FEASIBILITY PLAN FOR WATER CONTROL STRUCTURE AT DOG CAMP

FINAL REPORT

Prepared for:

SLR

SLR Consulting (Canada) Ltd.
on behalf of

Parks Canada

9 March 2020

NHC Ref. No. 1005166

nhc
northwest hydraulic consultants
water resource specialists

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Prepared for:

SLR Consulting (Canada) Ltd.
Calgary, Alberta

on behalf of

Parks Canada
Fort Chipewyan, Alberta

Prepared by:

Northwest Hydraulic Consultants Ltd.
Edmonton, Alberta

9 March 2020

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Date Mar 9/20
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The Association of Professional Engineers, Geologists and Geophysicists of Alberta

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This report has been prepared by Northwest Hydraulic Consultants Ltd. (NHC) in accordance with generally accepted engineering practices, for the benefit of SLR Consulting (Canada) Ltd. and the Government of Canada for specific application to the proposed Dog Camp water control structure site in Alberta. The information and data contained herein represent the best professional judgment of NHC, based on the knowledge and information available to NHC at the time of preparation.

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EXECUTIVE SUMMARY

This study examined the feasibility of a water control structure on the west arm of the Chenal des Quatre Fourches at Dog Camp. The intent of a structure at this location would be to raise water levels in Mamawi Lake, Lake Claire, and connected areas of the PAD so that perched basins would be inundated more frequently. The scope of work included knowledge gathering sessions with Indigenous communities in Fort Chipewyan, a site inspection and surveys, a hydrotechnical assessment of Mamawi Lake and connected Lake Claire, an evaluation of water control structure alternatives with input from the community, and a feasibility level design for the preferred options.

A hydrologic water balance model for Mamawi Lake and Lake Claire was created to understand the maximum achievable lake levels due to the construction of the Dog Camp water control structure and in different flow conditions. For an average year, the maximum achievable water level in Mamawi Lake and Lake Claire is about 210.0 m, based on inflow volumes from the Birch and McIvor Rivers and Cree Creek. This maximum achievable lake level is 0.8 m above the mean annual peak level for Mamawi Lake and 0.5 m above the mean annual peak level for Lake Claire. This increase in lake level produces an additional 179 km^2 of flooding including the perched basins surrounding the lakes. In a wet year, it may be possible to raise Mamawi Lake and connected Lake Claire as high as 210.5 m by the end of June, producing an additional 297 km^2 of flooding compared to the maximum achievable lake level in an average year (210.0 m). This maximum achievable lake level is 1.0 m above the upper quartile of the peak summer water level for Mamawi Lake and 0.8 m above the upper quartile of the peak summer water level for Lake Claire. Above this level, areas connected to Mamawi Lake south of Dog Camp will likely bypass the structure and spill into Lake Athabasca and possibly the Embarras River. In a dry year, the maximum achievable lake level is about 209.4 m, which is typically above the maximum Lake Athabasca and Mamawi Lake level in a dry year.

The width and height of a water control structure at Dog Camp and the need to adjust the height of the structure to control the rate of outflow through the drawdown period were seen to be very important considerations in the assessment. The preferred option based on the established criteria was an air-inflated rubber dam in combination with a rockfill embankment. Since virtually all options present a barrier to fish passage and boat navigation while they are in operation, provisions for a fishway and navigation lock are necessary. The estimated construction cost for the rubber dam option is $9.4M, including 10% for engineering design and construction supervision. An alternative option consisting of a manually-operated stop log structure in place of the rubber dam was also considered to be feasible. The estimated construction cost for the stop log structure is $5.7M, including 10% for engineering design and construction supervision.

CREDITS AND ACKNOWLEDGEMENTS

The project team gratefully acknowledges the local knowledge shared by members of the Indigenous communities of Fort Chipewyan. We would also like to thank the representatives from Parks Canada, Environment and Climate Change Canada, and Public Services and Procurement Canada for initiating this project and providing available background information and documentation. Additional background information and technical input provided by Alberta Environment and Parks is also appreciated. We would also like to thank Mel Hamilton from SLR Consulting (Canada) Ltd. for managing this project and engaging Northwest Hydraulic Consultants Ltd. as a subconsulting partner for this work.

Key members of the project team and their roles are:

- Robyn Andrishak – Team Lead and primary author of this report
- Makamum Mahmood – Coauthor this report and involved in data collection and water balance modelling
- Gary Van Der Vinne – Senior Advisor and technical reviewer of this report
- Ken Roy and Kate Neigel – Field survey crew
- Michael Brayall and Joshua Mueller– Engineering support

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1 INTRODUCTION

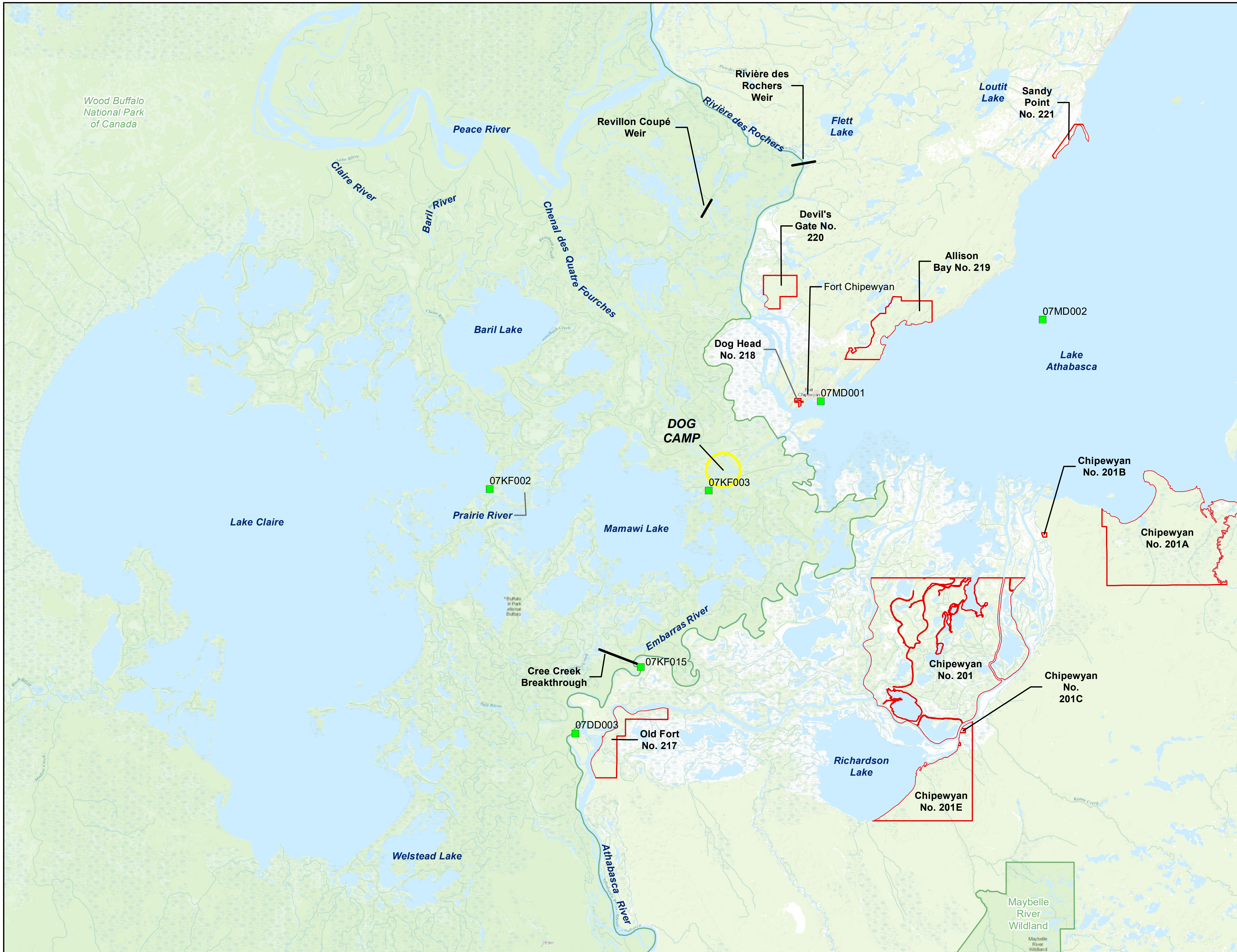
1.1 Background

The Peace-Athabasca Delta (PAD) is complex and dynamic system of lakes, wetlands, and connecting channels situated between the Peace, Birch, and Athabasca rivers on the west-side of Lake Athabasca. Due to the relatively flat topographic relief and channel gradients, high water levels on the Peace and Slave rivers, such as those created by ice jam events, can cause the normal direction of flow to reverse and recharge perched lakes and wetlands in the PAD. A perched lake is defined as a permanent lake in which the water elevation is higher than adjacent water bodies. Perched lakes within the PAD are generally surrounded by natural levees that isolate the lakes from the connected system of rivers and lakes. Precipitation is generally less than evaporation, so water levels within the perched lakes are only recharged during flood events in the connected system of rivers and lakes.

Dog Camp is located within the PAD along the west arm of the Chenal des Quatre Fourches (QF channel), approximately 11 km southwest of Fort Chipewyan, Alberta (**Figure 1**). The west arm of the QF channel generally serves as the outlet for Mamawi Lake, draining into Lake Athabasca via the east arm of the QF. When Lake Athabasca water levels exceed those in Mamawi Lake, the flow direction can reverse, sending water from Lake Athabasca into Mamawi Lake and connected areas including Lake Claire. Under normal conditions, the Riviere des Rochers, Revillon Coupé, and QF channel drain water from Lake Athabasca and the PAD into the Peace and Slave rivers.

Regulation of the Peace River for hydropower production has altered the flow regime of the Peace River since the completion of the W.A.C. Bennett Dam in 1967 (Aitken and Sapach, 1994). In response to an observed rapid decline in water levels in the PAD from about 1968-1971, various studies were undertaken to develop mitigation measures (e.g. Card and Yaremko, 1970; PADPG, 1973). Ultimately, two water control structures, consisting primarily of submerged rockfill weirs, were constructed on the Riviere des Rochers and the Revillon Coupé in 1975-76 (PFRA, 1976). These structures were designed to raise annual peak water levels in Lake Athabasca and connected areas of the PAD (PADPG, 1973).

A rockfill dam was also constructed at the Dog Camp site in 1971 as a temporary and quick measure, while long term options were being considered. The intent of this structure was to raise water levels in Mamawi Lake, Lake Claire, and connected areas of the PAD so that perched basins would be inundated more frequently. The rockfill dam was not controllable; consequently, when flooding occurred in the spring of 1974, too much water was retained in Mamawi Lake and the structure was partially washed out. This structure was subsequently removed in 1975 after construction of the Riviere des Rochers weir was completed (PFRA, 1976). Another water control structure at the Dog Camp site, consisting of a gated sluiceway and rockfill embankment, was previously investigated (PADIC, 1987) but not implemented.



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- Selected WSC Station
- Hydraulic Structure
- Indian Reserve
- Dog Camp

Data Sources: Basemap - AltaLIS Ltd. & Esri World Imagery;
Inset map - National Geographic World Map.

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FEASIBILITY PLAN FOR
WATER CONTROL STRUCTURE
AT DOG CAMP

STUDY AREA

FIGURE 1

SWM_P:_Projects (Active)\1005092 PAD Weir Surveys\90 GIS\1005092_MMM_FIG1_DOG_CAMP_SITE.mxd

1.2 Study Objectives

The objectives of this study are to provide a feasibility plan to support decision-making related to possible water control structure options. The scope of work included detailed bathymetric surveys, discharge and water level measurements, hydrotechnical assessment and modelling, feasibility-level designs, and cost estimates. The complete terms of reference for this study are provided in **Appendix A**.

2 DATA COLLECTION

Data collected from local knowledge gathering sessions, site inspections, and surveys were used to help guide the selection and design of the control structure.

2.1 Local Knowledge Gathering

Local knowledge and traditional use information for the PAD was collected during the Knowledge Gathering Sessions carried out on 17-19 September 2019 in Fort Chipewyan, Alberta. Knowledge holders of the Athabasca Chipewyan First Nation (ACFN), the Mikisew Cree First Nation (MCFN), and the Fort Chipewyan Métis Local 125 (FCML) provided valuable information about water level variations in the PAD and how this affected the wildlife and vegetation. Separate Knowledge Gathering Sessions held with each of the three groups are documented in reports by Lifeways of Canada Limited. In addition, community engagement sessions were organized in Fort Chipewyan on 18 and 19 September to describe the work being undertaken. The following is a summary of information provided in these Knowledge Gathering Sessions that was relevant to this study.

Historically, large floods replenished the perched basins, inland lakes, and other backcountry areas in the PAD, Peace River, and Athabasca River areas. This flooding was primarily due to ice jam formation on the Peace and Athabasca rivers in the spring time. The Peace River used to jam at the 30th baseline downstream of the confluence of the Riviere des Rochers and water from the Peace River would inundate the delta (MCFN, 2019). On the Athabasca River, ice jams would occur most frequently at Big Eddy and Devils Elbow (MCFN, 2019).

Flooding from spring ice jams is not the only major source of water in the PAD. Seasonal runoff from rivers such as the Birch, McIvor, and Athabasca Rivers are also important to the maintenance of water levels in the PAD (MCFN, 2019). High flow in the Athabasca River also provides high water levels and connectivity between Athabasca delta lakes (ACFN, 2019). Also, both ACFN and MCFN knowledge holders indicated that when Lake Athabasca levels were high, strong northeast winds would push water from Lake Athabasca into Lake Mamawi causing summer flooding (ACFN, 2019 and MCFN, 2019).

After a flood occurred, the water levels in the perched basins would drop slowly over time so the frequency of flooding was important to ensure that adequate water levels were maintained. One MCFN knowledge holder stated that there was “flooding every three to seven years” (MCFN, 2019). Another MCFM knowledge holder stated “that '96 flood just flooded the whole Peace-Athabasca Delta, and we had water like in the back country for at least six years after that” (MCFN, 2019). ACFN knowledge holders indicated that, in recent years, flooding has been less frequent and water levels are lower and attributed the changes to the operation of the Bennet Dam (ACFN, 2019).

Lower water levels and less frequent flooding of perched lakes cause changes to wildlife and vegetation. ACFN knowledge holders indicated that there used to be lots of muskrats when water levels were higher and that muskrats need more water than is currently available in some lakes (ACFN, 2019). Muskrat populations typically rebound in year two following a replenishing flood as the first year is needed for the recovery of food resources for them. One MCFN knowledge holder stated that “two years after a highwater event, then the muskrat comes back” (MCFN, 2019). A FCML knowledge holder indicated that lower water levels have also allowed a lot of thistle to grow (FCML, 2019) and an MCFN knowledge holder stated: “now all the basins that used to have muskrats and everything, it's all filled with willows and grass.” Flooding was cited by both ACFN and FCML knowledge holders as being needed to help clear out unwanted vegetation.

Low water levels have also made traditional use of the landscape more difficult. ACFN knowledge holders indicated that shallow channels are not allowing boat passage, which affects the ability of users to access cabins, hunting areas, and to move through their traditional territory and that the growth of willows in the shallow areas has also inhibited navigation (ACFN, 2019). An FCML knowledge holder indicated that the increase in willows also make trapping more difficult, with the traps getting tangled in the willows when muskrats are caught in them (FCML, 2019).

Increased water levels are required to restore muskrat populations and help clear out the willows and bulrushes. ACFN knowledge holders indicated that muskrat populations are healthy when a water depth of about 8 ft occurs in Big Egg Lake; however, currently, there are more beaver than muskrat present which indicates that the lake level is too low (ACFN, 2019). They also indicated that willows and bulrushes are also growing in the shallower water and this vegetation would be cleaned out if water levels were higher (ACFN, 2019).

FCML knowledge holders indicated that the Dog Camp site is considered to be the best site for controlling water levels in Mamawi Lake and Lake Claire (FCML, 2019). There is no other outlet to these lakes (ACFN, 2019) so it is an effective location for a control structure. Some MCFN knowledge holders indicated a downstream site such as at the 30th baseline on the Slave River would provide more widespread flooding in the delta (MCFN, 2019); however, this site was outside of the scope of the present study so a structure on the Slave River is not being contemplated or assessed in this report.

A control structure at Dog Camp can control seasonal runoff from the Birch River, McIvor River and a number of smaller streams as well as flows from the Athabasca River entering Lake Mamawi through Cree Creek. One MCFN knowledge holder indicated that a control structure at Dog Camp would be useless without flows from Cree Creek (MCFN, 2019). Another knowledge holder indicted that flows from Cree Creek were also seen as a negative, due to the quality of the water and that a weir at the inlet to Cree Creek could be used to limit flows into Lake Mamawi from the Athabasca River (MCFN, 2019). However, there was some concern that a weir at Cree Creek would wash out since the water comes up so high at this location (ACFN, 2019).

The historical maximum water level at Dog Camp is lower than the banks of the river. An FCML knowledge holder indicated that the banks at Dog Camp have never overflowed and the rock island in the channel is always visible (FCML, 2019). An MCFN knowledge holder indicated that the highwater level at Dog Camp is observable on the rocks and that these marks indicate the water level that is needed to cause flooding of the perched basins around Lake Mamawi and Lake Claire (MCFN, 2019).

The effectiveness of a control structure at Dog Camp should be assessed over more than one year because inflows are variable (FCML, 2019).

A weir was previously constructed at Dog Camp but was removed after it was damaged during a flood. FCML knowledge holders indicated that before the weir was constructed, the water level in Lake Mamawi was very low, but it filled up in a few months after the weir was built (FCML, 2019). They indicated that in 1974, after the weir was built, too much water was retained after construction, causing the lakes to flood (FCML, 2019). One FCML knowledge holder indicated that the dam was higher than the wall in the meeting room in the ACFN Youth and Elders Lodge when seen from the downstream side and may have prevented fish movement (FCML, 2019). He also indicated that when the water level behind the weir was too high, a strong west wind caused the north side of the weir to blow out and Lake Mamawi drained in two weeks (FCML, 2019). Afterwards, the south side of the structure was removed, and the rocks were dumped on the side of the channel (FCML, 2019). The complete removal of the weir was seen as a mistake by one MCFN knowledge holder (MCFN, 2019).

Ice dams at Dog Camp were not seen to be effective. A FCML knowledge holder indicated that a previous attempt to control flows with an artificial ice dam was not successful because the ice lifted and floated away in the spring (FCML, 2019).

2.2 Site Inspection

A site inspection by Mr. Gary Van Der Vinne, P.Eng. of NHC was undertaken by boat on 19 September and by helicopter on 20 September 2019 from Fort Chipewyan to the Dog Camp area. This allowed for a detailed visual observation of the proposed structure location and surrounding area, providing an overview of the locations of cabins along the QF channel as well as the Prairie River connecting Lake Claire and Mamawi Lake. The site inspection also covered Cree Creek from Mamawi Lake to the Embarras River. Significant amounts of woody debris were observed in the channel at the inlet to Cree Creek, which would affect access for the bathymetric survey. Also, a sand bar was noted on the upstream side of the Cree Creek inlet which could erode if a control structure were constructed at the inlet.

Photographs from the site inspection are presented in **Appendix B**.

2.3 Site Survey

Bathymetric surveys and flow measurements were conducted at Dog Camp and Cree Creek on 3 and 8 October 2019 by NHC personnel with the assistance of a local boat operator employed by Parks Canada. Deep water portions of channel cross sections upstream and downstream of the weirs were surveyed using an Odom Hydrotrac single-frequency digital echo sounder and Trimble R10/R8 real-time kinematic (RTK) survey-grade GPS. Near shore, shallow water and bank portions of cross sections were surveyed on foot using RTK GPS. Detailed bathymetry around the previously constructed weir was surveyed using an Edgetech 6205 multibeam sonar system. Standard survey methods and procedures for river bathymetric surveys in Alberta were employed, including establishing suitable temporary benchmarks and referencing existing survey control markers where they exist.

Coordinate system information for all survey data collected and reported is described as follows:

- Horizontal coordinate system: Universal Transverse Mercator Zone 12N
- Horizontal datum: North American Datum 1983 (Canada)
- Vertical datum: Canadian Geodetic Vertical Datum 2013
- Geoid: Canada CGG2013A

Local benchmarks at hydrometric gauging stations were surveyed to facilitate comparison and adjustments to water level data recorded by Water Survey of Canada (WSC) so that all elevations are referenced to a common datum. Table 1 provides a summary of the control point network coordinates.

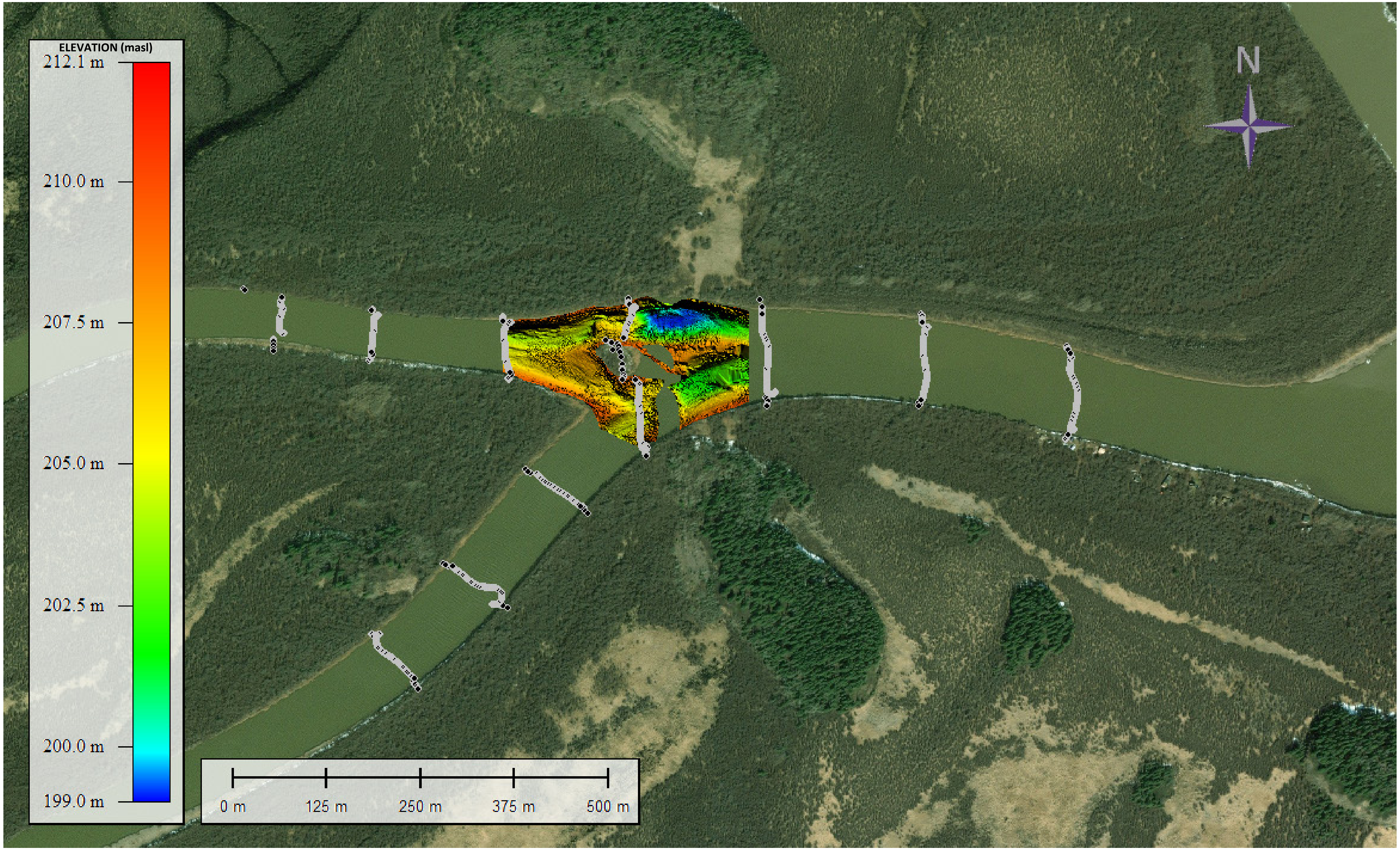
Table 1 Summary of network adjusted control point coordinates

Survey ID	Location	Northing (m)	Easting (m)	Elevation (m)
1	Rochers Weir	6531241.710	489638.792	212.557
104	Fort Chipewyan	6513157.848	494147.394	248.444
200	Dog Camp	6501172.866	481643.724	211.378
300	Cree Creek	6482261.901	471923.868	212.015
3000	Below Rochers Weir	6532224.191	487748.826	215.856
400	Big Egg Lake	6476791.674	500172.001	210.474
500	Revillon Coupé Weir	6530295.462	475637.119	209.159
100	Fort Chipewyan	6508182.786	491225.838	218.917

Ten cross sections were surveyed along the west arm of the QF channel, and the area around the rock island was surveyed in detail using multibeam sonar to obtain better resolution of possible remnants of the rockfill embankment that was removed at this location in 1975 (**Figure 2**). A summary of the flow measurements obtained during the survey is provided in **Table 2**.

Table 2 Discharge measurements from the October 2019 site survey

Date	Location	Discharge (m^3/s)
8 Oct 2019	Dog Camp, north channel upstream of rock island	184
8 Oct 2019	Dog Camp, south channel upstream of rock island	142
7 Oct 2019	Embarras River above Cree Creek breakthrough	179
7 Oct 2019	Embarras River below Cree Creek breakthrough	74
7 Oct 2019	Cree Creek breakthrough channel	104



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Job: 1005166

Date: 9-MAR-2020

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EXTENT OF BATHYMETRY SURVEY AT DOG CAMP

FIGURE 2

Photographs from the site survey are presented in **Appendix B**. A health and safety summary consisting of a copy of the survey team field safety plan and daily field reports is provided in **Appendix C**.

3 MAMAWI LAKE AND LAKE CLAIRE

3.1 Historical Water Levels

The recorded historical water surface elevations for the PAD lakes (Lake Athabasca, Mamawi Lake and Lake Claire) were available from the Water Survey Canada (WSC) gauge stations. The summary of these gauging stations is provided in **Table 3**. A review of the WSC water level records indicates that PAD lakes normally reach their lowest levels in late March to early April and peak in mid to late July. This pattern is somewhat different on lakes Mamawi and Claire in years when large-scale ice jamming occurs, and water levels can peak in May.

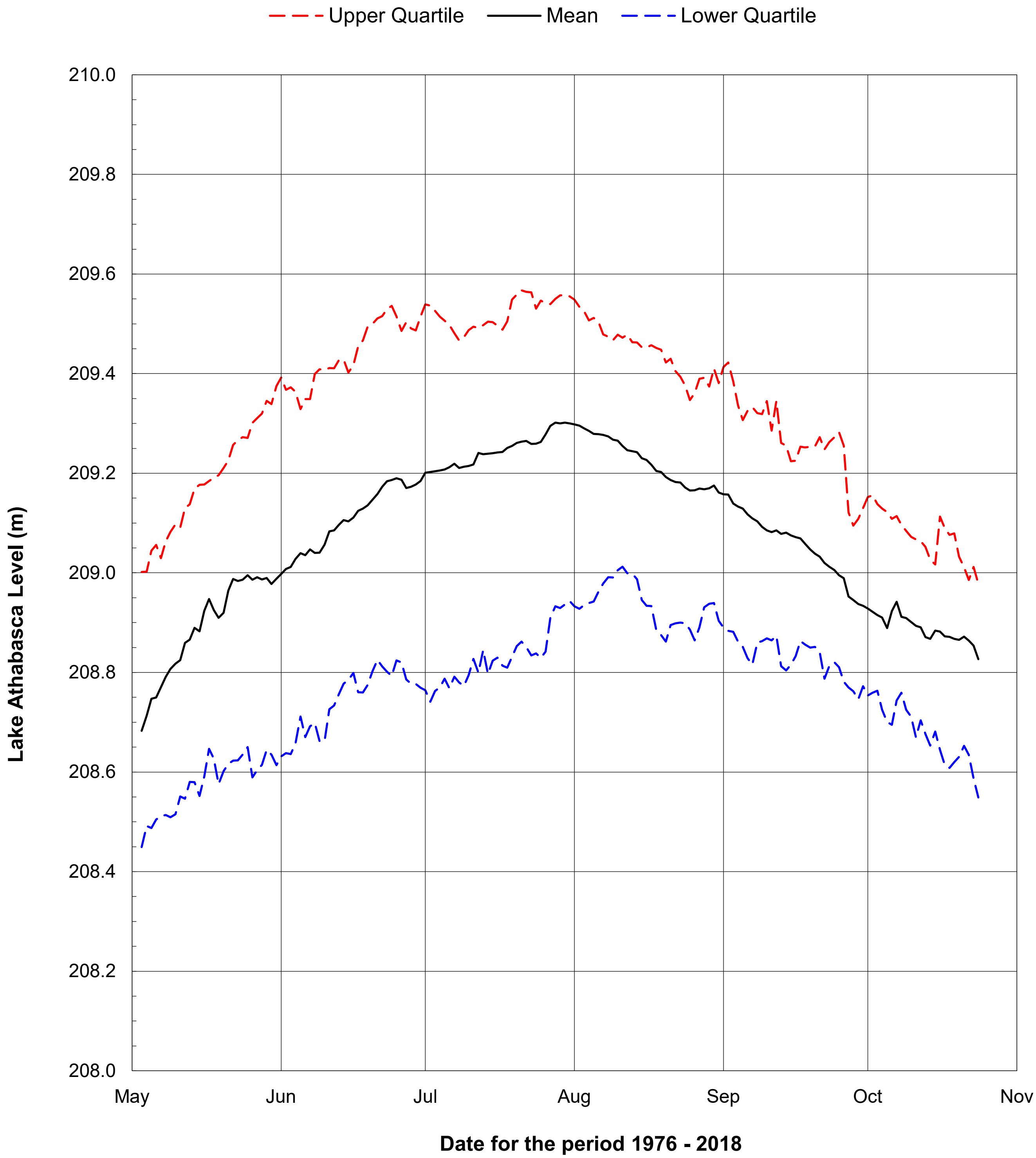
Table 3 WSC gauge stations on PAD lakes

Station ID	Name	Period of Historic Record
07MD001	Lake Athabasca at Fort Chipewyan	1930-2018
07MD002	Lake Athabasca at Bustard Island	1975-1995
07MC003	Lake Athabasca near Crackingstone Point	1956-2017
07KF003	Mamawi Lake Channel at Dog Camp Site	1971-2018
07KF002	Lake Claire near Outlet to Prairie River	1970-2018

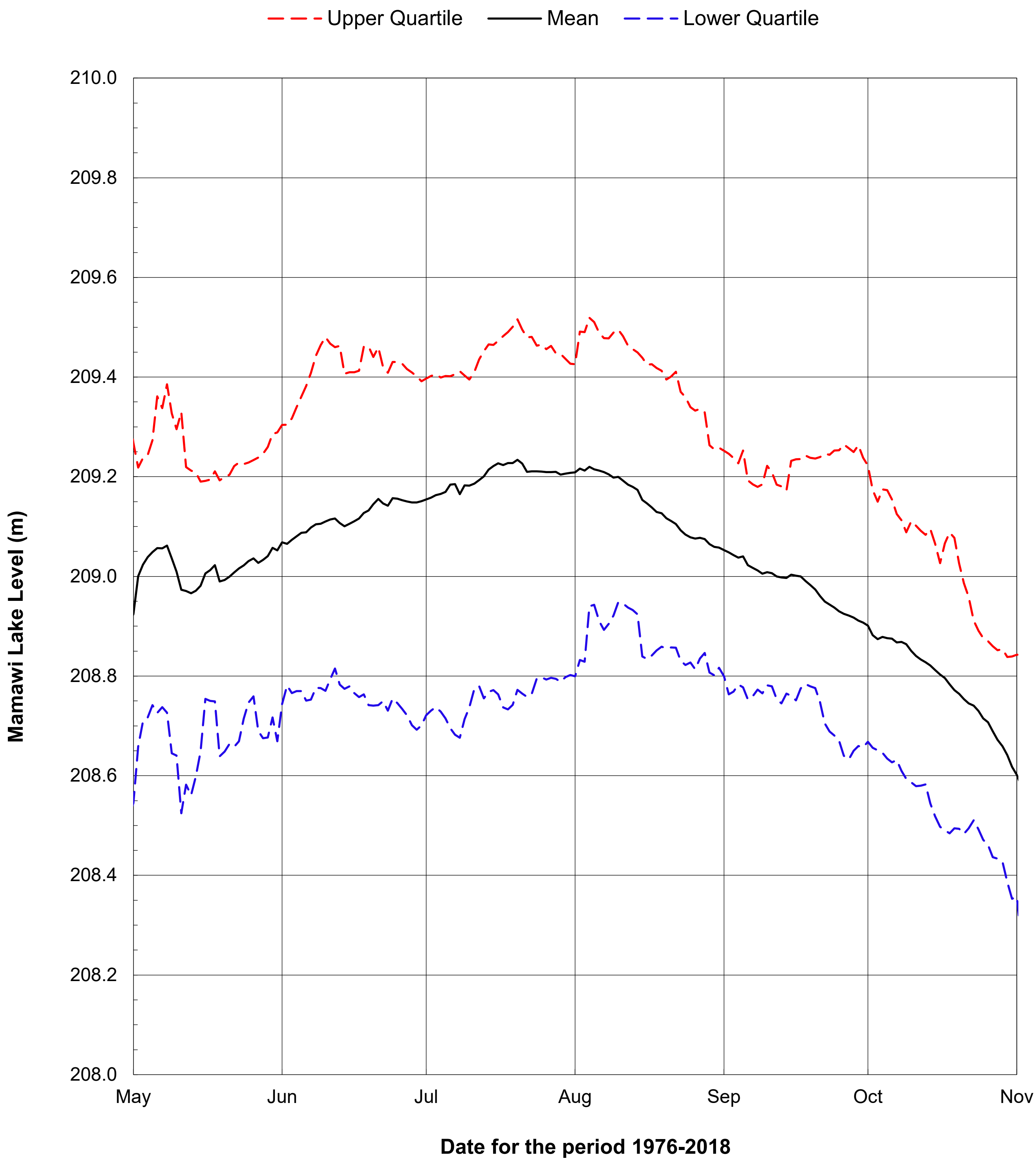
To establish the existing condition at the PAD lakes, historical water levels were assembled and summarized for the period after construction of the weirs was completed (1976-2018). The historical records include years when major ice jams occurred, and while they represent historical conditions, the Dog Camp water control structure can only increase water levels in a way similar to open-water flooding. The magnitude and trends in water level variations on Lake Athabasca (**Figure 3**), Mamawi Lake (**Figure 4**), and Lake Claire (**Figure 5**) were assessed in terms of the five-day moving mean values. For Lake Athabasca, data from WSC Station 07MD001 (Lake Athabasca at Fort Chipewyan) was used since it is closest to the lake outlet and has records for the full period of interest. The upper and lower quartiles are also shown to illustrate the expected "normal" range of values in addition to the mean. The summary of these peak statistics is also provided in **Table 4** below.

Table 4 Annual peak levels on PAD lakes

PAD Lakes	Annual Peak Lake Level (m) 1976-2018		
	Mean	Upper Quartile	Lower Quartile
Lake Athabasca	209.302	209.568	209.013
Mamawi Lake	209.234	209.519	208.948
Lake Claire	209.467	209.730	209.255



	SCALE – AS SHOWN	FEASIBILITY PLAN FOR WATER CONTROL STRUCTURE AT DOG CAMP
nhc northwest hydraulic consultants	Coordinate System: Units: As Shown	FIVE-DAY MOVING MEAN WATER LEVEL FOR LAKE ATHABASCA
	Job: 1005166 / Date: 9-MAR-2020	FIGURE 3



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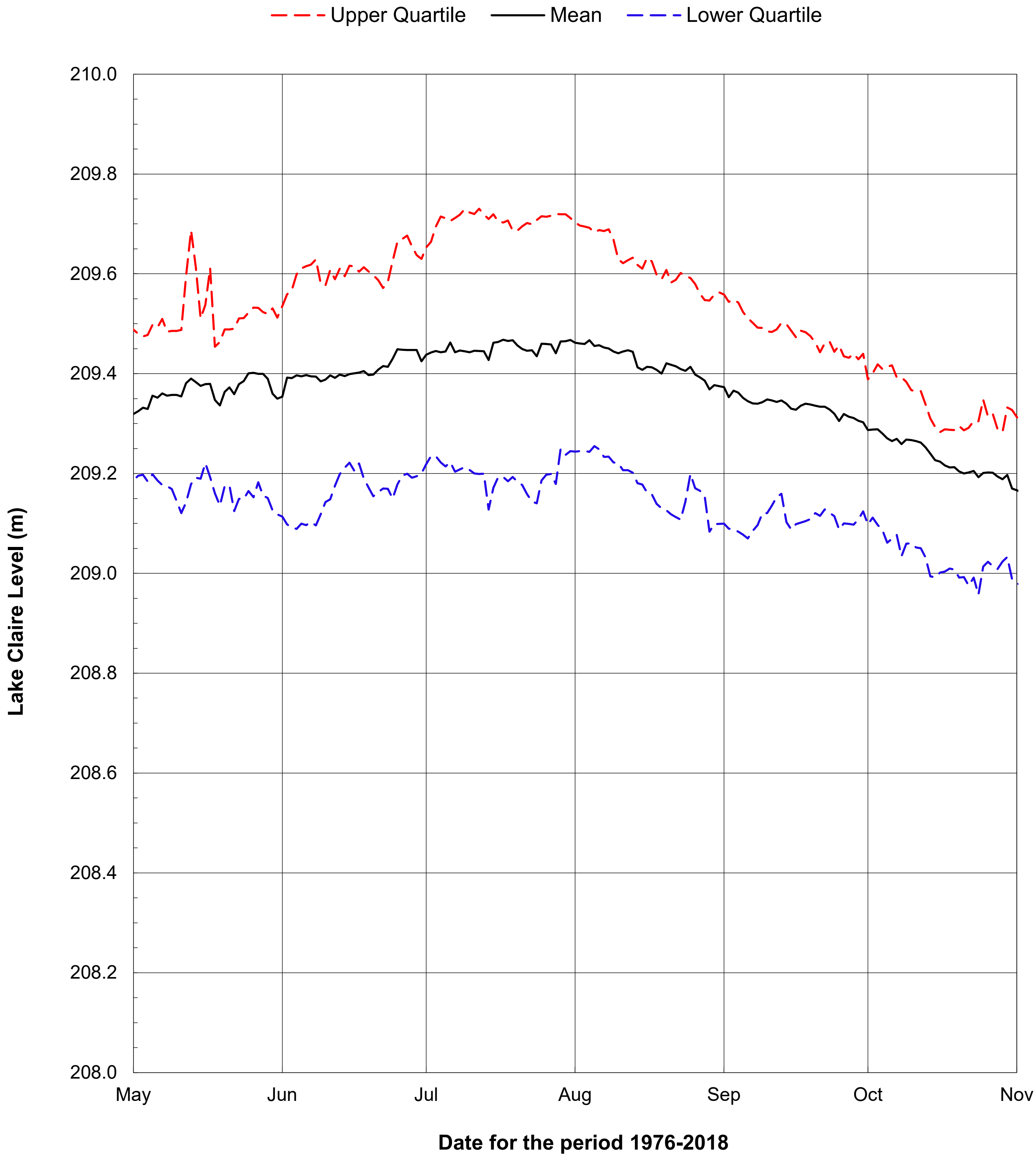
FEASIBILITY PLAN FOR WATER CONTROL STRUCTURE AT DOG CAMP

FIVE-DAY MOVING MEAN WATER LEVEL FOR MAMAWI LAKE

FIGURE 4



	SCALE – AS SHOWN	*FEASIBILITY PLAN FOR WATER CONTROL STRUCTURE AT DOG CAMP*
nhc northwest hydraulic consultants	Coordinate System: Units: As Shown	*FIVE-DAY MOVING MEAN WATER LEVEL FOR LAKE CLAIRE*
	Job: 1005166 / *Date: 9-MAR-2020*	*FIGURE 5*

For Lake Athabasca, the mean annual peak lake level was found to be 209.302 m, occurring on or about 28 July. The annual peak lake level for the lower quartile was found to be 209.013 m, occurring on or about 11 August. The upper quartile has an annual peak of 209.568 m on or about 21 July. Therefore, “normal” peak lake levels fall within a range of 0.56 m. Short-term effects such as wind seiches add to the variability in lake levels experienced. The lowest lake level for the period (207.617 m) occurred on 3 May 2002, and the highest lake level for the period (210.620 m) was recorded on 29 July 1997.

For Mamawi Lake, the mean annual peak lake level was found to be 209.234 m, occurring on or about 20 July. The annual peak lake level for the lower quartile was found to be 208.948 m, occurring on or about 10 August. The upper quartile has an annual peak of 209.519 m on or about 04 August. Therefore, “normal” peak lake levels fall within a range of 0.57 m. Short-term effects such as wind seiches add to the variability in lake levels experienced. The lowest lake level for the period (206.458 m) occurred on 19 November 1999, and the highest lake level for the period (210.683 m) was recorded on 04 May 1997.

For Lake Claire, the mean annual peak lake level was found to be 209.467 m, occurring on or about 19 July. The annual peak lake level for the lower quartile was found to be 209.255 m, occurring on or about 05 August. The upper quartile has an annual peak of 209.730 m on or about 12 July. Therefore, “normal” peak lake levels fall within a range of 0.48 m. Short-term effects such as wind seiches add to the variability in lake levels experienced. The lowest lake level for the period (208.125 m) occurred on 14 January 2007, and the highest lake level for the period (210.729 m) was recorded on 12 July 2013.

The maximum and minimum water levels in the three lakes do not necessarily occur at the same time due to the different sources of inflow to the lakes and the complex interaction between the lakes.

3.2 Sources of Inflow

Lake Athabasca has four main sources of inflow: the Athabasca River, the Fond du Lac River, the Peace River, and areas flowing directly into Lake Athabasca. Mamawi Lake and Lake Claire have five primary sources of inflow: the Birch River, the McIvor River, Lake Athabasca, the Athabasca River, and the Peace River. Flow from the Athabasca River diverted through the Embarras River and Cree Creek is the primary source of inflow into Mamawi Lake. The Birch (watershed area of 9,860 km^2) and the McIvor River (watershed area of 1,600 km^2) directly flow into Lake Claire. Overland flooding from the Peace River through the Baril and Claire rivers can also be a source of inflow to Mamawi Lake and Lake Claire. The levels of Mamawi Lake and Lake Claire are also dependent upon the level of Lake Athabasca.

The recorded historical WSC gauge data at the Athabasca River, the Embarras River, Cree Creek and the Birch River were used to calculate the inflows at Mamawi Lake and Lake Claire. The summary of these gauging stations is provided in **Table 5**.

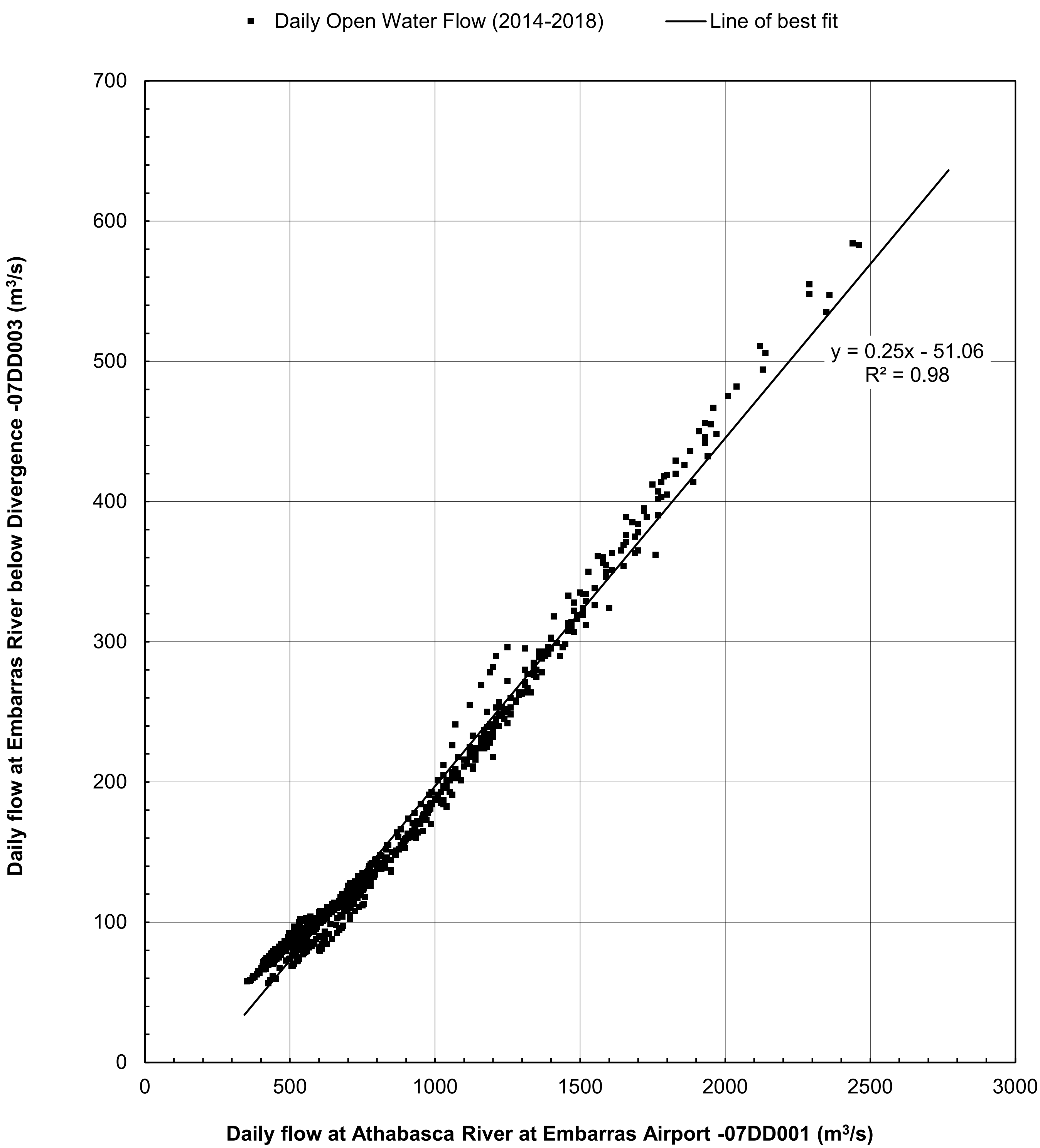
Table 5 WSC gauge stations to calculate Mamawi Lake and Lake Claire Inflows

Station ID	Name	Period of Historic Record
07DD001	Athabasca River at Embarras Airport	1971-2018
07DD003	Embarras River Below Divergence	1987-2018
07KE001	Birch River Below Alice Creek	1967-2018
07KF015	Embarras River Breakthrough to Mamawi Lake	1987-2018

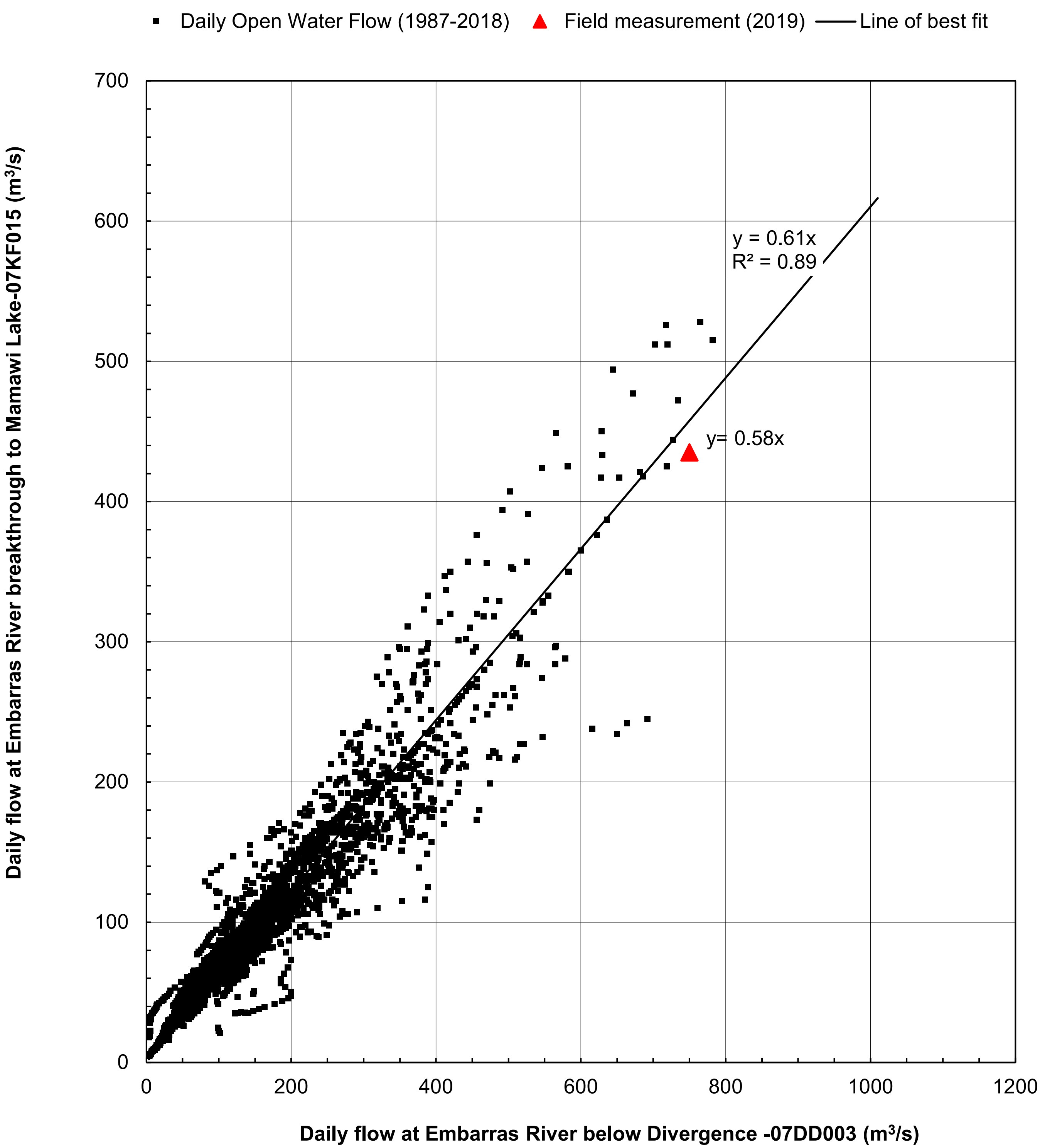
The flow from the Athabasca River diverted through the Embarrass River and Cree Creek is the only significant source of inflow to Mamawi Lake other than from Lake Claire and Lake Athabasca. A correlation between the Embarras River and the Athabasca River daily recorded open water (May to October) flows were established (**Figure 6**) to understand the amount of flow diverted to the Embarras River from the Athabasca River. The results suggested that on average, about 25% of the Athabasca River flow is diverted to the Embarras River. Embarrass River flows are partially diverted to Mamawi Lake through Cree Creek. WSC gauge 07KF015 (Embarras River Breakthrough to Mamawi Lake) represents the flow at Cree Creek. A correlation between Cree Creek and the Embarras River daily recorded open water (May to October) flows was established (**Figure 7**) to understand the amount of flow diverted to Cree Creek from the Embarras River. The results suggested that on average, 61% of the Embarras River flow is diverted to Cree Creek. Field flow measurements by NHC (7 October 2019) were also used to verify the diversion rate. At the time of the field survey, the measured Embarras River flow was 179 m^3/s, and the measured Cree Creek flow was 104 m^3/s; therefore the diversion rate was 58% of the Embarras River flow. Previous work (PADIC, 1987) and early field measurements (1982-1985) suggested that Cree Creek was receiving increasing discharge amounts as the breakthrough channel evolved. Based on the 2019 flow measurements and gauge data comparison, it is reasonable to conclude that the breakthrough channel has stabilized since the current proportion of flow being diverted from the Embarras River into Cree Creek is only slightly greater than it was in 1985 (46%).

The recorded WSC flow at Cree Creek represented by WSC gauge Embarras River Breakthrough to Mamawi Lake -07KF015 (1987-2018) was used to calculate the historical inflows to Mamawi Lake. To extend the record of inflows to Mamawi Lake, hypothetical flows into Cree Creek were estimated for the period from 1971 to 1984 using the correlations established in **Figure 6** and **Figure 7**. No flow records are available for Athabasca River at Embarras Airport (WSC Station 07DD001) from 1984 to 1987, so Cree Creek flows could not be estimated for this period. Thus, a daily time series of inflow at Mamawi Lake was established for the period of 1971-1984 and 1987-2018. From the daily time series, a range of possible maximum, minimum, and average inflows at Mamawi Lake was established (**Figure 8**). The peak mean daily inflow at Mamawi Lake was found to be 188.12 m^3/s (18 July), and the estimated peak maximum daily inflow at Mamawi Lake was 616.1 m^3/s occurred on 1 July 1997.

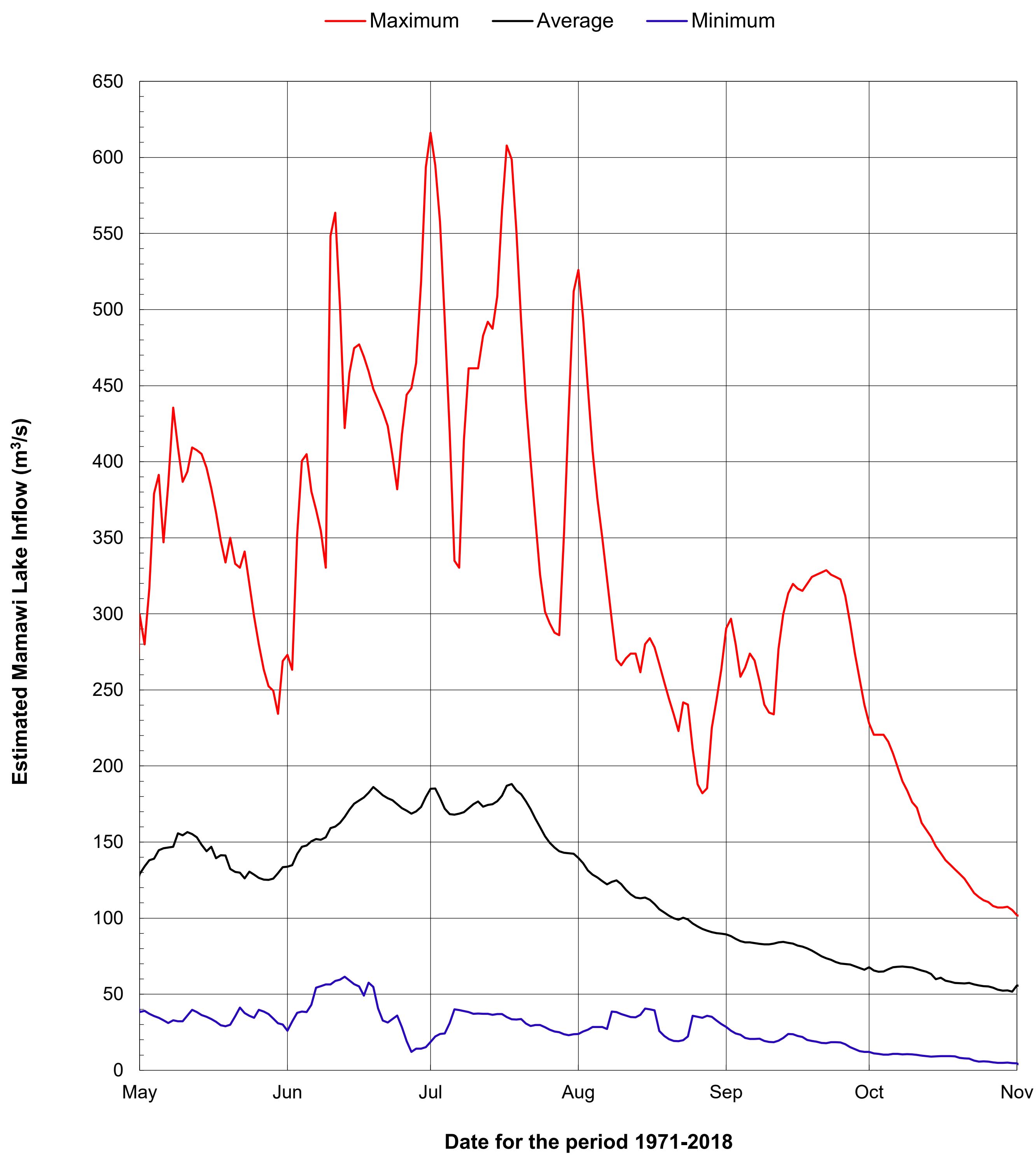
Flows from the Birch and McIvor rivers were considered as the primary sources of inflow to Lake Claire. The Birch River is gauged at Birch River below Alice Creek (WSC Station 07KE001), but there is no gauge



	SCALE – AS SHOWN	*FEASIBILITY PLAN FOR WATER CONTROL STRUCTURE AT DOG CAMP*
nhc northwest hydraulic consultants	Coordinate System: Units: As Shown	*CORRELATION BETWEEN EMBARRASS RIVER AND ATHABASCA RIVER DAILY RECORDED DISCHARGE*
	Job: 1005166 *Date: 9-MAR-2020*	*FIGURE 6*



	SCALE – AS SHOWN	*FEASIBILITY PLAN FOR WATER CONTROL STRUCTURE AT DOG CAMP*
nhc northwest hydraulic consultants	Coordinate System: Units: As Shown	*CORRELATION BETWEEN EMBARRASS RIVER AND CREE CREEK DAILY RECORDED DISCHARGE*
	Job: 1005166 / *Date: 9-MAR-2020*	*FIGURE 7*



	SCALE – AS SHOWN	*FEASIBILITY PLAN FOR WATER CONTROL STRUCTURE AT DOG CAMP*
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	Job: 1005166 / *Date: 9-MAR-2020*	*FIGURE 8*

data available at McIvor River. The recorded WSC daily flow at Birch River (1967-2018) was used to estimate the McIvor River flow (based on drainage area ratio) and later combined to come up with the daily inflow time series for Lake Claire (1967-2018). From the daily time series, a range of possible maximum, minimum, and average inflows at Lake Claire was established and presented in **Figure 9**. The peak annual mean inflow at Lake Claire was found to be 138.3 m^3/s (9 May), while the estimated maximum peak annual inflow at Lake Claire was 458 m^3/s occurred on 3 June 1984.

3.3 Outflow Characteristics

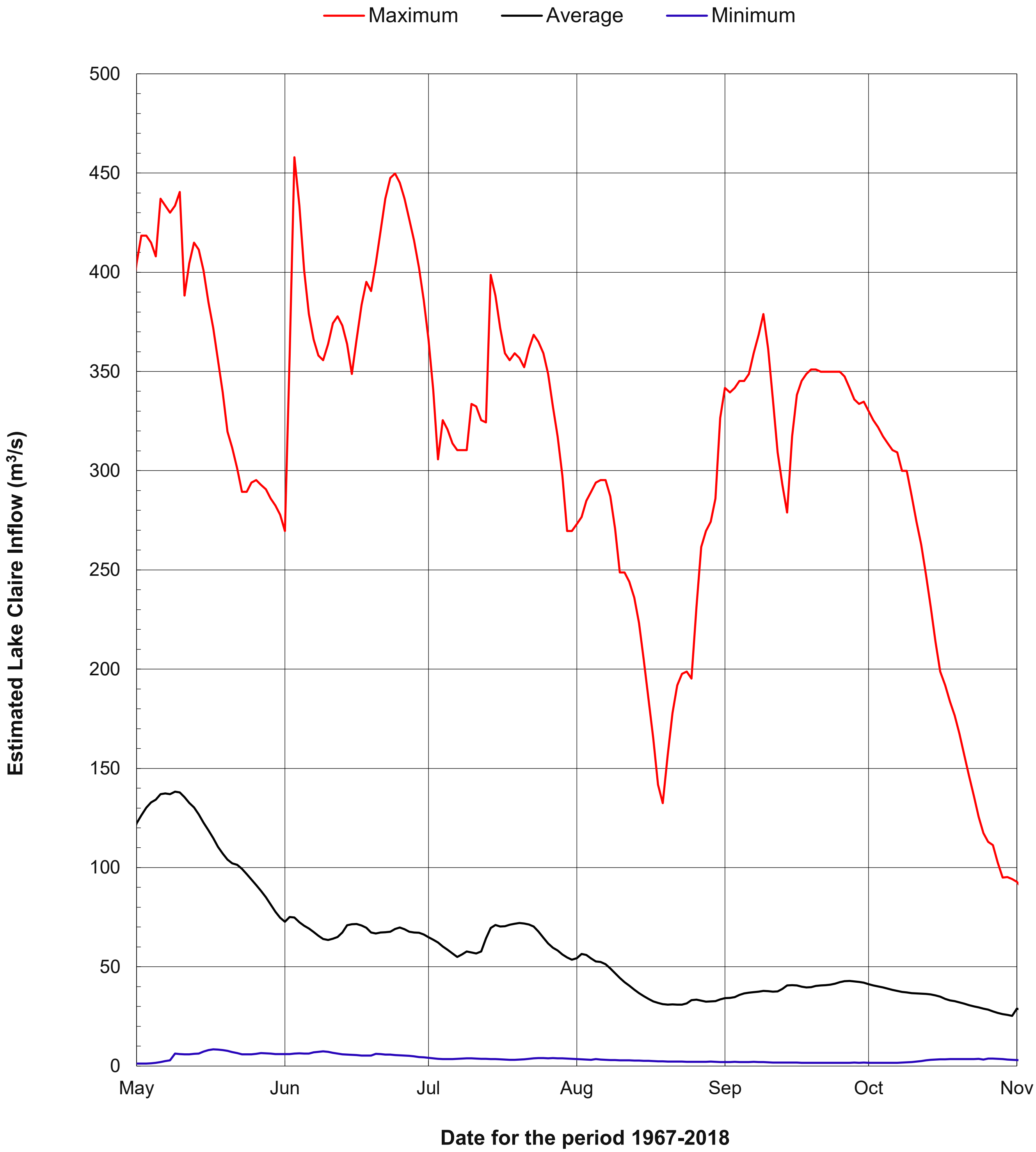
The three main outflow channels are the Riviere des Rochers, the Revillon Coupé, and the Chenal des Quatre Fourches. All of these three outlet channels discharge into the Peace/Slave River. The flows in these outlet channels are largely determined by the relative difference in water levels between the Peace River and the PAD lake levels. The water level at Lake Athabasca is the dominating factor to control the outflow through these three channels, especially for the Riviere des Rochers and the Revillon Coupé. The Chenal des Quatre Fourches mainly acts as an outflow channel from Mamawi Lake and Lake Claire but is also influenced by the Lake Athabasca level.

3.4 Precipitation and Evaporation

Annual average precipitation on PAD lakes was estimated at about 342 mm based on total precipitation data at Fort Chipewyan (1967-2018). The total precipitation includes both rainfall and snow water equivalent observed at the monitoring site. According to Peters (2003), the mean annual evaporation at Fort Chipewyan was estimated at about 443 mm. It suggests that without inflows, the PAD lakes will, on average, lose 101 mm from direct precipitation minus evaporation each year and the adjacent perched basins would dry out if not recharged periodically by high Mamawi Lake and Lake Claire levels. The net loss due to evaporation results in an average of about 0.20 $Mdam^3$ (million dam^3) total volume of water lost from Mamawi Lake and Lake Claire in a year. This amount is not significant compared to the average inflow volumes coming to these lakes.

3.5 Lake Storage

Storage-elevation curves for Mamawi Lake, Lake Claire, and connected areas were generated using the Canadian Digital Surface Model (CDSM) and ArcGIS software. The curves are illustrated in **Figure 10**. The figure shows storage volumes for Mamawi Lake, Lake Claire and combined Mamawi Lake and Lake Claire for different lake elevations. These storage-elevation curves were used in the hydrotechnical assessment (**Section 4**) to estimate the change in lake levels based on the inflow and outflow volumes and in different flow conditions.



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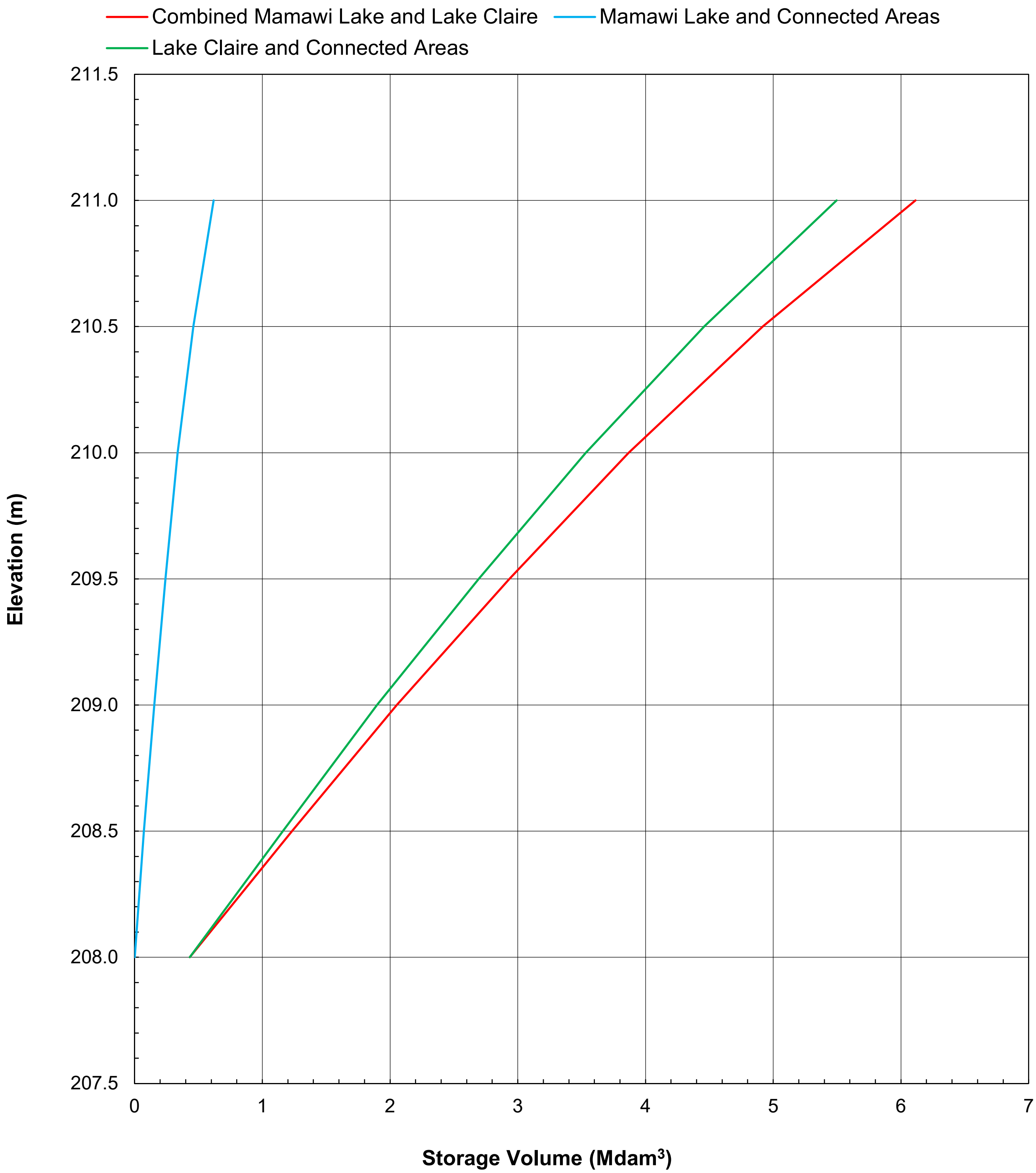
FEASIBILITY PLAN FOR WATER CONTROL STRUCTURE AT DOG CAMP

ESTIMATED LAKE CLAIRE INFLOWS FROM BIRCH RIVER AND MCIVOR RIVER

FIGURE 9



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FEASIBILITY PLAN FOR WATER CONTROL STRUCTURE AT DOG CAMP

STORAGE-ELEVATION CURVES

FIGURE 10

4 HYDROTECHNICAL ASSESSMENT

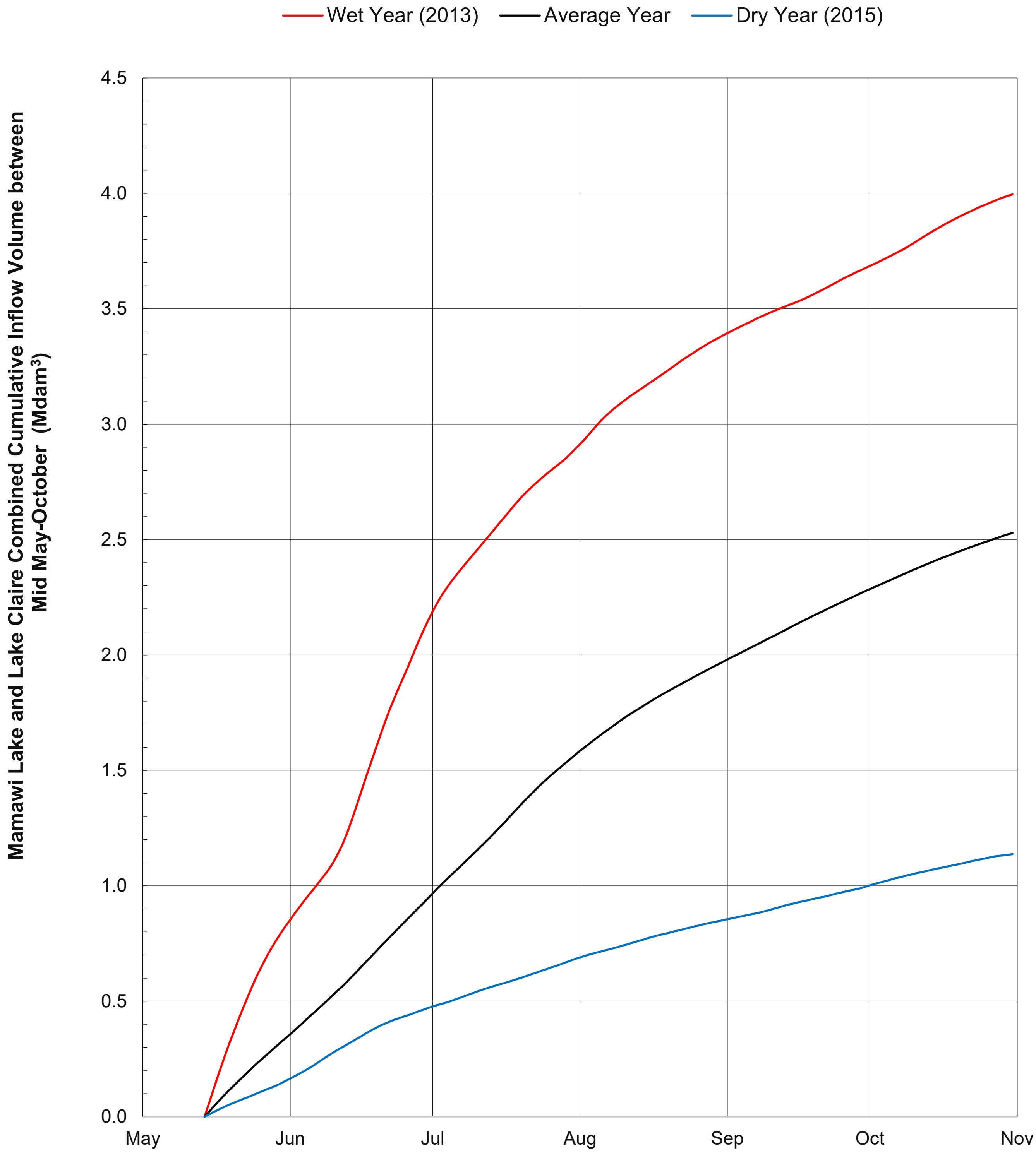
4.1 Modelling Approach

The modelling approach used for this study included two main components: (1) a numerical hydraulic model (HEC-RAS) of the QF channel at Dog Camp based on the 2019 bathymetry data collected and (2) a spreadsheet hydrologic water balance model for Mamawi Lake and Lake Claire. Previous modelling efforts by Sydor et al. (1979) were also considered in this hydrotechnical assessment. The Dog Camp hydraulic model was used to evaluate the outlet capacity under existing conditions and with a water control structure in place. The lake water balance model was used to evaluate the lake level response under various design conditions. The main sources of inflow to the lakes discussed in the previous section were utilized in the water balance model. The outflows from the lakes at Dog Camp water control structure was represented by a rating curve generated from the hydraulic model mentioned above. No precipitation and evaporation was considered in the water balance model as the net evaporation loss is insignificant compared to the inflow volume as mentioned in **Section 3.4**. Since the intent of the proposed water control structure at Dog Camp is to raise lake levels in Mamawi Lake and Lake Claire to flood riparian areas and replenish adjacent perched basins, any excess inflows from the Peace River under ice jam conditions were not considered in this analysis in order to be conservative. The Dog Camp structure can be opened earlier if ice jams on the Peace River flood the PAD lakes to a point where the structure would be overtopped (e.g. the 1974 flood event).

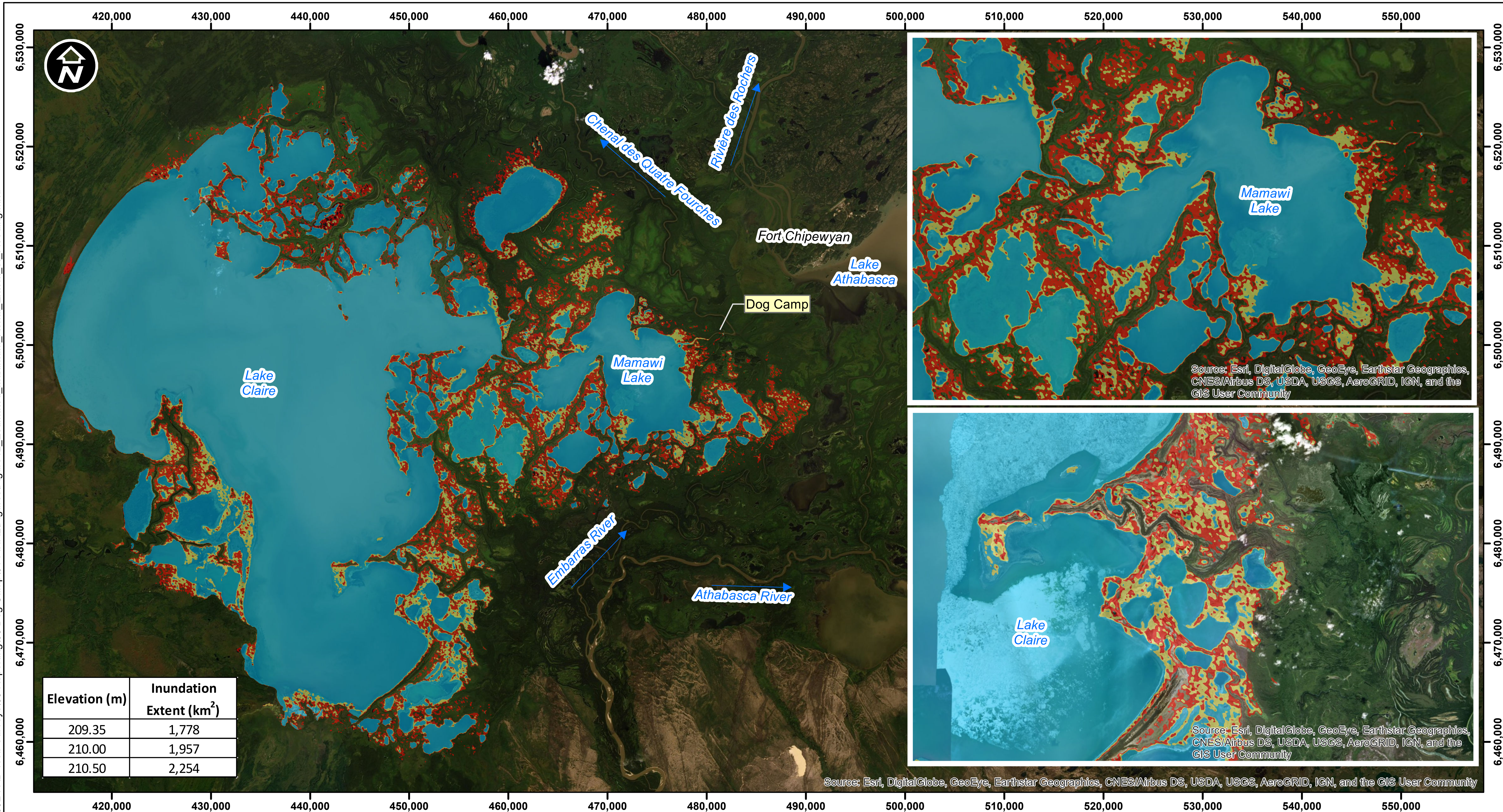
4.2 Maximum Lake Levels

The maximum achievable water levels in Mamawi Lake and Lake Claire in any given year are dependent on the initial spring lake levels, the inflow volumes from upstream areas, and the operating procedures adopted for the proposed Dog Camp water control structure. For this assessment, it was assumed that the structure would only be operated during the open water season (approximately 15 May to 15 October), that all outflow through the QF channel would be blocked until Mamawi Lake reached the desired highwater level. While it is known that previous year's water levels impact water levels the following year, to be conservative and to simplify the model, the cumulative year-over-year impacts of the water control structure on lake levels were not modelled.

Figure 11 shows the cumulative inflow volume to Mamawi Lake and Lake Claire in an average year, along with the cumulative inflows for the wettest (2013) and driest (2015) years on record for comparison. In an average year, the initial Mamawi Lake and connected Lake Claire water levels are at about their means for the month of May (combined average lake level of 209.19 m), with an associated initial volume of 2.39 $Mdam^3$ based on **Figure 10**. The average available inflow volume between 15 May and 1 August would be 1.56 $Mdam^3$ (based on **Figure 11**). Adding the average available inflow volume to the initial volume yields a total volume of 3.95 $Mdam^3$,which indicates the maximum achievable water level in an average year would be about 210.0 m (based on **Figure 10**), producing an aerial extent of flooding shown in **Figure 12**.



	SCALE – AS SHOWN	*FEASIBILITY PLAN FOR WATER CONTROL STRUCTURE AT DOG CAMP*
nhc northwest hydraulic consultants	Coordinate System: Units: As Shown	*CUMULATIVE INFLOW VOLUME TO MAMAWI LAKE AND LAKE CLAIRE*
	Job: 1005166 / *Date: 9-MAR-2020*	*FIGURE 11*



Elevation (m)	Inundation Extent (km^2)
209.35	1,778
210.00	1,957
210.50	2,254

Legend

- Mamawi Lake and Lake Claire Flood Extent (210.5 m)
- Mamawi Lake and Lake Claire Flood Extent (210.0 m)
- Mamawi Lake and Lake Claire Flood Extent (Mean Annual Peak = 209.35 m)

Scale: 1:375,000

0 10,000 20,000 Meters

Projection: NAD 1983 UTM Zone 12N

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FEASIBILITY PLAN FOR WATER CONTROL STRUCTURE AT DOG CAMP

ESTIMATED MAXIMUM AERIAL EXTENT OF FLOODING

1005092	March 2020	Figure 12

Path: P:_Projects (Active)\1005092 PAD Weir Surveys\05 Reporting\05 Dog Camp\01 FINAL\Figures\Figure12_Estimated_Maximum_Aerial_Extent_of_Flooding.mxd

Considering only the terrain surrounding Mamawi Lake and Lake Claire and historical recorded water levels, the maximum possible lake level is about 210.5 m. At this elevation, the areas between Mamawi Lake and Lake Claire will be mostly inundated along with perched basins surrounding the lakes (**Figure 12**). This inundation extent is comparable to the 1996 open water flood, which also had a peak lake level of about 210.5 m and lower than the 1935 flood (Peters et al., 2006). Above this level, water from Mamawi Lake is likely to bypass the water control structure and spill into Lake Athabasca and possibly the Embarras River through low-lying areas south of Dog Camp. In a wet year such as 2013, the 15 May average combined lake level was 209.64 m, and the associated initial volume estimation was 3.2 $Mdam^3$ (based on **Figure 10**). An additional inflow volume of 1.72 $Mdam^3$ (based on **Figure 10**) is required to reach a lake level of 210.5 m and could be achieved as early as 22 June (based on **Figure 11**).

In a dry year such as 2015, the 15 May average combined lake level was 208.98 m, and the associated initial volume estimation was 2.02 $Mdam^3$ (based on **Figure 10**). The inflow volume between mid May and 1 August was 0.68 $Mdam^3$ (based on **Figure 11**), resulting in a total volume of 2.70 $Mdam^3$ and a maximum achievable water level of 209.4 m (based on **Figure 10**). This maximum achievable water level is above the maximum Lake Athabasca and Mamawi Lake level of that year.

A comparison of maximum achievable lake levels achieved through the deployment of a Dog Camp water control structure in a dry, average, and wet year with the historical statistics is presented in **Table 6** below. The table also shows the increase in water level which can be gained from the structure. In an average year, the Mamawi Lake level would increase about 0.8 m, while Lake Claire level would increase about 0.5 m. The maximum achievable lake level of 210.0 m is also 0.5 m above the upper quartile of the peak summer water level for Mamawi Lake and 0.3 m above the upper quartile of the peak summer water level for Lake Claire.

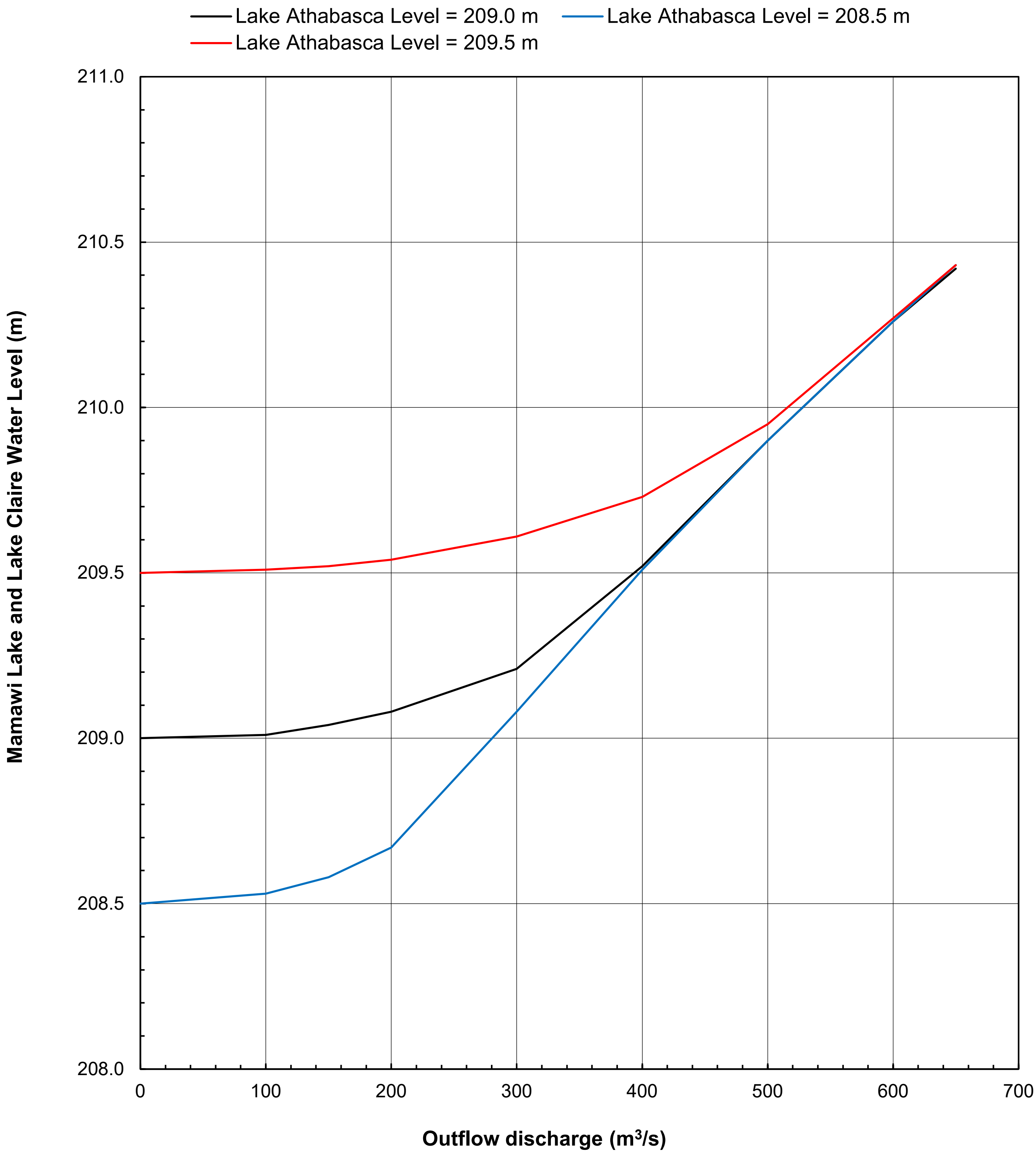
Table 6 Comparison of maximum achievable lake level with historical statistics

PAD Lake	Maximum Achievable Peak Lake Level (m) with Control Structure	Historical Statistics and Comparison					
		Mean Annual Peak Lake Level (m)	Increase in Level (m)	Upper Quartile of Annual Peak Lake Level (m)	Increase in Level (m)	Lower Quartile of Annual Peak Lake Level (m)	Increase in Level (m)
Dry Year (2015)							
Mamawi	209.4	209.2	0.2	209.5	-0.1	208.9	0.5
Claire		209.5	-0.1	209.7	-0.3	209.3	0.1
Average Year							
Mamawi	210.0	209.2	0.8	209.5	0.5	208.9	1.1
Claire		209.5	0.5	209.7	0.3	209.3	0.7
Wet Year (2013)							
Mamawi	210.5	209.2	1.3	209.5	1.0	208.9	1.6
Claire		209.5	1.0	209.7	0.8	209.3	1.2

4.3 Outlet Capacity and Drawdown

The capacity of the QF channel through Dog Camp was assessed using the numerical hydraulic model. In order to avoid significant bed and bank erosion of fine sediments, a maximum mean flow velocity of 2.0 m/s was used as a limiting criteria based on simulated conditions (using the numerical hydraulic model developed from the surveyed bathymetry) for the existing channel under the upper range of recorded water level differences between Mamawi Lake and Lake Athabasca. In this case, the absolute maximum discharge recommended for the QF channel is about 800 m^3/s. However, since the bathymetry of the channel closer to the lake outlet may be more susceptible to erosion than the reach through Dog Camp, the proposed water control structure should be operated such that the maximum discharge does not exceed 650 m^3/s. An outflow rating curve for the Dog Camp control structure site was generated adopting a 60 m wide water control structure opening having a raised bottom elevation of 207.0 m and Lake Athabasca water level of 209.0 m. The sensitivity of the outflow rating curve to varying initial Lake Athabasca levels was also evaluated and presented in **Figure 13**. The figure illustrates that the outflow discharges are not significantly sensitive to Lake Athabasca levels when Mamawi Lake and Lake Claire have a water level of 210.0 m (which is the maximum achievable Mamawi Lake and Lake Claire level in an average year) or above.

Estimates of the time it would take to draw down Mamawi Lake and Lake Claire after the maximum water levels are achieved in an average and a wet year were determined based on the simulated rating curve described above. For these conditions, it would take about 2 months to drawdown the lakes (**Figure 14**, top left graph). Note that the drawdown period still includes inflows coming to the lakes as defined by historical records. The maps on **Figure 14** show a time series of the aerial extent of water during the drawdown period for a constant Lake Athabasca water level of 209.0 m. Lake Athabasca water levels are typically lower than this after about the third week of September (**Figure 3**), so the water level graph on **Figure 14** includes scenarios for Lake Athabasca levels held constant at 209.0 and 208.8 m to demonstrate the sensitivity of Mamawi Lake drawdown to Lake Athabasca water levels in the late fall and early winter. A water control structure at Cree Creek divergence could be constructed to limit inflows to Mamawi Lake during the drawdown period. No specific criteria were available for a control structure at Cree Creek, but it is reasonable to assume that the intent would be to divert as much water as reasonably possible to the Embarras River without completely cutting off flow to Cree Creek. Therefore, a second scenario was considered where Cree Creek flows during the drawdown period were reduced by a factor of three. In this case, it would take about 52 days to drawdown the lake. The corresponding timeseries of aerial extent of water is shown in **Figure 15**. Comparing these scenarios, the reduction in drawdown time is not significant; however, the benefit of a Cree Creek structure to reduce suspended sediment loading into Mamawi Lake may make its implementation worthwhile.



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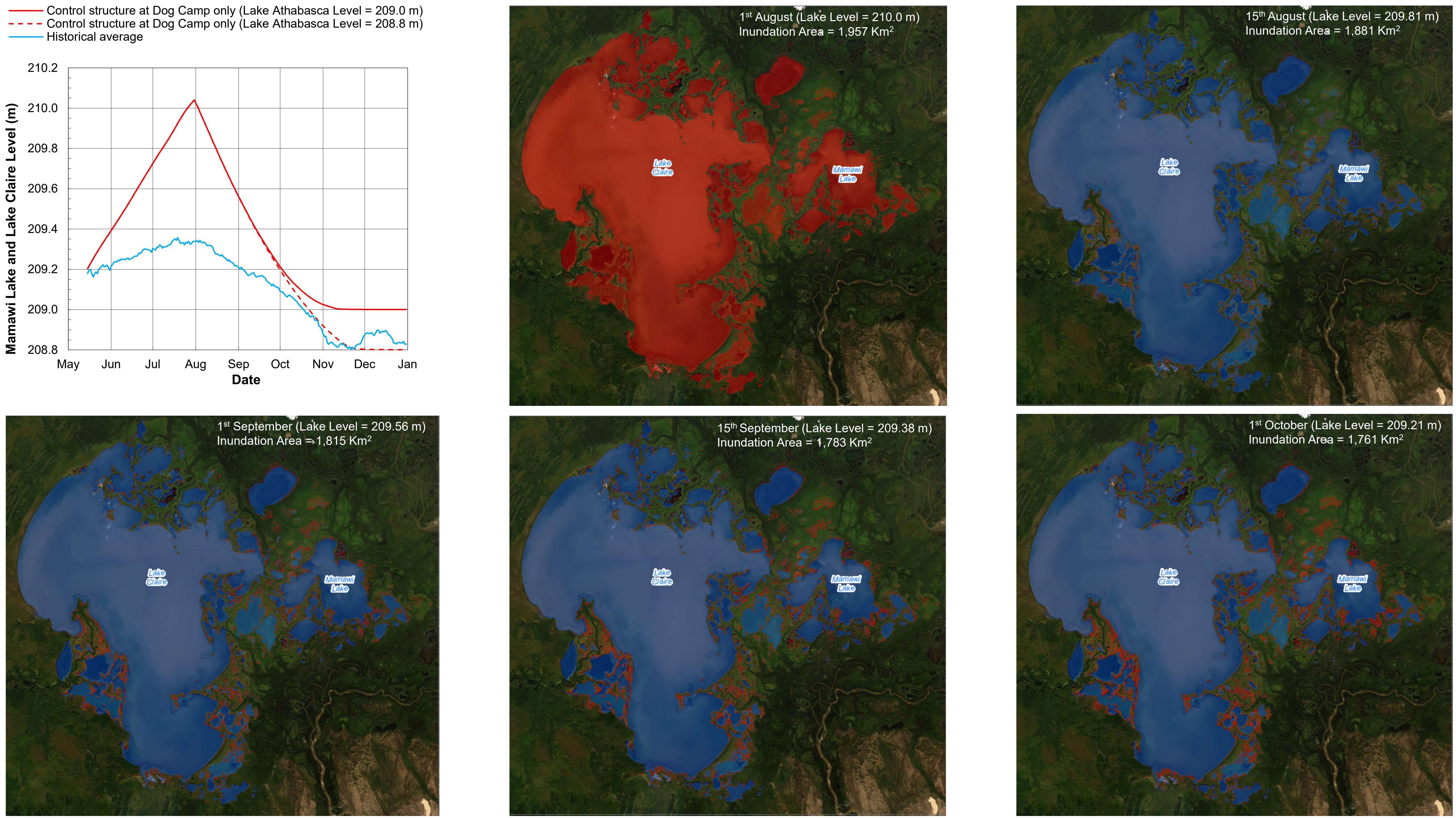
FEASIBILITY PLAN FOR WATER CONTROL STRUCTURE AT DOG CAMP

SIMULATED DOG CAMP CONTROL STRUCTURE OUTFLOW RATING CURVE SENSITIVITY TO INITIAL LAKE ATHABASCA LEVEL

FIGURE 13



Notes: The maximum Mamawi Lake and Lake Claire extent was shown in red on 1st August . For other time steps, the red area shows the additional lake extent at 210.0 m; while the blue area shows the actual lake extent at that time step with Lake Athabasca water level held constant at 209.0 m.

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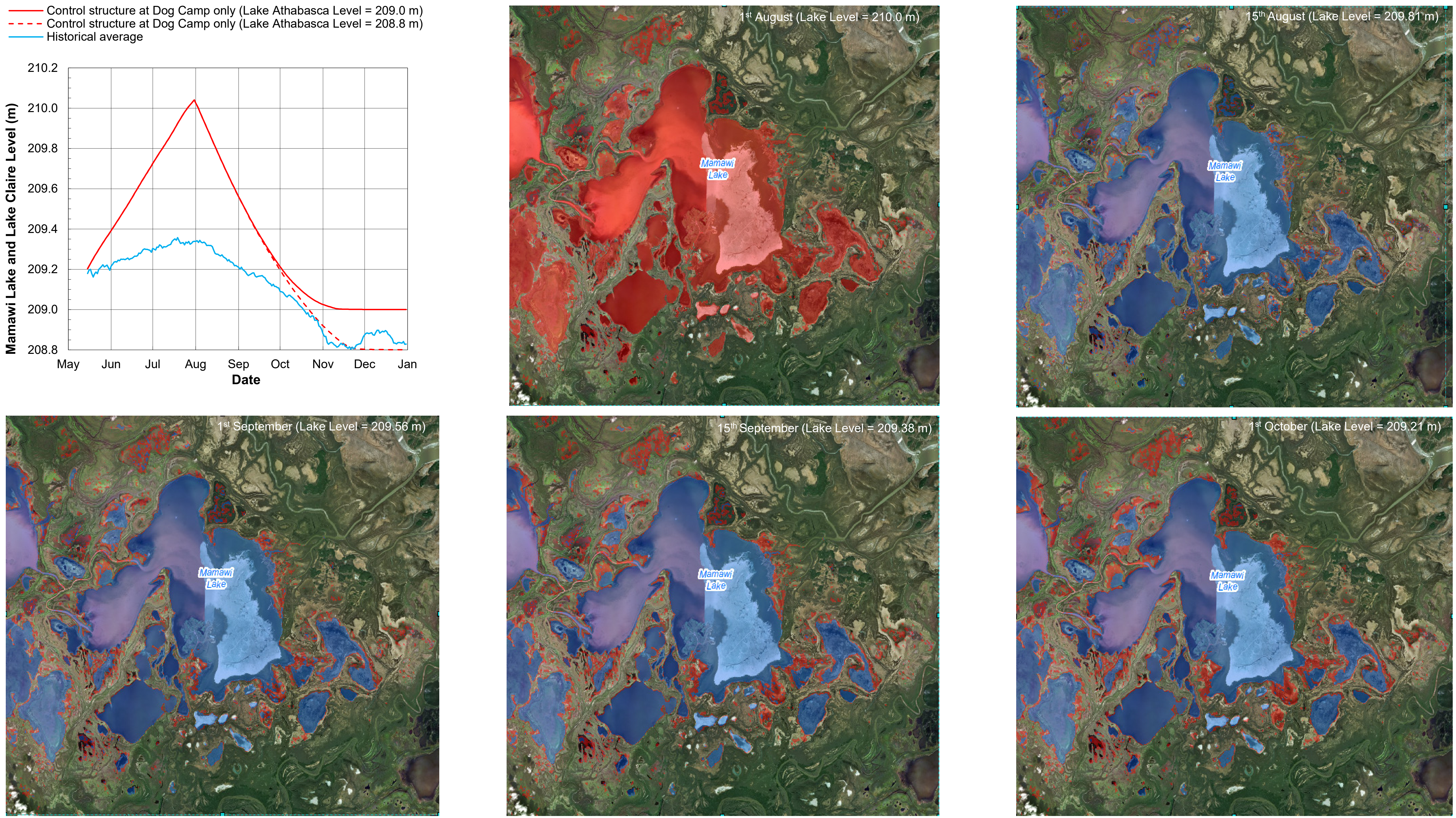
FEASIBILITY PLAN FOR WATER CONTROL STRUCTURE AT DOG CAMP

TIME-SERIES AERIAL EXTENT OF DRAINING

FIGURE 14A



Notes: The maximum Mamawi Lake and Lake Claire extent was shown in red on 1st August . For other time steps, the red area shows the additional lake extent at 210.0 m; while the blue area shows the actual lake extent at that time step with Lake Athabasca water level held constant at 209.0 m.

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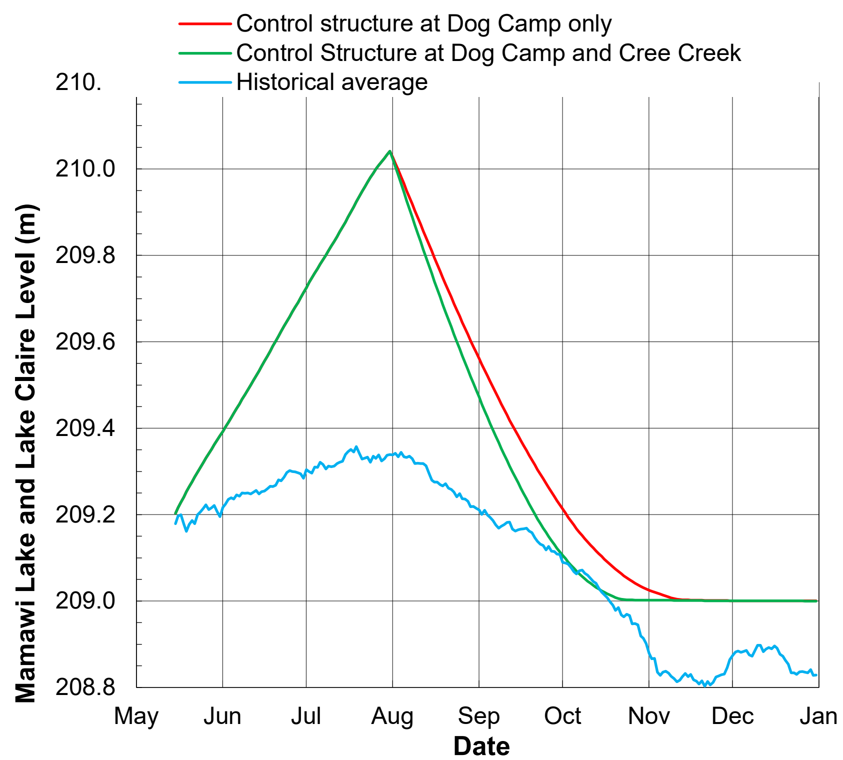
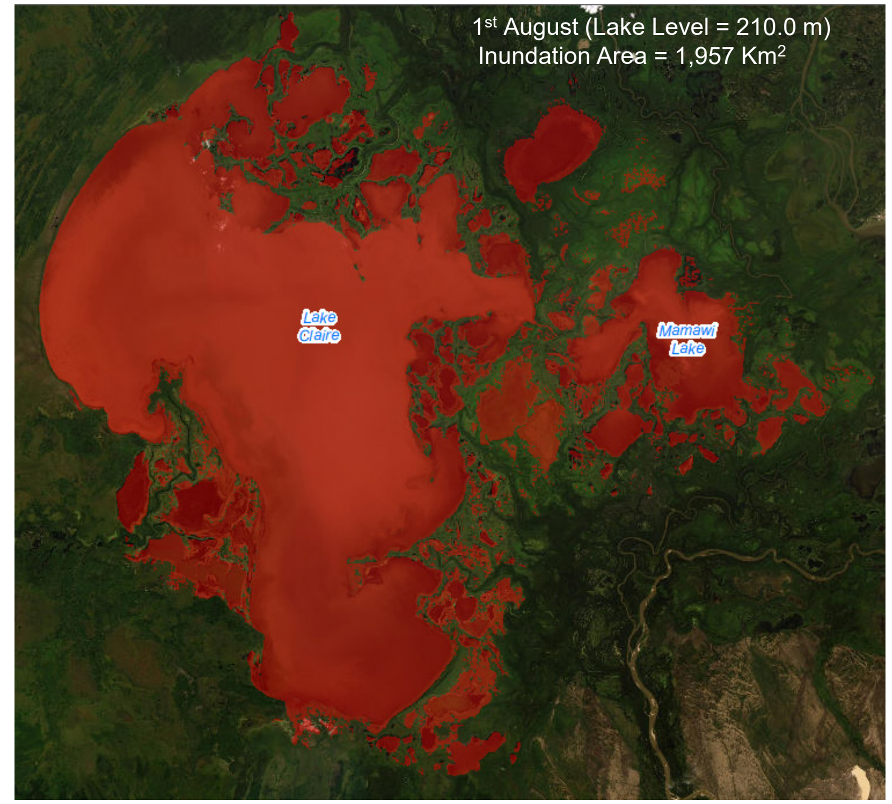
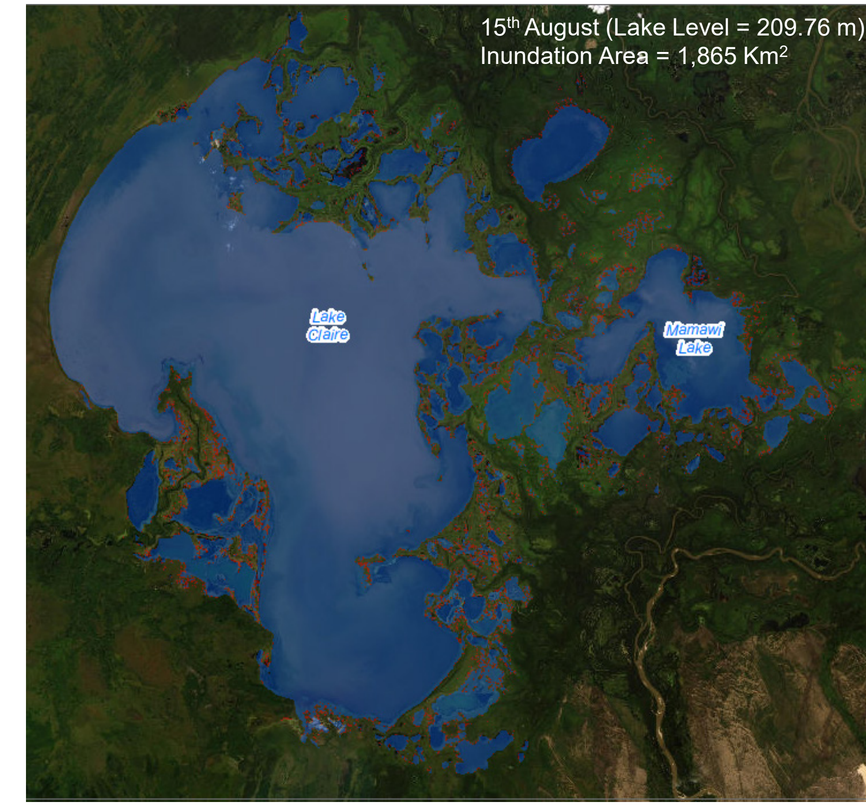
FEASIBILITY PLAN FOR WATER CONTROL STRUCTURE AT DOG CAMP

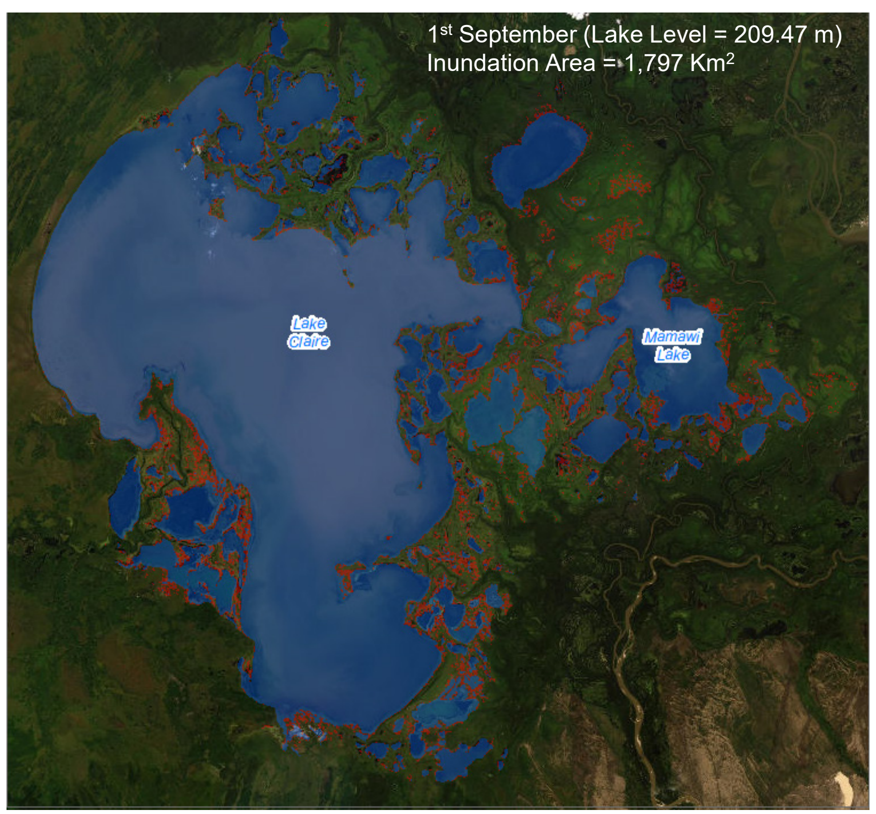
TIME-SERIES AERIAL EXTENT OF DRAINING (MAMAWI LAKE)

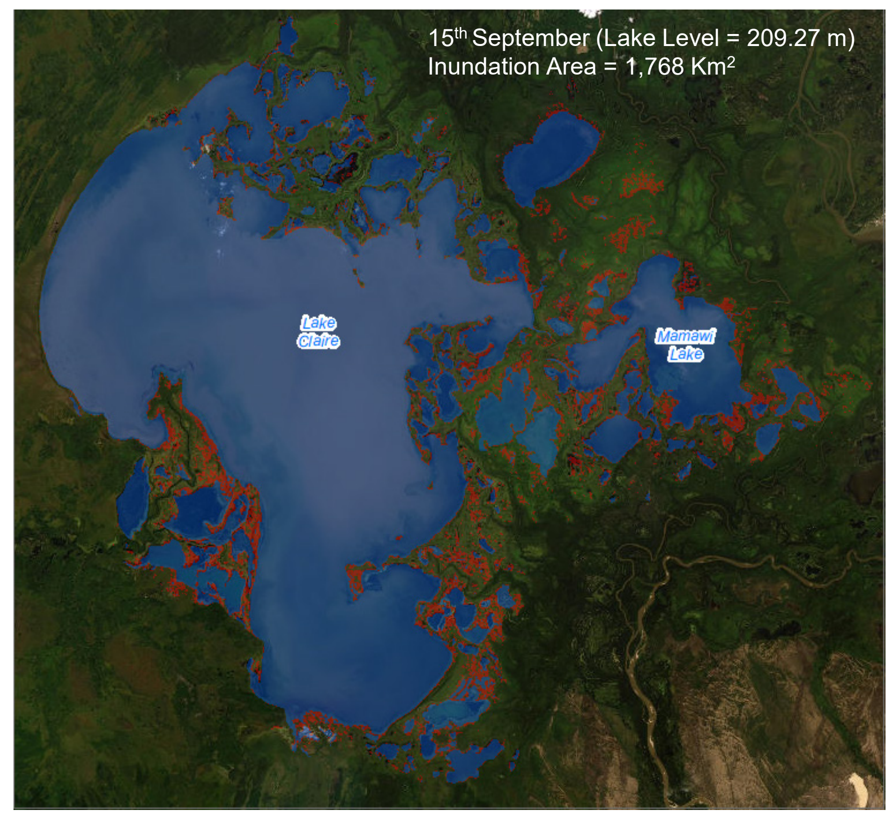
FIGURE 14B

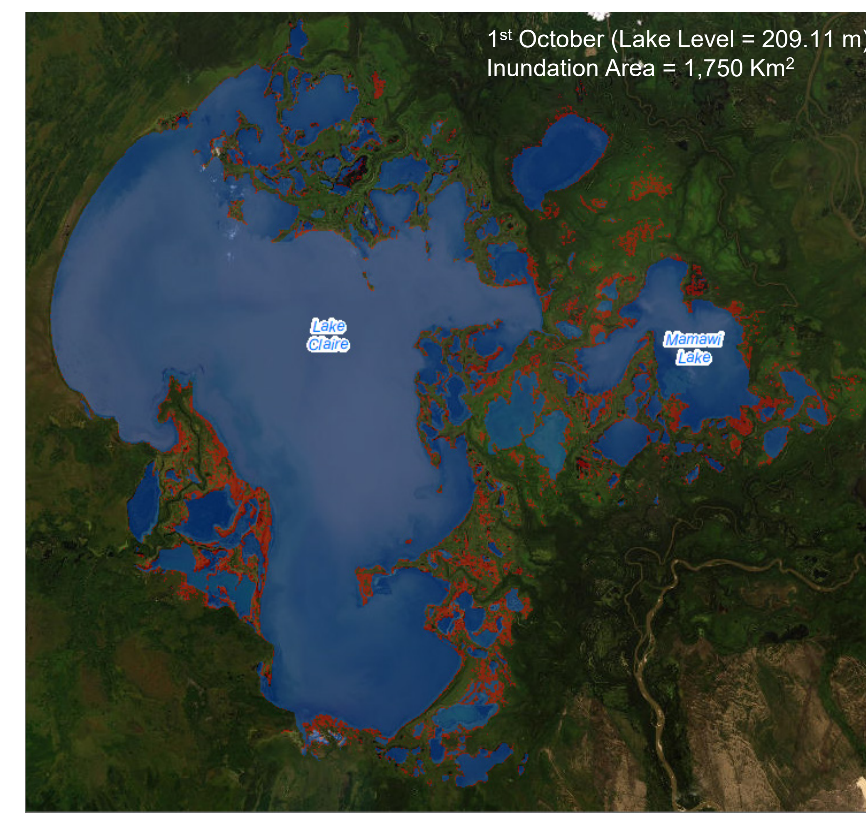












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Notes:
1. The drawdown curves were generated with Lake Athabasca water level held constant at 209.0 m.
2. The maximum Mamawi Lake and Lake Claire extent was shown in red on 1st August . For other time steps, the red area shows the additional lake extent at 210.0 m; while the blue area shows the actual lake extent at that time step with Lake Athabasca water level held constant at 209.0 m.

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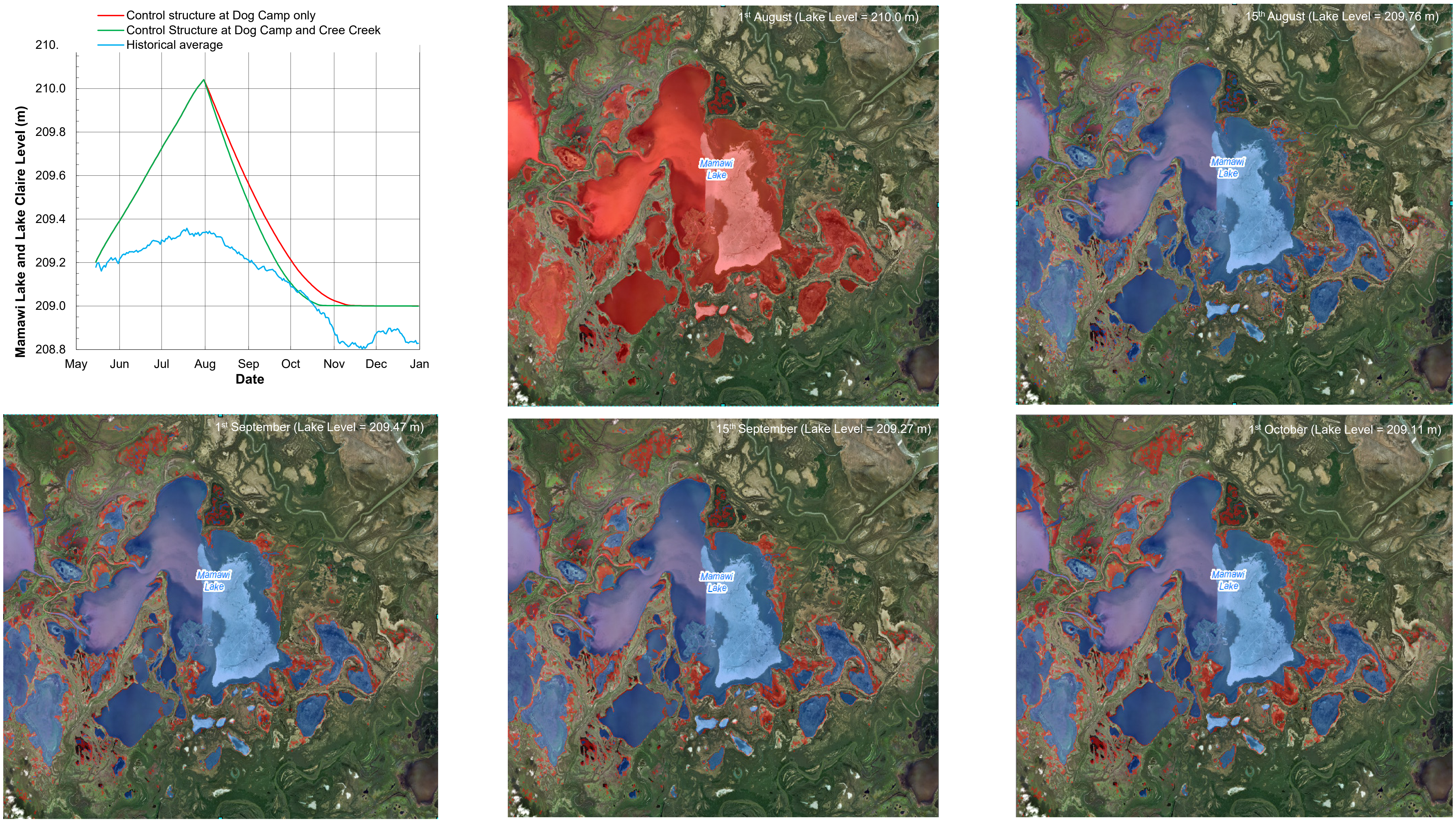
FEASIBILITY PLAN FOR WATER CONTROL STRUCTURE AT DOG CAMP

TIME-SERIES AERIAL EXTENT OF DRAINING WITH CREE CREEK CONTROL STRUCTURE

FIGURE 15A



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Notes:
1. The drawdown curves were generated with Lake Athabasca water level held constant at 209.0 m.
2. The maximum Mamawi Lake and Lake Claire extent was shown in red on 1st August . For other time steps, the red area shows the additional lake extent at 210.0 m; while the blue area shows the actual lake extent at that time step with Lake Athabasca water level held constant at 209.0 m.

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FEASIBILITY PLAN FOR WATER CONTROL STRUCTURE AT DOG CAMP

TIME-SERIES AERIAL EXTENT OF DRAINING WITH CREE CREEK CONTROL STRUCTURE (MAMAWI LAKE)

FIGURE 15B

4.4 Debris and Ice

Operation of the water control structure and high flows in the upstream watercourses are expected to mobilize woody debris (i.e. logs) based on comments from local knowledge holders. Such debris will pass through the water control structure site during operation, but this is primarily expected to occur during the drawdown period because during the filling period the QF channel will likely be completely blocked. If the structure is not completely submerged by at least 1.2 m through the drawdown period, after deflation or removal of the structure, a debris retention structure may be required upstream of the site to capture woody debris. Preferably, the water control structure should be robust enough so that upstream debris retention is not required as this will present an additional barrier to boat navigation through the QF channel.

Breakup of the river and lake ice covers in the PAD generally occurs during the month of May and can extend into early June. It is assumed that the structure would operate from about mid-May until mid-October at the latest. Since breakup may not be complete when the structure is placed into operation in any given year, it is important that it be robust enough to withstand ice impact forces. However, during breakup at Dog Camp, ice runs are expected to impose relatively mild ice forces compared to those along major river channels like the Peace and Athabasca rivers. If the structure is completely submerged by at least 1.2 m or is in operation only during the ice-free period, then ice impacts should not be of concern.

4.5 Sediment Transport

During the initial stages of the drawdown period, flow velocities should be sufficient to flush sediment deposits through the water control structure and keep the QF channel clear on a long-term basis. A separate consideration would be the impact of water flowing from Mamawi Lake into Lake Claire, since most of the water entering the combined area originates from the Athabasca River through Cree Creek and carries a higher suspended sediment load. Under existing conditions, Lake Claire normally flows into Mamawi Lake and reverse flows rarely, if ever, occur. With a control structure at Dog Camp, flow reversals on the Prairie River would occur if the structure were operated to raise Mamawi Lake levels above the water level in Lake Claire. If in fact the target water level was 210.0 m or higher, this would be the case, except in dry years when the inflow volumes are insufficient to achieve this objective.

Increased sediment loading to Lake Claire through Mamawi Lake would be expected to cause the lake and flooded perched basins to become shallower over time. However, it is important to note that flooding of these areas during ice jams on the Peace River also introduce a significant volume of sediment to these lakes. Currently, these events are relatively infrequent; therefore, operation of a water control structure at Dog Camp could accelerate sediment deposition rates that are naturally occurring.

4.6 Downstream Effects

Operation of the proposed water control structure will detain and then release up to approximately 1.83 Mdam^3 of water in an average year and up to 2.85 Mdam^3 of water in a wet year, less any increased net evaporation and water retained in perched basins around Mamawi Lake and Lake Claire. For this assessment, it was assumed that the structure would begin operation in mid-May and then begin releasing water no later than 1 August of any year. On average, about 275 m^3/s will be detained during the fill period and 350 m^3/s released during the drawdown period. The recommended maximum outflow rate through the west arm of the QF channel and the control structure is 650 m^3/s.

While the structure is in operation (i.e. detaining water), flows in the QF channel towards the Peace River are expected to be sustained by outflow from Lake Athabasca, although they may decrease slightly due to the structure. During the initial drawdown period while outflows are the highest, water levels on the QF channel, Riviere des Rochers, and Peace/Slave River would increase slightly. Water levels on Lake Athabasca are not expected to rise significantly as a result of the controlled release of water from Mamawi Lake.

The average detained flow is about 17% of the average June -July outflow from the PAD and 6% of the average discharge in the Slave River at Fitzgerald (WSC Station 07NB001). The average flow release is about 18% of the average Aug-Sept outflow from the PAD and 9% of the average discharge in the Slave River at Fitzgerald. The maximum outflow rate is roughly 30% of the typical summertime outflow from Lake Athabasca and the PAD and about 15% of the August mean Slave River discharge at Fitzgerald. The average change in water level at Fitzgerald due to the operation of the structure is expected to range from a decrease of 0.1 m to an increase of 0.15 m, with a maximum increase of about 0.3 m. Discharge changes downstream of the structure would not attenuate significantly because both the detained and released discharges would be relatively constant over a period of two months or more.

The structure should be operated such that outflows from Mamawi Lake and lake levels within the PAD are not significantly higher than normal during freeze-up. Higher freeze-up levels could reduce the potential for breakup ice jam formation events that are beneficial to the PAD and the Slave River downstream and potentially have other adverse social, ecological, and hydrological impacts.

5 OPTION EVALUATION

5.1 Structure Alternatives

The feasibility of several types of water control structures was evaluated for the Dog Camp area. These included both removable temporary structures and more permanent structures. A summary of the alternatives considered is provided below.

AquaDam

An AquaDam is a temporary water-filled barrier which can control and divert water. It consists of two flexible watertight inner tubes, side by side, contained within a woven outer sleeve. The inner tubes are filled with water, giving form to the AquaDam, and creating a temporary, highly-effective water barrier. (AquaDam, 2020)

These structures are frequently used to dewater instream construction areas or may be deployed as temporary dikes to protect buildings in flood prone areas.

Geotubes

Geotubes consist of a permeable geotextile membrane filled with a slurry of sediment-laden water. The solid contents of the tube are retained and consolidated to form a contained barrier that can serve as a temporary dike in certain applications.

Excavation is required to remove the geotube bags and their contents when no longer needed.

Portadam

Portadams are portable cofferdams consisting of a metal frame supporting a water-tight barrier. This type of structure is widely used for temporary flood protection and construction site dewatering applications.

This option has a height limitation of approximately 3 m and is intended to have water on only one side.

Cofferdam

Traditional cofferdams consist of either an earth fill or steel enclosure built within a waterbody. These are typically used to isolate and dewater an instream construction site.

Rockfill/Earth Embankment

A rockfill or earth embankment is similar to a cofferdam; however, it does not provide a complete enclosure and may span a river channel to completely or partially block the flow of water.

Embankments are often used as one component of a water control structure, such as the bypass channel embankment shown here at the Riviere des Rochers boat passage tramway.

Ice Boom

An ice boom is a floating structure anchored to the river bed and banks that is designed to hold ice floes in place during freeze-up, resulting in a thicker and more stable ice cover. Ice booms are often used to mitigate ice jam formation and flooding.

Spray Ice

Spray ice is a technique used in the construction of ice roads and ice platforms. The process involves pumping water from beneath an established ice cover and spraying it into the air to form solid ice crystals. The ice crystals fall onto the surface of the ice and accelerate the thickening process.

At breakup, a thicker ice cover will take longer to melt and may impede the flow of water underneath the ice.

Rubber Dam

A rubber dam acts as an adjustable weir. The rubber bladder is anchored to a concrete foundation and inflated with water or air, depending on site conditions and design considerations.

The crest height of the rubber dam is typically controlled automatically based on established operating rules. Mechanical and electrical components are required to inflate and deflate the rubber dam. When completely deflated, the bladder rests on the base of the structure.

Stop Logs

A stop log structure is effectively a variable height flood gate that is manually operated by installing or removing timber beams in a series of slots. The process of adding and removing the beams may be mechanically-assisted by a hoist. Upstream water levels can be controlled by adding or removing stop logs.

Stop logs are commonly used in combination with other types of water control structures to isolate components, such as gates, so that maintenance can be performed.

Gated Sluiceway

Sluice gates are used to control the release of water from a reservoir and are commonly used in irrigation works and dams. A sluiceway typically provides several gates that can be operated independently and in parallel. Operation of the gates can be manual or automated. These types of structures are highly robust and capable of withstanding debris and ice impact forces.

5.2 Assessment Criteria and Results

Each option was assessed first based on four high-importance criteria. These are:

1) Could the structure span the width and height required to manage the water?
2) Could the structure be operated (i.e. adjusted, installed, or removed) when necessary to manage flows and lake levels?
3) Could fish passage be maintained during operation of the structure?
4) Could boat passage be maintained during operation of the structure?

The total span width across the QF channel at the proposed structure location is about 150 m, not including the rock island mid-channel, and the highest practical bottom elevation for the structure is 207.0 m. Therefore, the required length and height of a structure at this location are 150 m and 3.5 m, respectively.

Portadams are not suitable for the length and height of water in this application; they are also not designed for the backflow conditions that could occur on the QF channel when Lake Athabasca water levels exceed those on Mamawi Lake. The installation and removal requirements, mainly with respect to the removal and disposal of sediment volumes contained within the geotubes, also make this option impractical for the Dog Camp site.

The ice thickening potential of ice booms and spray ice does not seem to be adequate to achieve the objectives at the Dog Camp site. Local knowledge holders indicated that an ice dam would lift and float downstream before it could raise water levels significantly in Lake Mamawi. Wilson (1995) provides a description of the ice dam construction program carried out in the winter of 1994-95 at the Dog Camp site which confirmed this. Ice dam construction started on December 3 and was completed on March 9. The ice dam was able to increase water levels by 0.4 m on April 27 before it lifted and washed out on May 1 (Wilson, 1995). The ice dam did not raise water levels to the target water level of 209.8 m, so the perched basins were not flooded. It was estimated that a starting water level in Lake Mamawi of 209.4 m would be required to attain the target water level; however, as shown in Figure 4, this required water level occurs in less than 25% of the years on record at the beginning of May.

Another problem encountered with the ice dam program was that water levels in Lake Mamawi dropped during the construction of the ice dam. The water level in Lake Mamawi dropped 1.79 m from January 1 to April 8 causing it to be 1.14 m below the water level in Lake Athabasca end of this period. This indicates that the ice dam may have been blocking flow into Lake Mamawi from Lake Athabasca.

Almost all of the options considered, and all of the removable temporary structures, provide virtually no ability to control flow and upstream lake levels during the season. Therefore, each would act effectively as a fixed-crest weir until the structure is removed. Once removed, the rate of lake drawdown would be uncontrolled, depending only on the channel capacity and downstream Lake Athabasca water levels. Only the inflatable rubber dam, stop log, or gated sluiceway structures offer the ability to manage and control outflows depending on seasonal conditions. Alternatives that provide the ability to readily adjust outflows during the season are more adaptable to climate variability and change than more temporary, fixed-height alternatives.

All of the options considered, except for ice booms and spray ice, will obstruct fish and boat passage while the structures are in use. Therefore, provisions for a fishway and navigation lock would be required with any of the other options.

A detailed summary of the overall assessment criteria and results is provided in Table 7.

Table 7 Option assessment criteria and results

Dog Camp (Mamawi Lake Outlet/Quatre Fourches Channel): Approx. channel width 150 m; approx. structure height required 3.5 m. Assess use of temporary control structures to be installed and removed periodically to provide seasonal flooding and drawdown of Mamawi Lake and Lake Claire. Water control required during the months of May through July or August.

	Type of Structure										
Assessment Criteria / Considerations	**Aquadam**	**Geotubes**	**Portadam**	**Cofferdam**	**Ice Boom**	**Spray Ice**	**Rockfill/Earth Embankment**	**Rubber Dam + Embankment**	**Stop Logs + Embankment**	**Gated Sluiceway**	**Remarks**
Suitable for span and height required	Possibly	No	No	Yes	Yes	No	No	Partial span	Partial span	Partial span	Most temporary structures not designed to span 150 m and extend up to 3.5 m in height.
Adjustable flow control during season	No	No	No	No	No	No	No	Yes	Yes	Yes	Ability to adjust outflows through season is very important to mitigate negative impacts.
Fish passage	Complete obstruction - Fishway would need to be incorporated if passage required when structure in use.				N/A	N/A	Complete obstruction	Complete obstruction	Complete obstruction	Complete obstruction	Fishway would need to be incorporated if passage required when structure in use.
Boat navigation	Complete obstruction - Lock system (or other) would be required for boat passage when structure in use.				N/A	N/A	Complete obstruction	Complete obstruction	Complete obstruction	Complete obstruction	Lock system (or other) would be required for boat passage when structure in use.
Installation/removal frequency	Annual	1-5 years	Annual	1-5 years	Annual	Annual	Semi-Permanent	> 10 years	1-5 years	Semi-Permanent	Geotubes may be left in place over winter but materials will degrade over time.
Length of service (life of materials)	10 years	5 years	25 years	> 10 years	< 1 year	< 1 year	> 50 years	25 years	> 20 years	> 30 years	Length of service for temporary structures will vary depending on care and maintenance.
Availability of materials	Regional Suppliers	Regional Suppliers	Rental only	Suppliers/ Contractors	Custom Built	Specialized Contractors	Local	Regional Suppliers	Part local	Custom Built	All options can be sourced. Portadams appear to be supplied on a rental basis only.
Relative ease of installation	Simple	Simple	Simple	Moderate	Complex	Moderate	Moderate	Moderate	Moderate	Complex	Based on type of equipment and skills necessary to install the structure.
Relative ease of removal	Simple	Simple	Simple	Moderate	Complex	Simple	Moderate	Moderate	Moderate	Complex	Based on type of equipment and skills necessary to remove the structure.
Can be installed and removed at appropriate times	Yes	No	Yes	Maybe	Yes	Maybe	Yes	Yes	Yes	Yes	May not be feasible to remove Geotubes during highwater to drawdown the lakes.
Relative supply and install cost	Low	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Low	High	Rubber dams require mechanical and electrical components.
Relative operation and maintenance cost	Low	Low	Low	Low	None	None	Low	High	Low	Moderate	Options that require annual installation and removal will cost more over time.
Resistant to debris impacts	No	No	No	Yes	N/A	N/A	Yes	Somewhat	Yes	Yes	Woody debris may not be significant for this site compared to other sites.
Resistant to ice forces	No	No	No	Yes	N/A	N/A	Yes	Yes	Yes	Yes	Lake ice breakup forces are expected to be moderate relative to river ice breakup.
Overall feasibility (Will it achieve objectives?)	Unlikely	Very unlikely	Very unlikely	Unlikely	Very unlikely	Very unlikely	**Yes, if embankment used in combination with stop logs, gates or rubber dam**				**Recommend embankment in combination with adjustable control structure.**
Other notes	**Risk of puncture, not resistant to ice, and not adjustable**	**Not tall enough, risk of puncture, not resistant to ice, cannot be easily removed and not adjustable**	**Not tall enough, not stackable, not resistant to debris or ice, not adjustable**	**Not adjustable**	**Because of width, depth and gradient, won't hold back water**	**Specific climatic conditions required, only applicable in spring, and not adjustable**	**Embankment required in combination with other adjustable component (logs or rubber dam)**	**Offers ease for adjustments and operation. Coupled with embankment, cost is higher for rubber dam portion, but low for embankment**	**Embankment required in combination with other adjustable component (logs or rubber dam)**	**Complex installation and removal, does not offer more adjustability compared to rubber dam.**	

5.3 Preferred Option

Implementation of a water control structure at Dog Camp is challenging due to the width and height of structure required, the need to carefully control outflows during the drawdown period, the volume of water potentially being detained, and the complex and sensitive environment of the PAD. For these reasons, emphasis was placed on the need for adjustable flow control during the season, or at a minimum allow for deployment and removal at the beginning and end of the season without mobilizing large equipment or barges for each operation.

The preferred option is an inflatable rubber dam in combination with a rockfill embankment. This type of structure would allow for continuous control and management of Mamawi Lake levels and could be operated in real-time so as to not significantly impede reverse flow events that might occur when Lake Athabasca water levels exceed those in Mamawi Lake. Although, when the objective is to retain as much water as possible in Mamawi Lake and inflow volumes are limiting, it would likely not be necessary to make intermediate adjustments during the operating period.

An alternative option to the rubber dam would be a stop log structure. In this case, the embankment portion, fishway, and navigation lock would be virtually the same. The major disadvantage to this alternative would be the need for manual operation of the structure to adjust Mamawi Lake levels and control the rate of drawdown.

6 FEASIBILITY-LEVEL DESIGNS

6.1 Rubber Dam and Rockfill Embankment

A concept plan and profiles of the rubber dam and rockfill embankment is shown in **Figure 16**. The proposed works consist of a 60 m wide rubber dam spanning the channel south of the existing rock island. The south channel is wider so it can accommodate this width of structure. An air-inflation system is recommended over water-inflation due to the cold climate and operating conditions, as a water-filled bladder system and associated piping components would be at risk of rupturing if frozen. A cast in place concrete foundation is required to anchor the bladder system, which would be constructed on the rockfill base that was left in the channel after removal of the rock weir at that location in 1975. Additional rockfill would be required to raise and level the base to about 206.5 m before the concrete is poured. The remaining portion of the channel would be blocked by a rockfill embankment having a design crest elevation of 211.5 m to prevent overtopping.

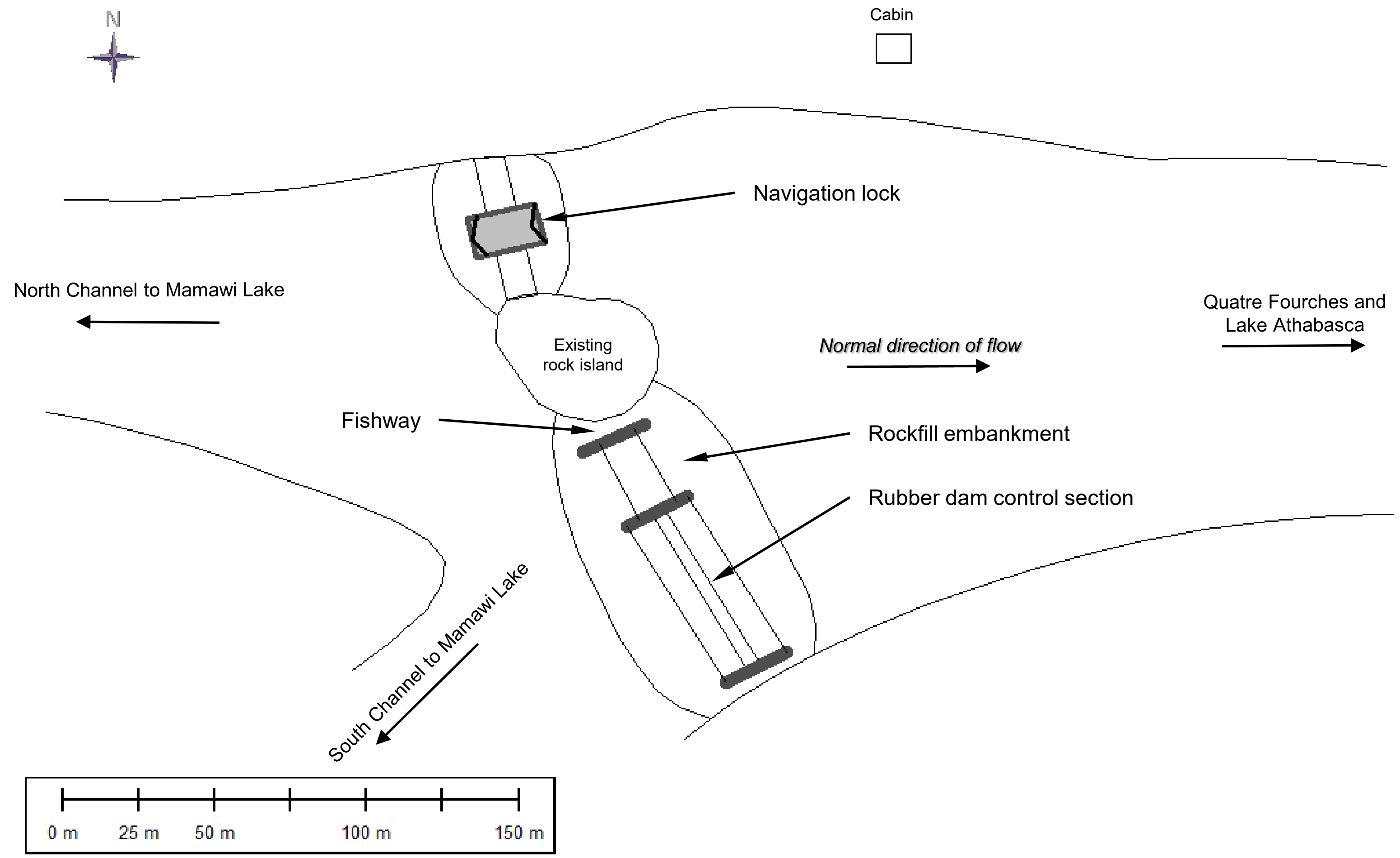
Mechanical and electrical control components would be housed in a small structure on the south shore. The floor level of this structure should be situated at or above an elevation of 212.0 m to protect it from flooding. The arrangement of the rubber dam system was based on the wider span of the south channel and indications from local residents that the north channel provides better access to Mamawi Lake by boat.

The anchoring system for the bladder will be designed to accommodate reverse flow conditions. When Mamawi Lake water levels are raised during operation of the structure, the frequency and magnitude of adverse water level gradients associated with reverse flows is expected to be less. After drawdown, the structures will likely remain fully-open; therefore, any subsequent reverse flow events will not be restricted.

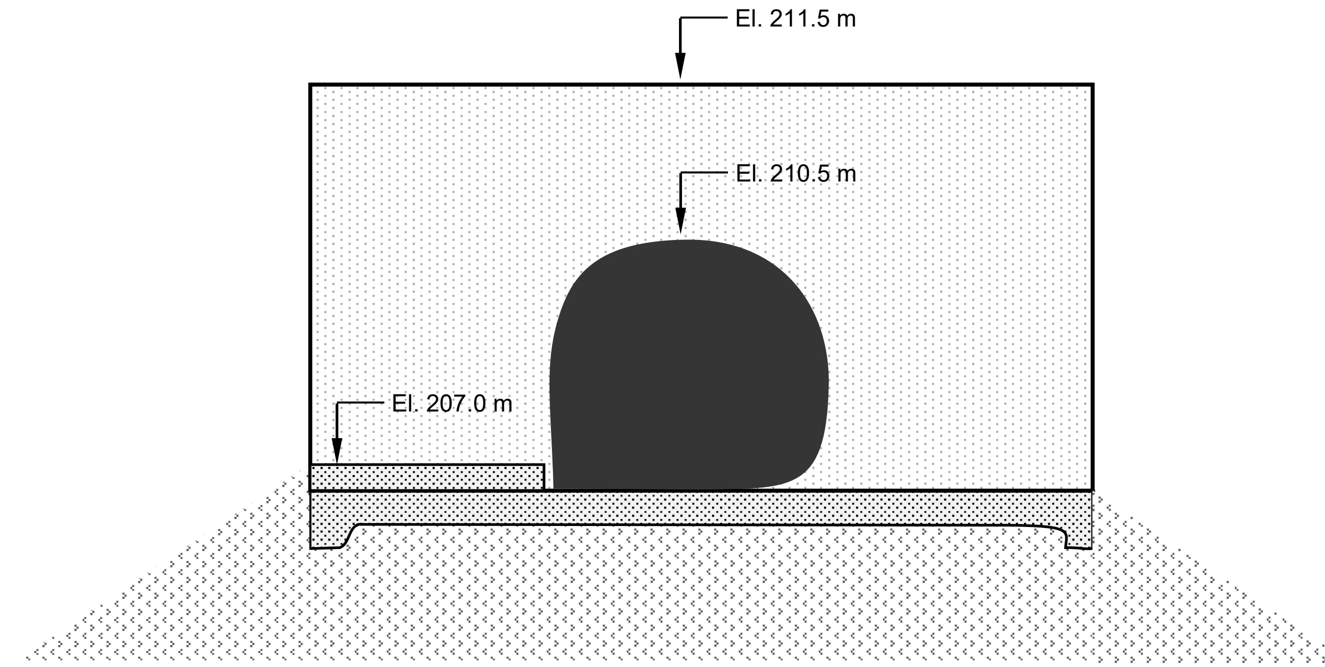
Although the bladder material is fairly robust to avoid damage from most ice and debris impacts, it is not designed to withstand impacts from boat propellers or ammunition. If the bladder is punctured, it may be possible to patch the hole, depending on the size of the puncture.

6.2 Stop Logs and Rockfill Embankment

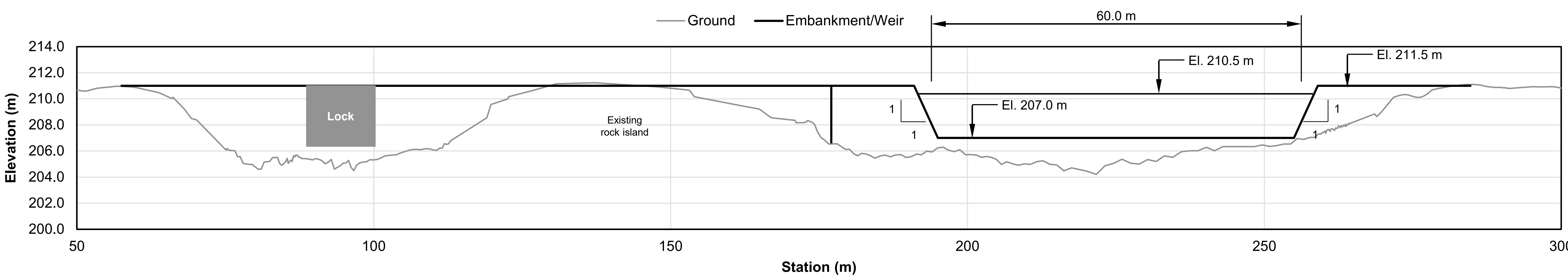
Figure 17 presents an alternative concept plan and profiles for a stop log structure and rockfill embankment. The proposed works would also consist of a 60 m wide control section spanning the channel south of the existing rock island. A cast in place concrete foundation is required to support the vertical slots as it is unlikely that the supports can be pile-driven into the riverbed at this site. As for the rubber dam option, the foundation would be constructed on the rockfill base that was left in the channel after removal of the rock weir at that location in 1975. Additional rockfill would be required to raise and level the base to about 206.5 m before the concrete is poured. The remaining portion of the channel would be blocked by a rockfill embankment having a design crest elevation of 211.5 m to prevent overtopping.



PLAN VIEW



LONGITUDINAL PROFILE OF RUBBER DAM



CROSS SECTION PROFILE

CONCEPTUAL – NOT FOR CONSTRUCTION

nhc
northwest hydraulic consultants

NOT TO SCALE

Coordinate System:
Units: As Shown

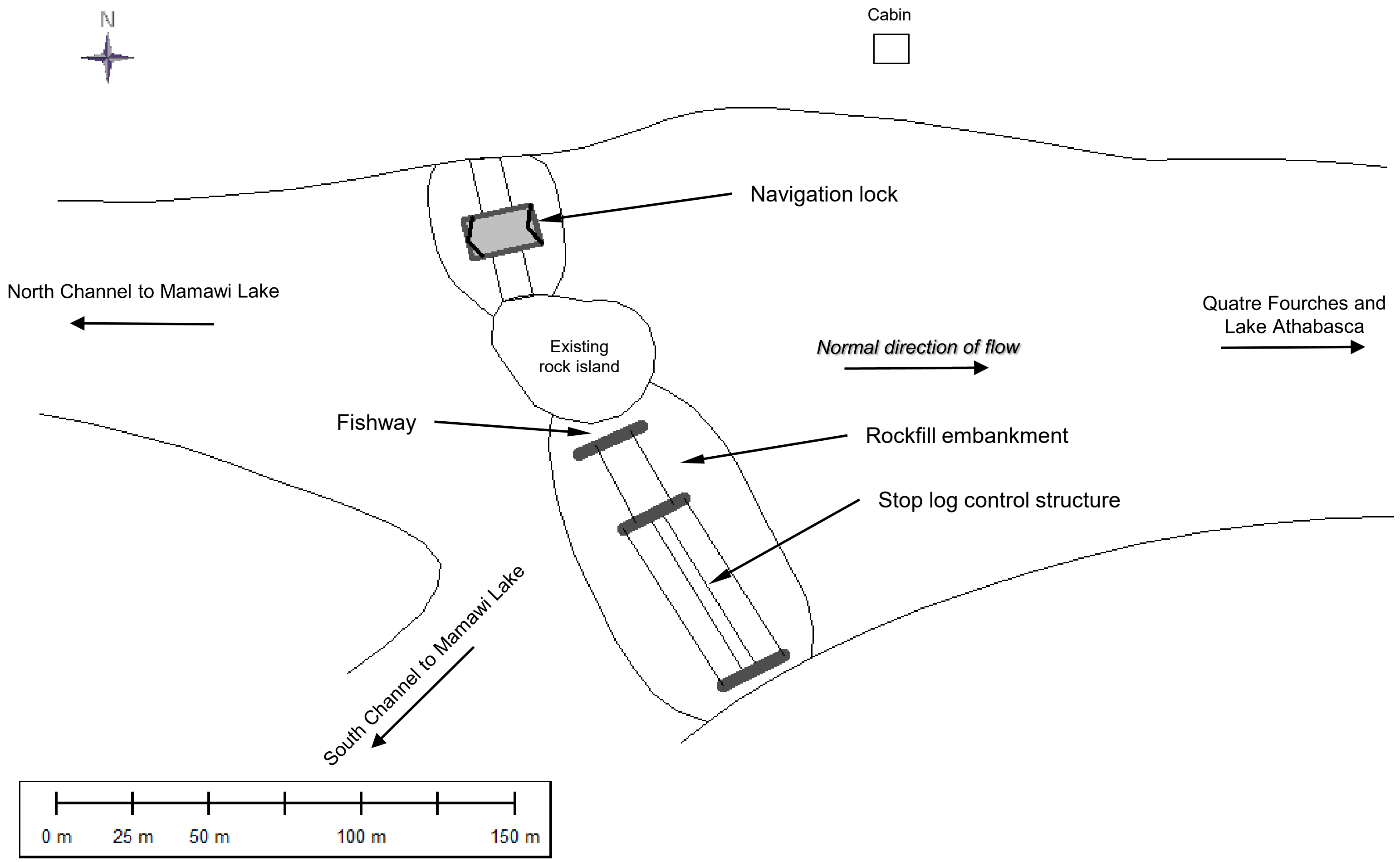
Job: 1005166

Date: 9-MAR-2020

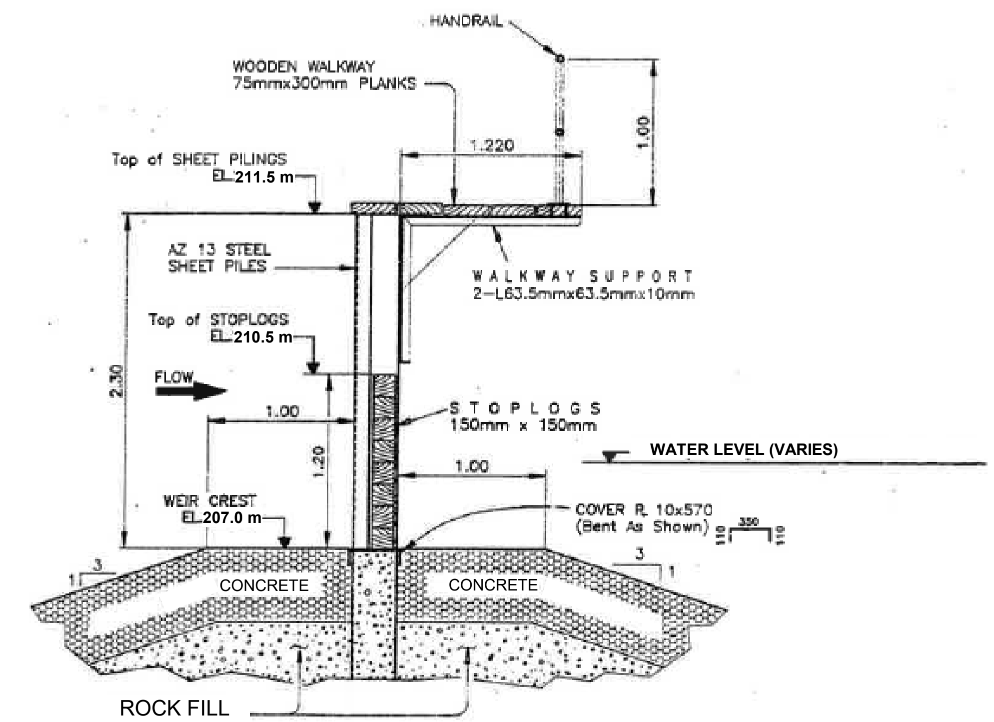
FEASIBILITY PLAN FOR WATER CONTROL STRUCTURE AT DOG CAMP

CONCEPT PLAN AND PROFILES FOR RUBBER DAM OPTION

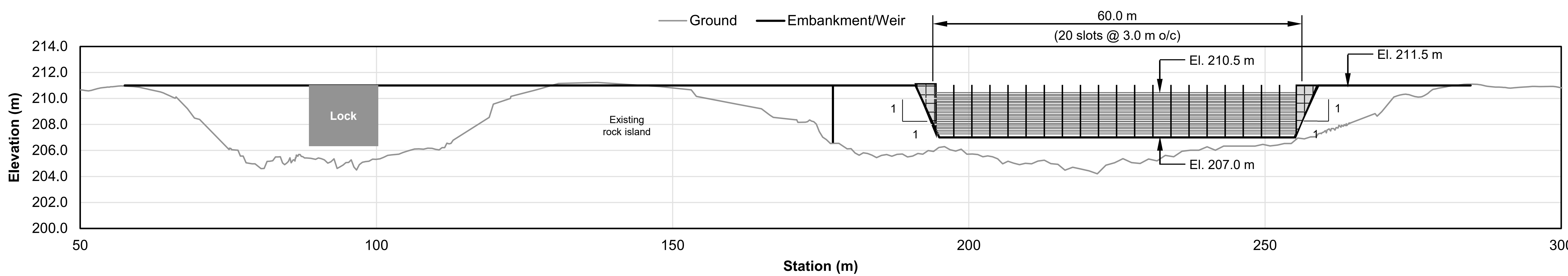
FIGURE 16



PLAN VIEW



STOP LOG SECTION DETAIL
(NOTE 1)



CROSS SECTION PROFILE

nhc northwest hydraulic consultants

CONCEPTUAL – NOT FOR CONSTRUCTION

Notes:

1. ADAPTED FROM BIG EGG LAKE CONTROL STRUCTURE REPORT (ALBERTA ENVIRONMENTAL PROTECTION, 1994)

NOT TO SCALE

Coordinate System:
Units: As Shown

Job: 1005166

Date: 9-MAR-2020

FEASIBILITY PLAN FOR WATER CONTROL STRUCTURE AT DOG CAMP

CONCEPT PLAN AND PROFILES FOR STOP LOG OPTION

FIGURE 17

Due to the height and width of the structure, a suitable hoist system will need to be provided for installation and removal of the stop logs. For this feasibility-level design, the length and height of each individual stop log was assumed to be 3 m and 0.15 m, respectively. For the required 60 m wide and 3.5 m high control structure opening, a total of 480 stop logs would be required. Although not all stop logs would need to be inserted and removed each season, manual adjustments would take a considerable amount of time to perform. It may be necessary to add or remove stop logs incrementally over a period of several days to complete the task, depending on the number of persons involved.

6.3 Ancillary Components

Ancillary components would include a fishway and navigation lock for both water control structure alternatives. It is proposed that the navigation lock be integrated into the rockfill embankment spanning the channel on the north side of the existing rock island. The north channel provides sufficient space for such a structure and was determined to be the preferred route of travel up the west arm of the QF channel based on information gathered from local knowledge holders. AMEC (2013) previously developed a conceptual design for a navigation lock on the Riviere des Rochers, and it is anticipated that a similar design would be suitable for the Dog Camp site. The proposed lock would require manual operation of the mitre gates and sluices but such operation would be possible for a single boat operator to perform. It is anticipated that the lock would remain completely open during the fall and winter months when the control structure is not in operation.

The proposed location for the fishway is between the south shore of the rock island and the embankment flanking the rubber dam control section. A vertical concrete wall is required to support the end of the embankment and provide a practical width and depth for the fishway. An alternative would be to cut or blast a vertical wall through the south side of the existing rock island, but it is recommended that this be avoided if possible to preserve this natural instream feature. The type of fishway has not been determined yet and will depend on the requirements of the fish species which pass through the channel.

Reverse flows may reduce the effectiveness of the seal on the mitre gates at the navigation lock, allowing water to flow through the lock towards Mamawi Lake. This should not present a significant operational concern for the structure. As it is anticipated that the control structure and lock will remain fully-open during the ice-covered period, the proposed structure should have minimal effect on flow velocities and ice thickness in the channel.

6.4 Construction Cost Estimate

The estimated construction costs for the preferred option is provided in **Table 8**. An estimated construction cost for the alternative stop log structure option is provided in **Table 9**. Additional costs for detailed engineering design fees, construction supervision, and environmental monitoring are estimated to be 10%. Environmental permitting costs are not included in these estimates.

Table 8 Estimated construction cost for rubber dam option

Item	Estimated Quantity	Unit Price	Total
Mobilization	Lump sum	\$300,000	\$300,000
Care of Water	Lump sum	\$100,000	\$100,000
Local Source and Place Rock Riprap	26,000 tonnes	\$60	\$1,560,000
Concrete	700 m^3	\$1,500	\$1,050,000
Rubber dam	210 m^2	\$10,000	\$2,100,000
Mechanical components	210 m^2	\$3,000	\$630,000
Electrical systems	Lump sum	\$200,000	\$200,000
Mitre gates (for navigation lock)	2 sets	\$500,000	\$1,000,000
Sluice gate (for navigation lock)	2 sets	\$50,000	\$100,000
Construction isolation	Lump sum	\$350,000	\$350,000
Contingency (15%)	Lump sum	\$1,108,500	\$1,108,500
		Total	**\$8,498,500**
		Engineering and Construction Supervision (10%)	\$849,850
		Grand Total	**\$9,348,350**

Table 9 Estimated construction cost for stop log option

Item	Estimated Quantity	Unit Price	Total
Mobilization	Lump sum	\$300,000	\$300,000
Care of Water	Lump sum	\$100,000	\$100,000
Local Source and Place Rock Riprap	26,000 tonnes	\$60	\$1,560,000
Concrete	625 m^3	\$1,500	\$937,500
Stop Logs	480 units	\$100	\$48,000
Walkway and hoist system	Lump sum	\$150,000	\$150,000
Mitre gates (for navigation lock)	2 sets	\$500,000	\$1,000,000
Sluice gates (for navigation lock)	2 sets	\$50,000	\$100,000
Construction isolation	Lump sum	\$350,000	\$350,000
Contingency (15%)	Lump sum	\$681,825	\$681,825
		Total	**\$5,227,325**
		Engineering and Construction Supervision (10%)	\$522,730
		Grand Total	**\$5,750,055**

The construction cost estimate for the stop log alternative is approximately 60% of the cost for the rubber dam; however, the manual operation requirements of the stop log structure should be weighed against the costs. It should also be noted that provisions for a navigation lock comprise about $2.3M of the estimated cost for each alternative, which includes approximately 480 m^3 of concrete and half of the care of water and construction isolation lump sums shown, plus 15% contingency.

It is assumed that site preparation and hauling of materials will be undertaken during the winter when access to the site is available by winter road. Portions of the rockfill embankment can also be placed during winter, preferably when water levels are low. Foundation work and cast in place concrete will need to be done in the dry, so appropriate temporary isolation works will need to be confirmed during detailed design.

Maintenance costs for each option were not assessed, but they are expected to be considerably higher for the rubber dam option due to the mechanical and electrical components (e.g. compressor, electrical generator, and control systems) required to operate the inflatable bladder. For the stop log structure, periodic maintenance of the winch system and replacement of logs should be anticipated. Maintenance requirements for the lock, fishway, and rockfill embankment for both options are expected to be relatively minimal. A rough estimate of average annual maintenance costs would be about $250,000 per year for the rubber dam option and about one-quarter of that amount for the stop log option; however, a more rigorous assessment of maintenance requirements should be done during detailed design.

A phased implementation approach was also considered. This would involve deploying an Aquadam in place of the adjustable rubber dam or stop log structure segment for one or more years before complete build-out. Due to the length and height of Aquadam required to span the opening, a suitable anchoring system would need to be designed to keep the temporary structure in place, and wear and tear on the dam would limit it to one-time use. An estimate for this option is in the range of $400,000 to $500,000 for supply of materials, shipping, and installation for each deployment, which could defer or replace the cost of the rubber dam and associated mechanical and electrical components. Costs for all other civil works at the site would remain similar, including contingency at 15% of the total cost.

7 SUMMARY AND CONCLUSIONS

The feasibility of a water control structure on the west arm of the Chenal des Quatre Fourches at Dog Camp was investigated in this study. Information from local knowledge gathering sessions held with Indigenous communities in Fort Chipewyan and local knowledge gathered from local experts during site work and project planning meetings, combined with site inspection observations, bathymetric survey and flow measurement data, and relevant data from other sources were used to complete a hydrotechnical assessment of the maximum lake levels that would be achievable from a water control structure at Dog Camp and the time it would take to drawdown Mamawi Lake, Lake Claire, and connected areas once the maximum water levels are achieved. Lastly, an evaluation of various options was done with input from the community and a feasibility level design for the preferred options was prepared.

Based on the results of the hydrotechnical assessment, the maximum achievable water level in Mamawi Lake and Lake Claire is about 210.0 m for an average year based on inflow volumes from the Birch and McIvor rivers and Cree Creek. In a wet year, it may be possible to raise water levels as high as 210.5 m as early as 10 July. Above this level, Mamawi Lake and connected areas are expected to spill south of Dog Camp into Lake Athabasca and possibly the Embarras River. Therefore, the absolute maximum water level for Mamawi Lake as regulated by a control structure at Dog Camp is 210.5 m. The current assessment could be greatly improved if high-resolution LiDAR digital terrain model data is acquired for Mamawi Lake, Lake Claire, and connected areas. This would help identify potential spill points and connections between various waterbodies.

Various water control structure alternatives were evaluated. For the Dog Camp site, the width and height of the structure required as well as the need to adjust the height of the structure to control the rate of outflow through the drawdown period were seen to be very important considerations in the assessment. The preferred option based on the established criteria was an air-inflated rubber dam in combination with a rockfill embankment. Since virtually all options present a barrier to fish passage and boat navigation while they are in operation, provisions for a fishway and navigation lock are necessary. The estimated construction cost for the rubber dam option is $9.4M, including 10% for engineering design, construction supervision, and environmental monitoring.

An alternative option consisting of a manually-operated stop log structure in place of the rubber dam was also considered to be feasible. The estimated construction cost for the stop log structure is $5.2M. Although this option is approximately 60% of the cost of the rubber dam option, the manual operation requirements for installing and removing up to 480 stop logs with a hoist system should be considered.

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APPENDIX A
STUDY TERMS OF REFERENCE

Public Services and Procurement Canada | Services publics et Approvisionnement Canada

Terms of Reference
For
Feasibility Plan for Removable Control Structures in the Peace-Athabasca Delta

R.106569.001

Prepared by

Public Services and Procurement Canada

Western Region

September 2019

Amendment #1

Table of Contents

Glossary of Terms

ECCC	Environment and Climate Change Canada
PAD	Peace-Athabasca Delta
PADIC	Peace-Athabasca Delta Implementation Committee
PADTS	Peace-Athabasca Delta Technical Studies
PADPG	Peace-Athabasca Delta Project Group
PFRA	Prairie Farm Rehabilitation Administration
PSPC	Public Services and Procurement Canada
WBNP	Wood Buffalo National Park
WHC	World Heritage Committee
EFH	Environmental Flows and Hydrology
ACFN	Athabasca Chipewyan First Nation
MCFN	Mikisew Cree First Nation
FCML125	Fort Chipewyan Metis Local 125

Definitions:

The term ‘temporary control structures’ means that the hydraulic control structures are non-permanent, such that they can be removed and preferably re-installed.

The Task Team is composed of representatives from three local Indigenous communities (ACFN, FCML125, and MCFN), and federal government departments including Parks Canada and ECCC with local and technical knowledge of the area that will guide and inform this work.

Amendment 1 – September 2019

As part of **Section 4.2 – Engagement with, and involvement of, local Indigenous communities**, the Consultant will provide catering for the Open Houses on September 18 & 19 and the three Indigenous Knowledge Sessions on September 17, 18 and 19, 2019. The Consultant proposal from August 2019 included catering services for these sessions. Due to the requests by the local Indigenous communities, dinner (e.g., bannock and stew) with refreshments is now being provided during the Open House on September 18, 2019 and a larger than initially estimated number of persons are now attending (from 60 to 100 persons), and will increase the catering budget. Catering for the second Open House on September 19th and the three Indigenous Knowledge Sessions will serve refreshments and light snacks.

Additional work is also required under Section 4.2 to complete the development and revision of the Knowledge Sharing agreements with the three Indigenous communities (Athabasca Chipewyan First Nation, Mikisew Cree Frist Nation and Fort Chipewyan Metis) and project administration for material/poster production and revisions.

For the Indigenous Knowledge Sessions under Section 4.2.3, an increase in budget is required as additional land users and Elders are expected at the Mikisew Creen First Nation session and increased sub-contract rate for the Athabasca Chipewyan First Nation session.

- MCFN knowledge gathering session- expecting to have 14 participants @ $300 each (that is 4 more participants than budgeted for) = $4,200.
- ACFN knowledge gathering session, expecting ~10 participants @ a fee of $500 per participant (this is of course above the $300 fee per participant budgeted) = $5,000
- FCML125 knowledge gathering session- expecting to have 10 participants @ $300 each = $3,000.

As indicated in **Section 6.7 – Method of Payment**, any consultant fees and disbursements for the community engagement activities and field work including contractor time, materials, and Indigenous subcontractors related to this Project (R.106569.001) will be invoiced and charged to the “Riviere des Rochers Little Rapid Weir & Revillon Coupé Structure Survey – 2019” (R.106570.001).

1. Context

Public Services and Procurement Canada (PSPC; formerly Public Works and Government Services Canada (PWGSC)) on behalf of Environment and Climate Change Canada (ECCC) has a requirement for environmental professional services from a qualified firm with the capability and expertise to successfully complete environmental services as outlined in this document.

The Peace-Athabasca Delta (PAD), located largely in Wood Buffalo National Park (WBNP), consists of a complex interconnected network of lakes and channels and interspersed perched basins. Three Indigenous communities (Athabasca Chipewyan First Nation (ACFN), Fort Chipewyan Metis local 125 (FCM125), and Mikisew Cree First Nation (MCFN)) make their home in and around Fort Chipewyan and the PAD is “their home, their grocery store, their classroom, their medicine cabinet, their church, their highway, their photo album, and the place where their happiest memories live.” (p. EX-03, Independent Environmental Consultants 2018). This work is to provide the members of these communities, the province of Alberta and the Wood Buffalo National Park

(WBNP) managers with the information that they require to make an informed decision on what option or options to pursue in further detail for water control structure(s) in the PAD to achieve their desired hydrology-related outcomes. Their traditional and present-day knowledge of the land is critical information to guide this plan and these Indigenous and Parks Canada partners are committed to supporting this work with ECCC.

It is important for the Consultant to recognize and appreciate this context, illustrate cultural sensitivity at all times, meaningfully incorporate the provided knowledge and expertise as is within scope, and respect that this undertaking is to support the Fort Chipewyan community and that they are, and have been, the experts in their own home for time immemorial.

Historically, naturally variable climatic conditions periodically caused the PAD to flood, maintaining water levels, and refreshing the perched basins. As a result of natural deltaic aggradation, climate change, and regulation, hydrological and hydraulic conditions have changed such that flooding in the PAD is reduced, temporal variability of water levels has changed and the perched basins are not regularly rejuvenated (Peters, 2003, Peters et al. 2006, Beltaos 2018). This has impacted the ecological integrity of the PAD and the ability of the local Indigenous peoples to travel using the waterways and to meaningfully practice their Aboriginal and Treaty Rights.

This region has had a history of flow interventions. It will be necessary for the Consultant to become knowledgeable on the hydrology of the PAD, and hydrologic conditions necessary for ecological and cultural sustainability in order to understand what is feasible, and what has and has not worked in the past and why. A list of references is provided for background.

In 2014, the MCFN petitioned the World Heritage Committee (WHC) to request that the WBNP World Heritage Site be included on the List of World Heritage in Danger. At the request of the World Heritage Committee, the Government of Canada, with input and collaboration from provincial and territorial governments, Indigenous communities, and stakeholders, produced an Action Plan[1] to ensure that Wood Buffalo National Park World Heritage Site is safeguarded for current and future generations.

This work directly addresses portions of the Environmental Flows and Hydrology (EFH) actions EFH 56 and 57 from the Action Plan, and will be the basis for actions EFH 58 and 59. It will also inform actions related to artificial ice dam installation (EFH 31-36).

[1] https://www.pc.gc.ca/en/pn-np/nt/woodbuffalo/info/action

<table>
<tr><td colspan="4">GOAL: Strategically-placed short- and/or long-term water management control structure(s) within the PAD create a local hydrological regime that supports the ecological functioning and Indigenous use in identified target areas</td></tr>
<tr><th colspan="2">Actions</th><th>Lead</th><th>Timeline</th></tr>
<tr><td colspan="4">Small-scale and/or temporary control structures</td></tr>
<tr><td colspan="2">EFH56: Assemble and review overview of the existing data and information related to past, current, or potential control structures in the PAD:
• state of the weirs currently in place;
• alternatives considered, rationale for chosen options, design criteria, and effectiveness of the weirs currently in place (including past modelling exercises).
• new alternatives that were not considered or available at time of construction (e.g., inflatable rubber dams);
• previous weir/dam experiments in the PAD (e.g., ice dam at Dog Camp and small trench/weirs on perched basins in Athabasca Delta); and
• Weirs and dams that have been considered in the past but not implemented and why not (e.g., Big Egg Lake).</td><td>FPTI Committee</td><td>Targeted Completion: Summer 2019</td></tr>
<tr><td colspan="2">EFH57: Obtain new information related to possible short-term or small-scale options to improve the hydrological regime in the PAD</td><td>FPTI Committee</td><td>2019-2020</td></tr>
<tr><td rowspan="3">Implementation Detail</td><td>Employ a contractor to assess the effectiveness of the two existing weirs (Rivière des Rochers and Revillon Coupé) and identify any maintenance required to ensure that the weirs operate as originally designed.</td><td>PCA (Coupé weir) / AB (Rochers weir)</td><td>2019-2020</td></tr>
<tr><td>Undertake a feasibility assessment on the potential use of one or more temporary control structures to meet specific water level objectives in the Lake Claire and Mamawi Lake area of the Peace–Athabasca Delta, including simple modelling of potential outcomes.</td><td>ECCC</td><td>Targeted Completion March 2020</td></tr>
<tr><td>Consult with Indigenous partners and potentially affected parties</td><td>Indigenous partners / AB / PCA</td><td>2019-2020</td></tr>
<tr><td colspan="2">EFH58: Pending feasibility assessment results and consultation with local communities, select the most appropriate action and complete the full design for one or more pilot control structures.
• Determine appropriate Indigenous and hydro-ecological indicators and monitor for the effects of the control structure(s).
• Learning from monitoring of implementation results, adjust timing and length of installation and/or site of installation.</td><td>FPTI Committee</td><td>2020-2021</td></tr>
<tr><td colspan="2">EFH59: Install one or more pilot control structures and/or repair existing weirs, as designed.</td><td>PCA and/or AB</td><td>2021-2024</td></tr>
</table>

Action 57 considers ‘temporary control structures’, which are the target of this work. For clarity, the use of the word ‘**temporary**’ means that the hydraulic control structures are intended to be non-permanent, such that they can be removed and ideally re-installed. Removal includes either if they are not producing the desired results or if the recommended operation schedule includes seasonal installation. The effectiveness of these structures will be monitored to inform longer-term options.

2. Objectives

The Consultant is to provide a feasibility plan as described herein to support decision-making related to options for removable control structures generally, and at two specific locations in the PAD to achieve desired outcomes, accounting for climate and flow pressures.

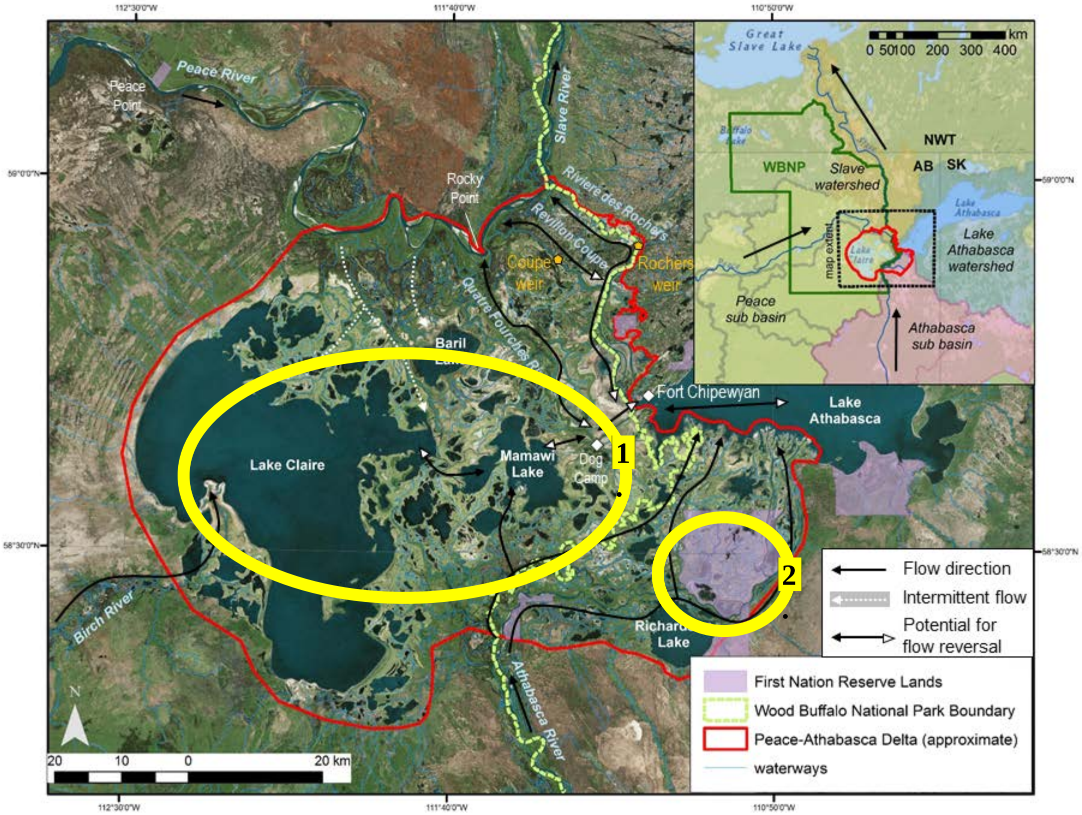


Figure 1. Peace Athabasca Delta (From Action Plan 2019). Yellow circles identify the general locations of the two areas of interest: 1. Mamawi Lake and connected Lake Claire (via assessment of a possible structure at Dog Camp and whether or not an associated structure at Cree Creek is needed to support water drainage and achieve low fall water levels) and 2. On the ACFN Jackfish reserve.

This feasibility plan will investigate the use of temporary control structures in the PAD to achieve desired water levels in two general locations selected by the Fort Chipewyan Indigenous communities (Figure 1). The Dog Camp and Big Egg Lake sites have been previously investigated for temporary or permanent water control structures.

1. Mamawi Lake and connected Lake Claire.
    a. This will include consideration for a structure on the west arm of the Quatre Fourches River at **Dog Camp**, and
    b. If required to achieve objectives, an associated structure at the **Cree Creek** diversion.
2. on the ACFN Jackfish reserve (I.R. 201).
    a. At the connection between **Big Egg Lake** and the Athabasca River.

3. Background

3.1 Peace Athabasca Delta water dynamics

The complex hydrology of the PAD is captured in the Golder (2012) reference provided and also at a high level in the Lake Athabasca section of the Atlas of Alberta Lakes (available online: http://albertalakes.ualberta.ca/?page=lake&region=1&lake=18). An excerpt is included in Annex E, and is further summarized below:

The Peace Athabasca Delta (PAD), is a complex and dynamic system, with inflows from the Peace, Athabasca, and Birch Rivers, connection to Lake Athabasca, and outflow to the Slave River (Figure 1). Lake Athabasca is drained primarily by Rivière des Rochers and its distributary, Revillon Coupé, with a smaller outflow through Chenal des Quatre Fourches (Atlas of Alberta Lakes). The drainage is primarily northward to the Peace River and then the Slave River, but when the Peace River is very high during spring or summer flooding, its elevation can exceed that of Lake Athabasca and cause flow reversals in these channels (Figure 1).

In 1982, the Embarras River breakthrough occurred, connecting the Embarras River directly to Mamawi Lake via Cree Creek and then Mamawi Creek. While this breakthrough increased water flow into Mamawi Lake, it also carries high levels of sediment and the Mamawi Creek delta has grown considerably since that time. While the additional water to the Delta lakes and the additional navigational route are considered desirable by the PAD communities, the increase in sediment deposition is likely an impediment to navigation. This additional inflow may cause the Mamawi Lake area to drain more slowly in the fall than it would have, prior to the breakthrough. The Implementation Committee and Biological Sub-committee in the 1986 PFRA Quatre Fourches study indicated that this delay in the recession of fall water levels was undesirable.

The PAD is comprised of open drainage (interconnected lakes and streams) and perched basins. Perched basins are separated from groundwater and are higher than the surrounding water table so they rely on flooding to be recharged. The aim of this study is to investigate whether there are feasible, removable options that could be installed to support flooding of perched basins or other wetlands and lakes that are not recharged annually.

3.1 Historic, Existing and Proposed Control Structures

Annex F contains detailed summaries of the past and existing control structures in the PAD. Figure 2 and Table 1 summarize the past and current water control structure locations.

Installation of the W.A.C. Bennett Dam in the 1960s influenced Peace River flows and in 1971 the governments of Canada, Alberta, and Saskatchewan established the Peace-Athabasca Delta Project Group (PADPG) to evaluate methods to raise water levels in the delta lakes and in Lake Athabasca. On recommendation by PADPG, the three signed an agreement and subsequently formed the PAD Implementation Committee (PADIC).

In 1971, a temporary rockfill dam was built on the Quatre Fourches near Mamawi Lake ("Dog Camp"), but it was damaged by flooding in 1974 and removed in 1975. During 1975 and 1976, permanent control structures were built on the Revillon Coupé and Rivière des Rochers. These permanent structures remain today, but their current state and functionality is unknown. This is being addressed through the linked contract "Rivière des Rochers Little Rapid Weir &Revillon Coupé Structure Survey" (R.106570.001).

Assessment in the 1980s (PADIC 1987) concluded that the weirs did not reproduce natural conditions, but nearly restored peak summer water levels and counteracted many of the hydrological changes from regulation of the Peace River.

However, the weirs did not influence flooding of the perched basins, nor did they restore the natural fluctuations of the delta lakes.

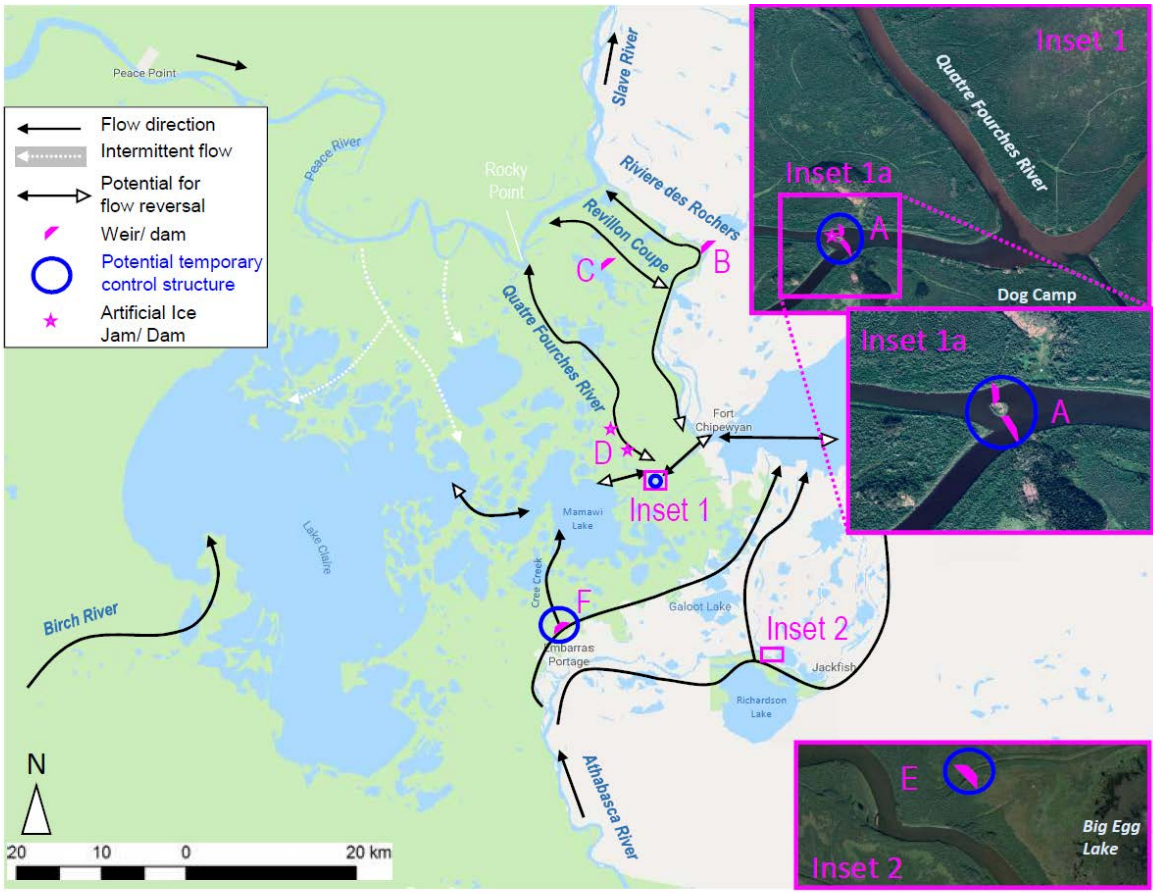


Figure 2. Summary history of water management in the PAD including proposed temporary control structure locations. A) west arm of Quatre Fourches (Dog Camp Location): previous location of rockfill dam (1971-1974, proposed gated control structure (1987), artificial ice dam (1995), and current proposed location of temporary control structure. B) Permanent rock weir at Riviere des Rochers (1975-present). C) Permanent rock weir at Revillon Coupé (1976-present). D) Historical artificial ice jams (1992-1993). E) Current proposed Big Egg Lake control structure on ACFN Reserve land F) Potential temporary control structure on Cree Creek.

Table 1: **Summary of Existing and Proposed Control Structures in the Peace Athabasca Delta. Letters for the location indicate their symbol as shown in Figure 2**

Location (Jurisdiction)	Structure	Purpose/Notes
A. West arm Quatre Fourches at **Dog Camp**	• 1971-1974 Rockfill dam	Rockfill dam removed in 1975.

(Federal-Parks Canada)	• 1986 Proposal - gated control structure (studied but not constructed) • 1994-1995 Artificial Ice Dam **• Current Proposal – Temporary control structures**	1995 Ice dam was unsuccessful. **Assess use of temporary control structures to be installed and removed periodically to provide seasonal flooding and drawdown in the vicinity of Mamawi Lake and Lake Claire.**
B. **Riviere des Rochers**: (Alberta)	• 1975/76 Submerged outflow weir with boat bypass and a tramway	To restore water levels in Lake Athabasca and the PAD. A gated control structure was studied but not constructed. There is a tramway to haul boats over a berm on an adjacent bypass channel, which works intermittently. An associated assessment will establish the current effectiveness of the Rochers and Coupé weirs.
C. **Revillon Coupé** (Federal-Parks Canada)	• 1976 Submerged outflow weir	To restore water levels in Lake Athabasca and the PAD. An associated assessment will establish the current effectiveness of the Rochers and Coupé weirs.
D. North arm Quatre Fourches (Federal-Parks Canada)	• 1992-1993 – Artificial Ice Jams	Ice jams were unsuccessful.
E**. Big Egg Lake on ACFN Jackfish reserve:** (Indigenous reserve lands; Alberta)	1987 & 1990s – adjustable control structure (studied but not constructed) **• Current Proposal – Temporary control structures**	Engineering pilot design for a permanent structure investigated in 1987 and then produced in 1994 to facilitate wetland restoration, but not implemented. Located on ACFN reserve, Athabasca River portion of PAD. **Assess use of temporary control structures to be installed and removed periodically to provide temporary flooding of the Big Egg Lake perched basin.**
F. Cree Creek (Federal)	**• Current proposal – Temporary control structures if necessary to support Dog Camp (an independent structure here is not envisioned).** No feasibility-level designs.	In the 1980s, concern was raised that additional inflow from the Athabasca River via Cree Creek and Mamawi Creek to Mamawi Lake would delay fall drainage and reduce habitat for waterfowl and wildlife. This may not be a concern today, but the increased sedimentation into Mamawi Lake is a concern for navigation. **Assess the use of a temporary control structure (likely in summer/fall) to assist in drainage of the PAD (and/or increase flow on the Embarras), if a control structure is implemented at Dog Camp. No feasibility-level designs.**

4. Scope of Work

This scope of work outlines the steps to be taken to achieve the objectives in Section 2. The overarching outputs of this work are:

- **General Feasibility.** Evaluation of the general feasibility and logistical considerations of using various available types of temporary (i.e. non-permanent; removable) hydraulic control structures within the PAD, including ice dams, given the dynamic hydrology and harsh winter climate. Provide a general assessment of why assessed types would or would not be feasible. For those that are feasible, provide cost estimates, installation, maintenance, and removal requirements, and anticipated longevity.

- **Location-specific data**. Collect detailed data (survey, bathymetry, photos) at the denoted locations and create a theoretical stage-discharge curve. Estimate the maximum achievable water level and areal extent of induced flooding and the time to drain to minimum water levels from any installation, plus estimate the flows to consider at each site.

- **Options assessment**. Comparison of the effectiveness of different product types, configurations and locations (e.g. Dog Camp alone vs Dog Camp with Cree Creek structure) under foreseeable operating conditions for the Mamawi Creek and the Jackfish Reserve location. Provide recommended options to move forward to feasibility-level design, not to exceed a total of 6 designs.

- **Feasibility-level designs.** Unless no feasible options exist, provide one or more technical feasibility level designs for the recommended configurations for <u>each</u> the (1) Dog Camp location and (2) Big Egg Lake, on the ACFN Jackfish reserve, optimizing low cost, durability, and ease of installation that provide a high likelihood of achieving the desired water level outcomes.

- **Inclusion of Indigenous engagement and knowledge.** Engage with the Fort Chipewyan community and the task team (see definition) to understand desired outcomes, specific areas of interest with respect to water levels, insights on historical floods, and to gain direction on structures that should undergo a feasibility assessment.

Detailed guidance on scope of work:

4.1 Desktop literature review and general assessment of potential applicability of different temporary control structure types for this dynamic, cold-weather delta

4.1.1 The Consultant will **review literature noted in Appendix E** to understand the current and historical timing and duration of flooding and hydrological regime of the Lake Claire/Mamawi Lake basin and the Big Egg Lake Jackfish Reserve area, including current and past control structures. Key documents are identified as required, further references are provided for additional information.

4.1.2 **Investigate the availability of temporary control structures and assess the potential for implementation in the dynamic, cold-weather environment of the PAD**. This may include, but is not limited to, coffer dams, rubber dams, portadams, and aquadams/ geotubes that can be filled with water or sediment. Other options to temporarily control flows include the construction of ice jams or ice dams.

4.1.2.1 Investigate the supply and availability of temporary control structures that may be useful for this application and document and compare their costs, characteristics, properties, benefits, etc. as well as their installation requirements, and any associated products and best practices required for sediment control during installation and removal. Include considerations for ability to withstand forces of nature present in cold regions such as ice and potential flows and identify any potential products that could be employed to help mitigate these factors. Considering the conditions at the proposed locations, provide a reasonable estimate of life spans of the structures and whether they could be re-used for more than one deployment.

4.1.2.2 Investigate the overall feasibility of installation of artificial ice dams, state of the art techniques, best practices, weather conditions required for their success, seasonal timing of their construction, availability of equipment and related costs.

4.1.2.3 Provide a brief summary of the types of control structures investigated, potential combinations (such as stacked geotubes and aquadams vs. one large aquadam), including why the options would or would not be recommended for general application in the PAD[2].

4.2 Engagement with, and involvement of, local Indigenous communities.

4.2.1 **The Consultant will communicate with the task team**, supported by ECCC and PSPC, throughout the life of the contract, at a mutually acceptable frequency. The task team, including Parks Canada, will provide information to the Consultant on how to identify and establish Indigenous subcontractors.

4.2.2 **The Consultant will engage with and present a PowerPoint presentation to community members in Fort Chipewyan for 2 community open-houses prior to field work on September 18 and 19** to inform the community about the work that they are undertaking and to learn from community members their desired outcomes, specific areas of interest with respect to water levels, insights on historical floods, and recommendations on structures that should undergo a feasibility assessment.

4.2.3 **The Consultant will participate in three knowledge gathering sessions as soon as possible considering the community and Consultant's availability;** one with each of the three PAD Indigenous communities. **The Consultant will subcontract local experts and Elders to share local knowledge at knowledge gathering sessions and meaningfully**

[2] ECCC has been in contact with certain suppliers and can provide information garnered to date on options discussed specific to the study area.

incorporate this information into the work, to the extent possible within the scope. The Consultant will provide a record of any notes, maps, or other products produced during these meetings to the respective community for validation and make any corrections prior to finalization. A data sharing agreement may be required, at the knowledge holder and community's discretion, to be finalized at least one week prior to the session. These expert (elders and/or land users) meetings are intended to provide:

- Site-specific pertinent local knowledge, such as specific locations to consider when assessing achievable water levels and information on how past and current control structures have influenced water levels; and
- Effects and timing of past open-water flood events in the (1) Mamawi Lake and connected Lake Claire and (2) Big Egg Lake and connected area, including key areas that were (or were not) flooded. This includes the rate of drainage and any impacts observed on plants or wildlife.
- Number of persons/day: Maximum of 10 persons/day

Current Western science related to elevation and topography data and mapping in the Peace-Athabasca Delta has not been completed. The Consultant will review historic flooding events as displayed on satellite imagery and coarse-level DEMs and outdated hydrological models that are no longer readily useable due to changes within the Peace-Athabasca Delta and with technology. The local knowledge provided by experts/elders who are local land users is critical as they can provide detailed information and observations that was observed at the time of historic flooding.

4.2.4 The Consultant will be **available in-person to address technical questions about the final report during a presentation by Parks Canada to the community in Fort Chipewyan.**

4.3 Conduct site investigations to collect site-specific data for design of temporary control structures

4.3.1 The Consultant will **conduct site assessment during the open-water season at the 3 identified locations (Dog Camp and Cree Creek; Big Egg Lake near community of Jackfish)**.

4.3.1.1 Perform an one day initial site reconnaissance trip by helicopter in conjunction with the community open house to gain an overview of each site, assess safety, and determine an a approach for collecting the required survey information during the field program. Aerial transportation will be provided by Parks Canada in kind.

4.3.1.2 Two boats will be required. Boat #1: boat and driver will be provided by Parks Canada or the Government of Alberta in kind. Boat #2: Facilitated by Canada (PSPC and/or Parks Canada), subcontract a local Indigenous person(s) or company with local knowledge of the area and of traditional sites of importance to serve as a boat guide to avoid navigational hazards when accessing the sites, and to provide on-the-ground and site-specific pertinent additional local knowledge, such as specific locations to consider when assessing achievable water levels (Section 4.4.1). The subcontractor**(s)** may also be used to supply and drive the boat to site. An Indigenous guide will also be required for Boat #1.

4.3.1.3 Collect detailed survey data, bathymetry data, and photos sufficient to assess the locations for implementation of the temporary control structures investigated in section 4.1.2, including information required to inform options for boat and fish passage.

4.3.1.3 Collect stage-discharge measurements at each site.

4.3.1.4 If possible, within time and budgetary constraints, survey for the base elevation of nearby structures to support an estimate of impacts to nearby property.

4.3.1.5 Provide the Preliminary e-mail report of field results, per the schedule.

4.4 Determine maximum possible areal extent of flooding

The work to be performed should be based on literature reviewed, surveyed data and Indigenous knowledge from site visits and knowledge gathering sessions, and taking into account the best available digital elevation data, geospatial data of historical open-water flooding (such as 1935 max historical, 1996) and associated water levels.

4.4.1 Based on the geography/ topography of the study areas, provide a reasonable estimate of the **maximum achievable water levels for the spring peak from implementation** of (a) temporary control structure(s) at the (1) Mamawi Lake and connected Lake Claire, and (2) Big Egg Lake and connected area. Show the areal extent of this maximum estimated flooding on a map.

4.4.2 Based on the geography/ topography of the study areas, provide a reasonable estimate of the **time it would take to drain water to minimum water levels in the fall after achievement of the maximum spring water level** at Mamawi Lake and connected Lake Claire from implementation of (1) a temporary control structure at Dog Camp and (2) a temporary control structure at Dog Camp plus a secondary structure at Cree Creek that limits inflow. Show a time-series of the areal extent of draining on a map under both scenarios.

4.4.3 **Include estimates of the influence on downstream flows/volumes** to be expected from holding back water and then releasing water, such that the impact to the Slave River are or can be inferred.

4.5 Evaluate the effectiveness of the temporary control structure options

4.5.1 **Estimate the flows to consider** when evaluating the effectiveness of the temporary control structures at withstanding conditions and at elevating water levels (for example, by conducting a frequency duration analysis of river flows, and determining the 5-year, 10-year and 100-year return flows). If possible, consider the additional influence of a strategic release of water from the Bennett dam, such as occurred in spring 1996.

To inform the estimate of flows, create a theoretical stage-discharge curve for example, by collecting discharge data and comparing them to the existing/ historical stations.

4.5.2 **Investigate and compare the effectiveness of different product types, configurations and locations of temporary control structures at holding back water under foreseeable operating conditions in the two areas.** For each scenario/configuration evaluated, present the maximum water level achievable plus reasonable estimates of the range of water levels and areal extents anticipated based on flows estimated in section 4.5.1.

a. Options for the **Mamawi Lake and connected Lake Claire** area include, but are not limited to:

    i. North section of Dog Camp structure: Installation of a temporary control structure at Dog Camp between the island and the north bank of the river (Figure 3);

    ii. North and south section of Dog Camp weir: Installation of a temporary control structure at Dog Camp between the island and the north bank of the river, and between the island and the south shore. (Figure 3);

    iii. Evaluate the influence, if any, of an additional structure at Cree Creek at Embarras River location (Figure 4) on the rate of fall drainage and the optimal configuration to achieve drainage objectives, should a structure be recommended. Include consideration of the influence on sedimentation rate into the Mamawi delta.

b. **Big Egg Lake** (ACFN Jackfish reserve):

    a. Investigate options for a temporary control structure(s) to retain water in Big Egg Lake to achieve the water level objectives for this site. This would include, but is not limited to, the natural levee low point between the restricted basin, Big Egg Lake, and the Athabasca River that was previously investigated for a permanent control structure (see PADTS, 1994 for specific location and previous work), (Figure 1, Figure 5).

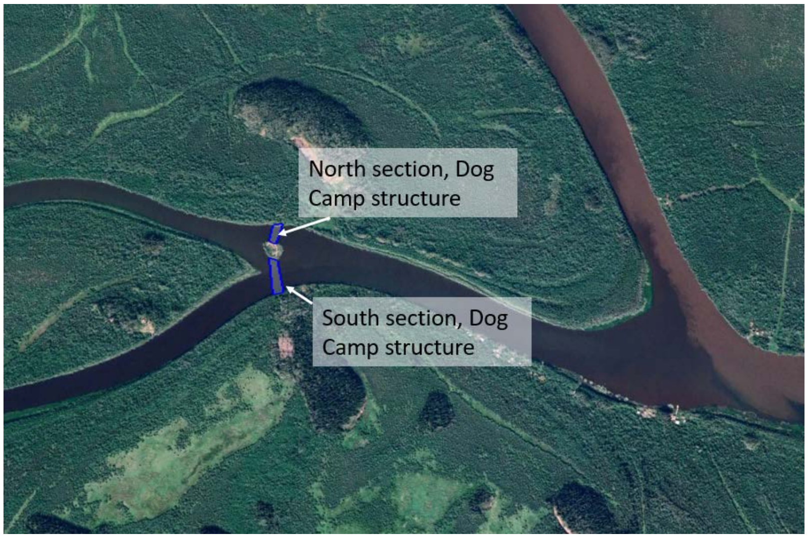


Figure 3. **Dog Camp weir configuration options, including north and south sections.**

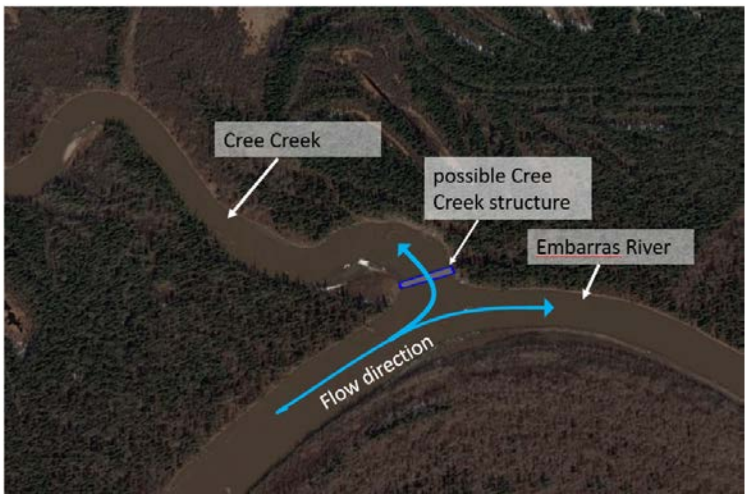


Figure 4. Possible Cree Creek structure location.

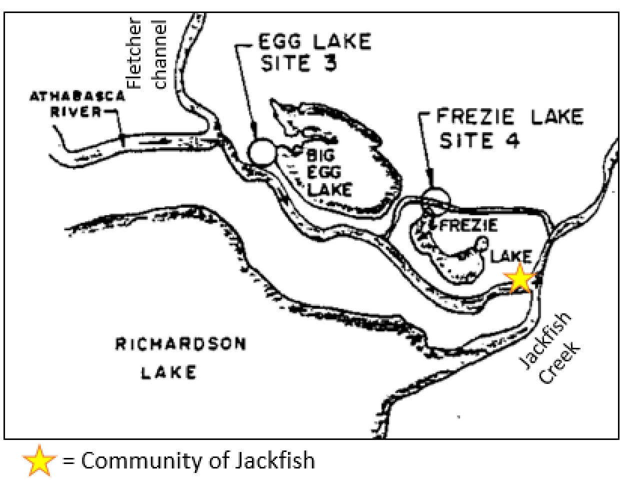


Figure 5. **Possible Jackfish Reserve structure locations from 1987 W-E-R report.**

4.5.3 **Provide the assessments of these scenarios/configurations in a written report to ECCC/PSPC to inform the decision on which should be selected to move to feasibility-level design.** This represents the submission of findings to date, draft results of scenarios for evaluating the effectiveness of the temporary control structures, and draft recommended structures and configurations in the schedule, below.

4.5.3.1 Provide the results both in detailed technical form, sufficient that results could be reproduced, and in the form of maps and possibly graphs, suitable to explain the results to non-technical audiences.

4.5.3.2 **Identify one or more of the most promising location(s), configuration, and type of control structure** for the (1) Mamawi Lake and connected Lake Claire [Dog Camp site], and (2) Big Egg Lake. Include consideration of optimizing low cost, maximizing durability and ease of installation (and removal, if appropriate), while ensuring functionality.

4.5.3.3 Provide ECCC with recommendations on which configurations should be considered to go to feasibility-level design. Within 2 weeks of receipt of this submission, ECCC will confirm which configurations to move to feasibility-level design phase.

4.6 Prepare technical feasibility level designs

4.6.1 **Prepare technical feasibility level design(s)** of the selected structure(s), including boat and fish passage(s). The level of detail provided should be adequate to inform a decision on whether to proceed with funding detailed design and construction. Designs should include, but are not limited to:

- **Drawings to indicate location, configuration, type, sizing (structure dimensions)**
- **site preparation, foundation, and if required, anchoring requirements**
- **recommended season(s) of deployment and removal (and rough installation/ removal schedule), and anticipated maintenance schedule**. Also assess site accessibility for installation work and ongoing operations, public safety and environmental impact considerations related to construction of temporary control structures
- **cost estimates for each design**, including materials, transportation to site, person hours for all installation and removal and operation.
- **potential impact of the proposed temporary water level increases on areas upstream and estimate downstream impacts both while water is being held back and when it is released (including an estimate of influence of flows on the Slave River, if applicable)**.

4.7 Produce a comprehensive feasibility plan report, and attend final presentation

4.7.1 **Document the feasibility plan process, input and results** (including feasibility plans and any results previously provided, as appropriate) **in a comprehensive report** that can be used as the basis for the detailed design/implementation phase of this project. The results from the Indigenous community sessions may be submitted separately, as determined during the course of the contract.

4.7.2 **Present draft report** the WBNP Environmental Flows and Hydrology Working Group for review and comment prior to finalization. Be available to answer questions either in-person in Edmonton or via webex.

4.7.3 **Attend, in-person, the Parks Canada presentation of the final report** (and the final report from the linked contract) **in Fort Chipewyan** and be available to answer technical questions related to the final report.

5. Scheduling and Reporting

5.1 Schedule

The Consultant will provide a detailed schedule for completion of contracted goals in order to meet the project timeline in their proposal submission. This schedule should include major project milestones such as a date for a Project Kick-off Meeting and a date for completion of field related activities.

The Consultant shall maintain the project schedule that is agreed upon with the PSPC Project Manager at the project initiation. The schedule will be in accordance with any necessary modifications agreed upon with the PSPC Project Manager.

The project schedule will adhere to the following milestone completion dates for this project:

Item	Timeline
Submission of Proposal	Within 10 days from receipt of Statement of Work
Kick-Off Meeting	Within one week of contract award
Submit Health & Safety Plan	1 week prior to travel
Submission of draft presentation material for Fort Chipewyan Community Meeting	At least 4 working days prior to Fort Chipewyan Community Meeting
Submission of final presentation material for Fort Chipewyan Community Meeting	At least 1 working day prior to Fort Chipewyan Community Meeting
Three (3) targeted knowledge gathering sessions in Fort Chipewyan, 1 per community	To be completed as early as possible, at the convenience of the communities. All notes, maps, records, etc. to be provided to the community for verification within 2 weeks of the session.
Community Open house presentations in Fort Chipewyan, Alberta	PowerPoint Presentation to the Fort Chipewyan community prior to site visit (field work). September 18 and 19, 2019. Same trip as the initial site reconnaissance visit.

Completion of Field Activities	The site visit (field work) must occur during open-water season (commencing no later than October 7, 2019).
Preliminary e-mail report of Field Results	Within 1 week of site visit, but no later than October 21, 2019
Submission of findings to date, draft results of scenarios for evaluating the effectiveness of the temporary control structures, and draft recommended structures and configurations (submission by email)	No later than November 8, 2019.
Mid-point Meeting to discuss draft results, and confirm proposed options to go to feasibility-level design	No later than November 15, 2019
Submission of Draft Report	January 6, 2020
Draft presentation of findings/ recommended structures to PSPC, ECCC, Task Team, and FPTI Committee in Edmonton or via webex	January 27, 2020
Submission of Feasibility Final Report	3 weeks following receipt of PSPC draft report review comments, but no later than February 17, 2020.
Attendance at Parks Canada meeting in Fort Chipewyan to answer technical questions related to the final report	Targeted February/March 2020.
Project Close-out Date/Final Invoice	Within 1 week of Parks Canada presentation in Fort Chipewyan and receipt of final report but no later than March 20, 2020.

Regarding the schedule, the Consultant is advised that a four (4) week period shall be included in the timetable at the end of the draft report submission to allow PSPC and ECCC to review and provide comments on the report, and to discuss any project adjustments. Once comments are received on the draft report, the Consultant must finalize the report and submit the report within three weeks.

A final report will incorporate PSPC/ECCC comments on the draft report. The Consultant will provide a spreadsheet with the final report identifying how every PSPC/ECCC comment has been addressed.

5.2 Project Management

A competent project manager on staff with the Consultant will be assigned to effectively manage this project on behalf of PSPC/ECCC. The project manager will oversee the communications, schedule control, and the overall quality of work.

The project manager will maintain regular contact with and submit progress updates to the PSPC project manager throughout the duration of the project including project status, budget updates and any factors which may influence the schedule, budget or deliverables.

The contact information for the PSPC project manager for this work is as follows:

Leslie Yasul
Senior Environmental Specialist
Public Services & Procurement Canada – Environmental Services & Contaminated Sites Management, Western Region
(780) 893-8665
leslie.yasul@pwgsc-tpsgc.gc.ca

The contact information for the ECCC project manager for this work is as follows:

Theresa Braat
Manager, Analysis, Relationships and Indigenous Affairs
Environment and Climate Change Canada
780-951-8610
Theresa.Braat@canada.ca

Lieserl Woods
Water Resources Specialist, Environmental Services
Environment and Climate Change Canada
(780) 951-8855
Lieserl.woods@canada.ca

5.3 Communication

A 1-hour project kick-off meeting is mandatory for the Consultant to attend and must be completed prior to the Consultant mobilizing to site. The meeting will discuss health and safety, schedule, logistics and issues for the field work. The *Consultant is responsible for taking meeting minutes and submitting the minutes to PSPC within 48 hours of the meeting.*

The Consultant shall maintain communications with the PSPC Project Manager throughout the contract. Copies of all correspondence shall be sent to them.

During the project the Consultant must provide updates to the PSPC project manager via email at least every two weeks including:

1. When the site visit travel is booked and for what dates.
2. Daily updates during field activities.
3. Weekly updates detailing the status of the project scope, schedule and budget will also be required. The Excel file for weekly updates will be emailed upon project award.
4. Within 1-week of completing the site visit provide an update on data results and how the project is progressing; and,
5. When any issues are encountered that may affect the project deliverables, schedule or contract budget.

A contact will be provided to the Consultant for them to use in the event that the PSPC project manager is unavailable during the field activities, if issues are encountered in the field and further direction and/or information is required. However, all other communication shall be directed to the PSPC Project Manager.

The Consultant's assigned project manager shall be responsible for the scheduled execution of the contract and coordination with the PSPC Project Manager. Changes to the designated project manager may be made only with prior approval from PSPC. The project manager shall have the experience and capability to be responsible for the overall supervision of work and serve as liaison between the Consultant and the PSPC Project Manager for all work required under this contract, unless alternate arrangements are agreed upon by both parties.

5.4 Reporting

Draft and final reports, incorporating any comments by PSPC PM, PCA and ECCC shall be issued no later than indicated in project schedule.

Draft Report:

- One electronic copy of the draft report in text recognized, non-password protected (unsecured) Portable Document Format (pdf).
- **Note: The draft report shall be submitted as if it were the Final report.** If PSPC determines that the report does not meet the objectives outlined in the TOR, the Consultant will be responsible for revising the draft report until it is satisfactory with no additional costs incurred to the Crown. Justification for any draft report comments that cannot or will not be addressed by the Consultant in the Final report must be provided to in writing and discussed to the satisfaction of PSPC prior to submission of the Final report.

Submit to PSPC Project Manager electronically along with the Comment Tracking Table (Appendix D) to identify questions for PSPC and the Client and to demonstrate how comments from PSPC and the Client were addressed.

5.5 Deliverables

- A start-up meeting will be held between PSPC/ECCC and the Consultant within one week of the issuance of the task authorization. The Consultant will provide the work plan submitted in their proposal for review at this meeting. The work plan should include a matrix illustrating the number of days/hours planned for each member of their team. They will also review all tasks related to the execution of the project, indicate the individuals who will be conducting the work and agree on milestone dates and deliverables.

- A written report of the field program initial results will be provided and presented to PSPC/ECCC.

- Reporting on each of the Indigenous knowledge sessions as described in the scope of work.

- A written report of the options assessment, results to date, and recommendations to proceed to feasibility-level design will be provided to ECCC prior to proceeding to feasibility-level design.

- Project deliverables will include one electronic copy of the draft report and 11 USB sticks of the resultant Final report, and one electronic copy of the final presentation to the FPTI Committee and Task Team. The Final copy will be sent electronically to the Project Manager over secure FTP. The final report(s) and products from the Indigenous knowledge gathering sessions will be provided as one electronic copy. The inclusion or not, of these reports in the final report will be determined prior to finalization of the draft report.

  The Consultant will provide PSPC/ECCC with the following documentation in English:
  - 14 USB sticks of the summary report, and final report in Microsoft Word and PDF formats;
  - A full listing and provision of reference materials/bibliography and data sources;
  - All pictures, aerial photographs, datasets and electronic worksheets/models developed to support the analysis in their native format in the table below

Report Component	*Requested Native File Type*
Pictures	.jpeg
Video	Files compatible with Windows Media Player
Figures	.jpeg and/or Adobe .pdf
Tables	Microsoft Excel - .xls
Maps	1. Shapefiles suitable for use in ArcGIS such as .shp, .shx,.dbf; and 2. CAD files such as .dwg (for MSC)
Report text	Microsoft Word - .doc

5.6 Health and Safety

The Consultant shall be responsible for making all employees, other Consultants and subcontractors and anyone at the site aware of safety hazards, and shall ensure the health and safety of all personnel at the site. Accordingly, for all site assessments a Health and Safety Plan shall be developed one week prior to the site visit, and then implemented by the Consultant during the field activities.

The Consultant shall ensure that all relevant safety policies, guidelines, and emergency response actions are reviewed with site personnel and that the Health and Safety Plan is easily accessible to staff during all field activities.

6. Special Requirements

6.1 Consultant Services and Responsibilities

The Consultant shall perform all work required to for this project. All work shall be performed in an environmentally acceptable manner conforming to existing applicable Federal and Provincial regulations and guidelines. The Consultant shall furnish all services, labor, materials, supplies, and equipment required to conduct the scope of work.

The Consultant shall have responsibility for the complete effort specified in the contract.

The Consultant is responsible for the professional quality, technical accuracy and timely completion and submission of all deliverables, services or commodities required to be provided under the contract.

The Consultant shall, without additional compensation, correct or revise any errors, omissions, or other deficiencies in its deliverables and other services. The approval of deliverables furnished under this contract shall not in any way relieve the Consultant of responsibility for the technical adequacy of its work.

The review, approval, acceptance or payment for any of the services shall not be construed as a waiver of any rights that TC/PSPC may have arising out of the Consultant's performance of this contract.

6.2 Confidentiality

It is understood and agreed that the Consultant shall, during and after the effective period of this contract, treat as confidential and not divulge, unless authorized in writing by the PSPC Project Manager, any information obtained in the course of the performance of the ensuing contract. Refer any queries regarding this project from the public, news media or other to the PSPC Project Manager.

6.3 Ownership of Material

Without affecting any existing intellectual property rights or relating to information or data supplied by Canada for purposes of the contract, copyright in anything conceived, developed, or produced as part of the Work under the contract will belong to the Crown.

To be explicit, all Traditional Knowledge and Traditional Use Information provided for the purposes of this work remains the exclusive intellectual property of the indigenous communities that provided it and that delivery or disclosure of Traditional Knowledge and Traditional Use Information will give the Crown no right or interest in the Traditional Knowledge and Traditional Use Information.

The Statement of Limitations in the Final report shall not contradict PSPC General Conditions.

6.4 Data Confidentiality

All financial, statistical, personnel and/or technical data supplied by PSPC/ECCC to the Consultant are confidential. The Consultant is required to use reasonable care to protect the confidentiality of such data. Any use, sale or offering of this data in any form by the Consultant, or any individual or entity in the Consultant's charge or employ, will be considered a violation of this contract and may result in termination.

6.5 News Releases

The Consultant is not permitted to issue news releases or speak to the Media pertaining to any aspect of the services being provided under this contract without prior written consent of PSPC and ECCC.

6.6 Budget Updates and Contract Amendments

At the completion of the project once the final invoice is received and processed, the Consultant shall submit an amended TAPF for the site to reflect project actuals.

6.7 Method of Payment

All invoices must be submitted to the PSPC Project Manager on a monthly basis. The final invoice shall be submitted on the same date as the final report.

The consultant is required to fulfill all responsibilities required to receive payment for the work. This includes the completion of a statutory declaration form. The statutory declaration form shall be signed on or after the date of the final invoice and shall be submitted on the same date as the final report and final invoice. The statutory declaration form is provided to the Consultant as part of the ToR package (Appendix D).

It is the responsibility of the Consultant to retain and provide receipts for all disbursements if requested. These receipts are to be included in the monthly invoice immediately following the travel. All travel shall be invoiced as per the Federal Travel Directive: http://www.njc-cnm.gc.ca/directive/d10/v10/s90/en#s90-tc-tm

Note: Consultant fees for the feasibility-level drawings and any consultant fees, travel and disbursements for the community engagement activities and field work including contractor time, materials, and Indigenous subcontractors related to this Project (R.106569.001) will be invoiced and charged to the "Riviere des Rochers Little Rapid Weir & Revillon Coupé Structure Survey – 2019" (R.106570.001). The intent is that field work and community meetings for both projects would occur concurrently.

6.8 Project Close Out

As per the Standing Offer Agreement, the Consultant is required to complete a Statutory Declaration form at completion of the task authorization. A copy of the form has been appended in Appendix B to the TOR.

7. Submission of Proposal

Proposals are to be forwarded to the PSPC Project Manager via email (.pdf format) as follows:

PSPC Project Manager

Leslie Yasul
Senior Environmental Specialist, Western Region
leslie.yasul@pwgsc-tpsgc.gc.ca / Tel: 780-893-8665

The project proposal shall be received no later than **August 2, 2019.**

The proposal will include the following information:

- Project scope and objectives.
- A description of the Consultant's overall approach that will ensure the objectives of the project will be satisfied cost effectively.
- Proposed project schedule presented in a table and Gantt chart format. The schedule must include critical path(s) and a timeline for all milestones, tasks, deliverables, meetings, travel, etc. The project schedule should be provided in a template that allows updating throughout the project.
- The proposed methodology to be used to meet the requirements as described above.
- The personnel to be assigned to the project including name, qualifications and experience and their individual roles and responsibilities within the project. <u>There shall be no substitutions to the project team unless written approval to do so is granted by the PSPC Project Manager before the substitution is used.</u>
- Work to be subcontracted must be specified at the time of the proposal. Background information such as company profile and past working relationship must be provided.
- The Consultant shall prepare a cost estimate and timetable outlining the relative cost and timing for all project tasks. The budget shall be organized as estimated fees and disbursements on a task basis using unit rates in accordance with the existing standing offer agreement. Three cost estimate tables are required as follows:
    - Table 1 - A total cost estimate for completing the entire project must be provided divided into tasks.
    - Table 2 – A cost estimate for all travel disbursements.
    - Table 3 – A cost estimate for all other disbursements
- The cost estimate shall include the Consultant fees and travel disbursements for the community engagement activities and field work related to the Feasibility Plan for Temporary Control Structures on Mamawi Lake in the Peace-Athasbaca Delta (R.106569.001) since the intent is that field work and community meetings for both projects would occur within the same trip. See that project's Terms of Reference for further details.
- **Note:** The *Task Authorization Proposal Form* (TAPF) will be forwarded to Consultant to be completed once the proposal and budget tables have been accepted.
- Price back-up documentation for disbursement items for which the total value exceeds $5,000.00 (GST included) must be provided with the TAPF.

It is the responsibility of the Consultant to retain and provide receipts for all disbursements if requested.

7.1 Coordination with the "Feasibility Plan for Removable Control Structures on Mamawi Lake in the Peace-Athabasca Delta" project

The contract for the "Rivière des Rochers Little Rapid Weir & Revillon Coupé Structure Survey" (R.106570.001) will be awarded concurrently with this contract to the same Consultant who must be capable of fulfilling requirements stipulated in each contract. Proposals should be submitted bearing this in mind. All field work, consultations and community meetings in Fort Chipewyan should be scheduled coincidentally to minimize costs, at the convenience of the communities.

8. List of Appendices

Appendix A - Weekly Update Reporting Form (To be submitted to PSPC on a weekly basis)

Appendix B – Statutory Declaration Form (To be notarized and submitted to PSPC with the final invoice)

Appendix C – Task Authorization Proposal Form (To be submitted to PSPC with the proposal package)

Appendix D – Comment Tracking table (to be submitted with any revisions to the report)

Appendix E – References (Available on BIM360 Site)

Appendix F – Details on past and current water control structures

Appendix E. References

<u>**Required for Review:**</u>

1. Golder. 2012. Jack Pine Mountain Expansion Project Appendix 3.4 Peace-Athabasca Delta Assessment.
    - Section 3.0 (Hydrology) pp.6-20 includes flow statistics, water level, differences in flow statistics pre- and post-Bennett dam, changes from water withdrawals on water level on the Athabasca River delta and more.
    - Attachment A includes hydrological baseline information

2. Aiken, B. and Sapach, R. 1994. Northern River Basin Study Project Report No. 43, Hydraulic Modelling of the Peace-Athabasca Delta: Under Modified and Natural Flow Conditions. Report. Published by the Norther River Basin Study, Edmonton, Alberta.

3. Candler, Craig and Rachel Olson, Steve DeRoy and the Firelight Group Research Firelight Group Research Cooperative, with the Mikisew Cree First Nation, 2010. As Long As The Rivers Flow: Athabasca River Use, Knowledge and Change, MCFN Community Report, August 16, 2010.
    - Indigenous navigation routes in the PAD, instances of lost access, cultural importance of the PAD.

4. Peace-Athabasca Delta Implementation Committee (PADIC) 1987c. McPhail, G.D. 1986. Peace-Athabasca water management works evaluation, final report. Appendix C. Ancillary Studies. *A technical feasibility study of the Quatre Fourches control structure in the Peace-Athabasca Delta*. Report.
    - Feasibility study for a control structure at the Dog Camp location. Not implemented.

5. Peace-Athabasca Delta Technical Studies (PADTS). 1994. Big Egg Lake Control Structure Project. Task H.1 – Alternative Remediation. Alberta Environmental Protection. Edmonton, AB.
    - Control structure study for Big Egg Lake on the Jackfish reserve. Not implemented.

6. Fort Chipewyan Indian Reserve No. 201 Water Management Control Structures Feasibility Report. 1987.
    - Feasibility report for permanent control structures in the Jackfish reserve for several locations.
7. Chipewyan IR 201 Big Egg Lake Site Specifications 1995.
    - Schedule D provides detailed drawings that reference Big Egg Lake in the ACFN Jackfish reserve 201. Not implemented.

Provided as references:

There is a considerable amount of published information on water management in the PAD. While most of this information is not explicitly germane to the work described herein, it is assumed that high-level background data are contained in the following documents, to be provided to the Consultant. In their proposal, the Consultant shall provide a list of any additional information that they will require to be provided prior to commencement of the assignment.

1. Beltaos. 2018. The 2014 ice-jam flood of the Peace-Athabasca Delta: Insights from numerical modelling. *Cold Regions Science and Technology* **155**, 367-380.

2. Independent Environmental Consultants. 2018. FINAL REPORT: Strategic Environmental Assessment of Wood Buffalo National Park. Markham, ON.

3. Peace-Athabasca Delta Implementation Committee (PADIC) 1987c. Garner, L. A., & Fonstad G. D. 1986. Peace-Athabasca water management works evaluation, final report. PADIC, under the Peace-Athabasca Implementation Agreement. Appendix C. Ancillary Studies. *Assessment of Creed Creek diversion*. Report. Alberta Department of the Environment, Water Resources Management Services, Technical Services Division, River Engineering Branch.

4. Peace-Athabasca Delta Implementation Committee (PADIC). 1987a. Peace-Athabasca Delta Water Management Works Evaluation – Final Report – A report prepared under the Peace-Athabasca Delta Implementation Agreement. Canada, AB and SK.

5. Peace-Athabasca Delta Implementation Committee (PADIC). 1987b. Peace-Athabasca Delta Water Management Works Evaluation – Appendix A – Hydrological Assessment. Canada, AB and SK.

6. Peace–Athabasca Delta Project Group (PADPG). 1973. Peace–Athabasca Delta Project, technical report and appendices. Vol. 1, Hydrological Investigations; Vol. 2, Ecological Investigations.

7. Peace-Athabasca Delta Technical Studies newsletter. 1995.

8. Peace-Athabasca Delta Technical Studies (PADTS), Peterson, M. 1993. Artificial Ice Jam 1992-93 Field Report – Task F.3 – Artificial Ice Strategies. Parks Canada, Fort Chipewyan, AB.

9. Peace-Athabasca Delta Technical Studies (PADTS), Wilson, E. 1995. Artificial Ice Dam 1994-95 Field Report – Task F.3 – Artificial Ice Strategies. Parks Canada. Ft. Chipewyan, AB.

10. Peace-Athabasca Delta Technical Studies (PADTS). 1996. Final Report. Parks Canada. Ft. Chipewyan, AB.

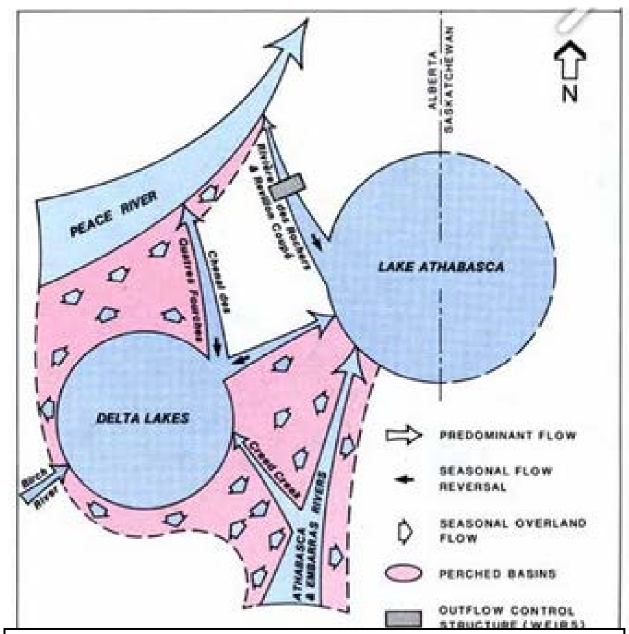
11. Peters, D. 2003. Controls on the Persistence of Water in Perched Basins of the Peace-Athabasca Delta. PhD. Thesis. Trent University. Ontario, Canada.

12. Peters, D. Prowse, T.D., Pietroniro, A., Leconte, R. 2006. Flood hydrology of the Peace-Athabasca Delta, northern Canada. *Hydrological Processes* **20**, 4073-4096.

13. Townsend, G. H. 1982. On Selecting a Control Structure for the Peace-Athabasca Delta. Canadian Wildlife Service, Western and Northern Region.

Excerpt from Lake Athabasca section of the Atlas of Alberta Lakes (available online: http://albertalakes.ualberta.ca/?page=lake&region=1&lake=18)

“Lake Athabasca is drained by Rivière des Rochers and its distributary, Revillon Coupé, which carry most of the outflow. Smaller volumes flow from the lake through Chenal des Quatre Fourches. These three rivers join the Peace River to form the Slave River.



Reproduced from the Atlas of Alberta Lakes Figure 1 of Lake Athabasca section.

Mamawi Lake, to the west of Lake Athabasca, is also drained by Chenal des Quatre Fourches. The volume of water leaving Lake Athabasca via Rivière des Rochers, Revillon Coupé and Chenal des Quatre Fourches is partly dependent on the water level in the Peace River. The predominant direction of streamflow in the three channels is northward, toward the Peace River (Figure 1). During spring or summer flooding, however, flow reversals in the channels can occur when the elevation of the Peace River exceeds the elevation of Lake Athabasca. This results in reversed flows in Rivière des Rochers, Revillon Coupé and Chenal des Quatre Fourches. As well, flow reversals can occur between Lake Athabasca and the delta lakes. At these times, strong easterly winds cause water from Lake Athabasca to flow west into the southwestern arm of Chenal des Quatre Fourches and then into the delta lakes rather than north into the Peace River (PADIC 1987). When inflow from the Athabasca River to Lake Athabasca is high during spring and summer, an estimated 80% to 90% of the lake's outflowing water originates from the Athabasca River (Neill et al. 1981). During fall and winter, more of the outflow originates from the main body of the lake.

The drainage network of the delta is made up of open drainage and perched basins. The open drainage network is an interconnected system of lakes and streams. Its extent is related to water levels in the delta. Perched basins, which have surface levels higher than the surrounding water table, are located between the open-water drainages. They are separated from groundwater by impermeable beds, so their existence depends on flooding. The topography of the delta is quite flat, so minor changes in water levels can cause either extensive flooding or drought (PADIC 1987): In the mid-1960s, the Government of British Columbia created Williston Lake by constructing the W.A.C. Bennett Dam on the Peace River. The resulting low water levels downstream threatened the ecological balance in the Peace-Athabasca Delta when annual floods did not occur. In 1971, the governments of Canada, Alberta and Saskatchewan established the Peace-Athabasca Delta Project Group to evaluate methods of raising water levels in Lake Athabasca and the delta lakes (PADPG 1973). In the fall of 1971, a temporary rockfill dam was constructed on the southwestern arm of the Chenal des Quatre Fourches, near Mamawi Lake. On recommendation of the Peace-Athabasca Delta Project Group, the three governments signed the Peace-Athabasca Delta Implementation Agreement. The agreement gave high priority to conservation of the Peace-Athabasca Delta and the governments agreed to jointly construct control structures on Rivière des Rochers and Revillon Coupé.

In 1974, the temporary control structure on Chenal des Quatre Fourches was severely damaged by flooding. It was removed in 1975, and during 1975 and 1976, permanent control structures were built on Revillon Coupé and Rivière des Rochers (PADIC 1987). In order to allow movement of boats past the weir on Rivière des Rochers, a tramway was built in 1976 and upgraded in 1986. The tramway operates during the open-water season and is maintained by Alberta Environment. The success of the two weirs in restoring water levels in the delta and the effect of the weirs on the delta's biological community were evaluated during 1983 and 1984 by the Peace-Athabasca Delta Implementation Committee (1987). It was concluded that, although the weirs did not reproduce natural conditions, they had nearly restored peak summer water levels in the delta and had successfully counteracted many of the hydrological changes in the delta caused by regulation of the Peace River by the Bennett Dam. The weirs did not affect water levels in the Peace River, so the perched basins that relied on flooding from the Peace River were lost. “

Appendix F. Detailed scope of work for guidance

F.1 Details of past studies and water management actions at <u>Dog Camp</u> (Quatre Fourches)

<u>West Arm of Quatre Fourches Rockfill Dam</u>:

- Extremely low water levels were experienced in the Peace Athabasca Delta in the 3 years immediately following 1967 as the Williston Lake reservoir was filled, raising concerns about environmental effects of the Bennett Dam on the PAD, and leading to establishment in January 1971 of the Peace-Athabasca Delta Project Group (PADPG), a joint Canada-Alberta-Saskatchewan government committee. The committee was authorized to study the water level regime and associated problems, and to propose mitigating measures. The PADPG published its findings in 1973. The main findings were that regulation of the Peace River was causing a lower water level regime in the PAD, and that this was detrimental to the local bio-physical environment, with adverse effects on the socio-economic condition of the local people. The final recommendation was for two structures: a weir on the Rivière des Rochers and a control structure on the Revillon Coupé.
- As a preliminary measure, a temporary rockfill dam was built in the fall of 1971 on the West Arm of the Quatre Fourches River, which serves as the outlet of Mamawi Lake. The purpose of the dam was to raise the water levels in Lake Claire and Mamawi Lake and to refresh the adjacent perched basins.
- The West Arm of Quatre Fourches rockfill dam was an interim solution to the problem of low water levels. The effect of this dam, combined with the exceptional floods of 1972 and 1974, resulted in the highest water levels experienced on the Mamawi lake and Lake Clairesince construction of the Bennett Dam. In its 1973 assessment of the structure, the PADPG concluded that this type of structure was not suitable as a permanent solution because it would only control water levels in 60% of the PAD, and should be removed. It was predicted that this structure would reduce the flushing action required to maintain the chemical quality of the Delta lakes and would form a barrier to fish spawning migration. It would neither duplicate the timing and amplitude of the natural PAD water regime nor alleviate low water levels in Lake Athabasca, in the ACFN Reserve and in the marshes outside of Wood Buffalo National Park.
- The structure was severely damaged during a flood in early May 1974. In the fall of 1975/winter 1976, following completion of permanent weirs on Rivière des Rochers and Revillon Coupé, this structure was removed. Despite limitations to regulation at the Mamawi Lake outlet, the site was considered for a permanent gated control structure subsequent to the PADPG studies.
- Townsend (1982) highlighted the importance of seasonal fluctuations of water levels in the PAD to maintain its flora and fauna, especially the abrupt spring flooding and rapid drawdown of water levels in the fall. When the West Arm of the Quatre Fourches River was blocked off, resulting in prolonged summer and fall flooding, negative impacts resulted on meadow communities, emergent aquatic vegetation at lower elevations, and to muskrat through their dependence on aquatic emergent for food. If the meadows remain flooded during freeze-up, they become unavailable for foraging by bison in winter. Water level fluctuations are equally important for staging habitat for waterfowl.

- The submerged rockfill weirs on Rivière des Rochers and Revillon Coupé are still in place, and while they have generally restored peak annual water levels on the large delta lakes, they have also raised mean and minimum water levels, and attenuated the ecologically-dependent seasonal water level fluctuations (PADIC 1987).

West Arm of Quatre Fourches Gated Control Structure Feasibility Study:

- In 1984, the Fort Chipewyan Hunters and Trappers Association expressed concerns to the PADIC about the drying up of the perched basins surrounding Lake Claire and Mamawi Lake. PADIC in turn requested Agriculture Canada, Prairie Farm Rehabilitation Administration (PFRA) to examine the technical feasibility of constructing a permanent gated control structure on the outlet channel of Mamawi Lake.
- The purpose of the structure was to manage water levels in Lake Claire and Mamawi Lake to their natural hydrological regimes. Recharging these lakes to their natural regime would recharge the perched basins surrounding these lakes. The study included a review of background information, a feasibility level design and cost estimate, and an evaluation of the impacts of the structure on the water levels of the Delta lakes (PFRA, 1986).
- While the Rochers and Coupe weirs increased water levels in Mamawi Lake compared to having on the Bennett dam in place, the fluctuations are not as great as under natural conditions (Figure F1). As noted above, the weirs also do not function to flood the perched basins, which was the concern raised at the time, and which remains today.
- As noted in the Peace-Athabasca Delta Technical Studies Final Report (1996), the design was never implemented as it was determined that while such a structure could restore peak water levels in Lake Claire and Mamawi Lake, it could not restore the equally important low fall and winter water levels because of the effects of the existing Revillon Coupé and Rivière des Rochers weirs.
- The final PADIC summary report (1987a) concluded that "If the capacity of Creed Creek continues to increase as it presently appears to be doing, the comparative water level simulation showed that a control structure on the Quatre Fourches Channel would not restore the hydrologic regime of the Delta Lakes to natural conditions as the outlet channel of Mamawi Lake appears to have insufficient capacity to release the additional water [...] Any control structure which further delays the outflow would only increase the difference between the existing and natural hydrologic regime. […] The effectiveness of any gated control structure built on the Quatre Fourches outlet channel of Mamawi Lake would be determined by operation of the gates. If the structure is built in the future, a model will have to be developed to predict water levels so that the control structure can be operated to achieve desired target levels."

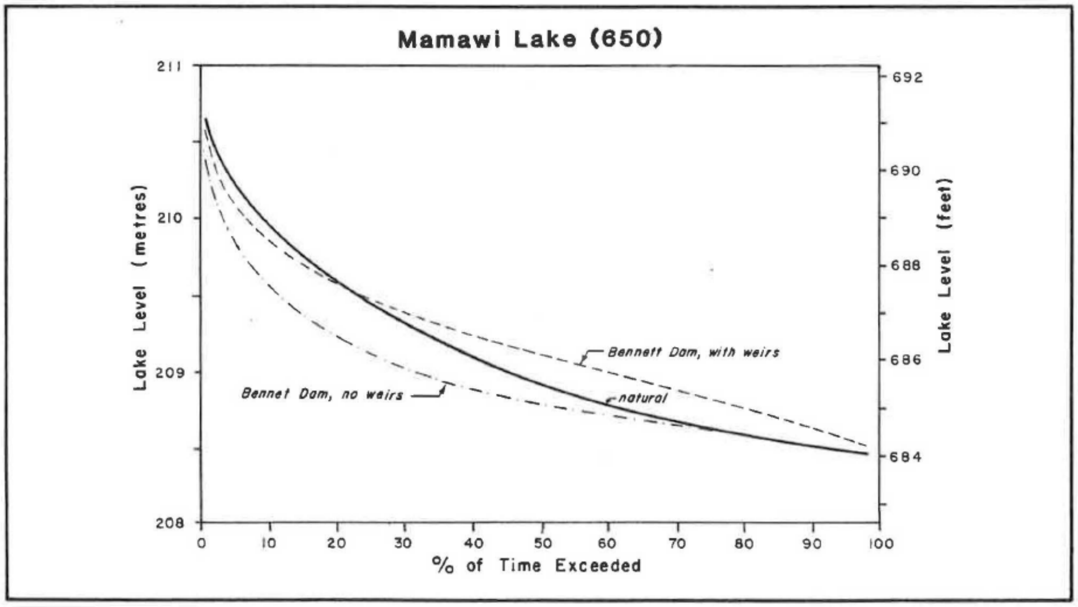


Figure F1. Mamawi Lake water level frequency-duration curves (PFRA, 1986). Note how the natural condition has the steepest curve, reflecting greater variability in seasonal fluctuations.

<u>Temporary Ice Dams on West Arm Quatre Fourches</u>:

- In the effort to raise water levels in Lake Athabasca, ice dams were first investigated to block the Rivière des Rochers at Little Rapids by using cryopiles to create an ice mass in January and keeping it frozen until after break-up. Field tests were conducted in 1972 (PADPG 1973), however that method was not considered feasible and not pursued.
- in 1993 the Governments of Canada and Alberta, BC Hydro and Power Authority, the Mikisew Cree First Nation, the Athabasca Chipewyan First Nation, and the Fort Chipewyan Metis Association signed a Memorandum of Understanding to establish Peace-Athabasca Delta Technical Studies to study the effects of regulation and climate variability on river flows and hydrological processes of the PAD, particularly related to flooding of perched basins.
- The initial testing of inducing artificial ice jamming was done on the north branch of the Quatre Fourches River in the winter of 1993. A late start to building up ice and a thermal break-up of ice in the spring resulted in no significant ice jamming (Peterson 1993).
- One of the experiments stemming from this research included a temporary ice dam that was constructed at Dog Camp in the winter of 1994-1995. The objective of this seasonal ice dam was to restrict the exit of the spring flow that enters Mamawi Lake from the Athabasca River, the Birch River and other minor tributaries and to elevate water levels in Mamawi Lake and Lake Claire. This would then increase the probability of flooding the basins that are hydraulically connected with these lakes (Wilson, 1995).
- Ultimately, the ice dam was unsuccessful at producing a flood due to a mild winter, low water levels, and minimal spring runoff, resulting in a thermal break-up of the ice; no further attempts to create temporary ice dams ensued (Wilson, 1995).

F.2 Details of past study at Big Egg Lake on the ACFN Jackfish Reserve

- Water control structures have been investigated several times for the Big Egg Lake on ACFN reserve 201 (Jackfish reserve). Although the Big Egg Lake control structure went to fairly detailed design, it was not implemented. The original investigation in 1987 (W-E-R Engineering Report) includes the Big Egg Lake site; the 1994 PAD Technical Study focuses on the Big Egg Lake site. The Chipewyan IR 201 Big Egg Lake Site Specifications schedule D provides drawings for Big Egg Lake site, plus an updated cost estimate at the time.

F.3 Hydraulic Models of the Delta Lakes

- Currently, due to changes in the delta and technology, there is no readily usable hydrodynamic model to simulate water levels in this portion of the PAD; however historical satellite images of past flooding are available and so are coarse-level DEMs such as the SRTM data available for download from the USGS with an approximate 30m x 30 m horizontal resolution and a 1 – 10m vertical resolution. Indigenous knowledge will be a key component in understanding past flooding impacts.
- Two previous hydrodynamic models of the PAD exist. The 1972 Stanley model, which treats the delta lakes and channels with Lake Athabasca as a single water body, informed the selection and design of the Rivière des Rochers and Révillon Coupe weirs. The other model was the PAD Implementation Committee's 1-D hydrodynamic model, which described varied water levels in the PAD's network of lakes and channels, with and without the Rivière des Rochers and Révillon Coupe control structures, and assessed the effects of these structures on water levels in the PAD (PADIC 1987a, 1987b).
- As part of the PFRA's Technical Feasibility Study of the Quatre Fourches Control Structures (PFRA 1986), PFRA modified the 1-D PADIC model to simulate storage in perched basins and to simulate the 1982 breakthrough diversion of Embarrass River water to Lake Mamawi through Creed Creek (PADIC 1987b).

APPENDIX B
SITE PHOTOS

Photo B1 **Aerial view of proposed water control structure site at Dog Camp looking west towards Mamawi Lake. Cabins can be seen on the north bank (right side of photo).**

Photo B2 **Aerial view of proposed water control structure location at Dog Camp looking north towards cabins.**

Photo B3 North side of rock island at Dog Camp site.

Photo B4 North bank of the Quatre Fourches west arm showing remnants of the rockfill weir/embankment removed in 1975 behind the vegetation.

Photo B5 Quarry used to source material for the rockfill weir/embankment constructed at Dog Camp in 1971.

Photo B6 Cabin on the south channel between Dog Camp and Mamawi Lake.

Photo B7 **Cabin on the south channel between Dog Camp and Mamawi Lake.**

Photo B8 **Cree Creek divergence to Mamawi Lake (left side of photo) from the Embarras River (right side of photo). View is looking northeast.**

APPENDIX C
HEALTH AND SAFETY SUMMARY

Project Number 1005092/1005166

NHC Field Safety Plan

Date 16-20 September 2019

This plan must be completed and reviewed at an on-site (tailgate) meeting with all on-site personnel prior to the start of work and placed on the dash of the vehicle or other prominent location.

Project Name:	**Client:**	**NHC Project Manager and Phone #:**
Little Rapids/Revillon Coupe Weir Surveys and Feasibility Plan for Removable Water Control Structures	SLR Consulting (Canada) Ltd.	Gary Van Der Vinne 587-759-7518

NHC Field Crew:

Name:	**Field Phone:**	**Home Phone and Contact:**
Gary Van Der Vinne	780-920-2978	

Location Description:		**Coordinates:**
Fort Chipewyan and Peace-Athabasca Delta Area		N58.71, W111.15
NHC On-Site Phone:	**Crew Accommodation & Phone #:**	**Crew Vehicle/Transportation:**
780-920-2978	Parks Canada House	
Other Communication Devices:		

Check-In

NHC Contact Name:	**Contact Number:**	**Check-in times*:**
Robyn Andrishak	780-913-6122	6 p.m. or end of working day

Remember: emergency response procedures will be implemented if crews do not call in within 1 hour of check-in time.
Emergency response will:

1. call field crew contact numbers
2. if no contact call field crew hotel
3. *if still no contact call field crew's home contacts*
4. *if still no contact a helicopter and/or emergency crew will be sent to crew's last known location.*

On-Site Emergency Contacts

Landowner/Operator		**Is 9-1-1 Available:**
Name:	**Phone:**	☐ Yes ☐ No
Other On-Site Supervisors (client/contractors)		**Other authorities or on-site numbers:**
Name: Stuart Macmillan (Parks Canada)	**Phone:** 867-872-0047	Blue Eyes Simpson (780-697-3662)
Fire: 911	**Ambulance/Emergency Transport:** 911	**Police:** 911

First Aid

Qualified First-Aid persons on site:	**Site Safe Area located:**	**Nearest Hospital/Medical Facility located:**
		Fort McMurray
Safety Bag/First-Aid kit located:	**Fire Extinguisher located:**	**Other Safety Equipment:**

Remote Site Access (if multiple locations use separate page to list trips)

Mode of Transportation:	**Make/Model or Registration #:**
☐ Boat ☐ ATV ☐ Argo ☐ Snowmobile ☒ Other	Helicopter TBD

Revised May 1, 2019 1 of 4

Project Number 1005092/1005166	**NHC Field Safety Plan**	Date 16-20 September 2019

Field Hazard List

Mark all hazards that apply to this job and list the item numbers in the hazards column on the next page

Vehicle
1. Traffic
2. Parking on road
3. Animals on road
4. Road conditions
   a. Rain
   b. Ice / Snow
   c. Wind
5. Visibility
   a. Sun
   b. Fog / Smoke
   c. Night
6. Driving alone
7. Tire condition
8. Towing trailer
   a. Hook Up
   b. Lights
   c. Backing up
9. Long distance
10. Fatigue
11. Breakdown

Helicopter
12. Helicopter rotors
13. Crashes
14. Noise

River Work
15. River Swim (snorkel)
16. Swift Water
17. Obstacles
18. Deep water
19. Rapids
20. Hidden entrapments
21. Ice floes
22. Low-head Dams
23. Underwater cables
24. Bridges
25. High Waves
26. Tides / currents
27. Sudden Winds
28. Drowning

Boat
29. Rope entanglement
30. Engine problems
31. Slip /Trip

ATV/Snowmobile
32. Slippery
33. Flying debris
34. Breakdown
35. Steep grades
36. Mud (deep and sticky)
37. Loading trailer

Site
38. Tripping hazards
39. Slippery slopes
40. Ice
41. Overhead Power
42. Overhead hazards
43. Falling rocks
44. Heavy lifting
45. Visibility
46. Noise

Tools/Equipment
47. Batteries (12V)
48. Chainsaw
49. Ice Auger
50. Winch
51. Propane Cylinders
52. Gas Cans

Weather
53. Lightning
54. Cold
55. Hot
56. Rain
57. Snow
58. Sleet
59. Sun
60. Wind

Environmental
61. Gasoline /oil spills
62. Litter

Animals
63. Bears
64. Rattle Snakes
65. Cougars
66. Dogs
67. Insects

Human
68. Hunger
69. Fatigue
70. Dehydration
71. Hypothermia
72. Heat stroke
73. Insufficient training

Other

Remember: "Stop & Think" & "See It Again for the First Time".

Project Number
1005092/1005166

NHC Field Safety Plan

Date
16-20 September 2019

Field Hazard Assessment

Identify the tasks and hazard numbers below, prioritize by risk and probability (eg. 2B) and identify the plans to eliminate/control the hazards.

Risk Rankings

1. Life Threatening
2. Serious injury or damage
3. Minor injury or damage
4. Negligible
5. Not Applicable

Probability Rankings

A. Very probable
B. Reasonably probable
C. Remote
D. Extremely remote

Task	Hazard #	Rank	Plans to Eliminate/Control Hazard
Helicopter reconnaissance	12, 13, 14	1C	**Refer to SWP 3.2.7 and SJP 4.7 – Helicopter Operations.** Obtain briefing from pilot and comply with all requirements of their safety protocols and procedures. If the weather is unfavourable, postpone or cancel the flight if recommended by the pilot.
Walking on uneven terrain; near river banks/slopes	38	3A	**Refer to SWP 3.8.2 and SJP 4.13 – Working on Hills and Slopes / Working near Water.** Walk and keep a close eye toward ground; check for uneven footing, debris, obstacles. Maintain a safe distance from river banks, slopes, and swift water.
Site reconnaissance in remote locations	63, 37	2B	Wear insect repellant. Remain together in group, do not venture off alone. Make lots of noise to make your presence known to wildlife in the area.

Note: This Field Safety Plan must be reviewed and signed by the NHC project manager or field manager prior to leaving for job site.

Reviewed by: Name: **Robyn Andrishak** Signature:

Revised May 1, 2019

Project Number 1005092/1005166	**NHC Field Safety Plan**	Date 16-20 September 2019

Site Safety Plan

All hazards & controls documented in the FHA are to be reviewed on site before work begins.

- [x] Field Hazard Assessment has been completed and reviewed
- [x] Required PPE is available and in working order
- [x] Safe Work Practices and Safe Job Procedures have been reviewed
- [x] Emergency Response Procedures and operation of communication devices have been reviewed
- [x] Field equipment is in good working condition
- [ ] Equipment manuals have been reviewed for maintenance and safety requirements/training

Remember: all accidents, incidents, near misses, or breaches of procedure must be reported to the Project Manager immediately. Lost time or medical aid must be reported to the appropriate WCB/WSIB within 72 hours.

On-site Training (for employees new to job tasks)

Name of employee	Name of supervisor	Job tasks

Initial Tailgate Meeting Attendance (nhc staff and other on-site personnel)

Name (print)	Signature	Affiliation	Date
Gary VanDerVinne	Gary VanDerVinne	NHC	Sept 19/19
Lieserl Woods	L. Woods	ECCC	"
Queenie Gray	Queenie	PCA	"
Gary VanderVinne	Gary VanderVinne	NHC	Sept 20/19
Queenie Gray	[illegible]	PCA	"
David Campbell	David Campbell	PCA	"
Matt Davis	Matt	Highland Heli	"

Revisions to Site Safety Plan (to Reflect Site Conditions, Weather or Changes in Work Plan)

Date	Description	Initials of on-site staff
Sept 19/19	Boat trip to Dog Camp - discussed boat safety and wore life jackets	G Z.V. QG

Environmental

If a spill or environmental emergency is encountered in the field, the landowner should be notified. On public land, the Alberta Environmental Hotline (1-800-222-6514) should be called.

Note: This Field Safety Plan must be reviewed and signed by the NHC field manager (or designate) after returning from job site.

Reviewed by: Name: Robyn Andrishak Signature: [signature]

Revised May 1, 2019

4 of 4

Applicable Safe Work Practices (SWP) and Safe Job Procedures (SJP)

3.8.2 Working on Hills and Slopes

General:

Protecting workers from injuries associated with working in hills and on slopes.

Supervisor Responsibility:

- Supervisors are responsible to facilitate and/ or provide proper instruction to their workers on protection requirements and training
- Hazard analysis
- Work site inspection
- Heavy equipment

Worker Responsibility:

- Ensure you are conversant with ERP
- Ensure warning signs/ devices are in place
- Ensure you are familiar with restraining devices and rigging
- Be familiar with anchoring of equipment
- Ensure you are in view of operator at all times
- Ensure you wear appropriate PPE (including high visibility vests)
- Ensure wheel chocks are utilized
- Be aware of rolling boulders or loose rocks

3.8.8 Working on Water

Work Activity:

- Measuring water levels and bank elevations from a river bank.
- Measuring water depths and velocities in a river from a boat/ in-river.
- Installing specialized equipment/ probes in a river.

This Activity Requires:

- The movement of personnel along the shore of a lake or river.
- Shallow wading in the lake or river.
- Work in a boat; on the water.
- Natural and man-made hazards in the lake or river cause safety concerns.

The hazards involved in this work may include but ARE NOT limited to:

Low-head dams, rapids, and white water.

Sudden winds, tides, and currents.

Overhead cables, underwater cables, and bridges.

Rapid build-up of high wave conditions.

Unexpected increases of water level from dam releases of heavy rains.

Steep and slippery banks.

Falling into the water.

Uneven terrain.

Wild animal encounters.

The work party will adhere to the following general requirements:

The level of equipment will be consistent with the severity of the work conditions.

A minimum of two people will be assigned to the work party.

A minimum of two members of the work party will be certified in first-aid.

A cellular or satellite phone will be available to maintain communication with emergency personnel outside the work party.

A list of emergency contact numbers, specific to the area, will be carried by the crew.

GPS will be available to provide position information in event of a need for assistance.

Verify your equipment is in good working order.

4.11 Open Water River Surveys

PPE

Life Jacket.

Precautions

The work party will adhere to the following general requirements:

A hazard assessment will be done before going to site.

Workers working on or near the water will be provided training on the hazards.

The level of equipment will be consistent with the severity of the work conditions.

A minimum of two people will be assigned to the work party.

A minimum of two members of the work party will be certified in first-aid.

A cellular or satellite phone will be available to maintain communication with emergency personnel outside the work party.

A list of emergency contact numbers, specific to the area, will be carried by the crew.

GPS will be available to provide position information in event of a need for assistance.

Verify your equipment is in good working order.

Once on site, a Safe Work Plan will be developed to define:

How the work will be carried out.

How the equipment will be used.

How to react to an emergency situation.

A visual assessment of the hazard potential of the work site will be undertaken to identify the following:

Natural hazards such as overhanging trees, log jams, boulders, or ice.

Dangerous conditions due to rapids, falls, weirs or spillways.

Fast water due to in-river structures such as piers, spurs, guide banks or water intakes.

Potential for rapid flow increases from dam releases or rainfall.

Important Notes:

Open top waders must not be worn during boating activities in fast flowing water where water levels are above the waist.

During an open water survey with cables and ropes in the boat a rescue life jacket with rescue knife attached should be worn securely at all times.

Plans and/ or specialized equipment should be in place to deal with identified hazards before the survey is started.

*Refer to SWP 3.8.8 Working on Water

Navigation Hazards:

While travelling by boat where hazards to navigation may potentially be present, the boat operator will (or staff will instruct the boat operator to) travel slowly until a safe route can be established. The safe route will be logged using GPS or other navigational aids so that this route can be navigated in future. Occupants of the boat will avoid sitting sideways to the boat travel direction, preferably behind a suitable support that can be relied upon as a brace in the event of a collision or sudden change in speed or vessel motion. This area will be reviewed during the pre-trip meeting and recorded on the pre-trip form. Staff will take care to be aware of, and remove or secure if possible, any equipment or loose objects that could contribute to injuries in the event of a collision.

Updated 04 April 2014

4.13 Working Near Water

PPE

Life jacket, waders, dry suit, throw bag, rope.

Precautions

1) Is there suitable safe access?

What is the risk of falling into the water? Is the water fast moving or are there hazards downstream?

If high above water, is there suitable edge protection to prevent falling into the water and is the structure/ bank/ material to be stood on or used sufficiently strong enough to hold the weight?

Are there trip hazards present?

Is the work a long duration?

Do staff need special training? E.g. swift water rescue, boat handling, first aid, etc.?

What are weather conditions? Will there be rain or high winds?

Are there tidal effects or flow changes which can cause strong currents or water level changes?

Daily Field Reports

Date	Remarks
30 Sep 2019	At 7:30 this morning we departed the Fort McMurray Best Western and drove to the McMurray Aviation hanger. We arrived in Fort Chipewyan at 10:30 and met with our local Parks Canada contact Queenie Gray. Our cargo arrived on three separate planes at 11:00, 12:00 and 4:00. We participated in a project safety meeting at 2:00 via Skype. We mounted all necessary clamps onto the Parks Canada boat, and set up the Hypack project line files. Tomorrow we will finish equipment setup, and test the multi beam sounder before heading up to the Coupé weir on Wednesday morning.
1 Oct 2019	Today we began working on the boat equipment mount setup at 7:30 am. At 10 am when the Northern store opened we purchased a secondary 12V marine battery to help supplement the existing 12V Parks Canada battery in the boat; our system was drawing power faster than the boat could recharge. We continued setting up the boat until 3:00 pm. We initially had some problems with the setup due to a broken serial pin, but managed to repair it in the Parks Canada garage. We started test scans with the multi-beam system near the Lake Athabasca dock at 330pm with Parks Canada. We were off the water at 530 pm with our the system working. Since we had bad satellite reception on the lake we made adaptations to the boat setup in the garage afterwards to raise the hydrolink GPS system higher. Tomorrow we will be heading to upstream of the Coupe weir provided our safety boater Kevin is able to join.
3 Oct 2019	Started the survey work at Dog Camp after completing work on the downstream side of the Revillon Coupé and Riviere des Rochers weirs.
7 Oct 2019	We surveyed the Cree Creek / Embarras River site.
8 Oct 2019	Today we surveyed the outlet of Big Egg Lake and the Athabasca River with a local band representative Freddy, and also finished off our survey at Dog Camp with Jumbo. Kate Neigel will be flying out early tomorrow morning, and Ken Roy will fly out Thursday afternoon with the rest of our gear. He will spend tomorrow packing gear and processing data.