Report Title: Athabasca River Reach 4 Fish Habitat IFN Assessment

Working Group: Surface Water Working Group

Final/Approved Report Date: September 2005

Contract Number: 2005-0003

CEMA Disclaimer

Contract Name: Athabasca River Reach 4 Fish Habitat IFN Assessment

Consultant Name: Golder Associates Ltd.

This report was commissioned by the Instream Flow Needs Technical Task Group of the Surface Water Working Group of the Cumulative Environmental Management Association (CEMA), in its tasks of developing a defensible, science based IFN recommendation that provides full longer-term protection to the aquatic ecosystem in the lower Athabasca River. Specifically, this report was intended to conduct an instream flow needs fish habitat assessment for Reach 4 of the lower Athabasca River.

This report has been completed in accordance with the terms of reference issued by the Instream Flow Needs Technical Task Group. The Surface Water Working Group has closed this project and considers this report final.

The Surface Water Working Group does not fully endorse all of the contents of this report, nor does the report necessarily represent the views or opinions of CEMA, the Surface Water Working Group, or any of its Task Group Members.

The conclusions and recommendations contained within this report are those of the consultant, and have neither been accepted nor rejected by the Surface Water Working Group.

Until such time as the Surface Water Working Group issues correspondence confirming acceptance, rejection, or non-consensus regarding the conclusions and recommendations contained in this report, they should be regarded as information only.

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FINAL REPORT

ATHABASCA RIVER REACH 4
FISH HABITAT IFN ASSESSMENT

Submitted to:

Cumulative Environmental Management Association
Fort McMurray, Alberta

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September 2005 **05-1337-001**

TABLE OF CONTENTS

SECTION **PAGE**

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1. INTRODUCTION

The Cumulative Environmental Management Association (CEMA) retained Golder Associates Ltd. (Golder) to conduct an instream flow needs (IFN) fish habitat assessment for Reach 4 of the Athabasca River according to the protocols described in Clipperton et al. (2003). The weighted useable area (WUA) data for Reach 4 were provided to Golder by CEMA. The WUA curves were calculated using workshop habitat suitability curves developed by CEMA and two-dimensional hydraulic model results from Trillium Engineering. A review of the hydraulic modelling results was not included in the scope of the assessment. Weekly flow data for Reach 4 of the Athabasca River was provided to Golder by Alberta Environment (AENV). The assessment protocol from Clipperton et al. (2003) specifies the use of natural, or naturalized, flow data; however, these data were not available for the Athabasca River below Fort McMurray. Recorded flows for the Athabasca River at Fort McMurray are very similar to the natural flow due to the minimal volume of flow abstraction upstream of Fort McMurray relative to the river discharge (AENV, pers. comm.), and are referred to as natural flows for the purpose of this analysis.

2. METHODS

CEMA provided Golder with 10 open-water WUA curves and 3 ice-covered WUA curves for the assessment. The open-water period was specified by AENV and CEMA as beginning in mid-April and ending in mid-November. These dates correspond to week numbers 16 through 43 in the flow files for the open-water period. The ice-covered period includes all remaining weeks (i.e., week 44 through week 15).

2.1 Fish Habitat IFN Assessment Protocols

The fish habitat assessment followed the protocols described in Clipperton et al. (2003). The assessment has five basic steps, which are summarized below.

2.1.1 Step 1: Percent Reduction in Flow from Natural

Flow time series were created as a constant percent reduction from natural, in 5% increments, based on weekly average flows provided by AENV. Using a constant percent departure from the natural flow regime as an IFN recommendation ensures the pattern of variability of the natural flow regime is preserved, both within years (intra-annual) and between years (inter-annual). The flow data provided by AENV had a period of record from 1971 through 2000. Athabasca River Reach 4 naturalized flows were calculated using the recorded flows from the Athabasca River at Fort McMurray and adding the recorded flows from the Steepbank River.

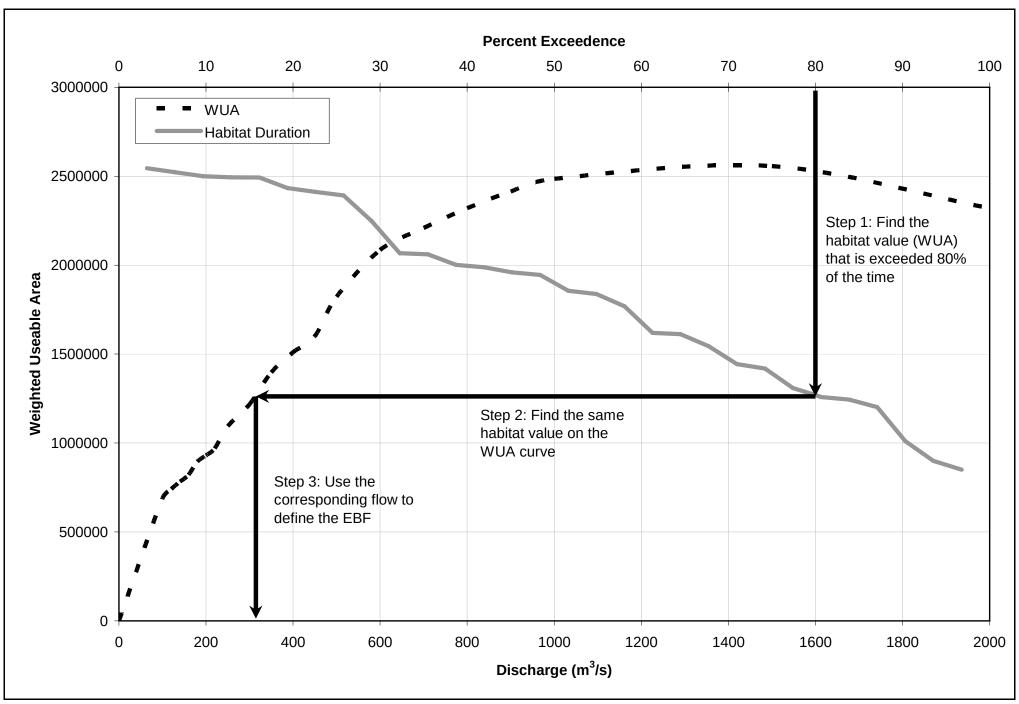
2.1.2 Step 2: Defining the Ecosystem Base Flow

To address instream needs at low flows, a threshold flow value was defined below which the instream flow need was the natural flow. This threshold value was referred to as the Ecosystem Base Flow (EBF). An Ecosystem Base Flow (EBF) was incorporated into all of the flow reduction time series assessed to protect habitat during seasonal low flow periods, when habitat can become limiting under natural flow conditions.

The EBF is reach-specific and is calculated on a weekly time step so that the EBF value varies from week to week to maintain seasonal flow variability. Site-specific WUA curves and site-specific hydrology are required to calculate the weekly EBF values. A combination of a habitat duration analysis approach, adapted from Sale et al. (1981), and a flow duration approach is used to determine the EBF.

The habitat duration approach (HDA) uses the 80% habitat exceedence value to represent a relatively limited habitat condition. Increasing the frequency of occurrence of limited habitat conditions is not desired in defining an IFN. The discharge corresponding to the 80% habitat exceedence value for the life stage with the WUA curve that peaks at the highest flow is initially defined as the EBF. The procedure for calculating the 80% HDA is illustrated in Figure 1. Because a WUA curve typically has low habitat values associated with both high and low discharges, the actual 80% habitat exceedence value may be due to a high or low discharge in the period of record, depending on the week. The lowest discharge that corresponds with the 80% habitat exceedence value is selected as the EBF.

Figure 1
Example of the 80% Habitat Exceedence Procedure for Defining the Ecosystem Base Flow



Note: Example for Reach 4 of the Athabasca River using Week 16 Habitat Exceedence Curve and the Goldeye Adult WUA Curve. The EBF in this example is 314 m^3/s.

The 95% flow exceedence for each week was defined as a secondary flow criterion for determining the EBF. The final EBF is established as the higher of the 95% flow exceedence discharge or the discharge corresponding to the 80% habitat exceedence for the life stage with the WUA curve that peaks at the highest flow.

2.1.3 Step 3: Determining the Range of Flows for the Fish Habitat-Time Series Analysis

High flows often pose a problem in evaluating physical habitat for fish. There is an upper flow limit where the validity of the fish habitat-based flow information (WUA curves) becomes questionable. Information that is used to generate the habitat suitability criteria (HSC) curves comes primarily from direct observations of fish. Fish habitat use at very high flows has rarely been sampled due to the physical limitations and safety considerations of collecting field data under high flow conditions. In the higher flow ranges, normally from the beginning to the end of the spring freshet, other ecosystem tools should be used to define an IFN instead of WUA curves for fish.

A flow range, based on an evaluation of site-specific WUA curves for all life stages, was determined for conducting the habitat time series analysis. All weeks with a median flow greater than the flow corresponding to the WUA peak that occurs at the highest flow were removed from the habitat time series analysis. This effectively removes the spring freshet from the habitat time series analysis.

2.1.4 Step 4: Conducting Habitat Time Series

Habitat time series for the constant percent departure from natural flow scenarios were evaluated by examining the percent reduction in habitat availability. Time series evaluations are a highly recommended component of the instream flow incremental methodology (IFIM) as described by Bovee et al. (1998). The two basic requirements for conducting a habitat time series are WUA curves and stream discharge data.

WUA curves were provided to Golder by CEMA and were based on HSC curves developed by CEMA through a workshop process, and the two-dimensional hydraulic modelling results for Reach 4 conducted by Trillium Engineering. The WUA curves were used to calculate the habitat time series for natural flow and for each constant percent departure from the natural flow, over the period of record. Habitat time series were calculated for each management species and life stage provided by CEMA for the open-water and ice-covered periods.

A habitat time series is based on calculation of the available habitat for every discharge record used in the evaluation. For each discharge, a habitat value was calculated by linear interpolation between the two adjacent discharges represented in the WUA curve. The discharge records for Reach 4 of the Athabasca River were provided to Golder by AENV and were based on mean weekly recorded flows from 1971 to 2000.

2.1.5 Step 5: Reviewing Evaluation Metrics

The overall strategy for determining instream flow needs for moderate and low-flow periods was to identify an instream flow regime that would limit fish habitat reductions, relative to the natural flow regime, to amounts that would be generally accepted as being small. The rationale is simply that, if habitat reductions are limited to small amounts, it can reasonably be assumed that a high level of protection has been provided by the IFN. Fish habitat is assumed to be an appropriate surrogate for providing ecosystem protection at low to moderate flows.

Several metrics were used to evaluate the effects of change in discharge relative to natural conditions. Each metric can be used to examine different effects of changes in flow, such as chronic (long-term) impacts, intermediate, or acute (short-term) impacts. The following key evaluation metrics were calculated for each species and life stage at each reach:

- **Metric 1 -** a 10% loss in total average habitat from natural, calculated as the average using data for all weeks and all years except for weeks removed as described in Step 3;
- **Metric 2 -** a 15% maximum weekly loss of average habitat from natural, calculated as the average habitat for each week (i.e., week 16, week 17, etc.) using data from every year in the period of record (i.e., 1971-2000) and the week with the greatest percent loss from natural was reported; and,

- **Metric 3 -** a 25% maximum instantaneous habitat loss from natural, calculated as the greatest single percentage habitat loss recorded for an individual flow record for all weeks in all years.

Starting with the 5% departure from the natural flow time series, each metric was checked to see if it met or exceeded the defined thresholds. If the criteria were met, then the 10% departure from the natural flow regime was evaluated through a similar time series analysis. This was repeated for each flow reduction time series, in 5% increments, until at least one of the three evaluation criteria was exceeded. The fish habitat IFN was then initially defined as the preceding flow reduction time series where all of the evaluation criteria were met.

3. RESULTS

The WUA curves, provided to Golder by CEMA, used to conduct the analysis are provided in Appendix I.

3.1 Ecosystem Base Flow

The EBF was calculated as the discharge corresponding to the 80% habitat exceedence (i.e., 80% HDA) for the life stage with the WUA curve that peaks at the highest flow. The species with the WUA curve peak at the highest flow was longnose sucker adult for the ice-cover period and goldeye adult for the open-water period. The discharge corresponding to the 80% habitat exceedence was always greater than the 95% exceedence flow for each week of the year. The final EBF is presented in Figure 2 and Table 1.

Figure 2
Ecosystem Base Flow (m^3/s) for Reach 4 of the Athabasca River

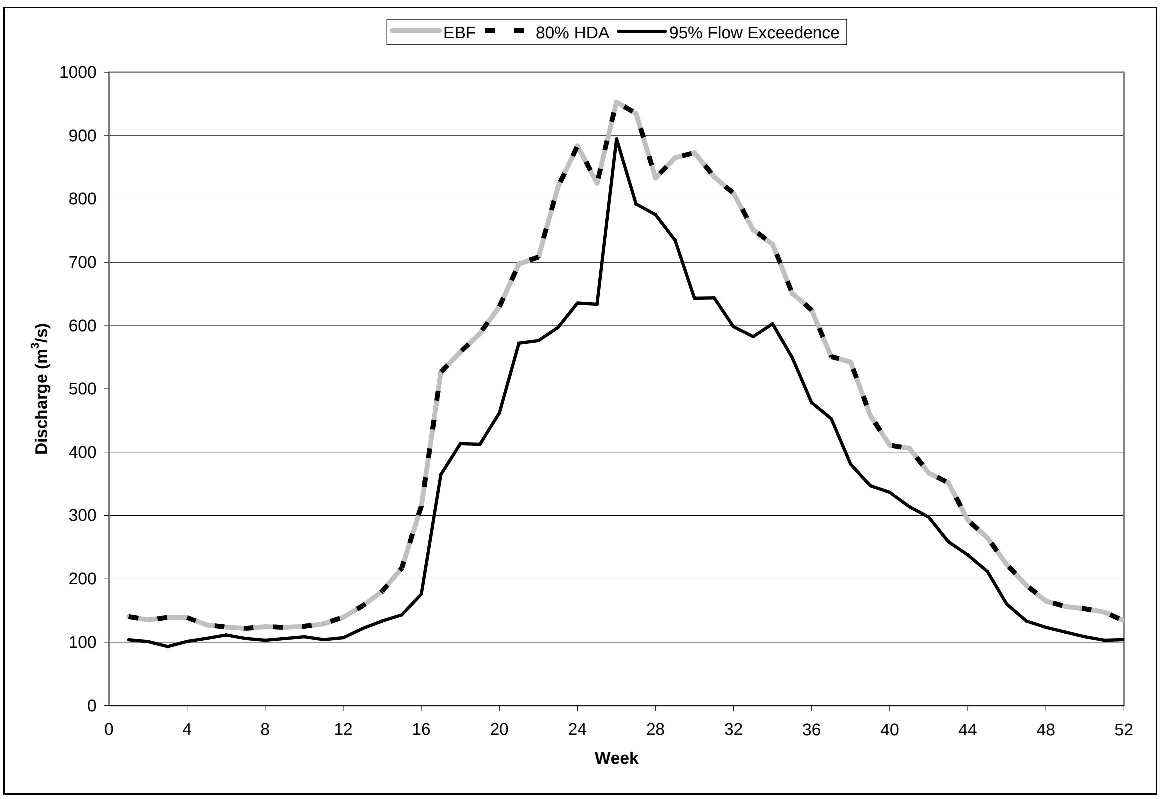


Table 1
Ecosystem Base Flow (m^3/s) for Reach 4 of the Athabasca River

Open-Water Season	**Week**													
	16	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**
80% Habitat Exceedence	314	527	558	588	630	698	708	819	884	825	953	935	833	865
95% Flow Exceedence	176	365	414	413	462	572	576	597	636	634	895	792	775	735
Final EBF	314	527	558	588	630	698	708	819	884	825	953	935	833	865
Open-Water Season	**Week**													
	30	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**
80% Habitat Exceedence	873	835	809	751	728	651	625	551	543	458	411	406	367	352
95% Flow Exceedence	643	644	598	583	603	550	479	453	381	347	337	314	298	259
Final EBF	873	835	809	751	728	651	625	551	543	458	411	406	367	352
Ice-Covered Season	**Week**													
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
80% Habitat Exceedence	140	135	139	139	127	124	122	124	124	125	129	140	158	180
95% Flow Exceedence	104	101	93	101	106	111	106	103	106	109	104	107	122	134
Final EBF	140	135	139	139	127	124	122	124	124	125	129	140	158	180
Ice-Covered Season	**Week**													
	15	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**				
80% Habitat Exceedence	217	293	265	223	190	165	156	153	147	134				
95% Flow Exceedence	143	238	212	160	133	123	116	109	103	104				
Final EBF	217	293	265	223	190	165	156	153	147	134				

3.2 Removal of High Flow Weeks

The peak of the longnose sucker adult WUA curve for the ice-cover period occurs at 500 m^3/s. The median discharge for week 44 is 518 m^3/s and therefore week 44 was removed for the calculation of total mean habitat. The peak of the goldeye adult WUA curve for the open-water period occurs at 1500 m^3/s. The median discharge for week 29 is 1562 m^3/s and therefore week 29 was removed for the calculation of total mean habitat. All other weeks remained in the calculation of total mean habitat.

3.3 Habitat Metrics

The key evaluation metrics are summarized in Table 2 through Table 4 for the open-water period and Table 5 through Table 7 for the ice-cover period.

Table 2
Summary of Average Percent Habitat Change from Natural (Metric 1) for the Open-water Period for All Weeks Except High Flow Weeks (Week 29 Excluded)

Species and Life Stage	Flow Scenario (% of Natural)				
	85%	80%	75%	70%	65%
	% Change from Natural	% Change from Natural	% Change from Natural	% Change from Natural	% Change from Natural
LNSC-Adult	-2.0%	-2.7%	-3.5%	-4.2%	-5.0%
GOLD-Adult	-2.4%	-3.3%	-4.3%	-5.2%	-6.3%
GOLD - Juvenile	-0.5%	-0.8%	-1.2%	-1.7%	-2.3%
GOLD - Fry	7.9%	10.4%	12.7%	14.8%	16.7%
NRPK - Adult	3.8%	4.9%	5.9%	6.8%	7.6%
NRPK - Juvenile	10.7%	14.0%	17.1%	20.0%	22.6%
CEMA1-Adult	-2.2%	-3.0%	-3.7%	-4.5%	-5.3%
WALL-Adult	-1.5%	-2.1%	-2.6%	-3.2%	-3.8%
WALL-Juvenile	4.9%	6.4%	7.7%	8.9%	9.8%
WALL-Fry	7.8%	10.2%	12.5%	14.6%	16.6%
WALL-Eggs	N/A	N/A	N/A	N/A	N/A

Note: LNSC = longnose sucker, GOLD = goldeye, NRPK = northern pike, CEMA1 = a theoretical composite fish developed by CEMA, WALL = walleye.

Table 3
Summary of Average Weekly Percent Habitat Change from Natural (Metric 2) for the Open-water Period

Species and Life Stage	Flow Scenario (% of Natural)				
	85%	80%	75%	70%	65%
	% Change from Natural	% Change from Natural	% Change from Natural	% Change from Natural	% Change from Natural
LNSC-Adult	-5.6%	-7.6%	-9.6%	-11.4%	-13.0%
GOLD-Adult	-7.5%	-10.4%	-13.4%	**-16.3%**	**-18.7%**
GOLD - Juvenile	-6.7%	-9.6%	-12.7%	**-15.6%**	**-17.7%**
GOLD - Fry	-2.0%	-3.9%	-5.6%	-6.7%	-6.6%
NRPK - Adult	-3.0%	-5.0%	-6.6%	-7.6%	-7.4%
NRPK - Juvenile	-0.9%	-3.2%	-5.9%	-8.0%	-8.1%
CEMA1-Adult	-6.6%	-9.1%	-11.8%	-14.2%	**-16.2%**
WALL-Adult	-6.0%	-8.3%	-10.7%	-12.9%	-14.6%
WALL-Juvenile	-3.4%	-5.1%	-7.1%	-8.8%	-9.8%
WALL-Fry	-2.0%	-3.9%	-5.6%	-6.7%	-6.6%
WALL-Eggs	-5.7%	-8.0%	-10.5%	-13.1%	**-15.6%**

Note: Bold numbers indicate exceedence of the habitat metric threshold.

Table 4
Summary of Maximum Instantaneous Percent Habitat Change from Natural (Metric 3) for the Open-Water Period

Species and Life Stage	Flow Scenario (% of Natural)				
	85%	80%	75%	70%	65%
	% Change from Natural	% Change from Natural	% Change from Natural	% Change from Natural	% Change from Natural
LNSC-Adult	-9.7%	-12.8%	-16.0%	-18.3%	-20.7%
GOLD-Adult	-15.7%	-19.3%	-23.1%	**-25.8%**	**-28.7%**
GOLD - Juvenile	-17.6%	-21.0%	-24.6%	**-26.5%**	**-28.5%**
GOLD - Fry	-18.8%	-22.7%	**-26.6%**	**-25.9%**	-24.8%
NRPK - Adult	-16.3%	-20.6%	-24.8%	-24.5%	-23.9%
NRPK - Juvenile	-24.1%	**-26.8%**	**-29.6%**	**-27.1%**	**-25.7%**
CEMA1-Adult	-13.8%	-17.2%	-20.6%	-22.9%	**-25.3%**
WALL-Adult	-12.7%	-15.9%	-19.2%	-21.2%	-23.2%
WALL-Juvenile	-13.0%	-15.6%	-18.3%	-18.5%	-18.8%
WALL-Fry	-18.8%	-22.7%	**-26.6%**	**-25.9%**	-24.8%
WALL-Eggs	-13.1%	-16.5%	-20.1%	-23.6%	**-28.2%**

Note: Bold numbers indicate exceedence of the habitat metric threshold.

Table 5
Summary of Average Percent Habitat Change from Natural (Metric 1) for the Ice-cover Period for All Weeks Except High Flow Weeks (Week 44 Excluded)

Species and Life Stage	Flow Scenario (% of Natural)				
	65%	60%	55%	50%	45%
	% Change from Natural	% Change from Natural	% Change from Natural	% Change from Natural	% Change from Natural
NRPK-Adult	-3.1%	-3.4%	-3.5%	-3.7%	-3.7%
WALL-Adult	-3.9%	-4.3%	-4.6%	-4.7%	-4.8%
LNSC-Adult	-9.0%	-9.8%	**-10.3%**	**-10.6%**	**-10.8%**

Note: Bold numbers indicate exceedence of the habitat metric threshold.

Table 6
Summary of Average Weekly Percent Habitat Change from Natural (Metric 2) for the Ice-cover Period

Species and Life Stage	Flow Scenario (% of Natural)				
	65%	60%	55%	50%	45%
	% Change from Natural	% Change from Natural	% Change from Natural	% Change from Natural	% Change from Natural
NRPK-Adult	-5.4%	-5.8%	-6.4%	-6.7%	-6.8%
WALL-Adult	-5.0%	-5.6%	-6.1%	-6.4%	-6.5%
LNSC-Adult	-12.3%	-13.1%	-14.1%	**-15.1%**	**-15.5%**

Note: Bold numbers indicate exceedence of the habitat metric threshold.

Table 7
Summary of Maximum Instantaneous Percent Habitat Change from Natural (Metric 3) for the Ice-cover Period

Species and Life Stage	Flow Scenario (% of Natural)				
	65%	60%	55%	50%	45%
	% Change from Natural	% Change from Natural	% Change from Natural	% Change from Natural	% Change from Natural
NRPK-Adult	-9.4%	-9.7%	-10.0%	-11.0%	-11.6%
WALL-Adult	-10.2%	-10.4%	-11.4%	-13.9%	-15.6%
LNSC-Adult	-20.0%	-21.9%	-23.4%	-24.7%	**-27.1%**

Note: Bold numbers indicate exceedence of the habitat metric threshold.

3.3.1 Open-Water Period

For the open-water period, flow reduction scenarios from 85% of natural to 65% of natural, with the added constraint of the EBF, were evaluated. Under these scenarios, no life stage had a total average habitat loss that exceeded the defined threshold of 10%.

Walleye fry exceed the 25% maximum instantaneous habitat loss threshold at flow scenarios of 75% natural flow, while northern pike juvenile exceeded this threshold at 80% of natural flow. However, in both cases, the maximum weekly habitat losses were well below the threshold value and the total average habitat losses were actually positive, indicating a habitat gain. The WUA curves for these two life stages have a peak at a very low flow with a secondary peak at a higher flow. The maximum habitat losses that exceed the threshold occur at higher flows as a result of the secondary curve peak. The frequency of occurrences where maximum habitat losses exceed the threshold value for northern pike juvenile are very low at less than 1% of the time for 80% of natural flow and less than 2% of the time for 75% of natural flow. The frequency of occurrences where maximum habitat losses exceed the threshold value for walleye fry are very low at less than 1% of the time for 75% of natural flow

Goldeye juvenile and goldeye adult exceed the 15% maximum weekly habitat loss threshold and the 25% maximum instantaneous habitat loss threshold at the 70% of natural flow scenario. These life stages also show a steady trend in continued habitat losses for the total average habitat metric. As a result, the IFN determination for the open-water period, based on the results of goldeye adult and juvenile habitat analysis, would be 75% of natural flow, with the added constraint of the EBF, as this is the flow scenario where all metrics are below the defined thresholds for these life stages.

3.3.2 Ice-Cover Period

For the ice-cover period, flow reduction scenarios from 65% of natural to 45% of natural, with the added constraint of the EBF, were evaluated. Of the three life stages evaluated, only longnose sucker adult exceeded any of the key evaluation metrics for these flow scenarios.

For longnose sucker, the habitat loss thresholds for total average, maximum weekly, and maximum instantaneous were exceeded at flow reduction scenarios of 55%, 40%, and 45% of natural flow, respectively. The IFN determination for the ice-cover period is therefore 60% of natural flow, with the added constraint of the EBF, as this is the flow scenario where all metrics are below the defined thresholds for longnose sucker adult.

3.4 Final Fish Habitat IFN

The integrated fish habitat IFN determination for Reach 4 of the Athabasca River is presented in Appendix II. The fish habitat IFN, as defined using the protocols described in Clipperton et al. (2003), are 60% of natural flow for the ice-cover period and 75% of natural for the open-water period. These correspond to a maximum instantaneous diversion of 40% for the ice-cover period and a maximum instantaneous diversion of 25% for the open-water period, with the added constraint of the EBF for both periods. No flow reduction is prescribed at flows below the EBF for each week of the year.

The winter habitat loss results were found to be unresponsive to reductions in flow using the SSRB method, as was the case in a few of the reaches in the SSRB (Clipperton et al. 2003). Relatively large flow reductions can result in relatively small habitat losses. Both the habitat suitability curves and the WUA curves for the winter period are relatively broad (i.e., a high suitability over a wide range of flows) and, as a result, are not sensitive to flow reductions. Interpretation of the results should be applied with caution.

The fish habitat IFN flow determination has been applied to all weeks and all flow ranges in the summary charts in Appendix II. This does not imply that other ecosystems components are necessarily protected by this IFN determination at higher flow ranges, nor does the IFN presented account for any potential water quality limitations that may apply. The procedure described in Clipperton et al. (2003) specifies that IFN requirements for other ecosystem components should be integrated with the fish habitat IFN to develop an ecosystem-based IFN.

The results for Segment 4 are site-specific and cannot be directly transferred to Segments 1, 2 or 5. Site-specific results were found to vary reach to reach in the SSRB assessment (Clipperton et al. 2003). Reach balancing (i.e., adjusting the IFN in upstream reaches to ensure downstream

IFN requirements are met) is typically completed once information is available for all segments of interest, resulting in changes to the final IFN in some segments. ASRD currently recommends a maximum reduction from natural flow of 15% with the added constraint of an Ecosystem Base Flow in cases where site-specific IFN information is not available (A. Locke, ASRD, pers. comm.). Applying the 15% maximum reduction rule with the added constraint of an Ecosystem Base Flow would be a conservative approach until the results from Segments 1, 2 and 5 are available.

4. CLOSURE

We trust the above meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

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