquatic ecosystem values at low flows might be characterized. This issue was discussed in detail in later Round 4 below.

this would still require less storage than the standard dataset case for any of the other alternatives – and this would, of course, be completely robust to low flow events in this range.

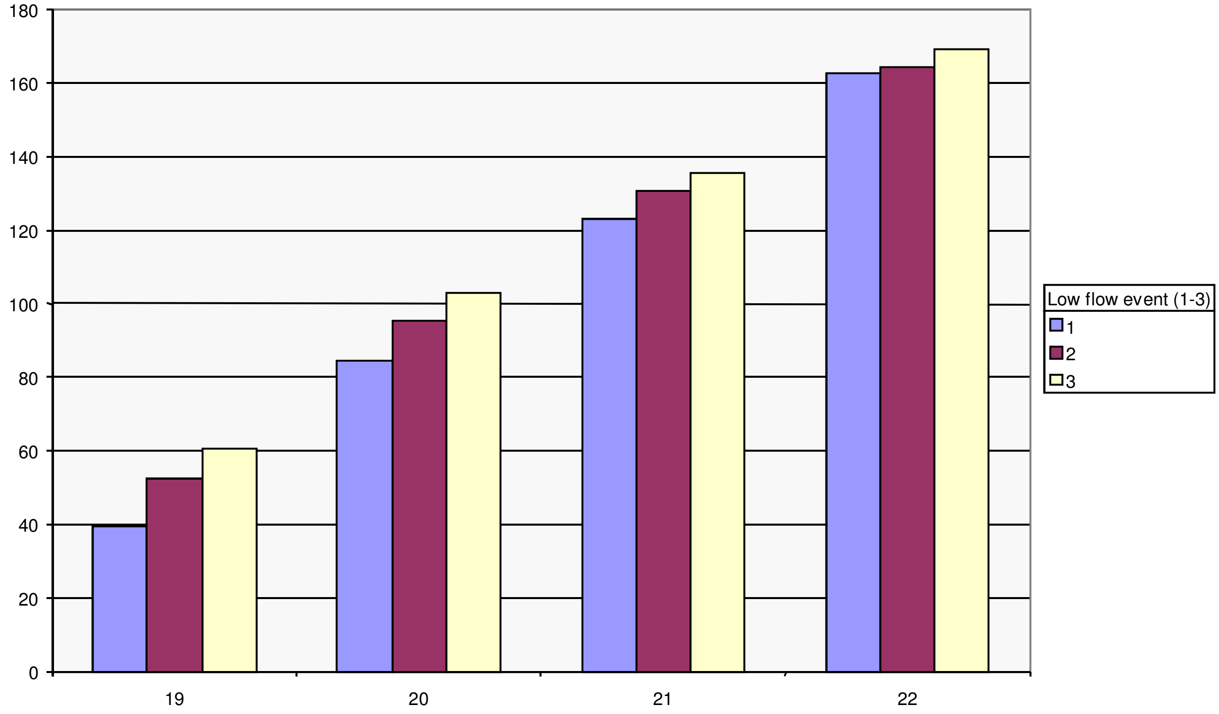


Figure 30: Storage requirements for low flow events for alternatives 19 to 22.
In the chart 1 = 1:50 yr event, 2 = 1:100 yr event and 3 = 1:200 yr event

Another way of looking at this effect might be to explore what might happen if industry built only the amount predicted by the calculator for the standard data set event, but then a 1 in 200 year event subsequently occurred.

The flow calculator was adapted to enable a 'storage override' to be entered to test this. For any set of input assumptions, the user could also now enter a fixed storage volume to be built. If insufficient volume was entered, the calculator would output statistics on the nature of the ensuing 'shortfall' events when storage runs out – how many weeks, how many m^3/s, how many consecutive weeks of insufficient water and so on. These findings were explored by the committee in detail. Ultimately, however, it was agreed that storage shortfalls was not an area that industry would actually intentionally accept, since this would entail loss of production and associated costs that would likely be greater than the cost of storage construction. The question of what flow event industry would design to was not fully resolved, but appeared to be either the 1 in 100 year or 1 in 200 year event. This discussion was revisited during Round 4 discussions described below.

7.3.3.2. Ecological Base Flow and Low Flow Exemptions

Also explored through sensitivity analysis were the potential impacts of applying a low flow (i.e., EBF) threshold to Alternatives 19 to 22, below which flow withdrawal rules change further.

The sensitivity analysis explored the use of various T2 thresholds, as well as different rules to be applied when flows in the river are below this threshold. At this point in the process, the rules discussed below T2 were absolute withdrawals, R3 rules, of 0 m^3/s, 3.5 m^3/s, 5 m^3/s and 8 m^3/s. Zero was selected as interest in an absolute cut-off had been expressed throughout the process. The other rules were included as possible ‘exemptions’ from an absolute cut-off representing potential combinations of factors relating to existing water license rights and existing infrastructure protection requirements.

One important lesson from this sensitivity analysis is presented in Figure 31 below. This figure shows the impact on storage in the 50 year flow event case for a “T2” threshold level of 100 m^3/s.

Looking first at storage impacts on alternative 19, we see that the “NA” T2 case, that is, Alternative 19 alone, results in a storage requirement of 40 million m^3. An “R3” exemption of 8 m^3/s sees storage requirement increase to around 60 million m^3, and further reductions in R3 result in more storage increase until almost reaching 120 million m^3 in the case of R3 = 0 m^3/s. For Alternative 19, then, the addition of a T2 and corresponding R3 has a significant and negative impact on storage requirement, the low flow cut-off of 0 m^3/s requiring almost three times more storage than is required without a low flow threshold. This result is intuitive, since storage is driven by the availability of water in the winter of the driest years.

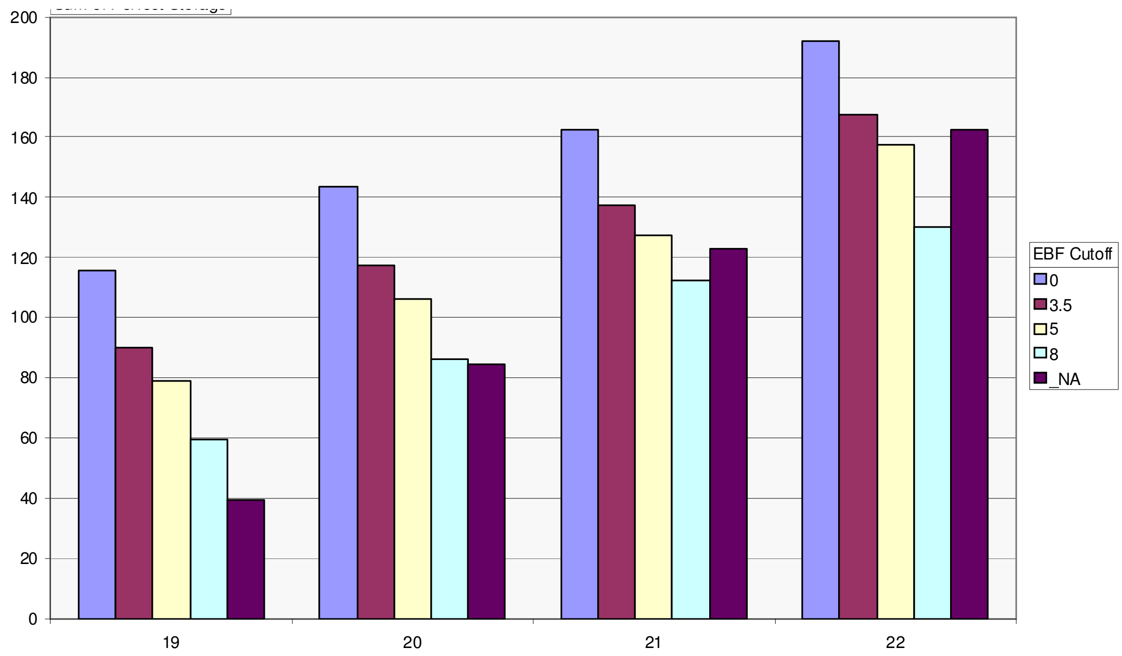


Figure 31: Storage required in alternatives 19-22 for various levels of low flow ‘exemptions’.

However, the result for Alternatives 21 and 22 is less intuitive. While the storage requirement for a zero R3 value is higher than the case without a T2 threshold, the storage requirement for a lower rule of 8 m^3/s is less than if the threshold were not there. That is, by applying a low flow threshold, we have improved the trade-off balance for industry. Why is this?

The answer is shown in Figure 32.

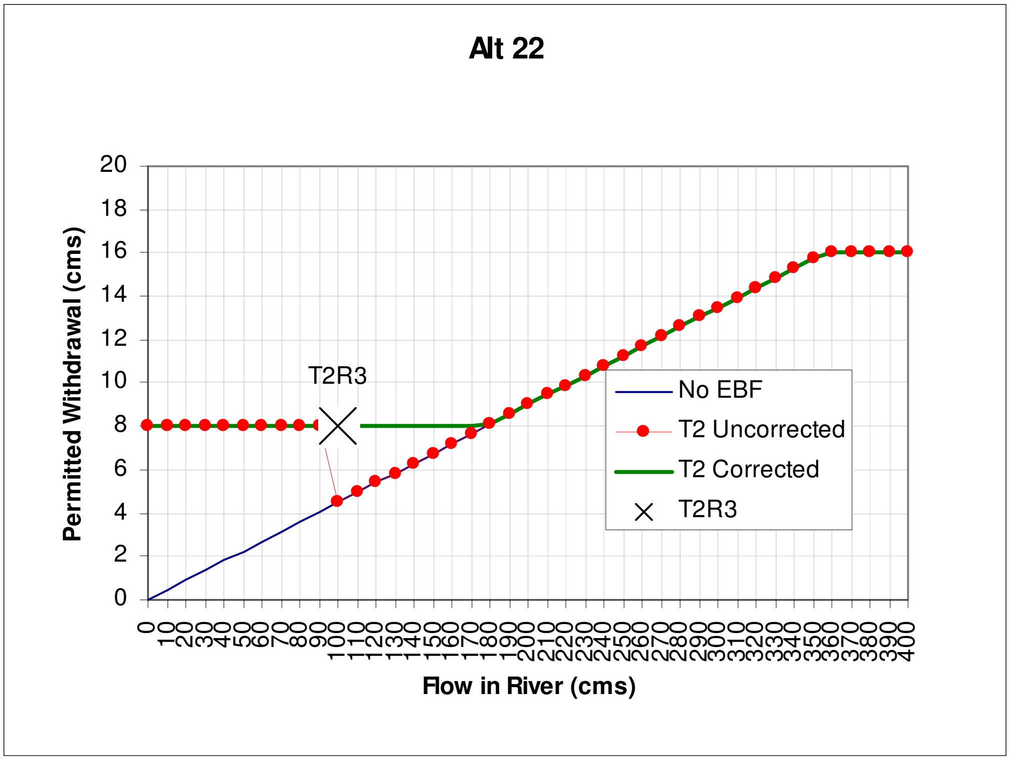


Figure 32: Low flow 'sawtooth' rule and its correction

Figure 32 shows the permitted withdrawals for Alternative 22, for example, for a T2 value of 100 m^3/s and an exemption of 8 m^3/s. The rules for Alternative 22, shown in red, would continue to allow 4.5% of flow in the river to the origin of the chart. With the addition of the T2/R3 combination, 8 m^3/s is therefore greater than the inclined line, creating an illogical 'sawtooth' rule. The flow calculator was programmed to remove this sawtooth effect by overriding the definition of T2 until it intercepted the 4.5% line – in this example (at a flow in the river of around 178 m^3/s): the green line. Therefore, for flows in the river below 178 m^3/s and greater than the T2 threshold of 100 m^3/s, the water in the triangle above the red line and below the green line is now available for withdrawal for industry, lowering the storage requirement.

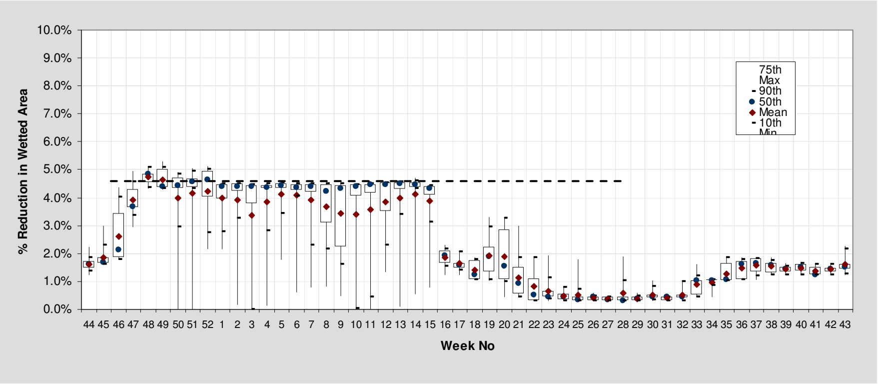
This finding is important because it was later exploited by another alternative, Option A.

Another way of exploring low flow cut-off levels is to understand what levels of fish and aquatic life performance in the 50 year set would need to be ‘exchanged’ for low flow benefits if overall storage requirement were kept at a constant level. The P2FC were shown the three options in Figure 33. Each figure has similar storage requirement (roughly in the 100 m^3/s range), but each has a different lower rule value.

In the first boxplot of Figure 33A, we see the base rules of Alternative 19 with a zero m^3/s cut-off at a T2 level of 97 m^3/s. This results in a storage requirement for the 50 year case of 102 million m^3. Because the alternative is based on the rules of Alternative 19, the average winter wetted area performance is relatively poor (dotted line). However, the long tails on the boxplots show how the driest years in the data set are very well protected, dropping to zero in many cases.

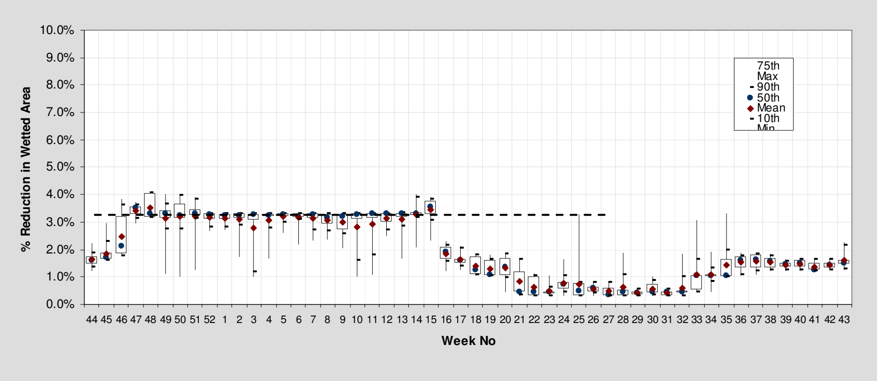
Another way of ‘spending’ roughly 100 million m^3 of storage might be to choose the second boxplot in Figure 33B. This alternative is based on Alternative 20 and so has better (lower) average wetted area reduction performance than the first one. We can also see from the tails of the winter boxplots that the very driest years are still protected considerably more than the other years, although they do not drop all the way to zero.

A third way of notionally ‘spending’ 100 m^3/s is shown last in Figure 33C. In this case, the rules for the main case are based on Alternative 21, which unmodified has a storage requirement of more than 120 million m^3. However, because of the additional water available resulting from the 8 m^3/s R3, this storage requirement drops, to 112 million m^3. Fish performance in all of the driest 20% of years, as well as the driest year, are all kept at the relatively low value of approximate 2.5% reduction.



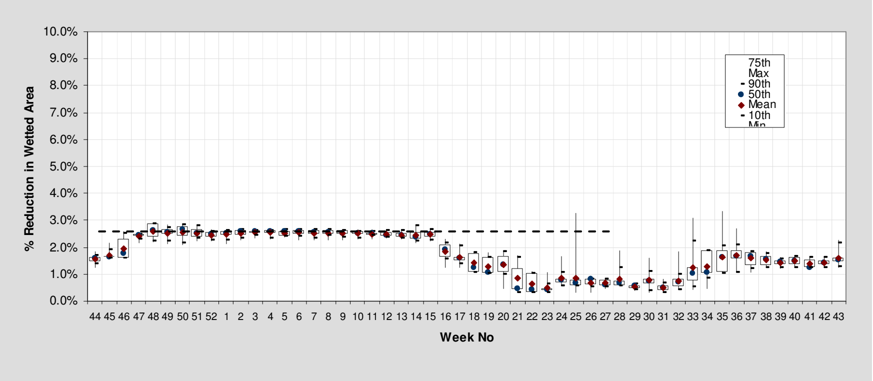
A) Alternative 19 as base, modified with: T2 =97 m^3/s, and R3 = 0 m^3/s

Storage requirement = 103 million m^3



B) Alternative 20 as base, modified with: T2 = 97 m^3/s, and R3 = 3.5 m^3/s

Storage requirement = 96 million m^3



C) Alternative 21 as base, modified with: T2 = 95 m^3/s, and R3 = 8 m^3/s

Storage requirement = 112 million m^3

Figure 33: Three ways of allocating a notional approximate 100 million m^3 storage 'budget'

7.3.4. Option A Emerges

Based on the trade-off analysis discussions surrounding options 19 through 22 (Table 9), and further informed by the results of the sensitivity analyses of both low flow events and EBF definitions, the P2FC launched into detailed discussions around a new alternative that was tabled as a potential balanced approach to meeting all interests – Option A.

Option A has the following rules:

		Start	End	R1	T1	R2	T2	R3
Option A	Period 1	1	15	16	270	F6	133	8
	Period 2	16	23	16				
	Period 3	24	43	29				
	Period 4	44	52	16	270	F6	133	8

In addition to these rules, it was suggested that Option A might incorporate a yet to be determined additional EBF 'cut-off threshold', perhaps at a flow lower than a level seen before in the river, in order to provide further instream protection against exceptional low flow events or significant climate change.

Because it is based on Alternative 21, Option A offers much better protection of fish and aquatic values in the 50-year set than either the Phase 1 or the 'No Constraints' reference points. Figure 34 shows the boxplots for Option A superimposed over the 'no constraints' case. In the winter, the impacts to wetted area reduction are approximately halved – far better than the Phase 1 framework.

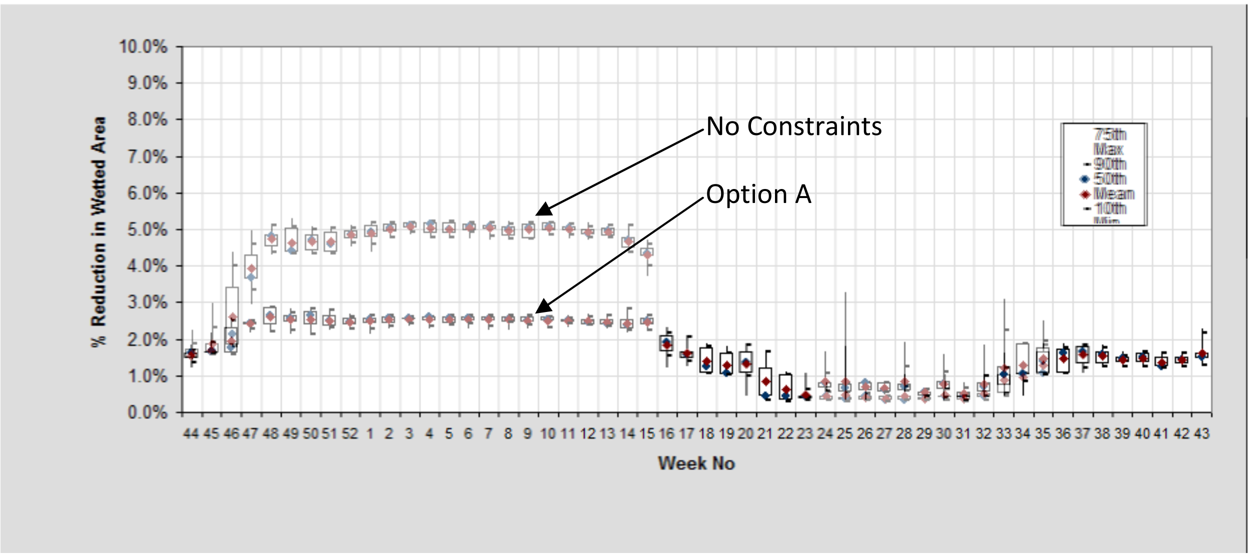


Figure 34: Wetted Area reduction boxplots for Option A relative to 'No constraints'

The storage requirement for Option A, in the 50 year case was 108 million m^3. The P2FC was also informed that this number could be lower if industry were prepared to 'risk manage' to very rare low flow events (e.g., build, say 90 m^3/s and accept the risk of some lost production should a very rare low flow year unfold).

Because of the 8 m^3/s low flow rule, storage is robust to very low flows.

Event	**Storage requirement, Option A**
50 year data set	108.1 million m^3
1:100 year event	108.1 million m^3
1:200 year event	108.1 million m^3

Following the introduction of Option A, a roundtable of comments from participants revealed that there was a general feeling that this alternative was 'in the ballpark' and a 'fair balance' of impacts to social, environmental and economic interests. However, several factors still required addressing:

1. Some participants expressed interest in incorporating an EBF to further protect the aquatic ecosystem during rare low flow events.
2. The IFNTTG needed to examine Option A in detail, and to further explore the question of how to weigh the importance of low flow withdrawals during very rare events for which impacts cannot be quantified versus the level of protection seen in EC results in more common low flow years (i.e. <Q80).
3. The Regulators were continuing to review the information on EBF developed to date and preparing to make a recommendation on an EBF threshold level.
4. The treatment of existing water rights and infrastructure protection requirements in relation to any proposed EBF remained unanswered.

7.4. Round 4 Alternatives – Moving From Option A to Option H

Several events subsequently occurred:

- The IFNTTG did re-examine the question posed, and collectively concluded that for a fixed amount of storage, protection of fish aquatic values at very low and rare events would need to be traded for better performance in all <Q80 years. However, if storage was not fixed, the general guiding principle that withdrawal rules should be more restrictive as river flows decrease would still apply.

- ENGO participants, after consultation with their peers, confirmed that their interest in seeking protection against impacts to fish and aquatic values at rare low flows events was consistent with a precautionary approach, and worth examining as a potential trade-off to more generally protective winter flow rules, such as those with Alternative 22. In short, an EBF should be an essential component of the water management rules.

- Some industry participants noted that the notion of 'risk managing' the projected storage requirement in any way was not viable. They suggested that they would build the required level of storage to meet the rules, and no less. The cost of lost production was often too great to do otherwise.

- The regulators came back with a proposal to set an EBF threshold level at 87 m^3/s, with an exemption level of 1.6 m^3/s. The threshold level was based on an average of the weekly 1 in 100 year low flows for weeks 1-11 as derived from the existing dataset. The exemption level was based on an amount assumed necessary for basic infrastructure protection.[17]

The regulators' proposal was highly significant for several reasons:

- If layered on top of Option A, it would change the balance of impacts. Table 11 shows the storage requirement under different low flow events for Option A amended to include a low flow threshold with a 1.6 m^3/s exemption.

- Also significant was the selection of 1.6 m^3/s as an exemption. While it acknowledged the need for infrastructure protection, it was well below the values for which Suncor and Syncrude have existing water licences to remove.

Table 11: Storage requirement under different low flow events for Option A amended to include a low flow threshold with a 1.6 m3/s exemption

Event	**Storage requirement, Option A**	**Storage requirement, Option A with an additional T2 = 87 m^3/s, R3 = 1.6 m^3/s**
50 year data set	108.1 million m3	108.1 million m^3
1:100 year event	108.1 million m3	122.1 million m^3
1:200 year event	108.1 million m3	141.4 million m^3

---

[17] The 1.6 m^3/s was notionally determined by providing 0.2 m^3/s to all existing and future oil sand mine operations to protect infrastructure from freezing.

Recognizing this change in the trade-off balance, several P2FC members offered suggestions on how to modify Option A in order to maintain the ‘spirit’ of the balance embodied in Option A. These Alternatives – labeled Options B through G – collectively explored different ways of relaxing flow rules in the shoulder seasons in order to reduce the 1 in 200 year event derived storage to something nearer to that value seen for Option A during that event.

At a meeting near the end of the planning process, Option H emerged from this process of exploration.

Option H has the following rules:

		Start	End	R1	T1	R2	T2	R3	T3	R4
Option H	Period 1	1	15	16	270	F6	150	9	87	4.4
	Period 2	16	18	16	87	4.4				
	Period 3	19	23	20	87	4.4				
	Period 4	24	43	29	87	4.4				
	Period 5	44	52	16	200	F8	150	12	87	4.4

Option H was based on Option A, but modified it in a number of ways. Most noticeably, of course, Option H has a lowest threshold flow level of 87 m^3/s (based on the regulators EBF proposal), and a lowest withdrawal rule of 4.4 m^3/s (based on voluntary peak rate reductions by each of the two senior license holder’s to their average annual demand of 2 m^3/s, and an allowance of 0.2 m^3/s for freeze-protection of existing infrastructure for two other license holders). In order to aim for a similar overall balance as that exemplified by Option A, the flow rules in the shoulder seasons were modified to allow for somewhat higher withdrawals.

A consequence table that includes the results for Option H, along with those of Option A, Phase 1 and the suite of alternatives 19-22 is presented in Table 12.

Note that by this stage of the process, there had been further developments with several ECs:

- Mesohabitat calculations were now available for the Delta reach
- Fish habitat and mesohabitat ECs had been broken out into two shoulder seasons for greater fidelity
- The Navigation EC shifted from a focus on the spring season to the fall season based on results from the Traditional Use study
- Methodologies to calculate cost and mitigation footprint ECs in relative terms, consistent with the IFN ECs, had been developed

Given these changes, and the interest to allow full examination of alternatives as the process narrowed in on potentially preferred options, the consequence tables under review included a much wider range of EC results.

The primary environmental condition that was incorporated into the development of Option H was a trade-off toward greater protection in rare low flow years over reduced ‘average’ environmental performance over most years. Unfortunately, as described in Section 5.2.12, the IFNTTG had not developed a quantitative approach to portraying the benefits of providing increased protection at rare low flow events such as a 1 in 200 year event. As one means of providing an indication of potential benefit, Table 12 includes an additional indicator: the average wetted area during the mid winter weeks (1-12) during the driest year. For the 1 in 200 year case, this indicator shows reduced loss of wetted area for Option H (2.0%) compared to Option A (2.6%). As seen in Table 12, Option A otherwise appears to outperform Option H on most other IFN ECs that are based on averaging conditions over multiple years. To some stakeholders, the just-released Delta mesohabitat EC results were an additional noted concern.

Another roundtable of comments from participants revealed that there was again a general feeling that this alternative was ‘in the ballpark’, yet the interest in exploring the opportunity in achieving a reduced EBF exemption value was becoming more pronounced. The key challenges remained as:

- A lack of biological tools to help assess the potential for increased protection by lowering or fully eliminating lowest flow water withdrawals.
- A lack of clarity on the legal and policy opportunities and limitations associated with limiting water withdrawals below levels held within existing senior water licences.

Table 12: Round 4 Consequence Table

	Objective	Attribute	Direction	Units	MSIC Type	MSIC Val	Threshold 1	Threshold 2	Phase 1	Alt 19	Alt 20	Alt 21	Alt 22	Option A	Option H
*	Ecosystem Health	FH - Ice Largest % Loss (mid-winter; Metric A)	L	%	A	2%	0%	10%	5.4%	5.9%	4.6%	3.4%	2.6%	3.7%	4.2%
*	Ecosystem Health	FH - Ice Largest % Loss (early shoulder; metric A)	L	%	A	2%	0%	10%	3.6%	4.1%	3.3%	2.4%	1.8%	2.5%	3.4%
*	Ecosystem Health	FH - Ice Largest % Loss (late shoulder; Metric A)	L	%	A	2%	0%	10%	4.6%	5.2%	4.1%	2.9%	2.2%	3.1%	3.3%
	Ecosystem Health	FH - Open Largest % Loss (Metric A)	L	%	A	2%	0%	10%	2.3%	2.3%	2.2%	2.4%	2.6%	2.4%	2.3%
*	Ecosystem Health	MH - Ice Most Sensitive % Loss (mid-winter; Metric A)	L	%	A	5%	10%	30%	21.0%	24.1%	18.2%	13.0%	9.7%	14.9%	16.7%
	Ecosystem Health	MH - Ice Most Sensitive % Loss (early shoulder; Metric A)	L	%	A	5%	10%	30%	20%	21%	21%	18%	14%	18%	21%
	Ecosystem Health	MH - Ice Most Sensitive % Loss (late shoulder; Metric A)	L	%	A	5%	10%	30%	22%	23%	22%	15%	12%	15%	15%
	Ecosystem Health	MH - Delta Most Sensitive % Loss (mid-winter; Metric A)	L	%	A	5%	10%	30%	60%	66%	53%	41%	32%	45%	49%
	Ecosystem Health	MH - Delta Most Sensitive % Loss (early shoulder; Metric A)	L	%	A	5%	10%	30%	41%	45%	37%	28%	22%	29%	38%
	Ecosystem Health	MH - Delta Most Sensitive % Loss (late shoulder; Metric A)	L	%	A	5%	10%	30%	55%	60%	50%	37%	29%	38%	41%
	Ecosystem Health	MH - Open Most Sensitive % Loss (Metric A)	L	%	A	5%	10%	30%	7%	7%	8%	11%	11%	11%	10%
*	Ecosystem Health	% Loss in Effective Whitefish Spawning Habitat	L	%	A	5%	10%	30%	17%	18%	14%	10%	7%	10%	12%
	Ecosystem Health	Walleye Population Reduction (% loss)	L	%	A	2%	10%	30%	9%	9%	8%	7%	5%	7%	7%
	Ecosystem Health	Walleye Population Viability (% extinction P)	L	%	A	0%	1%	10%	0.1%	0.1%	0.0%	0.0%	0.0%	0.1%	0.1%
	Ecosystem Health	Env - Fish - Extreme Yr Wks1-12 Ave Wetted Area	L	%					2.9%	3.7%	2.8%	2.0%	1.5%	2.5%	2.7%
	Ecosystem Health	Env - Fish - Extreme Yr Wks1-12 Ave (1:100 yr) Wetted Area	L	%					2.6%	3.3%	2.4%	1.7%	1.3%	2.4%	2.4%
	Ecosystem Health	Env - Fish - Extreme Yr Wks1-12 Ave (1:200 yr) Wetted Area	L	%					2.8%	3.3%	2.4%	1.7%	1.3%	2.6%	2.0%
	Ecosystem Health	Env - Footprint (based on 50 yr case)	L	km^2	R	10%			30	17	30	41	54	35	30
	Ecosystem Health	Env - Footprint (based on 50 yr case) - Relative Increase	L	%	R	10%			1.3%	0.7%	1.3%	1.8%	2.3%	1.5%	1.3%
	Navigation	Nav - Seg 4, EC4, Fall	L	%	A	2%			2%	2%	2%	2%	3%	2%	2%
	Cost	Ind - Capital Cost (based on 50 yr case)	L	$ millions	R	2%			$ 1,379	$ 698	$ 1,499	$ 2,126	$ 2,794	$ 1,900	$ 1,384
	Cost	Ind - Capital Cost (based on 50 yr case) - Relative Increase	L	%	A	2%			0.5%	0.2%	0.5%	0.7%	1.0%	0.7%	0.5%
	Data	Data - Storage (50 yr)	L	M m^3	R	2%			72	40	85	123	162	108	80
	Data	Data - Storage (1:100 yr)	L	M m^3	R	2%			84	52	96	130	165	108	91
	Data	Data - Storage (1:200 yr)	L	M m^3	R	2%			84	60	103	136	169	108	104

** Indicates IFN ECs recommended as most important by the IFNTTG in the round 3 assessment.*

ECs expressed in the form of percentages show the percent reductions from natural flow in years where the weekly flow in the river is below the Q80 exceedence level (i.e. the 20% of lowest flow years).

For all ECs, the lower the number, the better.

8. Detailed Performance Assessment of Option H

At this stage of the process, the P2FC embarked on a detailed performance assessment of the current option – Option H. Committee members were asked to take these assessments back to their constituents and to report back with any key findings or issues.

The sections below provide a synopsis on various aspects of performance, using comparisons to the Phase 1 Framework as a benchmark where appropriate.

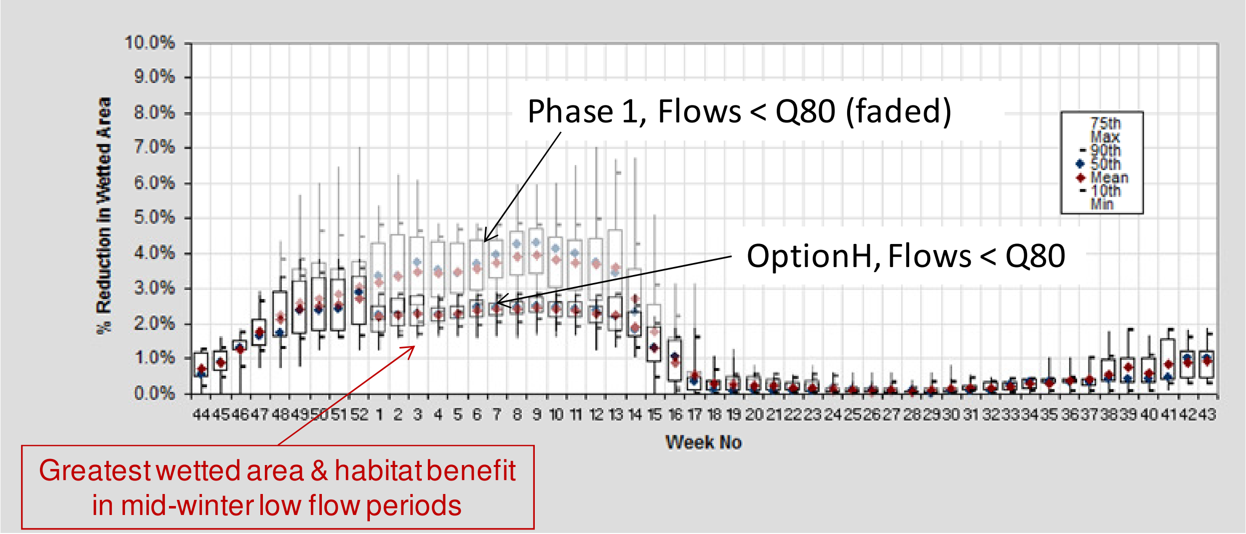
Note again that unless indicated otherwise, all of the data presented here assume the industry conditions of 16 m^3/s weekly average demand and a 29m^3/s peak withdrawal rate. See Section 3 for further information on these assumptions.

8.1. Environmental Performance

The Option H rules have clearly demonstrable environmental benefits over Phase 1. Referring back to Table 12, Option H outperforms Phase 1 on all winter and shoulder season IFN ECs, and in particular outperforms Phase 1 on all of the highest priority aquatic ecosystem ECs as identified by the IFNTTG.

These results are echoed by referring to the wetted area boxplots, where the Option H rules are shown to result in less wetted area impact in both average and wet years (Q0-Q80) (Figure 35), and in the driest 20% of years (Q8-Q100) (Figure 36).

Figure 37 shows how the performance of the Option H rules over the Phase 1 rules – in terms of average percent reduction in wetted area relative to natural flow – is expected to grow over time as water demand increases.

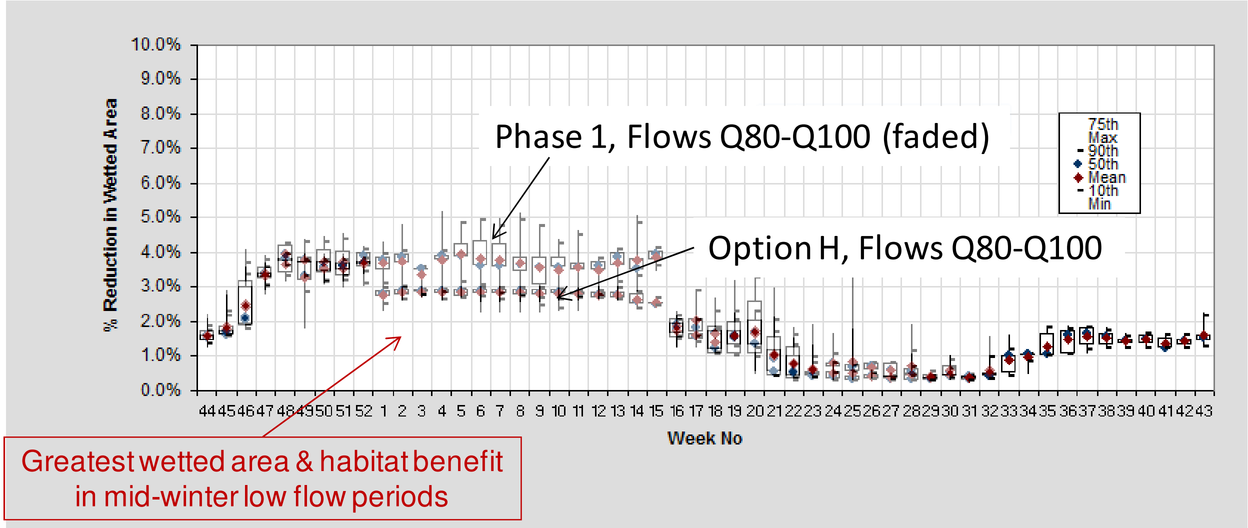


Phase 1, Flows < Q80 (faded)

OptionH, Flows < Q80

Greatest wetted area & habitat benefit in mid-winter low flow periods

Figure 35: Wetted area performance in non-low flow years (Q0-Q80)

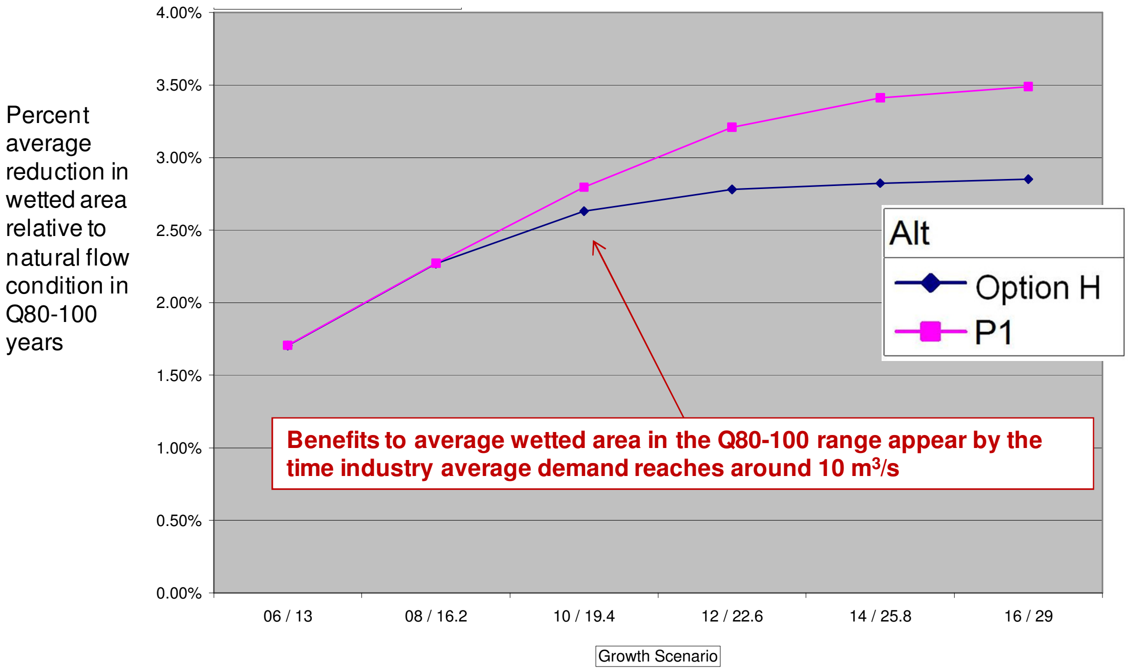


Phase 1, Flows Q80-Q100 (faded)

Option H, Flows Q80-Q100

Greatest wetted area & habitat benefit in mid-winter low flow periods

Figure 36: Wetted area performance in low flow years (Q80-Q100)



Benefits to average wetted area in the Q80-100 range appear by the time industry average demand reaches around 10 m^3/s

Growth scenarios shown are expected combinations of average industry demand and average intake capacities in the format ([average demand] / [expected intake capacity])

Figure 37: Projected change in wetted area impact for Phase 1 and Option H as water demand increases.

At the very lowest years, for example in a 1 in 100 year low flow event or worse, Option H allows less withdrawals from the river than is allowed under Phase 1:

- Maximum permitted under Phase 1 = 8 m^3/s
- Maximum permitted under Option H = 4.4 m^3/s

As previously described, it is not possible to indicate the potential benefit of this reduction of withdrawals in rare low flow events using the IFN ECs as currently developed. Nonetheless, the IFNTTG provided direction that it was beneficial to pursue gains in lowest flow protection at the expense of marginally higher impacts across most years, provided those losses were not too pronounced.

The one statistic that provides some insight is shown in Table 13. By focusing on the single lowest flow year in the dataset, rather than averaging across the range of the 20 % of lowest flow years as most of the IFN ECs do, the results in Table 13 show the increased protection that is provided in the regular 50 year dataset, and in the 1 in 100 and 1 in 200 year low flow events.

Table 13: Average wetted area impact for weeks 1-12 in the worst year for Phase 1 and Option H

Event	**Average Reduction in Wetted Area, Weeks 1-12, Worst Year** **Phase 1**	**Average Reduction in Wetted Area, Weeks 1-12, Worst Year** **Option H**
50 year data set	2.9 %	2.7%
1:100 year event	2.6 %	2.4%
1:200 year event	2.8%	2.0%

8.2. Storage Performance

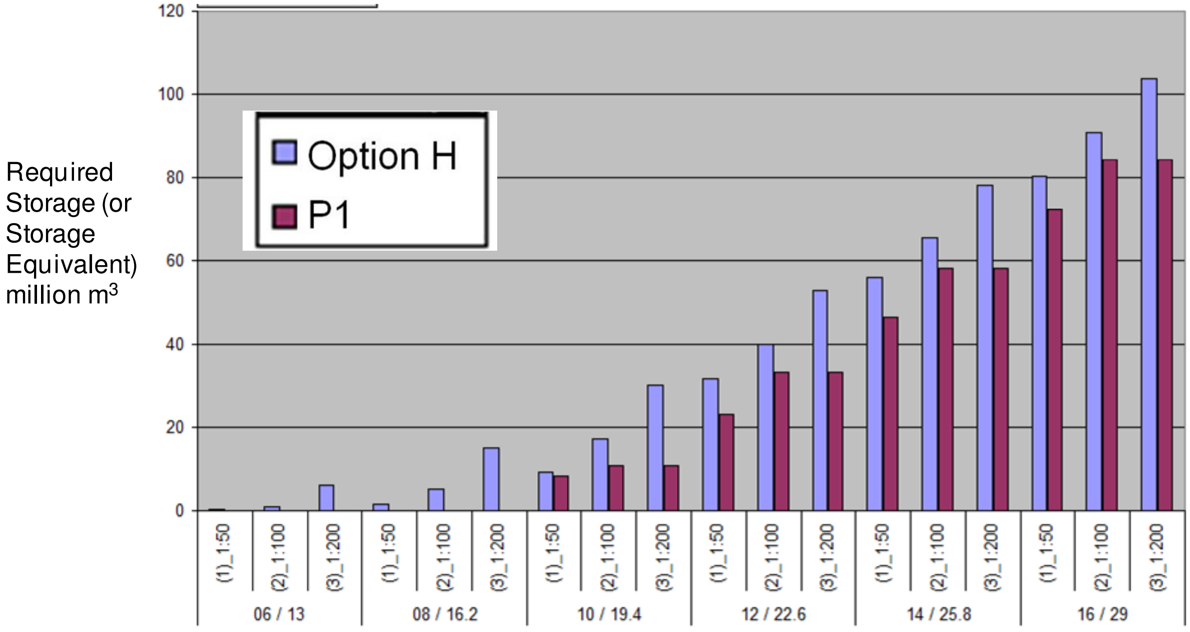
Option H would require more storage than required under Phase 1 in order to meet all flow rules at a full build out demand of 16 m^3/s and 29 m^3/s intake capacity (Table 14). It is understood that the target storage requirement for any individual company would be based on the unique water needs of the operation (actual storage volume may be greater or less than the industry average) and each company's risk tolerance for managing through low flow events. That said, the general assumption was that most companies would manage toward at least the 1 in 100 or 1 in 200 low flow year events.

Table 14: Comparison of storage requirements to meet low flow events for Phase 1 and Option H

Event **Case**	**Storage Requirement (million m^3)** **Phase 1**	**Storage Requirement (million m^3)** **Option H**
50 year data set	72.2	80.2
1:100 year event	84.4	90.8
1:200 year event	84.4	103.7

To fully meet the flow rules and demand assumptions, industry could not operate fully today to Option H without running the risk of shortfalls in low flow events. Figure 38 shows the projected growth in required storage calculated using the 50-year dataset, the 1 in 100 and 1 in 200 year low flow events, as industry water demand increases from the approximate current state of demand = 6 m^3/s / intake capacity = 13 m^3/s, to the full build out case of demand = 16 m^3/s / intake capacity = 29 m^3/s. The chart shows that in cumulative terms, storage might not be required under Phase 1 until demand reached 10 m^3/s, whereas under Option H, storage would be required immediately. This implies the need for a short term transition strategy to enable industry as a whole to become fully compliant should something like the Option H be implemented (See Section 9.4).

A further sensitivity analysis examined the potential for industry to risk manage demand requirements by building a fixed amount of storage that is less than the 'perfect' amount suggested by the flow calculator. Figure 39 shows the number of potential weeks of demand shortfall at projected fixed build storage amounts of 80 to 110 million m^3 using the (1) 50-year dataset, (2) the 1 in 100 and (3) 1 in 200 year low flow events. The chart shows the intuitive result that building to higher levels of storage results in cumulative operations that are more robust to low flow events. It should be emphasized that although the number of weeks of shortfall may appear low, the technical implications of running out of water and needing to shutdown water distribution operations could cause significant hardship on industry (e.g., significant cost due to equipment damage, lost production revenue, etc.).



Growth scenarios shown are expected combinations of average industry demand and average intake capacities in the format ([average demand] / [expected intake capacity])

Figure 38: Growth in required storage calculated using the (1) 50-year dataset, (2) the 1 in 100 and (3) the 1 in 200 year low flow events

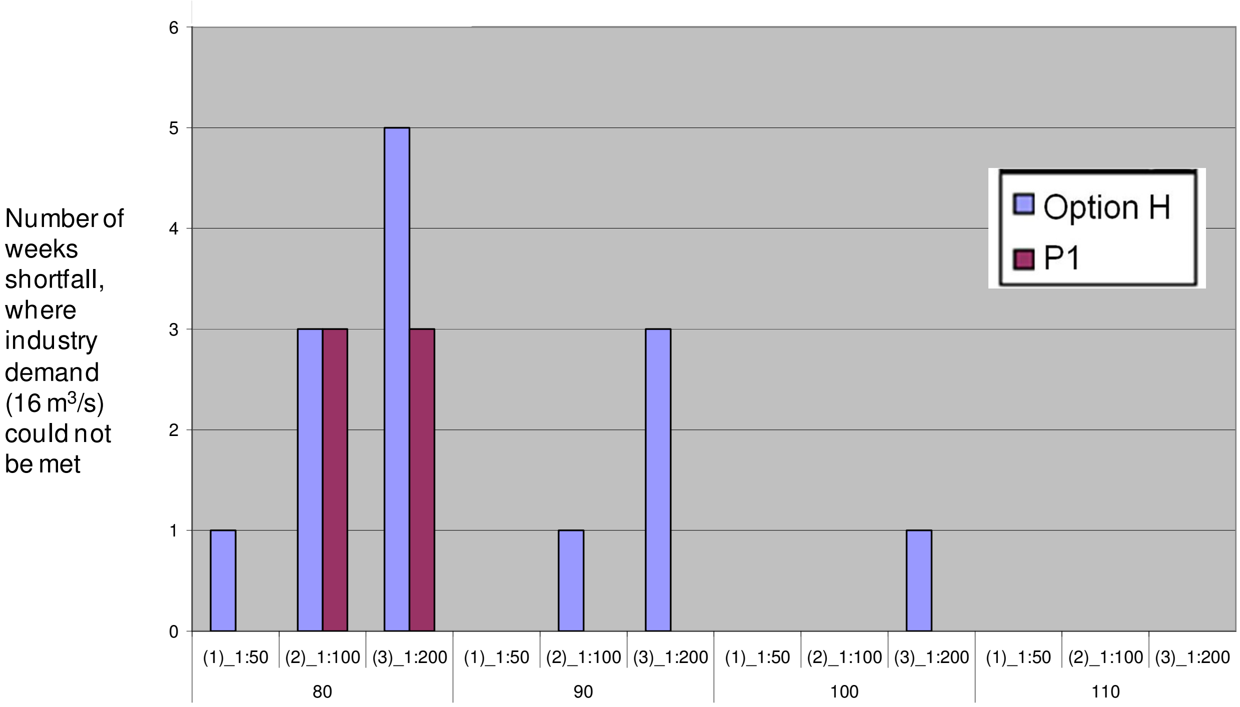


Figure 39: Number of weeks of demand shortfall at projected fixed build storage amounts of 80 to 110 million m^3 using the (1) 50-year dataset, (2) the 1 in 100 and (3) the 1 in 200 year low flow events.

A primary interest for Industry is to achieve certainty – certainty that the flow/withdrawal rules will remain constant over time (and hence the volume of water available for withdrawal over time would be predictable), and that their legal right to withdrawal water per issued water licences would not be challenged. Both of these conditions would create a business environment where investments in necessary mitigation, whether that be actual storage or further research and development into other approaches to reduce or meet water demand, can occur in an organized manner.

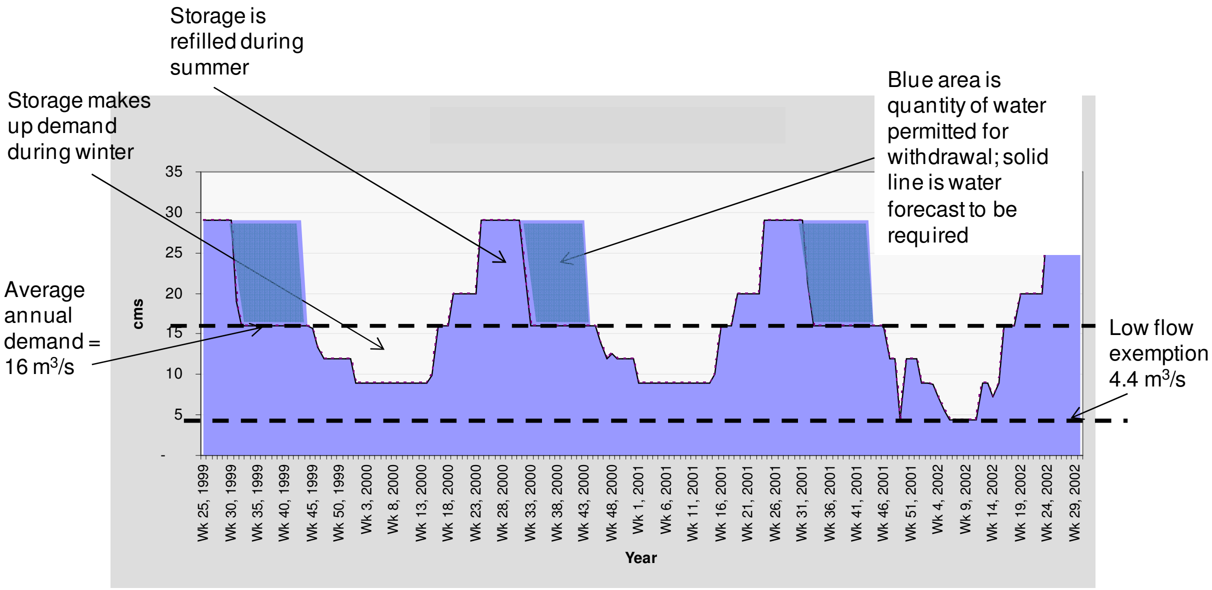
Considering the analyses above, it appears that the cumulative operations under Option H could be robust across a wide range of rare events should the long term storage target be set at the value calculated for the 1 in 200 year low flow event, which is approximately 104 million m^3. From an industry perspective, the EBF low flow exemption value of 4.4 m^3/s serves to provide certainty that water is available for operations that were constructed in the past.[18]

Another interest of industry is to achieve flexibility in operations. A highly constrained set of flow/withdrawal rules across all weeks of the year could lead to operational or maintenance challenges. Figure 40 shows a typical cycle of anticipated withdrawals and storage use simulated during a 1 in 200 year low flow event. The clear pattern of drawing on storage in winter periods and re-filling storage during open water periods is evident. The shaded blue areas of the figure that are not simulated for use during filling periods provide an indication of the amount of time during the year that would be available should maintenance requirements or operational challenges restrict water withdrawals during the year.[19]

---

[18] It was noted that the 4.4 m^3/s amount is roughly double the historic winter withdrawal rate of the two senior operators. The potential for future water transfers that might make part of this exempt volume available to future operators was noted as a concern for some stakeholders.

[19] Note that none of the alternatives simulated water withdrawals late into the fall open-water period, so the potential implications of such withdrawals is unknown.



Storage is refilled during summer

Storage makes up demand during winter

Blue area is quantity of water permitted for withdrawal; solid line is water forecast to be required

Average annual demand = 16 m^3/s

Low flow exemption 4.4 m^3/s

Figure 40: Typical cycle of anticipated withdrawals and storage use simulated during a 1 in 200 year low flow event

As a final note on operational flexibility, analyses have shown that although Option H was designed based on an assumption of a combined intake capacity of 29 m^3/s, the rules are actually robust down to a lower capacity of 22 m^3/s.

8.3. Climate Change Assessment

A key interest stated by all participants in the process was to understand the potential implications of climate change. As described in Section 5.6, the Climate Sub Group proposed a range of 6 hydrological scenarios that were derived from both trend analysis and global climate modelling techniques (Table 15).

Table 15: Summary of Climate Change Scenarios developed by the Climate Sub Group

Scenario Name	**Basis**[20]	**% change winter flow**	**% change summer flow**
Base Case	No change[1]	0	0
Global Climate Model 1	Mid-range scenario (CGCM2 / A2)	-3.5 %	-12.2 %
Global Climate Model 2	Extreme scenario (CSIRO / B2)	-18.3 %	-40.2 %
Global Climate Model 3	Extreme scenario (NCAR / A2)	+8.5 %	+5.3 %
Trend 1	50-year trend[2]	-10.8 %	-12.1 %
Trend 2	30-year trend[2]	-38.4 %	-28.9 %

1 The Base Case of no change is equivalent to the long term (90-100 year) trends of annual flow for the Athabasca River at the town of Athabasca (Rood and Stupple, 2009) (Alberta Environment, 2004).

2 It should be noted that trend analyses are very sensitive to the duration chosen.

In terms of applying these scenarios, the Climate Sub Group made no attempt to indicate which of the 6 scenarios was more plausible than another. The P2FC understood that for the Base Case scenario, which would assume that the future flows will be like the past, that there was no need for additional analyses – all previous analyses using the existing 50-year flow dataset were already available. For further screening, the P2FC also recognized that the GCM3 scenario, which would result in a modest increase in flows year-round would likely be of benefit to the river, and thus needed no further analysis. The potential for reduced flows such as indicated in the GCM 2 and Trend 2 scenarios were immediately recognized as extreme hydrological changes. Such changes, it was agreed, would have significant Provincial-scale policy and management implications that would far dominate the potential implications of water withdrawals of the scale considered in this process. Therefore, while the flow calculator remained available with all climate change scenarios entered ready for use, the emphasis of further detailed analysis focussed on the GCM 1 and Trend 1 climate change scenarios.

---

[20] See "Climate Change Sensitivity Analysis" prepared for the P2FC by Lebel *et al.* (2009), Volume 2: Technical Appendix.

As a first step in understanding this assessment, the flow calculator was used to provide an indication of the impact on wetted area due to climate change alone, i.e., without any industry water withdrawals. For example, Figure 41 shows the average wetted area impact in dry years for the Mid-Range Climate Change scenario “GCM1”, which forecasts a drop in Athabasca River flows of 3.5% in the winter and 12.2% in the summer. Figure 42 shows the increase in average wetted area impact when water withdrawals under the Option H are included.

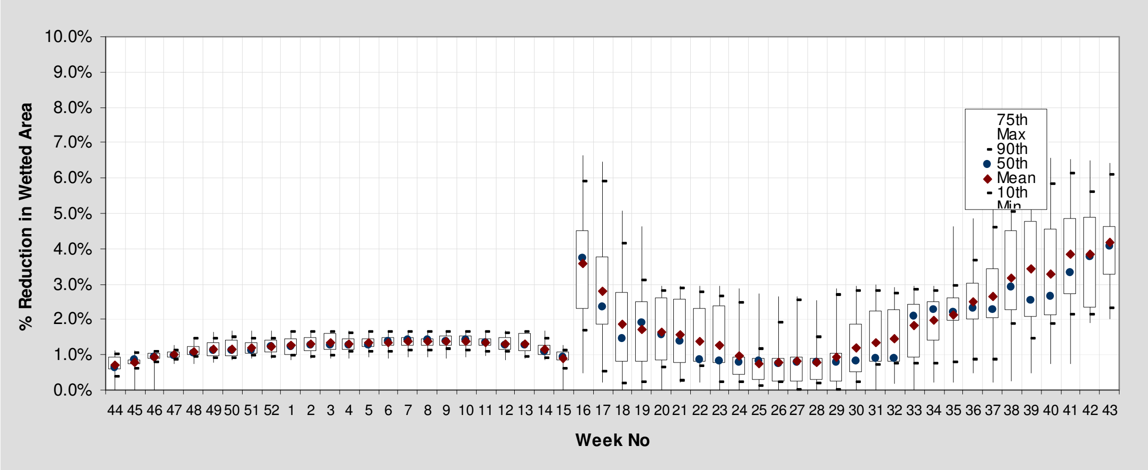


Figure 41: Reduction in average wetted area in dry years (Q80 – Q100) for the GCM1 climate change scenario.

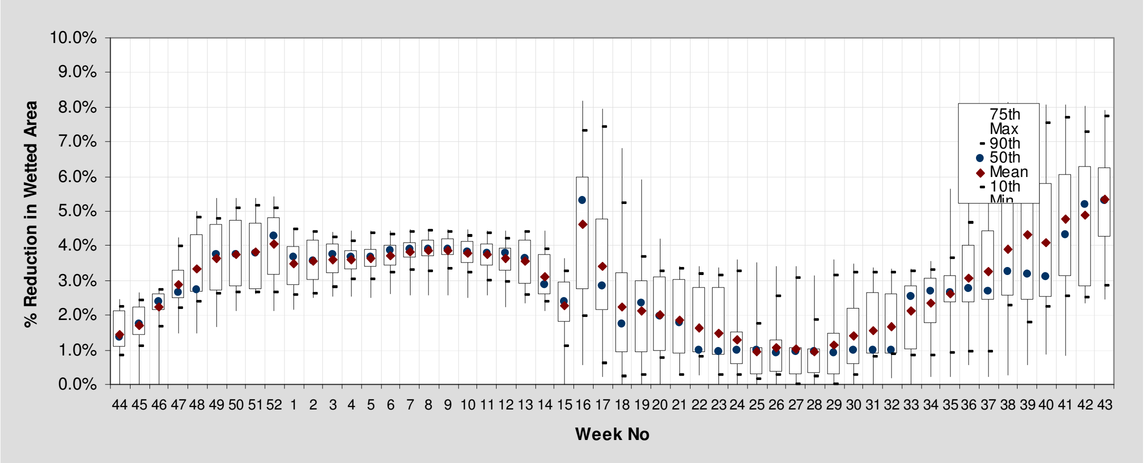
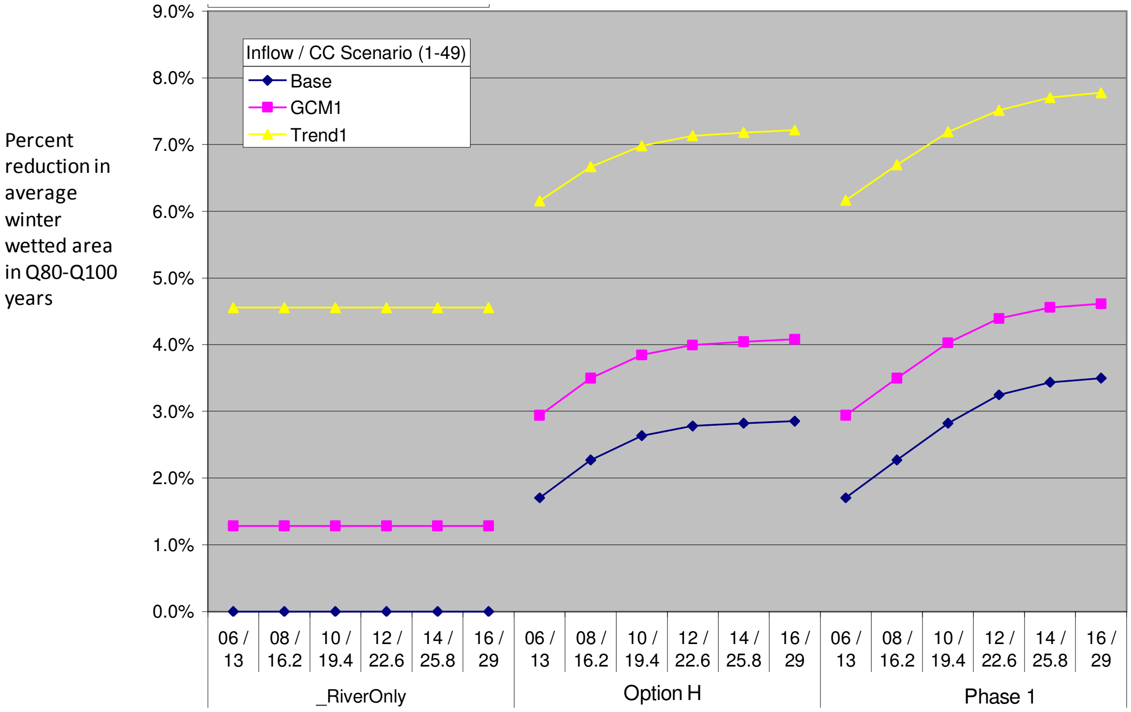


Figure 42: Reduction in average wetted area in dry years (Q80 – Q100) for the GCM1 climate change scenario combined with water withdrawals under Option H at the full industry build-out of 16 m^3/s.

A further sensitivity analysis on potential wetted area impact was developed by simulating the combination of potential climate change with water withdrawals over the projected growth in demand requirements. The left side of Figure 43 shows the ‘River Only’ cases, meaning that there are no water withdrawals and the increases in winter wetted area impact due the climate change scenarios alone are evident. The potential cumulative incremental increases due to water withdrawals over time under Phase 1 or Option H are also shown.



Growth scenarios shown are expected combinations of average industry demand and average intake capacities in the format ([average demand] / [expected intake capacity])

Figure 43: Reduction in average winter wetted area in dry years (Q80 – Q100) for the Base Case, GCM1 and Trend1 climate change scenarios for the River Only (i.e., no water withdrawals), and combined with water withdrawals under Phase 1 and Option H for alternative growth scenarios over time.

As a final step in the climate change assessment, the IFN ECs were calculated for the following scenarios:

- 'River Only' under the GCM1 scenario
- Option H under the GCM1 scenario
- 'River Only' under the Trend1 scenario
- Option H under the Trend1 scenario

The results are shown in the consequence table format below (Table 16).

In terms of the increased potential impact caused by climate change at the time of full build out to 16 m^3/s, the results indicate that Option H would be fairly robust to climate change scenarios such as GCM1 since none of the most important aquatic ecosystem ECs as identified by the

IFNTTG cross the upper threshold of significance.[21] The impact of climate change to the degree indicated by the Trend1 scenario or higher would start to raise more concern.

____

Finally, returning to the discussion of industry storage requirements from a potential climate change perspective, the P2FC noted that building to the target requirement of 104 million m^3 as discussed in the previous section for the 1 in 200 year low flow event case would be robust to moderate climate change such as those represented by the GCM 1 scenario. Building additional storage up to 112 million m^3 (i.e., the ‘perfect’ storage calculated for the Trend1 scenario) would make Option H robust to all but the most extreme climate change scenarios.

---

[21] Impacts on mesohabitat in the delta were noted as a concern by some, as high impact thresholds are crossed and as mentioned earlier, their significance is difficult to assess due to the lack of explicit connection between the mesohabitat hydraulic measures and biological species or communities.

Table 16: Consequence table including climate change sensitivity analysis results

	Objective	Attribute	Direction	Units	MSIC Type	MSIC Val	Threshold 1	Threshold 2	Option H	River Only, GCM1	Option H + GCM1	River Only, Trend 1	Option H + Trend 1
*	Ecosystem Health	FH - Ice Largest % Loss (mid-winter; Metric A)	L	%	A	2%	0%	10%	4.2%	2.0%	5.7%	5.7%	8.3%
*	Ecosystem Health	FH - Ice Largest % Loss (early shoulder; metric A)	L	%	A	2%	0%	10%	3.4%	1.4%	4.8%	4.4%	7.7%
*	Ecosystem Health	FH - Ice Largest % Loss (late shoulder; Metric A)	L	%	A	2%	0%	10%	3.3%	1.7%	4.9%	5.2%	8.1%
	Ecosystem Health	FH - Open Largest % Loss (Metric A)	L	%	A	2%	0%	10%	2.3%	7.2%	9.7%	7.1%	9.6%
*	Ecosystem Health	MH - Ice Most Sensitive % Loss (mid-winter; Metric A)	L	%	A	5%	10%	30%	16.7%	7.6%	23.6%	22.8%	35%
	Ecosystem Health	MH - Ice Most Sensitive % Loss (early shoulder; Metric A)	L	%	A	5%	10%	30%	21%	11%	29%	31%	46%
	Ecosystem Health	MH - Ice Most Sensitive % Loss (late shoulder; Metric A)	L	%	A	5%	10%	30%	15%	9%	24%	27%	41%
	Ecosystem Health	MH - Delta Most Sensitive % Loss (mid-winter; Metric A)	L	%	A	5%	10%	30%	49%	26%	64%	63%	86%
	Ecosystem Health	MH - Delta Most Sensitive % Loss (early shoulder; Metric A)	L	%	A	5%	10%	30%	38%	17%	51%	46%	70%
	Ecosystem Health	MH - Delta Most Sensitive % Loss (late shoulder; Metric A)	L	%	A	5%	10%	30%	41%	23%	56%	59%	79%
	Ecosystem Health	MH - Open Most Sensitive % Loss (Metric A)	L	%	A	5%	10%	30%	10%	40%	48%	40%	48%
*	Ecosystem Health	% Loss in Effective Whitefish Spawning Habitat	L	%	A	5%	10%	30%	12%	4%	14%	16%	25%
	Ecosystem Health	Walleye Population Reduction (% loss)	L	%	A	2%	10%	30%	7%	4%	12%	14%	24%
	Ecosystem Health	Walleye Population Viability (% extinction P)	L	%	A	0%	1%	10%	0.1%	0.0%	0.2%	0.4%	4.4%
	Ecosystem Health	Env - Fish - Extreme Yr Wks1-12 Ave Wetted Area	L	%					2.7%	0.0%	0.0%	0.0%	0.0%
	Ecosystem Health	Env - Fish - Extreme Yr Wks1-12 Ave (1:100 yr) Wetted Area	L	%					2.4%	0.0%	0.0%	0.0%	0.0%
	Ecosystem Health	Env - Fish - Extreme Yr Wks1-12 Ave (1:200 yr) Wetted Area	L	%					2.0%	0.0%	0.0%	0.0%	0.0%
	Ecosystem Health	Env - Footprint (based on 50 yr case)	L	km^2	R	10%			30	0	31	0	39
	Ecosystem Health	Env - Footprint (based on 50 yr case) - Relative Increase	L	%	R	10%			1.3%	0.0%	1.3%	0.0%	1.7%
	Navigation	Nav - Seg 4, EC4, Fall	L	%	A	2%			2%	7%	9%	6%	9%
	Cost	Ind - Capital Cost (based on 50 yr case)	L	$ millions	R	2%			$ 1,384	$ 0	$ 1,655	$ 0	$ 2,032
	Cost	Ind - Capital Cost (based on 50 yr case) - Relative Increase	L	%	A	2%			0.5%	0.0%	0.6%	0.0%	0.7%
	Data	Data - Storage (50 yr)	L	M m^3	R	2%			80	0	91	0	115
	Data	Data - Storage (1:100 yr)	L	M m^3	R	2%			91	0	NA	0	NA
	Data	Data - Storage (1:200 yr)	L	M m^3	R	2%			104	0	NA	0	NA

** Indicates IFN ECs recommended as most important by the IFNTTG in the round 3 assessment.*

ECs expressed in the form of percentages show the percent reductions from natural flow in years where the weekly flow in the river is below the Q80 exceedence level (i.e. the 20% of lowest flow years).

For all ECs, the lower the number, the better.

8.4. EBF Assessments

As discussed previously, interest in the final determination of an appropriate EBF threshold and potential low flow withdrawal exemption dominated discussions at the P2FC toward the end of the process.

Section 7.3.3.2 previously described the range of sensitivity analyses that were undertaken to explore different EBF exemption values, and the subsequent consequences for storage and wetted area. The lessons learned from these analyses fed into the development of Option H rules.

For an EBF threshold, the committee generally adopted the regulators proposal to apply the winter period 1 in 100 year low flow statistics as the basis for setting the threshold value at 87 m3/s.

However there was much more controversy over the options for a possible exemption. The committee evaluated the full range of possible values, ranging from 0 m^3/s (i.e., a true cut-off) to 8 m^3/s. Table 17 presents a summary table of the implications for alternative exemption values that were discussed by the P2FC. The key trade-off framed within the information is that the increasing protection believed to accrue at lower exemption values comes at a cost of either storage or increased operational risk.

Table 17: Implications of different low flow exemption values for Option H at full build out (i.e., 16 m3/s demand, 29 m3/s intake capacity)

Exempt when flows in river <87 (m^3/s)	Average Reduction in Winter Wetted Area (1:50 yr)	Protection of flows outside historical record (i.e. rarer than 1:50 yr)	'Perfect' Storage million m^3 (1:50 yr)	'Perfect' Storage million m^3 (1:200)	# Shortfalls if built to 103.7 million m^3@ 1:200 yr event	Requires resolution of legal /policy constraints?
8	2.86%	INCREASING	79.3	84.1	0	NO*
5.6	2.85%		79.3	96.3	0	NO*
4.4	**2.85%**	→	**80.2**	**103.7**	0	NO*
2	2.84%		84.6	121.9	4	YES
0.8	2.83%		86.2	133.3	5	YES
0	2.83%		90.2	141.3	6	YES

* Assumes voluntary reductions in water withdrawals

9. Phase 2 Framework Recommendations

9.1. Context for Committee Member Recommendations

The information on the detailed performance of Option H as described in Section 8 was summarized into presentation materials and provided to P2FC members for their use in soliciting feedback from their constituent organizations. The final two meetings of the committee process were devoted to discussing this feedback, exploring opportunities for further improvements, and generally developing the recommendations presented below.

While there was agreement on the majority of challenging topics addressed in the process, by the time the process was required to end to meet regulatory deadlines, there was not yet complete consensus among the committee. Some P2FC members were of the view that the water withdrawal rules specified in Option H and the recommendations as a whole result in an acceptable balance between environmental, social and economic considerations. Some were of the view that they do not.

The key area of disagreement revolved around issues associated with the EBF exemption. While full agreement on the existence of and level of an exemption to the EBF was not reached, there was agreement on the following principles:

1. There is a low flow at which continued minimum water withdrawals could pose an unacceptable risk to the aquatic ecosystem.
2. At such a flow, it may be appropriate for all water withdrawals to cease.
3. This would require the investigation of the legal, administrative and policy options for doing this in a manner consistent with water rights granted to licensees under the Water Resources Act and preserved in the Water Act.

Despite agreement on these principles, there was disagreement on the EBF exemption and, by extension, the set of water withdrawal rules as a whole. There was also disagreement on the potential voluntary and policy actions that industry and government could or should take to seek resolution.

Based on feedback from constituent organization consultations, and stated as succinctly as possible, the disagreement can be summarized across a spectrum of differing perspectives as highlighted in Table 18. Note that these perspectives are not “either / or” as some P2FC members found merit in aspects of perspectives across the spectrum.

Table 18: Range of perspectives expressed by P2FC members

	Range of Perspectives ↔	
Water Withdrawal Rules	The EBF threshold serves effectively as a full cut-off for all future operators, while the 4.4 m^3/s exemption is appropriate for both freeze protection and operations of existing facilities that cannot easily be adapted to maintain production without sufficient water. In the development of Option H, the EBF exemption was arrived at through a process of balancing impacts in low flow events with those under average flow conditions, and balancing aquatic impacts with industry storage requirements; any changes to the EBF exemption would require a re-evaluation of the balance of interests embedded in Option H.	Establishing an EBF threshold is a fundamental component of an IFN prescription. In principle, when flows reach the EBF threshold, there should be no withdrawal of water in order to protect the aquatic ecosystem. In the case of the Lower Athabasca River it may be appropriate for interim, minimum infrastructure freeze protection withdrawals for existing operations. The constant withdrawal allowance in the Option H EBF exemption would allow the withdrawal of an increasing fraction of the water remaining in the river as flows and habitat decline to unprecedented levels. This does not represent a balance of interests.
Science & Uncertainty	Option H's 4.4m^3/s EBF exemption is a precautionary approach to managing low flow events (being significantly below the assumed 16 m^3/s demand requirement). Until compelling scientific evidence supports otherwise, however, further reductions of withdrawal are not justified.	Option H's exemption is insufficiently precautionary with respect to the EBF concept. In the absence of scientific certainty, continuing withdrawals is not justified at rare low flows when the potential for increased aquatic impacts is greatest.
Means	Considering further reductions to the EBF exemption raises legal and policy issues that are explicitly outside the scope and terms of reference for this planning process as defined in the agreed upon principles of the P2FC process. Rules governing water transfers are outside the P2FC's scope, and would be subject to government public consultation requirements.	There are voluntary and regulatory actions consistent with existing water rights that could be taken to implement a lower EBF exemption, and these were not effectively explored during the process. The potential for future water transfers could further limit the opportunity to reduce the EBF exemption in the future.

9.2. Overview

The results of the P2FC process are organized into three basic components – water management rules, implementation requirements and adaptive management plans as shown in Figure 44. There are important interrelationships between the water management rules, implementation requirements and adaptive management plans.

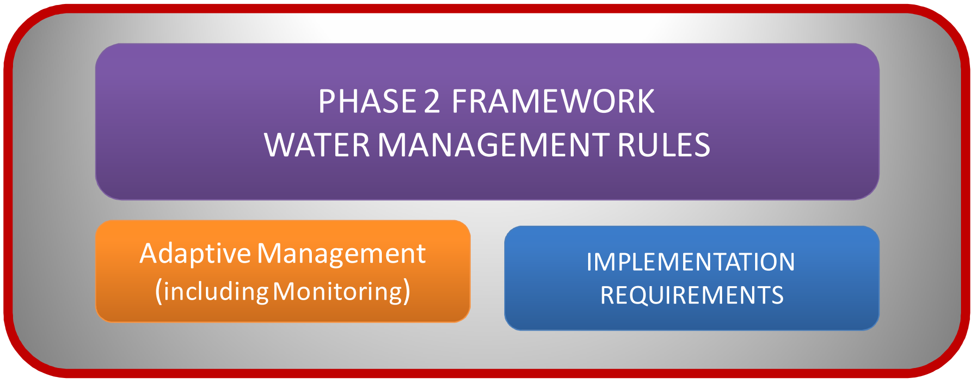


Figure 44: Overview of Phase 2 Framework Recommendations

9.3. Water Management Rules

As described above, the P2FC iteratively examined four rounds of alternative rule sets over many months. Substantial insights were gained from detailed technical analyses and modeling which allowed increasingly sophisticated and innovative alternatives to be developed. Although it was unable to reach full agreement on a single recommended rule set, it did substantially narrow the set of alternatives that merited further consideration.

The closest the P2FC was able to get to a preferred alternative was one referred to as ‘Option H’. The definition of Option H in terms of withdrawal rules (R) and thresholds (T) is presented in Table 19 and Figure 45 below.[22]

---

[22] Threshold crossing: Flow rules ‘ramp down’ to ensure a smooth transition above threshold changes according to the formula:
Permitted Withdrawal = Either a) LSA or b) (F + MSA – T), whichever is lower
Where F= Flow in river before withdrawals, T = Threshold being crossed, MSA = ‘More stringent allowance below the threshold’, LSA = ‘Less stringent allowance above the threshold’ (all values in m^3/s)

Table 19: Option H Water Management Rules

Week		R1 (m^3/s) If Flow in River F > T1 allow up to:	T1 (m^3/s) natural flow	R2 (m^3/s) If Flow in River T1 > F > T2 allow up to:	T2 (m^3/s) natural flow	R3 (m^3/s) If Flow in River T2 > F > T3 allow up to:	T3 (m^3/s) natural flow	R4 (m^3/s) If Flow in River T3 > F allow up to:
From	To							
1	15	16	270	6% of flow in the river	150	9	87	4.4 (*)
16	18	16	87	4.4 (*)				
19	23	20	87	4.4 (*)				
24	43	29	87	4.4 (*)				
44	52	16	200	8% of flow in the river	150	12	87	4.4 (*)

* The 4.4 m^3/s is based on an allowance of 2 m^3/s to both Suncor and Syncrude (i.e., voluntary reduction of 50 % from licensed peak instantaneous rates to their average annual allocation rates) and an allowance of 0.2 m^3/s to both Albian Muskeg River and Canadian Natural Horizon for freeze-protection of existing infrastucture.

Where:

"Week From" and "To" refer to weeks of the year defining periods of applicable rules and thresholds (e.g. week 1 means January 1-7, week 2 means January 8-15 etc)

"T" = A threshold flow in the river in m^3/s, used to determine the application of rules.

"R" = A rule prescribing the maximum permitted weekly average withdrawal by the cumulative oil sands mining industry (m^3/s)

Note that there are four increasingly protective rules that apply during weeks 1 to 15 and weeks 44 to 52: R1, R2, R3 and R4. The application of each is determined by three threshold flows in the river (m^3/s): T1, T2 and T3. R1 applies when the flow in the river exceeds T1. R2 applies when the flow in the river is less than T1 but greater than T2, and so on.

During weeks 19 to 23 and 24 to 43, only one threshold, T1, is used in each case to determine the applicable rule R1 or R2.

Option H includes a Lower Athabasca River Ecosystem Base Flow (EBF) threshold to be set at 87m^3/s, which is based on the winter period 1 in 100 year low flow statistic for mean weekly flows over the current period of record.[23] The withdrawal rule below this threshold exempts up to a maximum of 4.4 m^3/s from a full cut-off. That is, at levels of flow in the river below 87 m^3/s (i.e., at or below a 1 in 100 low flow event), industry may continue to withdraw up to a maximum of 4.4 m^3/s. This exemption recognizes voluntary peak rate withdrawal reductions from existing water license rights for the two senior companies (Suncor and Syncrude) of 50 % from licensed peak instantaneous rates to their average annual allocation rates of 2 m^3/s, and provides an allowance of 0.2 m^3/s for freeze-protection of existing infrastructure for each of two other existing operations (Albian Muskeg River and Canadian Natural Horizon). The 87 m^3/s

---

[23] The 87 m^3/s value was calculated by averaging the weekly 1 in 100 year low flows for weeks 1 through 11. For reference, it is thought that the lowest weekly average flow in the river over the past 50 years was 88 m^3/s.

effectively serves as a full cut-off threshold for all other water licences, although there is uncertainty regarding how any potential future water transfer application might be considered through the existing regulatory system.[24]

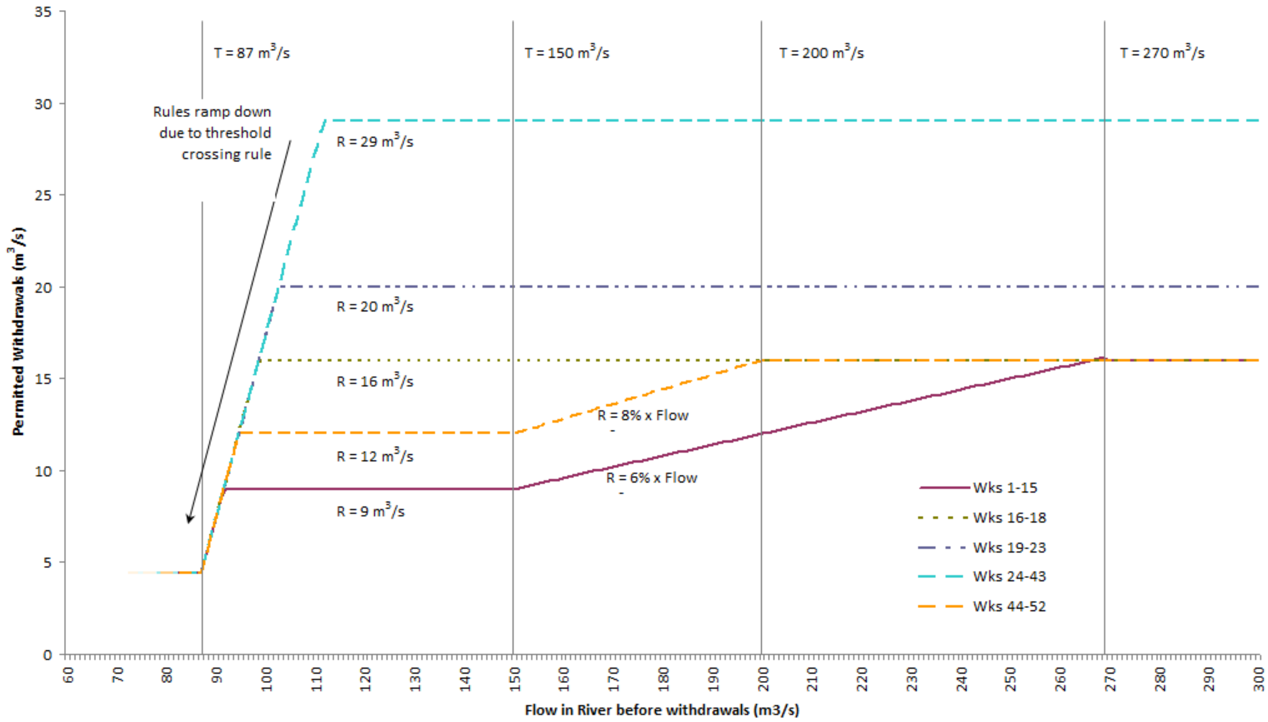


Figure 45: Graphical Summary of the Option H Water Management Rules

The performance of Option H relative to the current Phase 1 Framework is shown in the following consequence table (Table 20).

---

[24] There are a number of initiatives underway in Alberta focused on recommending changes and improvements to the current water allocation system.

Table 20: Consequence table comparing the performance of Option H to the Phase 1 Framework

	Objective	Attribute	Direction	Units	MSIC Type	MSIC Val	Threshold 1	Threshold 2	Phase 1	Option H
*	Ecosystem Health	FH - Ice Largest % Loss (mid-winter; Metric A)	L	%	A	2%	0%	10%	5.4%	4.2%
*	Ecosystem Health	FH - Ice Largest % Loss (early shoulder; metric A)	L	%	A	2%	0%	10%	3.6%	3.4%
*	Ecosystem Health	FH - Ice Largest % Loss (late shoulder; Metric A)	L	%	A	2%	0%	10%	4.6%	3.3%
	Ecosystem Health	FH - Open Largest % Loss (Metric A)	L	%	A	2%	0%	10%	2.3%	2.3%
*	Ecosystem Health	MH - Ice Most Sensitive % Loss (mid-winter; Metric A)	L	%	A	5%	10%	30%	21.0%	16.7%
	Ecosystem Health	MH - Ice Most Sensitive % Loss (early shoulder; Metric A)	L	%	A	5%	10%	30%	20%	21%
	Ecosystem Health	MH - Ice Most Sensitive % Loss (late shoulder; Metric A)	L	%	A	5%	10%	30%	22%	15%
	Ecosystem Health	MH - Delta Most Sensitive % Loss (mid-winter; Metric A)	L	%	A	5%	10%	30%	60%	49%
	Ecosystem Health	MH - Delta Most Sensitive % Loss (early shoulder; Metric A)	L	%	A	5%	10%	30%	41%	38%
	Ecosystem Health	MH - Delta Most Sensitive % Loss (late shoulder; Metric A)	L	%	A	5%	10%	30%	55%	41%
	Ecosystem Health	MH - Open Most Sensitive % Loss (Metric A)	L	%	A	5%	10%	30%	7%	10%
*	Ecosystem Health	% Loss in Effective Whitefish Spawning Habitat	L	%	A	5%	10%	30%	17%	12%
	Ecosystem Health	Walleye Population Reduction (% loss)	L	%	A	2%	10%	30%	9%	7%
	Ecosystem Health	Walleye Population Viability (% extinction P)	L	%	A	0%	1%	10%	0.1%	0.1%
	Ecosystem Health	Env - Fish - Extreme Yr Wks1-12 Ave Wetted Area	L	%					2.9%	2.7%
	Ecosystem Health	Env - Fish - Extreme Yr Wks1-12 Ave (1:100 yr) Wetted Area	L	%					2.6%	2.4%
	Ecosystem Health	Env - Fish - Extreme Yr Wks1-12 Ave (1:200 yr) Wetted Area	L	%					2.8%	2.0%
	Ecosystem Health	Env - Footprint (based on 50 yr case)	L	km^2	R	10%			30	30
	Ecosystem Health	Env - Footprint (based on 50 yr case) - Relative Increase	L	%	R	10%			1.3%	1.3%
	Navigation	Nav - Seg 4, EC4, Fall	L	%	A	2%			2%	2%
	Cost	Ind - Capital Cost (based on 50 yr case)	L	$ millions	R	2%			$ 1,379	$ 1,384
	Cost	Ind - Capital Cost (based on 50 yr case) - Relative Increase	L	%	A	2%			0.5%	0.5%
	Data	Data - Storage (50 yr)	L	M m^3	R	2%			72	80
	Data	Data - Storage (1:100 yr)	L	M m^3	R	2%			84	91
	Data	Data - Storage (1:200 yr)	L	M m^3	R	2%			84	104

** Indicates IFN ECs recommended as most important by the IFNTTG in the round 3 assessment.*

ECs expressed in the form of percentages show the percent reductions from natural flow in years where the weekly flow in the river is below the Q80 exceedence level (i.e. the 20% of lowest flow years).

For all ECs, the lower the number, the better.

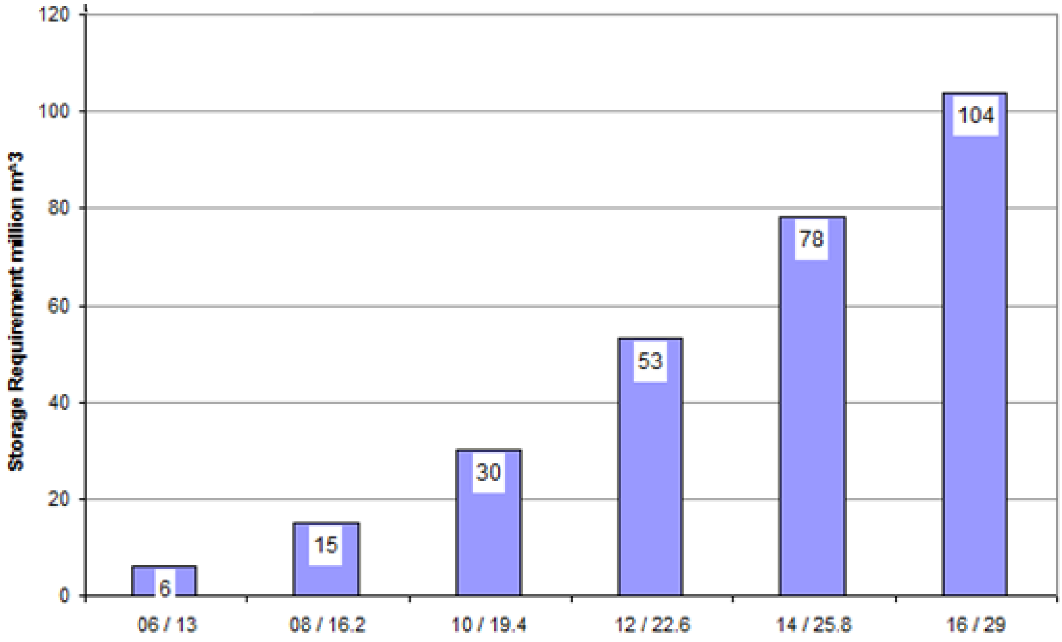
9.4. Implementation Requirements

To support and ensure the effective implementation of the final water management rules to be set by the regulators for the Phase 2 Framework, the P2FC developed additional recommendations in four categories:

1. Requirement and timeline for built storage or storage equivalent
2. Industry Water Management Agreement
3. Flow & Withdrawal Notification Protocols and Compliance Reporting
4. Implementation / Management under the Water Act, the Fisheries Act and the Alberta Land Stewardship Act

9.4.1. Requirement for built storage or storage equivalent

The Water Management Rules for Option H were developed based on the design criteria of: 1) the 50 years of historical Athabasca River flows, and 2) a low flow event expected to occur in only 1 year every 200 years. The forecast growth in cumulative industry water storage requirement for this case is shown in Figure 46. [25]



Growth scenarios shown are in the format the format A / B, where A= expected average industry cumulative demand in m^3/s and B= expected cumulative industry intake capacity in m^3/s

Figure 46: Projected growth in storage requirement for cumulative oil sands mining water demand and intake capacity assumptions used in the process

Note that these are not firm prescriptions of how much storage must be built. Rather, industry should collectively meet the Water Management Rules by either building the required storage amounts over time or through equivalent means, such as:

- Water sharing agreements (see below),
- Technological improvements in water use efficiency,
- Curtailing production,
- Alternate drought response measures.

---

[25] Note that this pattern is represented as growth in demand; the timeline under which any growth may occur is unknown.

It is recommended that the Phase 2 Framework begin to take effect from 1 January 2011, though the winter flow rules will not be enforced until winter 2011/2012 (i.e., the Phase 1 rules will remain in effect). From the winter of 2011/12 to 1 January 2016, the full set of Phase 2 rules will apply with the exception of the EBF rule.[26] This delayed implementation is required to accommodate the necessary regulatory processes and engineering/construction activities that would enable industry with the storage or storage equivalent necessary to meet Phase 2's more demanding requirements. The Phase 2 framework should be fully operational by 1 January 2016.

The Phase 2 rules governing water withdrawals will be upheld in all circumstances excepting those designated as special cases under the current provisions of Provincial and Federal law. Examples of such special cases include fires, the requirement to build ice bridges across the river etc. In all such cases, any temporary diversion licences that are granted should be done so in recognition of the overall Phase 2 Water Management Framework.

9.4.2. Industry Water Management Agreement

It is recommended that an annual Industry Water Management Agreement be developed by Industry and submitted to the regulators by November 15 each year. This document should:

- Clearly state the commitment to meet the cumulative withdrawals allowed under the Phase 2 Water Management Framework
- Provide details for dividing allowable water withdrawals under the Phase 2 Water Management Framework for each operator
- Be clear on the process by which individual operators will be held accountable should cumulative withdrawals exceed those permitted under this framework
- Include a medium term outlook[27] on cumulative demand and storage (or storage equivalent) necessary to achieve the Phase 2 Water Management Framework

It is also recommended that the regulators provide a backstop and prescribe the necessary water sharing requirements if required by December 15 each year.

It is recognized that during the low flow season, industry may negotiate different individual operator allocations to respond to emerging circumstances and opportunities, while remaining

---

[26] The R3 rules will apply.

[27] The frequency and timing of this outlook will be driven by project development details, such as when a new oil sands operation is expected to come on line.

within the overall framework rules. For legal certainty, an efficient process should be developed to notify the regulators in advance of departures from individual Industry Water Management Agreement allocations.

9.4.3. Flow & Withdrawal Notification and Compliance Reporting

It is recommended that Alberta Environment maintain the responsibility to determine an accurate flow rate in the Athabasca River and notify Industry of water withdrawal limits and requirements.

There is an interest in accountability, transparency and continual improvement in the implementation of the Phase 2 Water Management Framework. Therefore, it is recommended that flow and withdrawal compliance reporting include web-based reporting on a weekly basis of the following:

Previous Week / month / season	Current Week
▪ Official River Flow Forecast(1) ▪ Cumulative Withdrawal Allowance(2) ▪ Actual Cumulative Withdrawal(3,4)	▪ Official River Flow Forecast (1) ▪ Cumulative Withdrawal Allowance(2)

(1) AENV may choose to set the official river flow level by either forecasting or through the use of the most recent actual measurement.

(2) As per the Framework. Individual operator allowances to be described in the Industry Water Management Agreements each year.

(3) Detailed reporting of actual daily water withdrawals by operator are also submitted to AENV on an annual basis.

(4) Confirmed cases of non-compliance will be reported in annual reports.

Additional notes of clarification:

- All data that are reported publicly will need to carry disclaimers designating such information as preliminary.
- Industry is accountable to withdrawals based on flow forecast information as provided by AENV.
- AENV will determine the required frequency of flow measurements and industry withdrawal reporting as necessary.
- Some stakeholders expressed a strong preference that web-based reporting include actual withdrawals by individual operator, with appropriate disclaimers designating such information as preliminary.

9.4.4. Implementation / Management under the Water Act, Fisheries Act & Alberta Land Stewardship Act

There was a strong interest in ensuring legal certainty in the implementation of the Phase 2 Framework. To enable greater legal certainty, it was understood that there are several important regulatory tools and approaches available under the existing Water Act and Fisheries Act. Some of these were discussed in a cursory manner within the P2FC, including provisions and opportunities for:

- Applying terms and conditions in existing Water Act and Water Resources Act licences.
- Water Act license amendments (Water Act section. 54), and potential requirements for compensation (Water Act section. 158).
- Management orders (Water Act section. 99) and enforcement orders (Water Act section. 136).
- Water transfers (Water Act section. 81), water assignments (Water Act section. 33), and potential requirements for conservation holdbacks (Water Act section. 35).
- DFO's harmful alteration, disruption or destruction of habitat (Section 35) and position statement regarding existing infrastructure.

Although it was recognized as outside the scope of the P2FC's mandate to directly influence the regulatory process, based on committee discussions, several key recommendations were arrived at.

The recommendations include:

- Beyond what is recommended below, Government should clarify the linkages with all important, relevant legislation as part of the final Phase 2 Framework.
- Government should pursue *Approved Water Management Plan* (Water Act section. 11) status for the Phase 2 Framework Flow / Withdrawal Rules.
- Key IFN provisions in the Phase 2 Framework Water Management Rules should be declared as *Water Conservation Objectives* (Water Act section. 15).
- The Phase 2 Framework Water Management Rules should be adopted into the forthcoming *Lower Athabasca Regional Plan* (LARP) and integrated into other planning frameworks as required.
- Future water licenses in the basin should not affect the oil sands mining water withdrawal rules or storage / storage equivalent requirements as indicated by the Phase

2 Framework as of the date of implementation. One potential tool for this might be the use of a *Crown Reservation* (Water Act section. 35).

- Government should include conditions in new and newly amended Federal and Provincial Authorizations and Licences that ensure compliance with the Phase 2 Water Management Framework.
- Government should examine the practicality of Fish Habitat compensation options to satisfy DFO's No Net Loss policy for impacts resulting from withdrawals below a fully protective threshold.
- Clarify and improve the integration of planning across inter-related processes, e.g., Phase 2 Water Management Framework, Athabasca WPAC, Lower Athabasca Regional Plan, Tailings Directive, etc.

9.5. Adaptive Management

9.5.1. Overview and Key Uncertainties

Choices made during the Phase 2 process were based on an assessment of the consequences across multiple objectives, using the best available information and knowledge of participants. Inevitably, this knowledge is imperfect, and steps should be taken to address key uncertainties.

The proposed adaptive management program is intended to serve the following purposes:

- To provide the basis for both effectiveness and compliance monitoring;
- To address the fundamental data gaps, uncertainties and competing biological hypotheses that posed a challenge during the Phase 2 analyses;
- To specify management triggers that may signal the need for a formal review prior to a regular 10-year review.

The fundamental uncertainties, knowledge gaps and competing biological hypotheses that were central to the planning process discussions and supporting analyses leading to the Water Management Framework recommendations are identified in Table 21.

Appendix E contains a list of preliminary technical proposals for each topic listed in Table 21.

It should also be noted that there was insufficient time to fully discuss all aspects of the adaptive management recommendations and thus fully reveal the level of committee agreement.

Table 21: List of key topics identified for detailed monitoring plan designs

Hydrology and Compliance	Biological / Social
1. LAR Hydrology (including climate change) ▪ Install downstream gauge with winter capability (potentially at the confluence with the Firebag) ▪ Investigate opportunity to improve Fort McMurray gauge winter capability 2. Delta Hydrology (including climate change) 3. Water Use (Withdrawals)	4. Baseline Monitoring 5. Biotic Response to Low Flows ▪ EBF Thresholds and Allowances ▪ Competing hypotheses 6. Delta connections 7. Mesohabitat in the Delta 8. Aquatic Mammals 9. Dissolved Oxygen 10. Navigation

9.5.2. Monitoring Plan Implementation and Next Steps

Recommendations to further develop and implement these proposals include:

- Beginning early in 2010, the SWWG task group, or similarly convened group, should begin the technical work of developing the draft proposals into full programs.
- The following principles should guide the development and implementation of all monitoring plans:
    - Transparency – Open membership in implementing organizations.
    - Peer Review – Formal detailed external peer review and synthesis of management implications every 5 years or other appropriate timescale.
    - Reporting – Monitoring results and reports made available for review by external parties on an ongoing basis. Annual reports developed and made available.

  - Issue Tracking – Plans that are formally linked to resolving a key uncertainty (e.g., mesohabitat linkages with biological factors in the delta) should be highlighted in reporting (above) or formally linked with plan reviews (below).
  - Proper Resourcing – perhaps best achieved by multiple sources of funding.
- RAMP and PADEMP are potential organizations to be tasked with implementing monitoring components on the river and delta respectively.

9.5.3. Review Period & Protocols

The timeframe for revisiting key elements of the Framework should be 10 years, unless:

- Projected water demand for oil sands mining water withdrawals increases (or decreases) significantly from the design basis of 16 m^3/s used during this process.
- A key biological trigger is uncovered that warrants a re-examination of the Water Management Rules.

10. Summary and Next Steps

10.1. Committee Summary

The P2FC worked hard over a period of nearly 2 years to discuss issues and interests, to conduct and review detailed technical assessments, and to develop and evaluate alternatives.

This report summarizes those activities, and the recommendations that came as a result of the process. At its final meeting, P2FC members unanimously supported the process and the learning that emerged from it.

The Committee puts forward this report and the recommendations it contains, complete with noted areas of agreement and disagreement, with an understanding that the regulators will take it forth as part of their consultation activities over the next year.

10.2. Consultation Plan

Alberta Environment (AENV) and the Department of Fisheries and Oceans (DFO) have the responsibility to develop a final Phase 2 Water Management Framework and to consult with First Nations and the public in the process. Receipt of this report is viewed as a first step in the necessary process of consultation. The preliminary schedule for consultation and completion of the Final Phase 2 Water Management Framework for the Lower Athabasca River includes the following key milestones:

- January 2010 – AENV & DFO receive this report.
- January 2010 – AENV & DFO make available to First Nations and the public, with presentations as required.
- April 2010 – AENV and DFO accept written submissions.
- June 2010 – AENV and DFO develop a Draft Phase 2 Water Management Framework and make available to First Nations and the public, with presentations as required.
- September 2010 – AENV and DFO accept written submissions.
- December 2010 - AENV and DFO release the Final Phase 2 Water Management Framework.

11. REFERENCES

AECOM. 2009. *Review of Water Management Alternatives on Water Depth in the Lower Athabasca River*. Report prepared for the Cumulative Environmental Management Association.
See: *Volume 2: Technical Appendix*.

Alberta Environment. 2004. *Trends in Historical Annual Flows for Major Rivers in Alberta*. Prepared by M. Seneka. Alberta Environment, Edmonton.

AENV/DFO. 2007. *Water Management Framework: Instream Flow Needs and Water Management System for the Lower Athabasca River*. (The Phase 1 Framework)
See: *Volume 2: Technical Appendix*.

Bothe and Franzin. 2009. *Evaluation Criteria for Flow Alterations in the Lower Athabasca River – Channel Maintenance Flows*. Prepared for the Instream Flow Needs Technical Task Group.
See: *Volume 2: Technical Appendix*.

CEMA. 2006. *Surface Oil Sands Water Management Summary Report*. Alberta Technology and Science Inc.

Ghamry, Shatford and Locke. 2009a. *Evaluation Criteria for Connectivity of Distributaries in the Lower Athabasca River (Fletcher Channel) – Segment 1*. Prepared for the Instream Flow Needs Technical Task Group.
See: *Volume 2: Technical Appendix*.

Ghamry, Shatford and Locke. 2009b. *Evaluation Criteria for Connectivity of Perched Basins in the Lower Athabasca River– Segment 1*. Prepared for the Instream Flow Needs Technical Task Group.
See: *Volume 2: Technical Appendix*.

Lebel, M., Kerkhoven, E., Bothe, R., Hornung, J. and Ohlson, D. 2009. *Climate Change Sensitivity Analysis*. Report of the Climate Change Sub Group.
See: *Volume 2: Technical Appendix*.

McEachern. 2009. *Evaluation Criteria for Flow Alterations in the Lower Athabasca River – Dissolved oxygen in over-wintering fish habitat.* Prepared for the Instream Flow Needs Technical Task Group.
See: *Volume 2: Technical Appendix*.

OSDG. 2009a. *Athabasca River Water Requirements for Oil Sands Operations*. Report submitted by Golder & Associates. Report Number 07-1345-0027.
See: *Volume 2: Technical Appendix*.

OSDG. 2009b. *Engineering Mitigation Options for meeting the Athabasca River Water Management Framework*. Report submitted by Golder & Associates. Report Number 07-1345.0027.5000.
See: *Volume 2: Technical Appendix*.

Okyere. 2009. *Technical Memo: Routed Flows for Lower Athabasca River from 1958-2007*. Available from Alberta Environment, Northern Region, Reference 07DA/006/2009.

Paul. 2009a. *Evaluation Criteria for Flow Alterations in the Lower Athabasca River –Walleye Recruitment*. Prepared for the Instream Flow Needs Technical Task Group.
See: *Volume 2: Technical Appendix*.

Paul. 2009b. *Evaluation Criteria for Flow Alterations in the Lower Athabasca Rive r –Effective Spawning Habitat for Lake Whitefish*. Prepared for the Instream Flow Needs Technical Task Group.
See: *Volume 2: Technical Appendix*.

Paul and Locke. 2009a. *Evaluation Criteria for Flow Alterations in the Lower Athabasca River – Fish Habitat*. Prepared for the Instream Flow Needs Technical Task Group.
See: *Volume 2: Technical Appendix*.

Paul and Locke. 2009b. *Evaluation Criteria for Flow Alterations in the Lower Athabasca River – Abundance and Diversity of Mesohabitat*. Prepared for the Instream Flow Needs Technical Task Group.
See: *Volume 2: Technical Appendix*.

Rood and Stupple. 2009. Athabasca River at Athabasca. In: Athabasca History Highlights Planning Challenge, Fossil Water Report 4 (1): 1.

Westland Resource Group. 2009a. *Traditional Use Mapping of the Lower Athabasca River: Information Summary.* Report prepared for the Cumulative Environmental Management Association.

Westland Resource Group. 2009b. *Lower Athabasca River: Recreation Sector Information.* Report prepared for the Cumulative Environmental Management Association.

Westland, 2009c. *Impact Hypothesis Analysis: Effects of water withdrawal on traditional use of the Lower Athabasca River*. Report prepared for the Cumulative Environmental Management Association.
See: *Volume 2: Technical Appendix*.

12. APPENDICES

A	Evaluation Criteria Summary Tables
B	Exploration of the Ecosystem Base Flow Concept and Potential Assessment Methodologies.
C	Threshold Crossing Methods
D	Comparing water withdrawal alternatives' effect on traditional use. Memorandum submitted to the Socio-Economic Task Group. Westland, 2009.
E	Draft monitoring plan proposals