

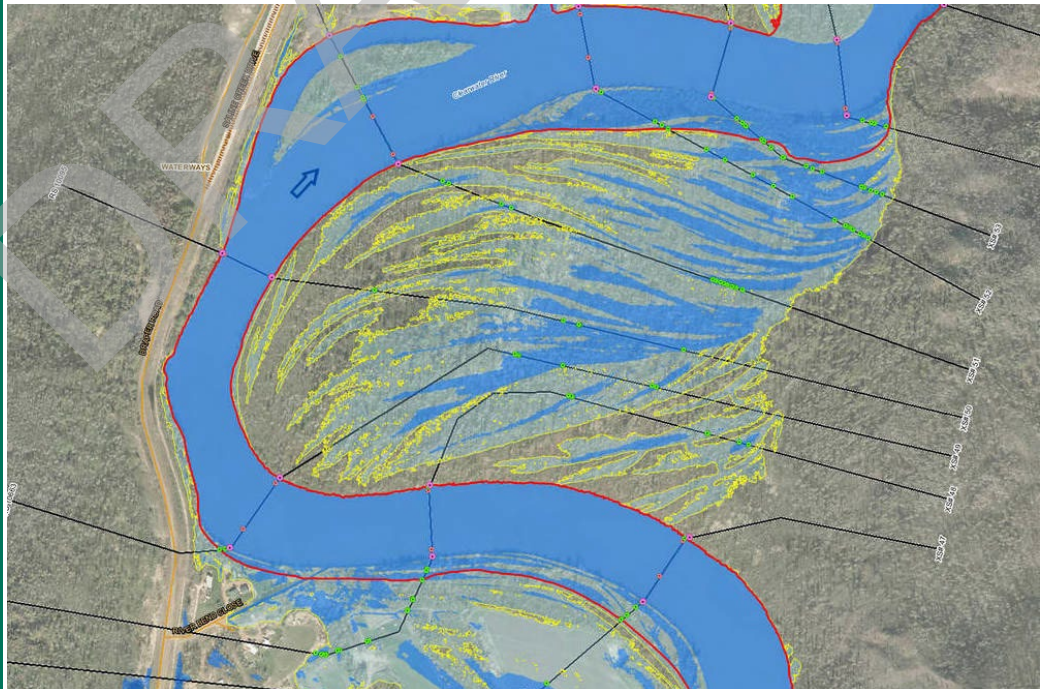


July 2022

FORT MCMURRAY RIVER HAZARD STUDY

Open Water Flood Hazard Identification Report

Submitted to:
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REPORT





Executive Summary

Alberta Environment and Parks (AEP) retained Golder Associates Ltd. (Golder), in collaboration with SG1 Water Consulting Ltd. (SG1) and Hatch Ltd. (Hatch), in September 2016 to conduct the Fort McMurray River Hazard Study. The primary purpose of the study is to assess and identify river and flood hazards along the Athabasca River, the Clearwater River (including the Snye), and the Hangingstone River through Fort McMurray, Alberta in the Regional Municipality of Wood Buffalo (RMWB). Project stakeholders include the Government of Alberta, the RMWB, and the public.

The study includes multiple components and deliverables. This report summarizes the open water flood hazard identification component of the study. The main tasks associated with this work involves producing open water floodway criteria maps. Floodway criteria maps document the technical flood information used to delineate the floodway, including 100-year flood extents and hydraulic characteristics, previous floodways, and proposed floodway limit stations throughout the study area.

The study area includes the river reaches listed in Table i.

Table i: River Reaches in the Study Area

River	Reach Description	Length
Athabasca River	From a location 6 km upstream of Highway 63 bridges to a location 8 km downstream of the Clearwater River confluence	15 km
Clearwater River	20 km river reach upstream of the confluence with Athabasca River	20 km
Hangingstone River	From a location 3 km upstream of Memorial Drive (Highway 63) Bridges to the confluence with Clearwater River	5 km
The Snye	Full length from Snye Dike to the confluence with Clearwater River	1.5 km

Floodways defined by previous flood studies in the study area were considered as part of the floodway delineation for this flood study, and were not made larger by default in most circumstances unless required for technical reasons or if deemed necessary or appropriate.

Open water floods along the Athabasca River and Clearwater River typically result in lower water levels than ice jam floods. However, open water flood levels along the Hangingstone River can be higher than ice jam floods, especially in the reach upstream of Saline Creek Drive.



Acknowledgements

This component of the Fort McMurray River Hazard Study was managed by Dr. Wolf Ploeger. Overall direction and senior review for this component was provided by Dr. Dejiang Long and Dr. Wolf Ploeger. The open water floodway criteria mapping was performed by Wolf Ploeger, Nancy Guo and Peter Thiede.

The authors express their special thanks to Jim Choles and Abdullah Mamun, Project Managers for Alberta Environment and Parks (AEP), who provided overall study management, background data, and technical guidance.

The authors also express their gratitude to Patricia Stevenson, Peter Onyshko and Lance Katan of AEP for their additional support and guidance.

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Open Water Floodway Criteria Maps

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1.0 INTRODUCTION

1.1 Study Objectives

Alberta Environment and Parks (AEP) retained Golder Associates Ltd. (Golder), in collaboration with SG1 Water Consulting Ltd. (SG1) and Hatch Ltd. (Hatch), in September 2016 to conduct the Fort McMurray River Hazard Study. The primary purpose of the study is to assess and identify river and flood hazards along the Athabasca River, the Clearwater River (including the Snye), and the Hangingstone River through Fort McMurray, Alberta in the Regional Municipality of Wood Buffalo (RMWB).

The study is conducted under the provincial Flood Hazard Identification Program (FHIP), the goals of which include enhancement of public safety and reduction of future flood damages through the identification of river and flood hazards. Project stakeholders include the Government of Alberta, the RMWB, and the public.

The study includes multiple components and deliverables. This report summarizes the open water flood hazard identification component of the study. The main tasks associated with this work involves producing open water floodway criteria maps. Floodway criteria maps document the technical flood information used to delineate the floodway, including 100-year flood extents and hydraulic characteristics, previous floodways, and proposed floodway limit stations throughout the study area.

There is one previous FHIP study:

- Review of Flood Stage Frequency Estimates for the City of Fort McMurray (AEP, 1993, mapping updated in 1995 and 2003)

Existing floodways defined by the above-listed previous studies were considered as part of the floodway delineation for this flood study and were not made larger by default in most circumstances, unless required for technical reasons or if deemed necessary or appropriate.

Dedicated flood control structures are assumed to be effective, and protected areas are not mapped as flooded unless they are overtopped. Areas of residual risk behind dedicated flood control structures that could be flooded if a flood control structure fails or does not perform as expected are identified as protected flood fringe.

1.2 Study Area and Reaches

Fort McMurray is located at the confluence of the Athabasca and Clearwater Rivers, and has a history of ice jam flooding. In the spring, the ice cover on the Athabasca River can break up dynamically, and large ice runs are not uncommon. When an ice jam forms on the Athabasca River at or downstream of the Clearwater River confluence, it can cause significant flooding in downtown Fort McMurray. Additionally, the presence of a competent ice cover on the Athabasca River when the Clearwater River is undergoing breakup can also lead to ice jams and significant flooding.

Open water floods along the Athabasca River and Clearwater River typically result in lower water levels than ice jam floods. However, open water flood levels along the Hangingstone River can be higher than ice jam flood levels, especially along the reach upstream of Saline Creek Drive.

The study area includes approximately 15 km of the Athabasca River, approximately 20 km of the Clearwater River (including 1.5 km of the Snye), and approximately 5 km of Hangingstone River through Fort McMurray (see Figure 1). The study area is within the RMWB. The study reaches are summarized in Table 1.

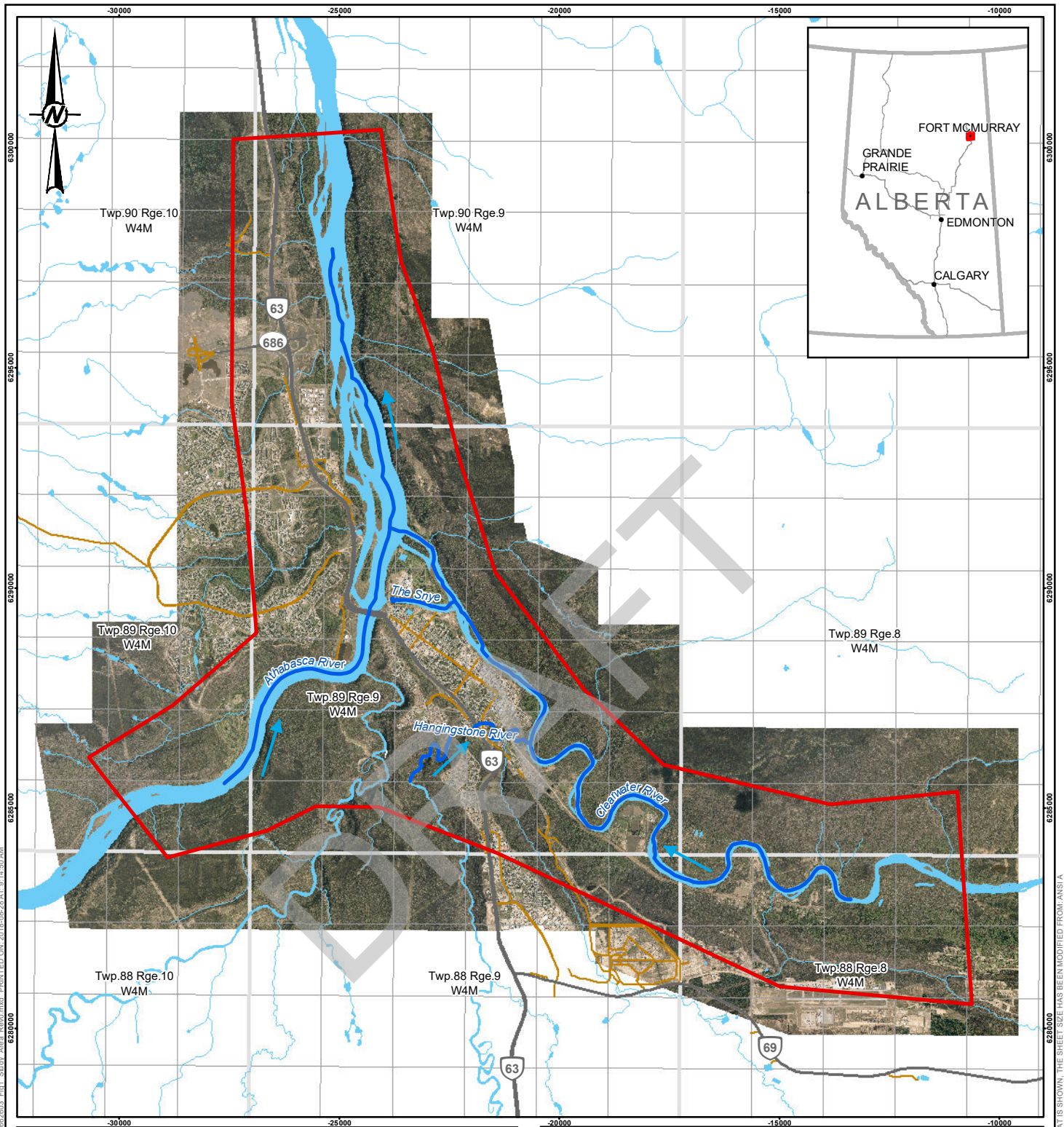


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Table 1: River Reaches in the Study Area

River	Reach Description	Length
Athabasca River	From the location 6 km upstream of Highway 63 bridges to the location 8 km downstream of the Clearwater River confluence	15 km
Clearwater River	20 km river reach upstream of confluence with Athabasca River	20 km
Hangingstone River	From the location 3 km upstream of Memorial Drive (Highway 63) Bridges to the confluence between Hangingstone and Clearwater Rivers	5 km
The Snye	Full length from Snye Dyke to confluence with Clearwater River	1.5 km

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LEGEND

- STUDY REACH
 - STUDY AREA
 - ➔ FLOW DIRECTION
 - WATERCOURSE
 - WATERBODY
- TRANSPORTATION FEATURES**
- PRIMARY HIGHWAY
 - SECONDARY HIGHWAY
 - LOCAL ROAD

REFERENCE(S)

IMAGERY CAPTURED MAY 2017 BY GEODESY GROUP INC. FOR THE GOVERNMENT OF ALBERTA.
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 PROJECTION: 3TM 111° DATUM: NAD 83 CSRS

CLIENT



PROJECT

FORT MCMURRAY RIVER HAZARD STUDY

TITLE

STUDY AREA

CONSULTANT



YYYY-MM-DD 2018-05-30

DESIGNED WP

PREPARED SK

REVIEWED WP

APPROVED DL

PROJECT NO.

1662603

CONTROL

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FIGURE

1



2.0 AVAILABLE DATA

2.1 Flood Frequencies

The flood flow frequency estimates for the Athabasca River, Clearwater River and Hangingstone River are documented in a separate report entitled “Fort McMurray River Hazard Study - Open Water Hydrology Assessment Report” (Golder, 2017). The 100-year design flood flow estimates at key locations in the study area are summarized in Table 2.

Table 2: Design Flood Flow Frequency Estimates

Location	100-Year Flood Peak Discharges (m ³ /s)
Athabasca River above Clearwater River Confluence	5,480
Athabasca River below Clearwater River Confluence	5,920
Clearwater River at Draper (upstream of Hangingstone River Confluence)	900
Clearwater River below Hangingstone River Confluence	949
Hangingstone River above Saline Creek Confluence	206
Hangingstone River below Saline Creek Confluence	206

2.2 Survey and DTM Details

Topographic, control point, and shallow-water surveys were performed using Real-time Kinematic (RTK) GPS units. Bathymetric surveys were conducted on the Athabasca River and the Clearwater River using an Acoustic Doppler Profiler (ADP) in combination with a boat-mounted RTK unit where flow depths were too deep to wade. Bridge survey data were collected using either a RTK or total station. The features surveyed as part of this project are summarized in Table 3.

Table 3: Summary of Survey Features

Feature	Athabasca River	Clearwater River	Hangingstone River	The Snye	Totals
Cross Sections	26	51	79	4	160
Bridges	3 ⁽¹⁾	-	8	-	11
Culverts	1	-	-	-	1
Flood Control Structures	-	2	1 ⁽²⁾	1	4

Notes:

1. The bridges on the Athabasca River are treated as one bridge in the HEC-RAS model as their opening widths are similar and the piers are lined up in series with respect to the flow direction.
2. There is one flood control structure along the downstream reach of Saline Creek, a tributary to the Hangingstone River.

A detailed description of the survey data is provided in a separate report entitled “Fort McMurray River Hazard Study – Survey and Base Data Collection Report” (Golder 2018a).

The detailed Digital Terrain Model (DTM) for the study area was provided by AEP. It was developed from a 2016 LiDAR survey and is available as gridded raster with 0.5 m resolution, ESRI Terrain and triangulated irregular network (TIN). The DTM was delivered in the local study coordinate system and datum (3TM 111°, NAD83 CSRS).



2.3 HEC-RAS Model

All river reaches in the study area are integrated into one HEC-RAS model. The model was calibrated for:

- low flow conditions based on water levels and discharges measured in September 2016;
- high flow conditions based on high water marks and high water levels collected by AEP and RMWB during and after the June 2013 flood; and
- the flow-stage rating curves for the Water Survey of Canada (WSC) gauging stations in the study area.

The calibrated main channel Manning's *n* values for high flow conditions are listed in Table 4.

Table 4: Calibrated River Channel Roughness Values for High Flow Conditions

River	Calibrated Manning's <i>n</i> Value
Athabasca River	0.030
Clearwater River	0.030 – 0.032
Hangingstone River	0.038 – 0.040
The Snye	0.030

The calibrated model was used to simulate the open water surface profiles for the 2-, 5-, 10-, 20-, 35-, 50-, 75-, 100-, 200-, 350-, 500-, 750-, and 1,000-year flood events in the study area.

The model sensitivity was evaluated using the 100-year flood simulation results. The results of the sensitivity analysis show that variation of the river channel roughness values has a much higher influence on the simulated flood levels than variation of the floodplain roughness values. The average variation was estimated to be within a range of ± 0.34 m of the simulated values along the Athabasca River, ± 0.30 m along the Clearwater River, ± 0.29 m along the Hangingstone River, and ± 0.28 m in the Snye.

A detailed description of the open water HEC-RAS model is provided in a separate report entitled “Fort McMurray River Hazard Study – Hydraulic Model Creation and Calibration” (Golder 2018b).



3.0 OPEN WATER FLOOD HAZARD DETERMINATION

3.1 Design Flood Details

The 100-year open water flood was selected as the design open water flood throughout the study area, in accordance with provincial FHIP guidelines (AEP 2011). Open water design flood water levels are the same as the 100-year open water flood water levels throughout the study area, and the open water design flood hazard area footprint is the same as the 100-year open water flood inundation extent (Golder 2018c).

3.2 Floodway and Flood Fringe Terminology

The design flood hazard area is the area of land that will be flooded during the design flood event. Flood hazard maps divide the flood hazard area into floodway and flood fringe zones, including high hazard flood fringe and protected flood fringe sub-zones where appropriate. Flood hazard maps can also illustrate additional information, including incremental areas at risk for floods larger than the 100-year design flood, such as the 200-year and 500-year floods. Flood hazard maps are typically used for long-term flood risk management and land-use planning.

The floodway and flood fringe zones are defined as follows:

- **Floodway:** When a floodway is first defined on a flood hazard map, it typically represents the area of highest flood hazard where flows are deepest, fastest, and most destructive during the 100-year design flood. The floodway generally includes areas where the water is 1 m deep or greater and where local velocities are 1 m/s or faster. The floodway typically includes the main channel of a stream and a portion of the adjacent overbank area. Previously mapped floodways do not typically become larger when a flood hazard map is updated, even if the flood hazard area gets larger or design flood levels get higher.
- **Flood Fringe:** The flood fringe is the portion of the flood hazard area outside of the floodway that typically has relatively shallow water (less than 1 m deep) and lower velocities (less than 1 m/s velocity) during the 100-year design flood. However, areas with deeper or faster moving water may also be identified as high hazard flood fringe areas within the flood fringe. Areas with residual risk behind dedicated flood control structures may also be mapped as protected flood fringe areas within the flood fringe.

3.3 Open Water Floodway Determination Criteria

In areas being mapped for the first time, the floodway typically represents the area of highest hazard where flows are deepest, fastest, and most destructive during the design flood. The following criteria, based on those described in current FHIP guidelines and supplemented by the project-specific Terms of Reference, are used to delineate the floodway in such cases:

- The floodway must include the main river channel area.
- Areas where water depths exceed 1 m or flow velocities exceed 1 m/s are typically part of the floodway.
- Exceptions may be made for small backwater areas, ineffective flow areas, or to support creation of a hydraulically smooth floodway.
- For reaches of supercritical flow, the floodway boundary should correspond to the edge of inundation or the main channel, whichever is larger.



When a flood hazard map is updated, an existing floodway will not change in most circumstances. Exceptions to this can include, but are not limited, to the following circumstances: (1) a floodway could get larger if a main channel shifts outside of a previously-defined floodway or (2) a floodway could get smaller if an area of previously-defined floodway is no longer flooded by the design flood.

Areas of deeper or faster moving water outside of the floodway are identified as high hazard flood fringe. These high hazard flood fringe sub-zones are identified in all areas, whether they are newly-mapped or have a previously-defined or existing floodway. The depth and velocity criteria used to define high hazard flood fringe areas are typically aligned with the 1 m depth and 1 m/s velocity floodway determination criteria for newly-mapped areas.

All areas protected by dedicated flood control structures (e.g., flood berms) that are not overtopped during the design flood are excluded from the floodway. Areas behind flood berms will still be mapped as flooded if they are overtopped, but areas of residual risk of behind flood berms that are not overtopped are mapped as protected flood fringe sub-zones.

The floodway determination criteria for the left and right floodway limits at each cross section are provided together with the open water design flood levels in Table 5.

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FORT MCMURRAY RIVER HAZARD STUDY - OPEN WATER FLOOD HAZARD IDENTIFICATION

Table 5: Open Water Design Flood Water Levels, Floodway Station Limits and Governing Criteria

River	Reach	Cross Section	River Station	Open Water Design Flood Level (m)	Floodway Limit		Governing Criteria	
					Left Station (m)	Right Station (m)	Left Station	Right Station
Athabasca	Upper Reach	1	17519	249.03	196.76	583.55	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Athabasca	Upper Reach	2	16535	248.46	189.32	604.12	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Athabasca	Upper Reach	3	15716	247.86	660.75	1013.94	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Athabasca	Upper Reach	4	15048	247.41	1760.87	2153.53	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Athabasca	Upper Reach	5	14346	247.03	712.34	1197.27	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Athabasca	Upper Reach	6	13706	246.70	460.20	924.03	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Athabasca	Upper Reach	7	13071	246.29	143.20	564.63	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Athabasca	Upper Reach	8	12237	245.92	593.39	1026.94	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Athabasca	Upper Reach	9	11791	245.65	588.85	988.35	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Athabasca	Upper Reach	10	11309	245.13	434.02	811.31	1 m Depth	Inundation Extent ⁽¹⁾
Athabasca	Upper Reach	11	10747	244.83	301.28	765.31	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Athabasca	Upper Reach	12	10564	244.56	261.34	685.85	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Athabasca	Upper Reach	13	10306	244.55	189.12	906.75	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Athabasca	Upper Reach	14	9779	244.18	210.58	929.41	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Athabasca	Upper Reach	15	9174	243.92	626.32	1364.13	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Athabasca	Lower Reach	16	8559	243.81	899.58	1864.93	1 m Depth	Inundation Extent ⁽¹⁾
Athabasca	Lower Reach	17	7895	243.59	1004.16	1956.76	Mixed	Inundation Extent ⁽¹⁾
Athabasca	Lower Reach	18	7144	243.23	946.87	2035.69	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Athabasca	Lower Reach	19	6438	243.03	1205.55	2148.36	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Athabasca	Lower Reach	20	5675	242.90	1184.98	2103.23	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Athabasca	Lower Reach	21	4899	242.57	1263.12	1830.07	1 m Depth	Inundation Extent ⁽¹⁾
Athabasca	Lower Reach	22	4246	242.27	1562.90	2057.65	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Athabasca	Lower Reach	23	3083	241.88	1462.33	2053.14	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Athabasca	Lower Reach	24	2347	241.71	1390.34	2051.18	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Athabasca	Lower Reach	25	1420	241.45	935.00	1775.24	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Athabasca	Lower Reach	26	129	241.00	1177.74	1920.83	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Clearwater	Upper Reach	27	20359	247.22	535.72	647.35	Inundation Extent ⁽¹⁾	Main Channel
Clearwater	Upper Reach	28	19986	247.16	610.29	761.63	Main Channel	1 m Depth
Clearwater	Upper Reach	29	19705	247.08	950.34	1171.40	Inundation Extent ⁽¹⁾	1 m Depth
Clearwater	Upper Reach	30	19182	246.99	1179.14	1377.12	1 m Depth	Inundation Extent ⁽¹⁾
Clearwater	Upper Reach	31	18685	246.87	870.37	1022.35	Inundation Extent ⁽¹⁾	1 m Depth
Clearwater	Upper Reach	32	18262	246.79	597.89	837.52	1 m Depth	Inundation Extent ⁽¹⁾
Clearwater	Upper Reach	33	17883	246.66	783.05	912.44	1 m Depth	1 m Depth



FORT MCMURRAY RIVER HAZARD STUDY - OPEN WATER FLOOD HAZARD IDENTIFICATION

Table 5: Open Water Design Flood Water Levels, Floodway Station Limits and Governing Criteria

River	Reach	Cross Section	River Station	Open Water Design Flood Level (m)	Floodway Limit		Governing Criteria	
					Left Station (m)	Right Station (m)	Left Station	Right Station
Clearwater	Upper Reach	34	17460	246.60	1331.39	1499.54	Inundation Extent ⁽¹⁾	Inundation Extent ⁽²⁾
Clearwater	Upper Reach	35	16972	246.52	1633.52	1881.85	Inundation Extent ⁽¹⁾	1 m Depth
Clearwater	Upper Reach	36	16560	246.39	1594.77	1738.44	Main Channel	Inundation Extent ⁽²⁾
Clearwater	Upper Reach	37	16223	246.34	1506.49	1724.57	1 m Depth	Inundation Extent ⁽¹⁾
Clearwater	Upper Reach	38	15826	246.16	1125.73	1268.96	1 m Depth	Inundation Extent ⁽¹⁾
Clearwater	Upper Reach	39	15382	246.09	693.93	915.28	Main Channel	1 m Depth
Clearwater	Upper Reach	40	14757	245.99	576.65	784.54	Inundation Extent ⁽¹⁾	1 m Depth
Clearwater	Upper Reach	41	14127	245.90	455.31	708.09	1 m Depth	Inundation Extent ⁽¹⁾
Clearwater	Upper Reach	42	13537	245.81	681.64	946.21	Inundation Extent ⁽¹⁾	1 m Depth
Clearwater	Upper Reach	43	13179	245.75	1142.84	1391.33	Inundation Extent ⁽¹⁾	1 m Depth
Clearwater	Upper Reach	44	12786	245.72	1631.85	1860.67	Inundation Extent ⁽¹⁾	1 m Depth
Clearwater	Upper Reach	45	12424	245.66	1662.76	1791.19	Mixed	Inundation Extent ⁽¹⁾
Clearwater	Upper Reach	46	11985	245.61	1539.70	1702.61	Mixed	Inundation Extent ⁽¹⁾
Clearwater	Upper Reach	47	11537	245.57	1382.86	1594.19	Mixed	Inundation Extent ⁽¹⁾
Clearwater	Upper Reach	48	11033	245.48	986.89	1182.15	1 m Depth	Inundation Extent ⁽¹⁾
Clearwater	Upper Reach	49	10663	245.44	443.27	639.27	1 m Depth	Inundation Extent ⁽¹⁾
Clearwater	Upper Reach	50	10095	245.31	360.82	476.66	Inundation Extent ⁽¹⁾	1 m Depth
Clearwater	Upper Reach	51	9674	245.29	464.75	768.83	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Clearwater	Upper Reach	52	9210	245.23	586.59	1381.40	Inundation Extent ⁽²⁾	1 m Depth
Clearwater	Upper Reach	53	8934	245.16	1210.24	1752.74	Inundation Extent ⁽²⁾	1 m Depth
Clearwater	Upper Reach	54	8679	245.10	1089.53	1726.97	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Clearwater	Upper Reach	55	8440	245.04	1061.87	1585.13	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Clearwater	Upper Reach	56	8121	244.99	1012.00	1690.44	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Clearwater	Upper Reach	57	7780	244.91	850.40	1629.26	Inundation Extent ⁽²⁾	Inundation Extent ⁽²⁾
Clearwater	Upper Reach	58	7396	244.86	727.41	1631.90	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Clearwater	Upper Reach	59	7081	244.81	556.04	1528.52	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Clearwater	Upper Reach	60	6802	244.77	618.09	1511.48	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Clearwater	Mid Reach	61	6605	244.74	534.38	1505.00	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Clearwater	Mid Reach	62	6350	244.70	562.58	1125.83	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Clearwater	Mid Reach	63	6078	244.66	150.11	885.40	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Clearwater	Mid Reach	64	5806	244.63	136.20	743.65	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Clearwater	Mid Reach	65	5535	244.51	104.97	560.89	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Clearwater	Mid Reach	66	5194	244.47	106.13	366.20	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾



FORT MCMURRAY RIVER HAZARD STUDY - OPEN WATER FLOOD HAZARD IDENTIFICATION

Table 5: Open Water Design Flood Water Levels, Floodway Station Limits and Governing Criteria

River	Reach	Cross Section	River Station	Open Water Design Flood Level (m)	Floodway Limit		Governing Criteria	
					Left Station (m)	Right Station (m)	Left Station	Right Station
Clearwater	Mid Reach	67	4760	244.42	146.87	393.47	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Clearwater	Mid Reach	68	4324	244.35	116.68	470.97	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Clearwater	Mid Reach	69	3906	244.33	1211.08	1555.19	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Clearwater	Mid Reach	70	3541	244.27	1277.80	1632.18	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Clearwater	Mid Reach	71	3183	244.22	1334.28	1668.38	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Clearwater	Mid Reach	72	2815	244.18	1434.29	1704.67	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Clearwater	Lower Reach	73	2250	244.11	1199.90	1445.39	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Clearwater	Lower Reach	74	1848	244.08	984.37	1274.35	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Clearwater	Lower Reach	75	1471	244.06	837.04	1139.40	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Clearwater	Lower Reach	76	1043	243.97	607.96	1036.31	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Clearwater	Lower Reach	77	480	243.95	76.16	573.57	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Snye	Snye	78	1332	244.17	37.76	193.64	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Snye	Snye	79	932	244.17	67.70	239.36	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Snye	Snye	80	456	244.17	23.83	201.86	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Snye	Snye	81	172	244.17	27.37	n/a	Inundation Extent ⁽¹⁾	No floodway ⁽³⁾
Hangingstone	Hangingstone	82	5586	266.83	302.57	334.68	Main Channel	Main Channel
Hangingstone	Hangingstone	83	5507	266.54	178.93	217.71	1 m/s Velocity	Inundation Extent ⁽¹⁾
Hangingstone	Hangingstone	84	5377	265.19	102.81	132.63	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingstone	Hangingstone	85	5278	264.73	158.02	191.21	Inundation Extent ⁽¹⁾	Main Channel
Hangingstone	Hangingstone	86	5162	264.15	272.50	309.35	Inundation Extent ⁽¹⁾	1 m/s Velocity
Hangingstone	Hangingstone	87	5048	263.22	351.82	381.93	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Hangingstone	Hangingstone	88	4975	262.94	360.12	393.77	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Hangingstone	Hangingstone	89	4942	262.86	374.00	408.53	Main Channel	Inundation Extent ⁽¹⁾
Hangingstone	Hangingstone	90	4874	262.38	491.59	522.15	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingstone	Hangingstone	91	4788	261.92	580.73	618.49	Inundation Extent ⁽¹⁾	Main Channel
Hangingstone	Hangingstone	92	4694	261.57	645.29	687.30	Inundation Extent ⁽¹⁾	1 m/s Velocity
Hangingstone	Hangingstone	93	4600	261.26	615.88	658.51	1 m/s Velocity	Inundation Extent ⁽²⁾
Hangingstone	Hangingstone	94	4525	261.01	610.48	643.76	1 m/s Velocity	Inundation Extent ⁽¹⁾
Hangingstone	Hangingstone	95	4506	260.79	539.50	578.19	1 m/s Velocity	Inundation Extent ⁽¹⁾
Hangingstone	Hangingstone	96	4449	260.57	457.54	501.57	Main Channel	Inundation Extent ⁽¹⁾
Hangingstone	Hangingstone	97	4409	260.47	391.46	445.99	1 m/s Velocity	1 m/s Velocity
Hangingstone	Hangingstone	98	4314	259.96	274.10	305.84	Inundation Extent ⁽¹⁾	1 m/s Velocity
Hangingstone	Hangingstone	99	4172	259.10	253.01	280.66	Inundation Extent ⁽¹⁾	1 m/s Velocity



FORT MCMURRAY RIVER HAZARD STUDY - OPEN WATER FLOOD HAZARD IDENTIFICATION

Table 5: Open Water Design Flood Water Levels, Floodway Station Limits and Governing Criteria

River	Reach	Cross Section	River Station	Open Water Design Flood Level (m)	Floodway Limit		Governing Criteria	
					Left Station (m)	Right Station (m)	Left Station	Right Station
Hangingsstone	Hangingsstone	100	4122	258.72	197.03	233.45	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	101	4051	258.21	255.88	287.48	Inundation Extent ⁽¹⁾	1 m/s Velocity
Hangingsstone	Hangingsstone	102	3971	257.85	350.91	382.04	Inundation Extent ⁽¹⁾	Main Channel
Hangingsstone	Hangingsstone	103	3906	257.71	422.17	459.95	1 m/s Velocity	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	104	3803	257.09	450.56	481.79	1 m/s Velocity	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	105	3759	256.81	435.65	470.36	1 m/s Velocity	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	106	3667	255.93	399.16	430.12	1 m/s Velocity	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	107	3544	255.65	310.30	349.51	1 m/s Velocity	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	108	3410	254.48	212.58	243.73	Inundation Extent ⁽¹⁾	1 m Depth
Hangingsstone	Hangingsstone	109	3298	253.95	115.96	150.11	Inundation Extent ⁽¹⁾	1 m/s Velocity
Hangingsstone	Hangingsstone	110	3204	253.56	82.26	113.26	Main Channel	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	111	3112	253.11	68.09	100.91	Inundation Extent ⁽¹⁾	1 m/s Velocity
Hangingsstone	Hangingsstone	112	3031	252.83	49.52	90.51	Inundation Extent ⁽¹⁾	1 m Depth
Hangingsstone	Hangingsstone	113	2953	252.41	127.16	165.99	Inundation Extent ⁽¹⁾	1 m/s Velocity
Hangingsstone	Hangingsstone	114	2823	251.75	276.70	311.41	Inundation Extent ⁽¹⁾	1 m Depth
Hangingsstone	Hangingsstone	115	2710	251.19	353.46	388.49	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	116	2612	250.96	372.99	426.24	Main Channel	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	117	2557	250.91	353.73	404.22	Main Channel	Main Channel
Hangingsstone	Hangingsstone	118	2491	250.57	362.92	392.23	Main Channel	Main Channel
Hangingsstone	Hangingsstone	119	2471	250.48	364.28	390.37	Main Channel	Main Channel
Hangingsstone	Hangingsstone	120	2448	250.40	349.53	375.01	Main Channel	Main Channel
Hangingsstone	Hangingsstone	121	2418	250.02	346.07	371.31	Main Channel	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	122	2354	249.83	354.84	385.92	Main Channel	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	123	2294	249.47	410.42	441.86	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	124	2276	249.47	438.77	474.48	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	125	2236	249.20	474.84	528.06	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	126	2222	249.13	495.62	539.95	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	127	2156	248.98	571.81	726.36	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	128	2072	248.99	712.43	910.02	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	129	2007	248.62	61.50	225.50	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	130	1923	248.52	49.25	311.04	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	131	1861	248.37	51.14	316.27	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	132	1831	248.15	273.12	333.52	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾



FORT MCMURRAY RIVER HAZARD STUDY - OPEN WATER FLOOD HAZARD IDENTIFICATION

Table 5: Open Water Design Flood Water Levels, Floodway Station Limits and Governing Criteria

River	Reach	Cross Section	River Station	Open Water Design Flood Level (m)	Floodway Limit		Governing Criteria	
					Left Station (m)	Right Station (m)	Left Station	Right Station
Hangingsstone	Hangingsstone	133	1809	248.19	281.95	348.02	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	134	1771	247.87	90.30	157.36	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	135	1744	247.71	119.35	186.88	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	136	1707	247.53	143.90	219.78	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	137	1631	246.97	161.86	223.13	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	138	1541	246.66	205.68	251.18	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	139	1460	246.30	184.70	238.96	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	140	1408	246.16	179.00	220.44	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	141	1389	245.99	175.85	226.21	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	142	1314	246.08	128.47	275.75	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	143	1243	245.92	51.64	280.62	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	144	1193	245.76	196.97	243.78	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	145	1171	245.66	209.55	247.61	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	146	1130	245.51	231.65	274.41	Inundation Extent ⁽¹⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	147	1088	245.49	243.68	316.81	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	148	1023	245.39	275.37	426.14	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	149	960	245.29	378.25	528.68	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	150	882	245.27	425.99	674.28	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	151	769	245.23	646.45	895.93	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	152	701	245.21	551.16	936.62	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	153	648	245.15	556.78	901.38	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	154	549	244.99	564.91	888.51	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	155	490	244.96	571.63	876.83	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	156	435	244.94	574.72	897.70	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	157	372	244.91	578.15	934.16	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	158	293	244.87	581.26	989.75	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	159	227	244.83	585.14	920.89	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	160	134	244.78	590.23	859.22	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	161	106	244.79	597.59	877.82	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾
Hangingsstone	Hangingsstone	162	92	244.80	600.03	895.55	Inundation Extent ⁽²⁾	Inundation Extent ⁽¹⁾

Notes:

- 1) No viable flood fringe
- 2) Floodway set at interior inundation extent, no viable interior flood fringe
- 3) No floodway station because edge of inundation is outside of cross section extent



4.0 OPEN WATER FLOODWAY CRITERIA MAPS

4.1 Flood Mapping Methodology

The design flood hazard extent is generally the same as the 100-year open water inundation extent. The mapping method for the inundation mapping is described in detail in the open water flood inundation mapping report prepared for this study (Golder 2018c). Exceptions are areas where the floodway crosses small areas of dry land for the purpose of floodway smoothing and consistency with previous mapping.

4.2 Open Water Floodway Criteria Maps

Floodway criteria maps document the technical flood information used to delineate the floodway, including 100-year flood extents and hydraulic characteristics, previous floodways, and proposed floodway limit stations throughout the study area. The open water floodway criteria maps include the following information:

- the location and extent of all cross sections used in the HEC-RAS model with appropriate labels;
- the extent of the 100-year open water design flood;
- areas meeting or exceeding the 1 m depth floodway determination criterion;
- portions along each model cross section where flow velocities are calculated to be 1 m/s or greater;
- the locations of the main channel top of bank along each model cross section;
- the proposed floodway boundary, as well as associated floodway stations corresponding to the floodway determination criteria;
- areas of potential flood control structure failure inundation (i.e., protected areas with residual risk);
- the previous floodway boundaries (AEP 1993/1995/2003);
- background aerial imagery; and
- roads, bridges, and dedicated flood control structures.

The floodway criteria maps use the same template as the flood inundation maps, and are provided in Appendix A

4.3 Areas in the Floodway

The following areas are in the open water floodway:

- The main channels of the Athabasca, Clearwater and Hangingstone Rivers and the Snye.
- Approximately 1.4 km of the downstream end of the main channel of the Horse River.
- All islands in the Athabasca River main channel.
- Parts of the undeveloped low lying Clearwater River floodplains on the right (north-east) side of the river.
- Parts of the Hangingstone River floodplains, including the Fort McMurray Tarsands Lions Club and the confluence area.



4.4 Areas in the Flood Fringe

The following areas are in the open water flood fringe:

- Limited low lying floodplain areas along the Athabasca River.
- Large portions of the Clearwater River floodplain on both sides of the river including parts of the properties along Garden Lane.
- Limited low lying floodplain areas along the Hangingstone River upstream of the Memorial Drive Bridges (Highway 63).

5.0 CONCLUSION

Open water floods along the Athabasca and Clearwater Rivers at Fort McMurray typically result in lower water levels than ice jam floods. However, open water flood levels along the Hangingstone River can be higher than ice jam floods, especially in the reach upstream of Saline Creek Drive.

The results of the open water flood hazard identification are the delineation of the open water floodway.

The open water floodway within the study area is limited to the main river channels of the Athabasca, Clearwater and Hangingstone Rivers and some undeveloped floodplain areas along the Clearwater River. The open water flood fringe includes some developed areas as described in Section 4.3.

DRAFT



Report Signature Page

This report was prepared and reviewed by the undersigned.

GOLDER ASSOCIATES LTD.

Prepared by:

Reviewed by:

ORIGINAL SIGNED BY

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Senior River Engineer

NG/WP

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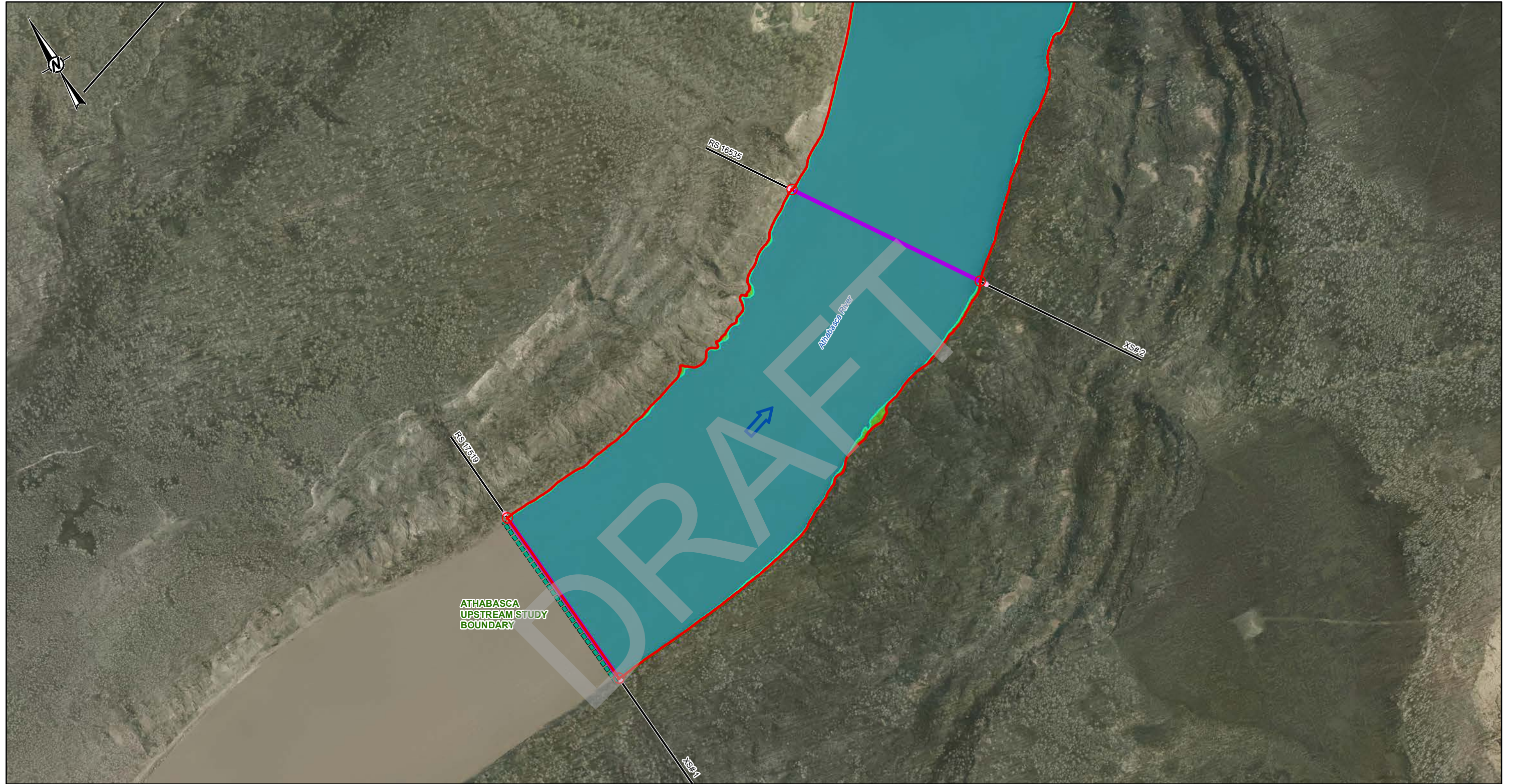
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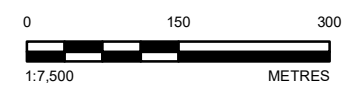
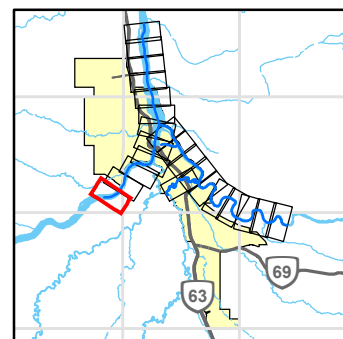
APPENDIX A

Open Water Floodway Criteria Maps

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LEGEND	
	CROSS SECTION
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	RS57085 RIVER STATION
	FLOW DIRECTION
	BRIDGE
	LOCAL ROAD
	PRIMARY HIGHWAY
	STUDY BOUNDARY
	FLOOD CONTROL STRUCTURE
	PROPOSED FLOODWAY BOUNDARY
	BANK STATION
	PROPOSED FLOODWAY STATION
	PREVIOUS FLOODWAY
	DEPTH ≥ 1 M
	100-YEAR DESIGN FLOOD EXTENT
	VELOCITY ≥ 1 M/S
DESIGN DISCHARGE ATHABASCA RIVER ABOVE CLEARWATER RIVER CONFLUENCE = 5480 M ³ /S	



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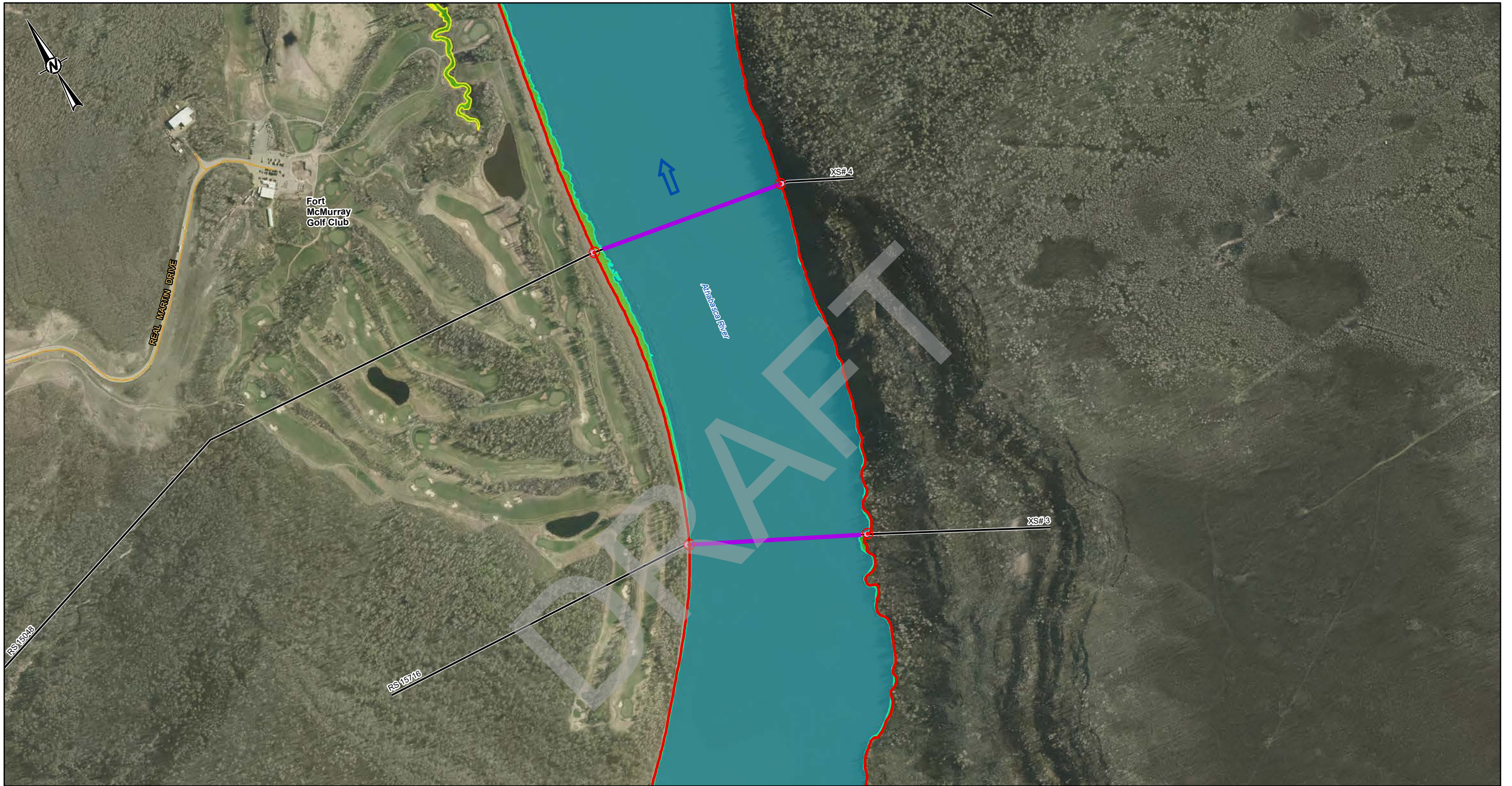
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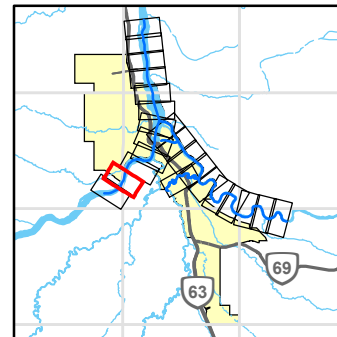
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FORT McMURRAY RIVER HAZARD STUDY

TITLE
OPEN WATER FLOODWAY CRITERIA MAP

PROJECT NO.	CONTROL	REV.	FIGURE
1662603	5000	0	Sheet 1 of 23



LEGEND	
	CROSS SECTION
	XS#110 CROSS SECTION NUMBER
	RS57085 RIVER STATION
	FLOW DIRECTION
	BRIDGE
	LOCAL ROAD
	PRIMARY HIGHWAY
	STUDY BOUNDARY
	FLOOD CONTROL STRUCTURE
	PROPOSED FLOODWAY BOUNDARY
	BANK STATION
	PROPOSED FLOODWAY STATION
	PREVIOUS FLOODWAY
	DEPTH ≥ 1 M
	100-YEAR DESIGN FLOOD EXTENT
	VELOCITY ≥ 1 M/S
DESIGN DISCHARGE ATHABASCA RIVER ABOVE CLEARWATER RIVER CONFLUENCE = 5480 M ³ /S	



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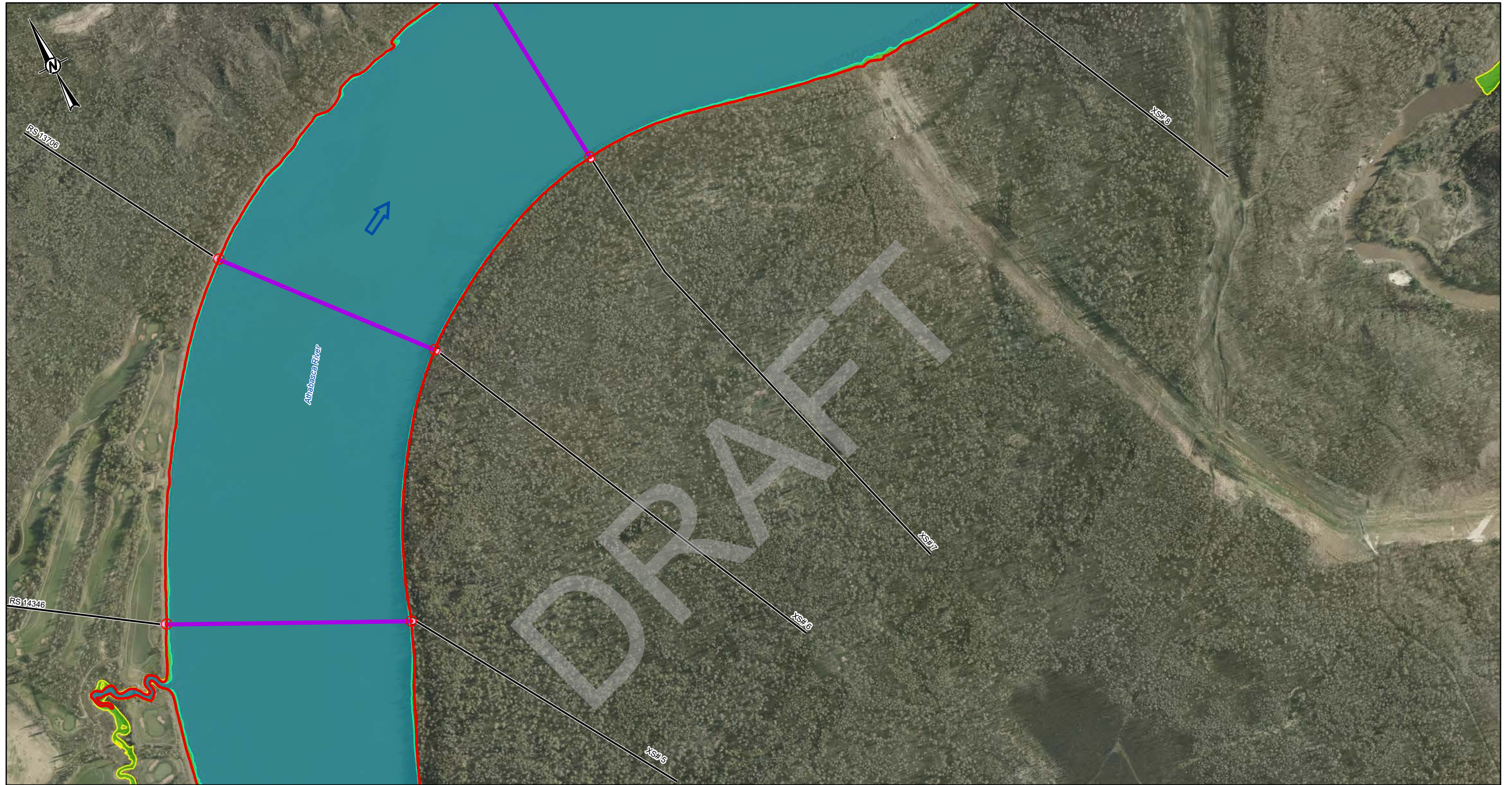
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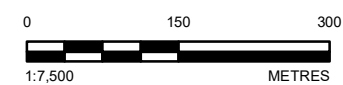
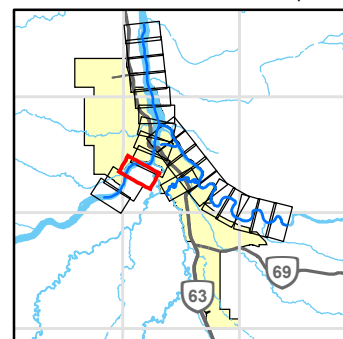
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FORT McMURRAY RIVER HAZARD STUDY

TITLE
OPEN WATER FLOODWAY CRITERIA MAP

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LEGEND	
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	XS#110 CROSS SECTION NUMBER
	RS57085 RIVER STATION
	FLOW DIRECTION
	BRIDGE
	LOCAL ROAD
	PRIMARY HIGHWAY
	STUDY BOUNDARY
	FLOOD CONTROL STRUCTURE
	PROPOSED FLOODWAY BOUNDARY
	BANK STATION
	PROPOSED FLOODWAY STATION
	PREVIOUS FLOODWAY
	DEPTH ≥ 1 M
	100-YEAR DESIGN FLOOD EXTENT
	VELOCITY ≥ 1 M/S
DESIGN DISCHARGE ATHABASCA RIVER ABOVE CLEARWATER RIVER CONFLUENCE = 5480 M ³ /S	



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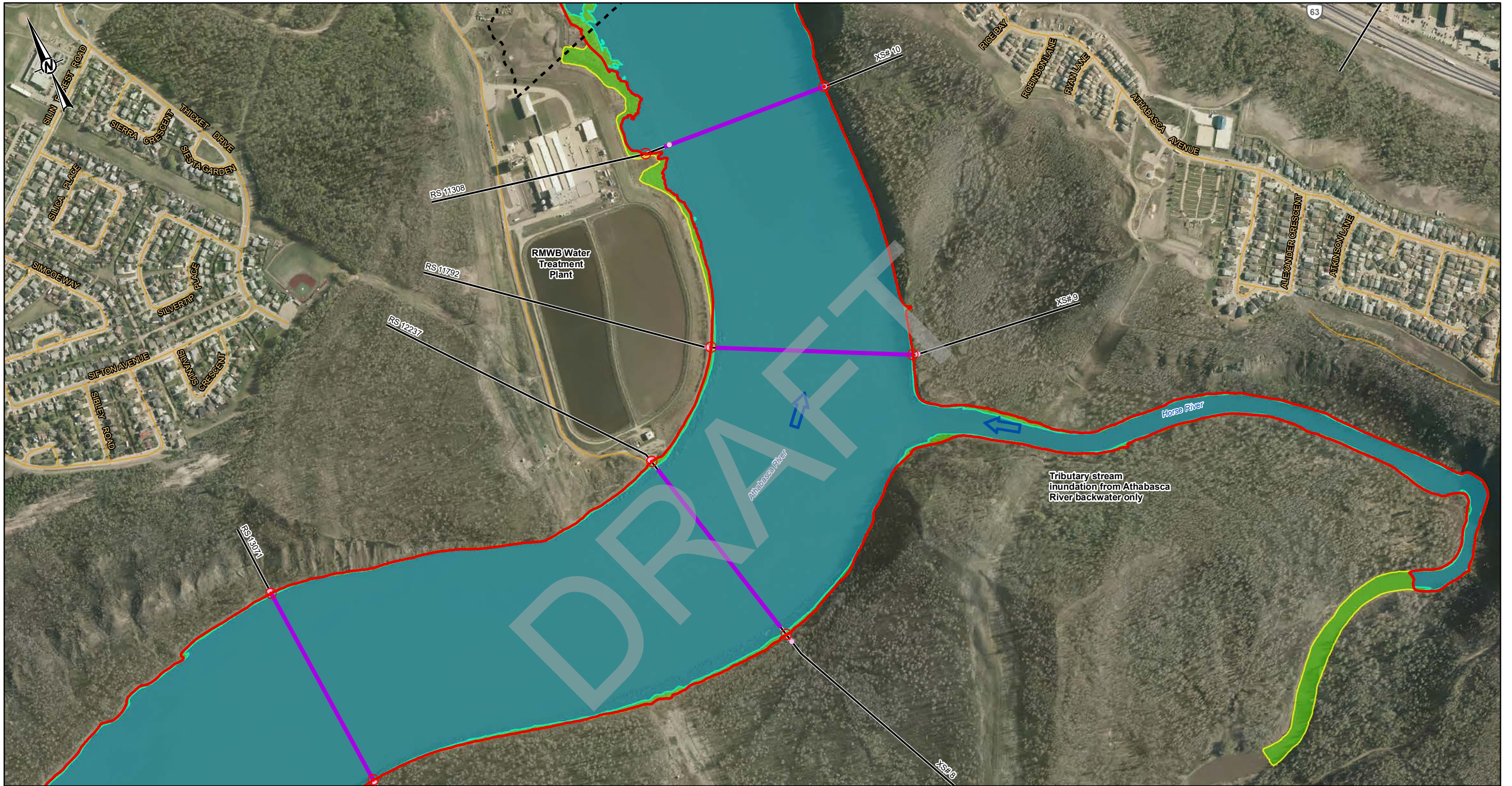


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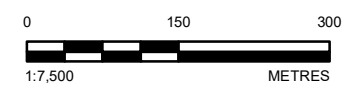
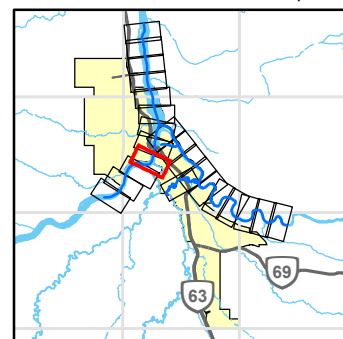
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PROJECT NO.	CONTROL	REV.	FIGURE
1662603	5000	0	Sheet 3 of 23



LEGEND	
—	CROSS SECTION
XS#110	CROSS SECTION NUMBER
RS57085	RIVER STATION
➔	FLOW DIRECTION
— —	BRIDGE
—	LOCAL ROAD
—	PRIMARY HIGHWAY
— — —	STUDY BOUNDARY
— — —	FLOOD CONTROL STRUCTURE
—	PROPOSED FLOODWAY BOUNDARY
●	BANK STATION
⊙	PROPOSED FLOODWAY STATION
- - -	PREVIOUS FLOODWAY
■	DEPTH ≥ 1 M
■	100-YEAR DESIGN FLOOD EXTENT
■	VELOCITY ≥ 1 M/S
DESIGN DISCHARGE ATHABASCA RIVER ABOVE CLEARWATER RIVER CONFLUENCE = 5480 M ³ /S	



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REVIEWED	WP
APPROVED	WP

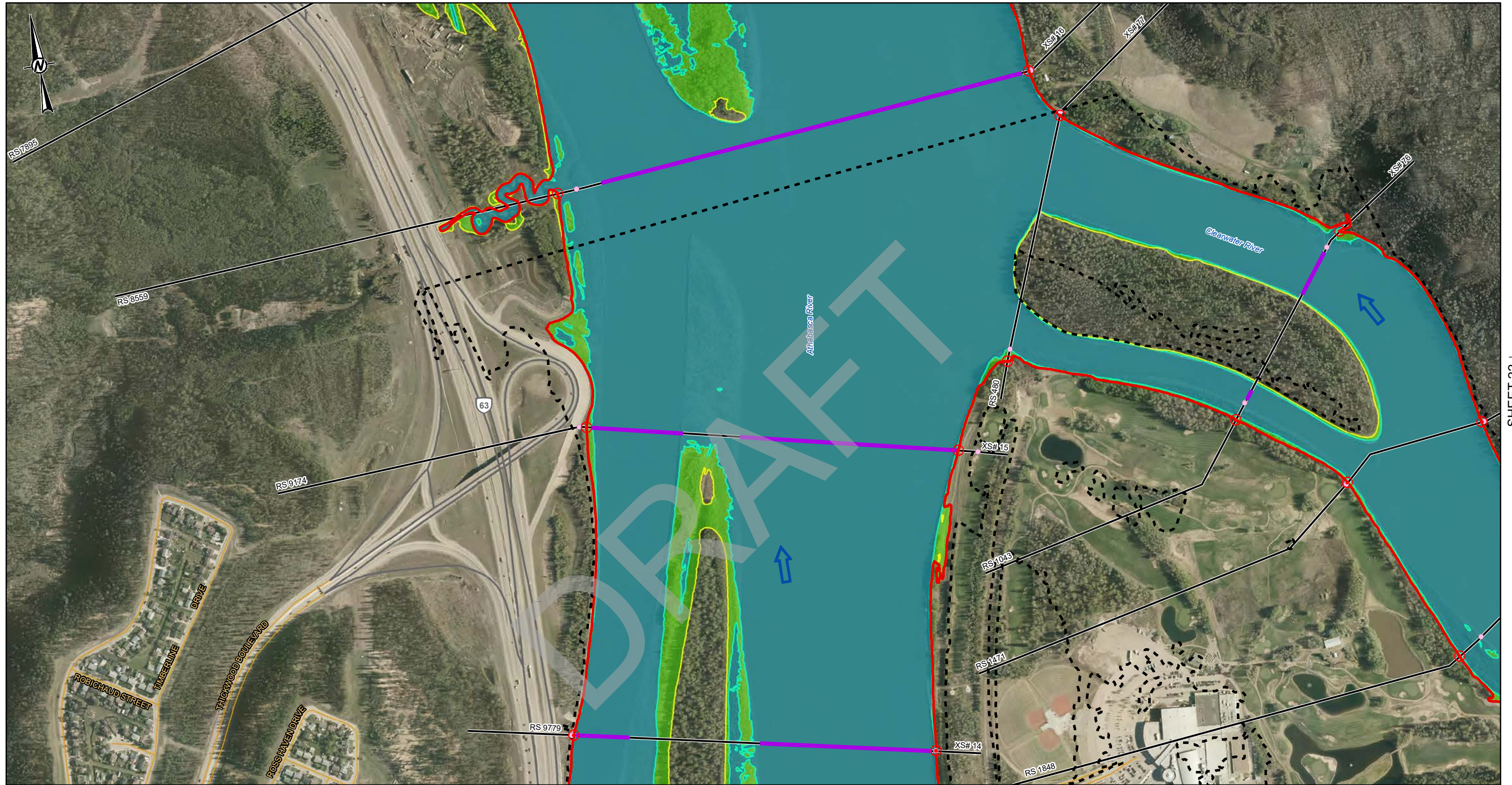
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DATUM: NAD 83 CSRS PROJECTION: 3TM 111

PROJECT
FORT McMURRAY RIVER HAZARD STUDY

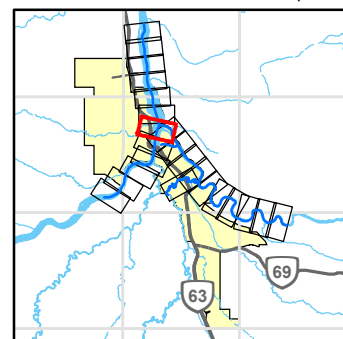
TITLE
OPEN WATER FLOODWAY CRITERIA MAP

PROJECT NO.	CONTROL	REV.	FIGURE
1662603	5000	0	Sheet 4 of 23

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LEGEND	
—	CROSS SECTION
XS#110	CROSS SECTION NUMBER
RS57085	RIVER STATION
➔	FLOW DIRECTION
—+—	BRIDGE
—	LOCAL ROAD
—	PRIMARY HIGHWAY
—	STUDY BOUNDARY
—	FLOOD CONTROL STRUCTURE
—	PROPOSED FLOODWAY BOUNDARY
●	BANK STATION
⊙	PROPOSED FLOODWAY STATION
- - -	PREVIOUS FLOODWAY
■	DEPTH ≥ 1 M
■	100-YEAR DESIGN FLOOD EXTENT
■	VELOCITY ≥ 1 M/S
DESIGN DISCHARGE	
ATHABASCA RIVER ABOVE CLEARWATER RIVER CONFLUENCE = 5480 M ³ /S	
CLEARWATER RIVER BELOW HANGINGSTONE RIVER CONFLUENCE = 949 M ³ /S	
ATHABASCA RIVER BELOW CLEARWATER RIVER CONFLUENCE = 5920 M ³ /S	



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DESIGNED	NG
PREPARED	PT
REVIEWED	WP
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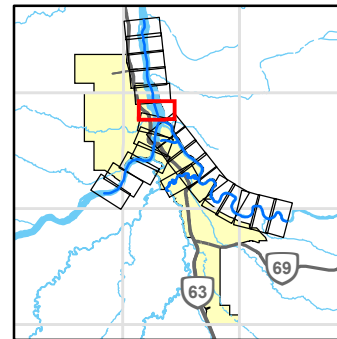
PROJECT
FORT McMURRAY RIVER HAZARD STUDY

TITLE
OPEN WATER FLOODWAY CRITERIA MAP

PROJECT NO.	CONTROL	REV.	FIGURE
1662603	5000	0	Sheet 6 of 23

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LEGEND	
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	XSS#110 CROSS SECTION NUMBER
	RS57085 RIVER STATION
	FLOW DIRECTION
	BRIDGE
	LOCAL ROAD
	PRIMARY HIGHWAY
	STUDY BOUNDARY
	FLOOD CONTROL STRUCTURE
	PROPOSED FLOODWAY BOUNDARY
	BANK STATION
	PROPOSED FLOODWAY STATION
	PREVIOUS FLOODWAY
	DEPTH ≥ 1 M
	100-YEAR DESIGN FLOOD EXTENT
	VELOCITY ≥ 1 M/S
DESIGN DISCHARGE ATHABASCA RIVER BELOW CLEARWATER RIVER CONFLUENCE = 5920 M ³ /S	



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DESIGNED	NG
PREPARED	PT
REVIEWED	WP
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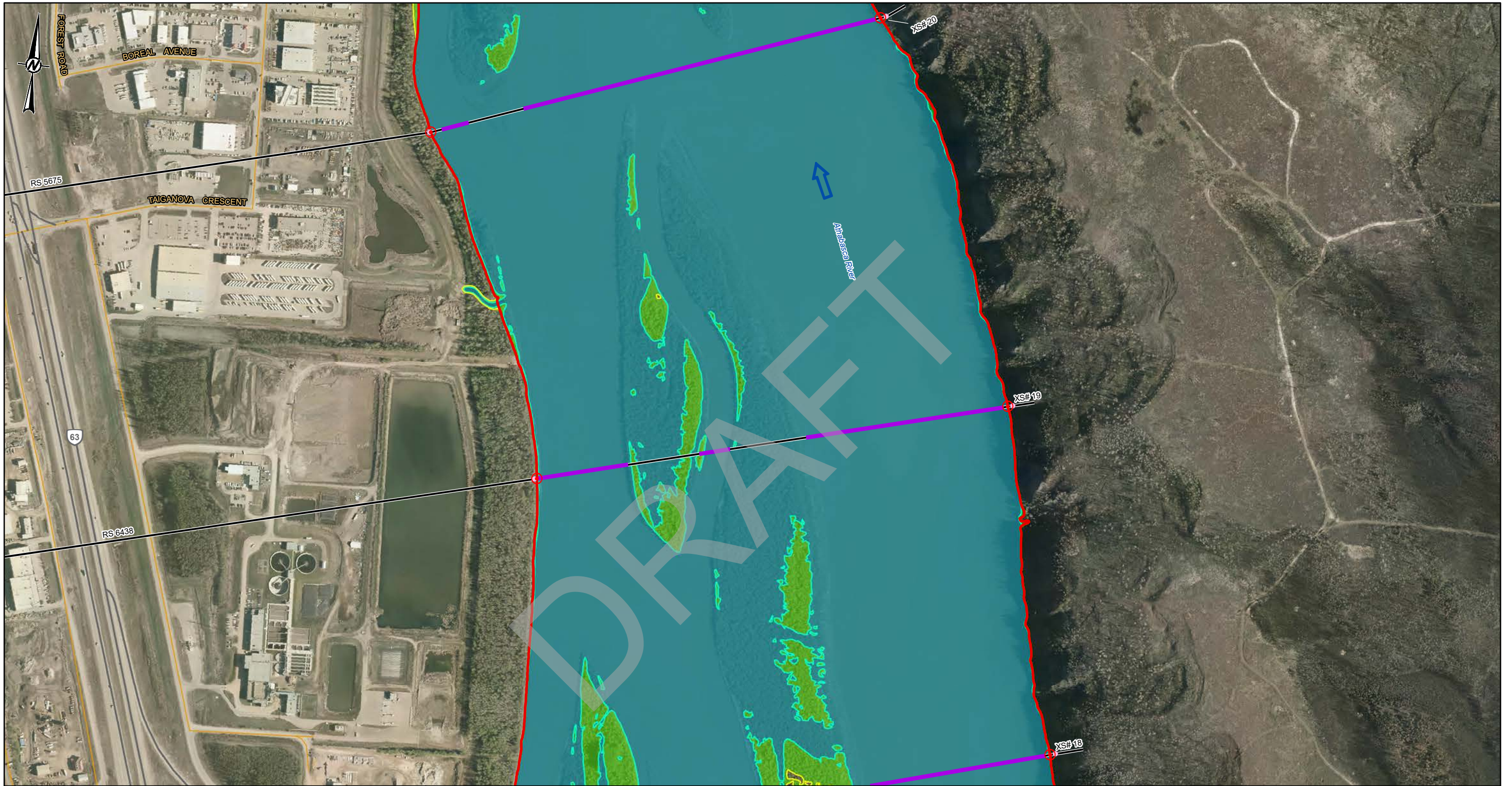
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PROJECT
FORT McMURRAY RIVER HAZARD STUDY

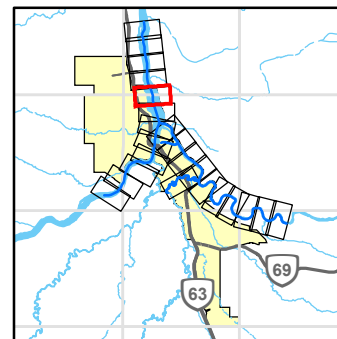
TITLE
OPEN WATER FLOODWAY CRITERIA MAP

PROJECT NO.	CONTROL	REV.	FIGURE
1662603	5000	0	Sheet 7 of 23

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B



LEGEND	
—	CROSS SECTION
XS#110	CROSS SECTION NUMBER
RS57085	RIVER STATION
➡	FLOW DIRECTION
⌈	BRIDGE
—	LOCAL ROAD
—	PRIMARY HIGHWAY
■	STUDY BOUNDARY
⌈	FLOOD CONTROL STRUCTURE
▭	PROPOSED FLOODWAY BOUNDARY
●	BANK STATION
⊙	PROPOSED FLOODWAY STATION
⋯	PREVIOUS FLOODWAY
■	DEPTH ≥ 1 M
■	100-YEAR DESIGN FLOOD EXTENT
■	VELOCITY ≥ 1 M/S
DESIGN DISCHARGE ATHABASCA RIVER BELOW CLEARWATER RIVER CONFLUENCE = 5920 M ³ /S	



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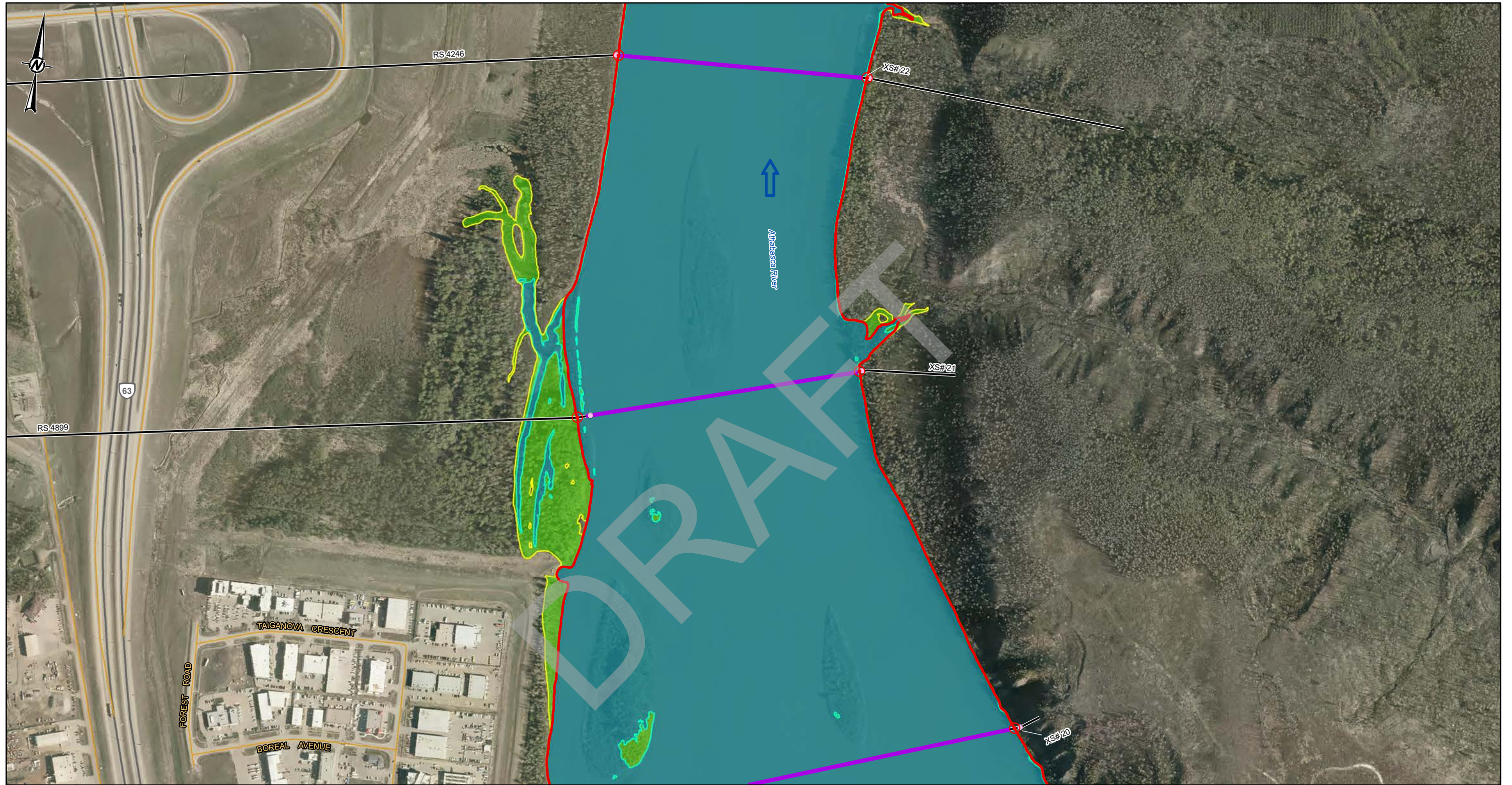
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REVIEWED	WP
APPROVED	WP

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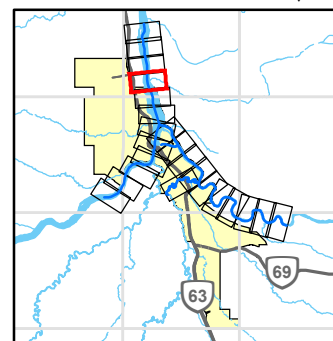
PROJECT
FORT McMURRAY RIVER HAZARD STUDY

TITLE
OPEN WATER FLOODWAY CRITERIA MAP

PROJECT NO.	CONTROL	REV.	FIGURE
1662603	5000	0	Sheet 8 of 23



LEGEND	
	CROSS SECTION
	CROSS SECTION NUMBER
	RIVER STATION
	FLOW DIRECTION
	BRIDGE
	LOCAL ROAD
	PRIMARY HIGHWAY
	STUDY BOUNDARY
	FLOOD CONTROL STRUCTURE
	PROPOSED FLOODWAY BOUNDARY
	BANK STATION
	PROPOSED FLOODWAY STATION
	PREVIOUS FLOODWAY
	DEPTH ≥ 1 M
	100-YEAR DESIGN FLOOD EXTENT
	VELOCITY ≥ 1 M/S
DESIGN DISCHARGE ATHABASCA RIVER BELOW CLEARWATER RIVER CONFLUENCE = 5920 M ³ /S	



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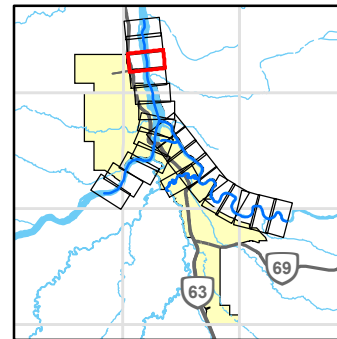
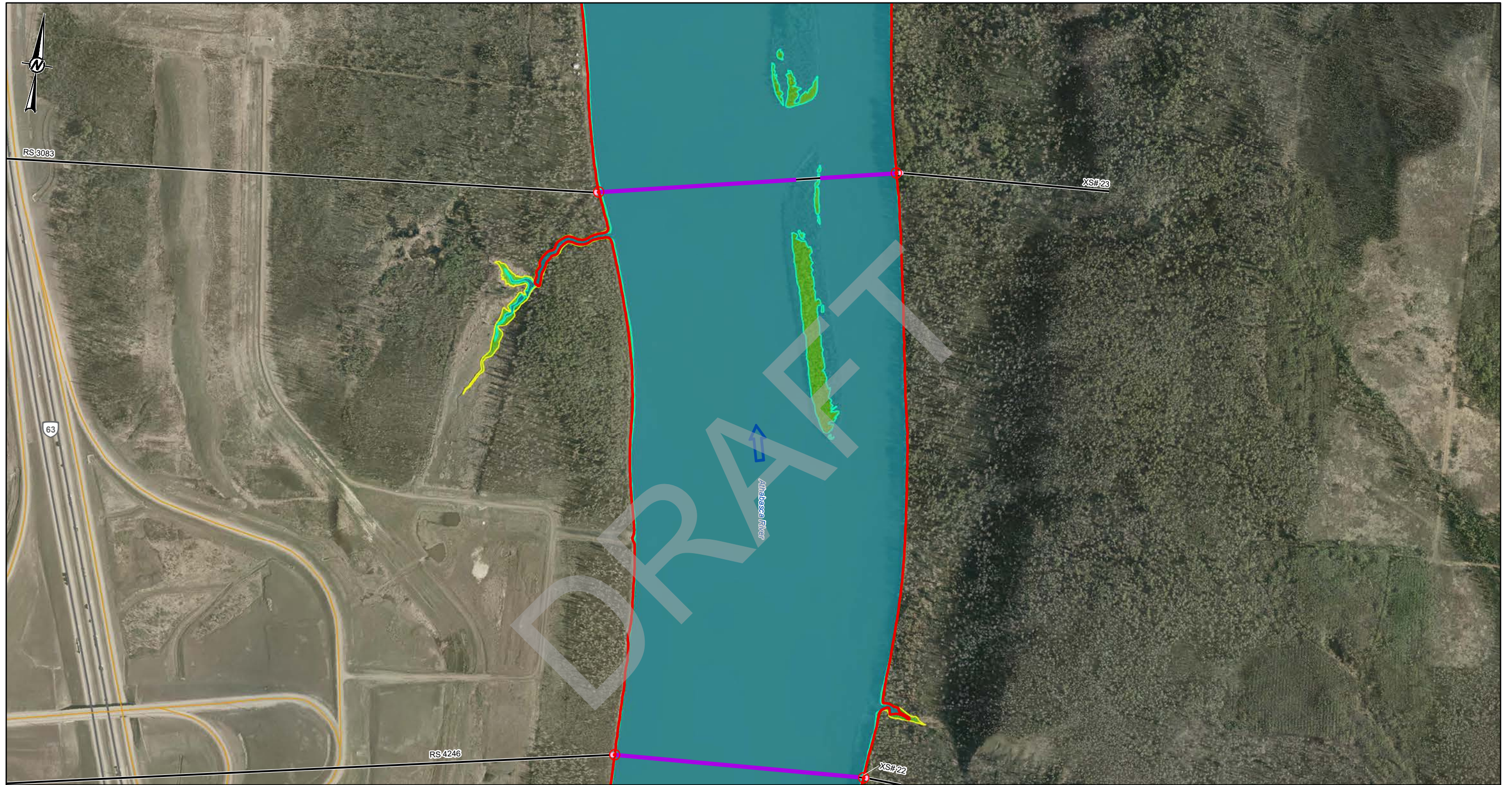
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APPROVED	WP

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PROJECT
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TITLE
OPEN WATER FLOODWAY CRITERIA MAP

PROJECT NO.	CONTROL	REV.	FIGURE
1662603	5000	0	Sheet 9 of 23



LEGEND	
—	CROSS SECTION
XS#110	CROSS SECTION NUMBER
RS57085	RIVER STATION
➔	FLOW DIRECTION
—+—	BRIDGE
—	LOCAL ROAD
—	PRIMARY HIGHWAY
—+—+—	STUDY BOUNDARY
—+—+—+—	FLOOD CONTROL STRUCTURE
—	PROPOSED FLOODWAY BOUNDARY
●	BANK STATION
⊙	PROPOSED FLOODWAY STATION
- - -	PREVIOUS FLOODWAY
■	DEPTH ≥ 1 M
■	100-YEAR DESIGN FLOOD EXTENT
■	VELOCITY ≥ 1 M/S
DESIGN DISCHARGE ATHABASCA RIVER BELOW CLEARWATER RIVER CONFLUENCE = 5920 M ³ /S	



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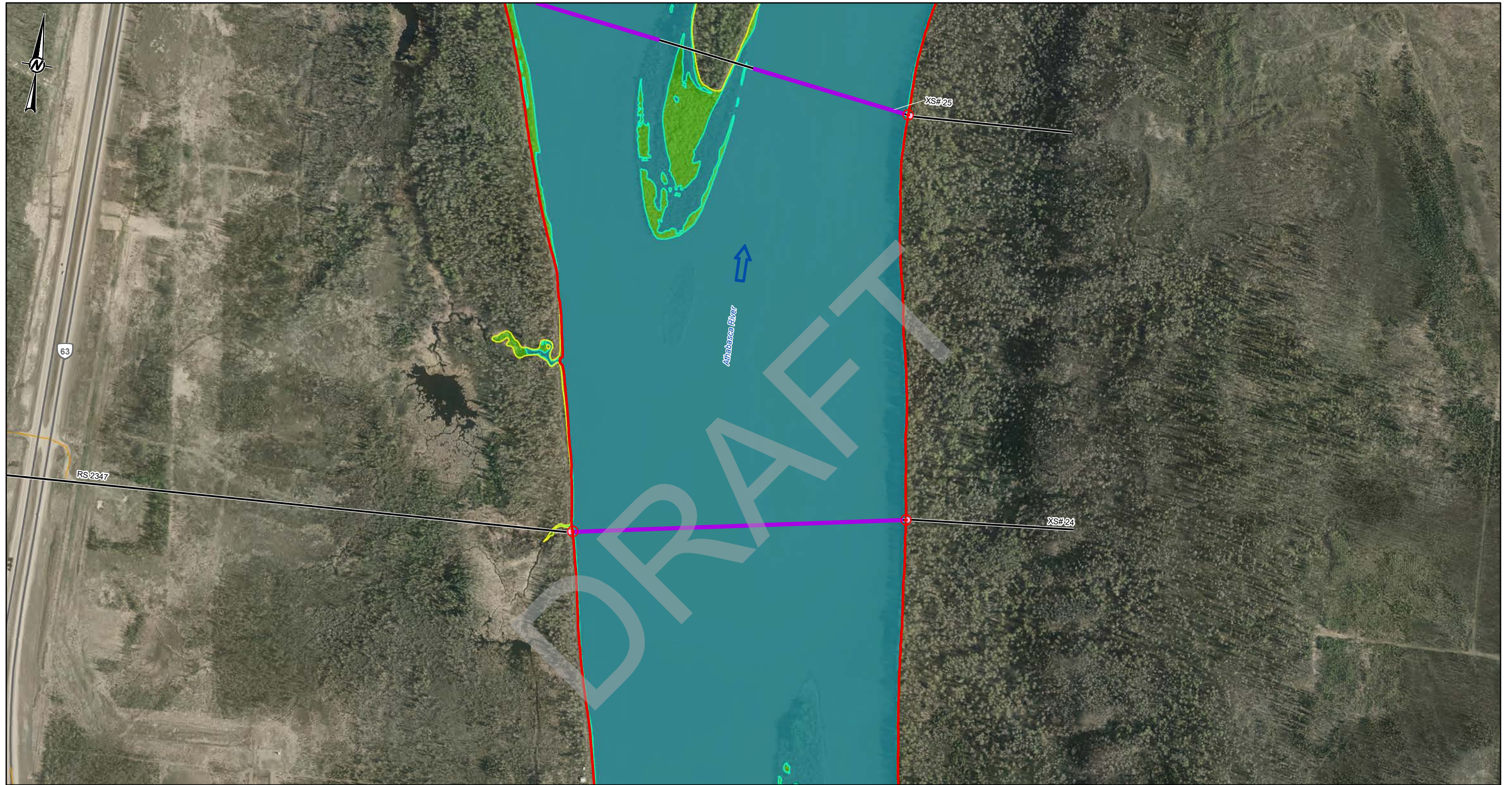
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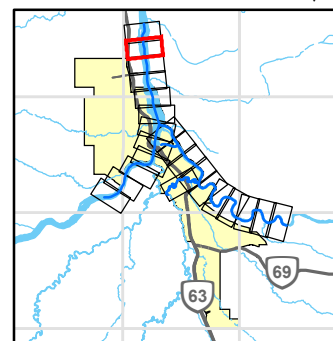
TITLE
OPEN WATER FLOODWAY CRITERIA MAP

PROJECT NO.	CONTROL	REV.	FIGURE
1662603	5000	0	Sheet 10 of 23

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LEGEND	
	CROSS SECTION
	PROPOSED FLOODWAY BOUNDARY
	BANK STATION
	PROPOSED FLOODWAY STATION
	FLOW DIRECTION
	PREVIOUS FLOODWAY
	DEPTH ≥ 1 M
	100-YEAR DESIGN FLOOD EXTENT
	VELOCITY ≥ 1 M/S
	DESIGN DISCHARGE
	ATHABASCA RIVER BELOW CLEARWATER RIVER CONFLUENCE = 5920 M ³ /S
	FLOOD CONTROL STRUCTURE
	RS57085 RIVER STATION
	XS#110 CROSS SECTION NUMBER
	LOCAL ROAD
	PRIMARY HIGHWAY
	STUDY BOUNDARY



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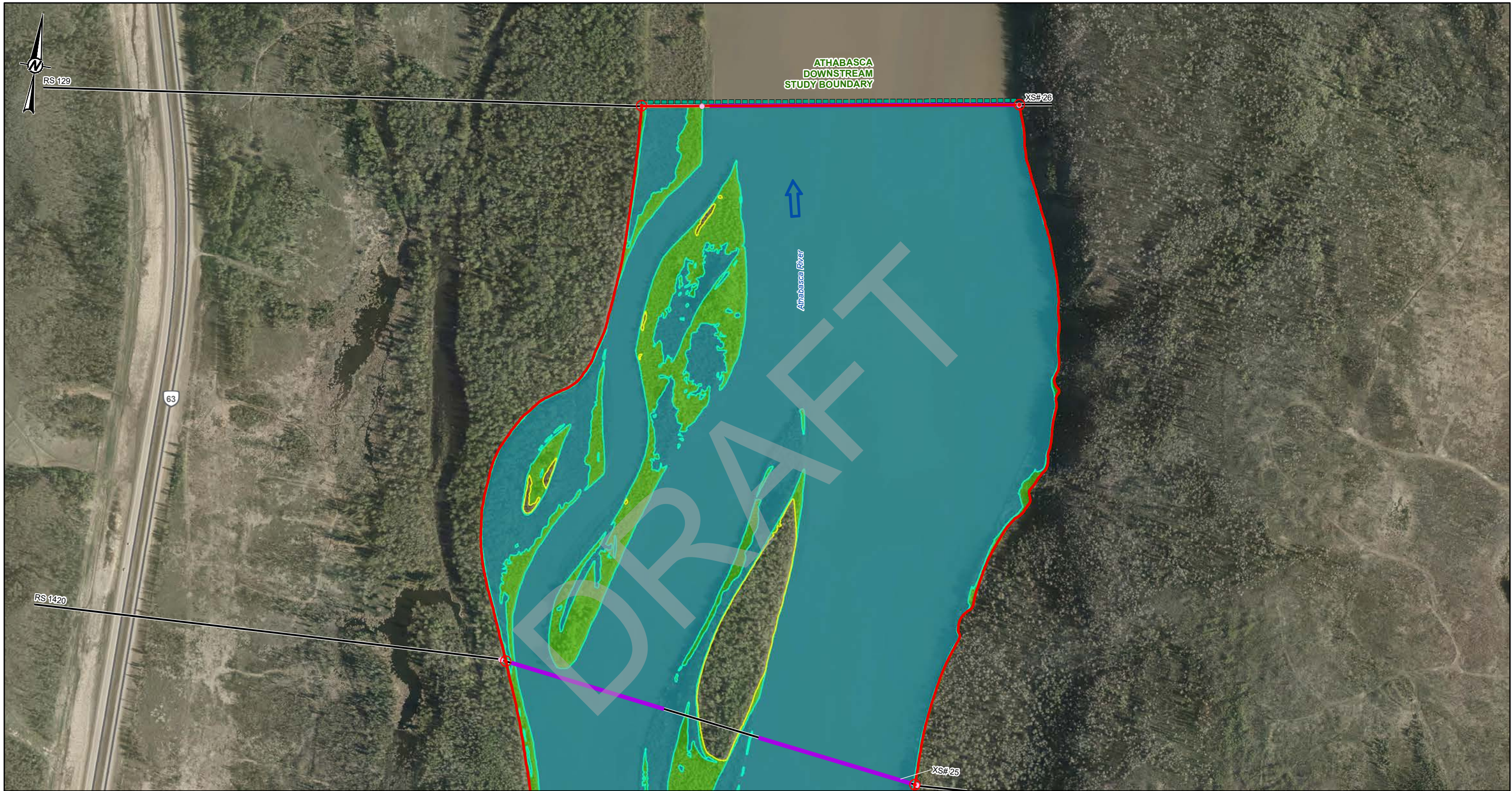
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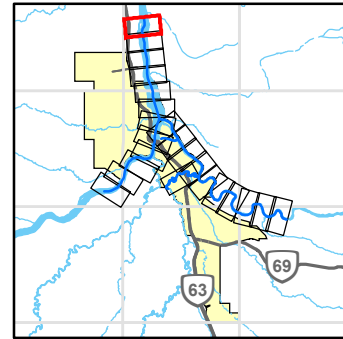
TITLE
OPEN WATER FLOODWAY CRITERIA MAP

PROJECT NO.	CONTROL	REV.	FIGURE
1662603	5000	0	Sheet 11 of 23



LEGEND	
	CROSS SECTION
	CROSS SECTION NUMBER
	RIVER STATION
	FLOW DIRECTION
	BRIDGE
	LOCAL ROAD
	PRIMARY HIGHWAY
	STUDY BOUNDARY
	FLOOD CONTROL STRUCTURE
	PROPOSED FLOODWAY BOUNDARY
	BANK STATION
	PROPOSED FLOODWAY STATION
	PREVIOUS FLOODWAY
	DEPTH ≥ 1 M
	100-YEAR DESIGN FLOOD EXTENT
	VELOCITY ≥ 1 M/S
DESIGN DISCHARGE ATHABASCA RIVER BELOW CLEARWATER RIVER CONFLUENCE = 5920 M ³ /S	

SHEET 11 ↓



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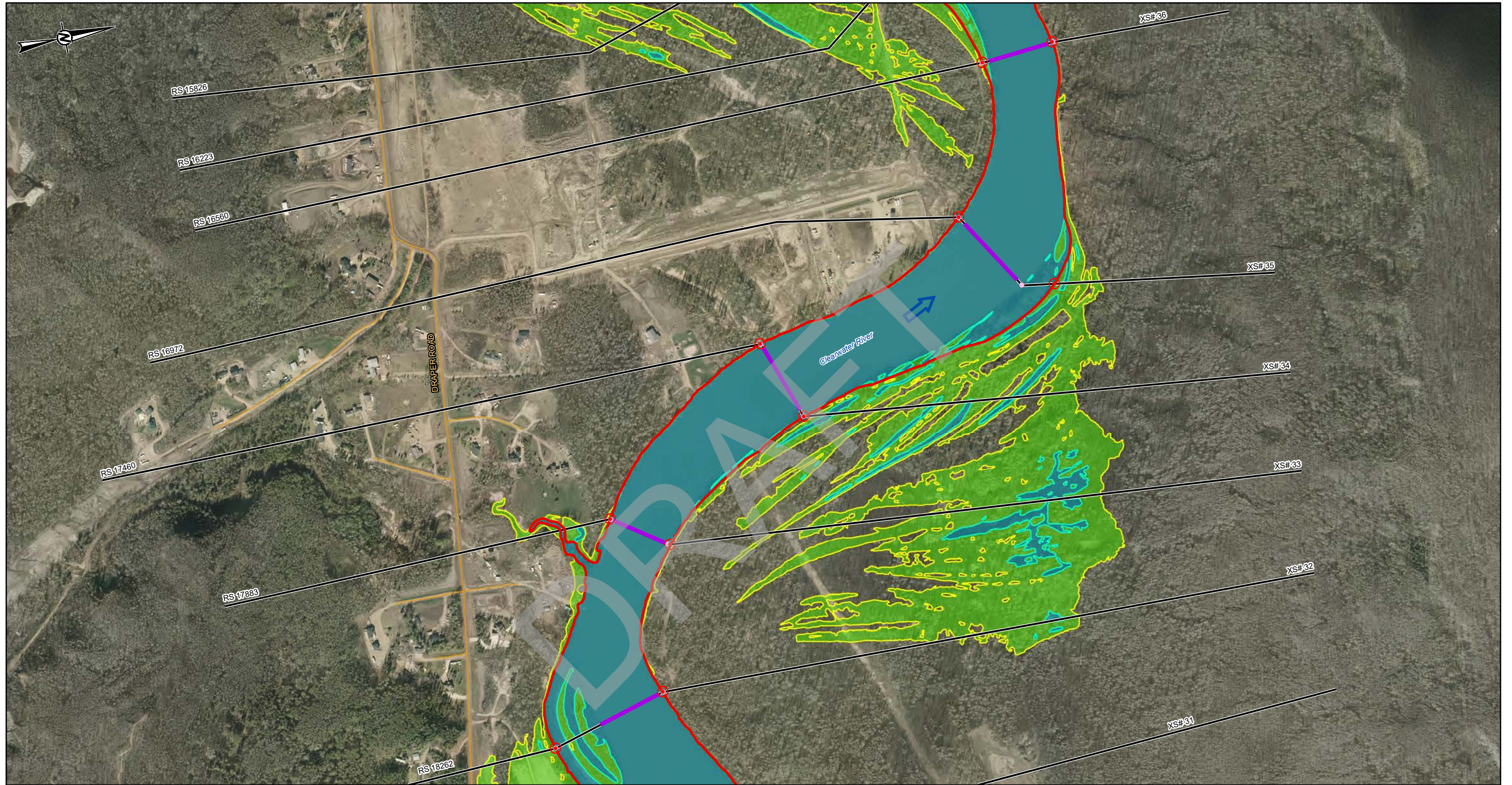
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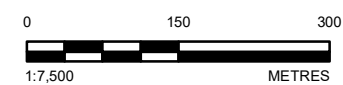
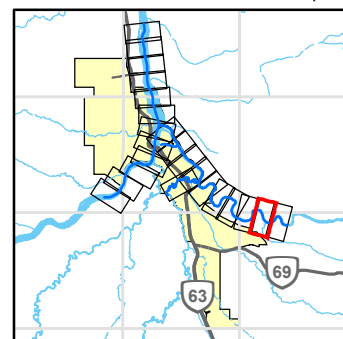
PROJECT
FORT McMURRAY RIVER HAZARD STUDY

TITLE
OPEN WATER FLOODWAY CRITERIA MAP

PROJECT NO.	CONTROL	REV.	FIGURE
1662603	5000	0	Sheet 12 of 23



LEGEND	
	CROSS SECTION
	CROSS SECTION NUMBER
	RIVER STATION
	FLOW DIRECTION
	BRIDGE
	LOCAL ROAD
	PRIMARY HIGHWAY
	STUDY BOUNDARY
	FLOOD CONTROL STRUCTURE
	PROPOSED FLOODWAY BOUNDARY
	BANK STATION
	PROPOSED FLOODWAY STATION
	PREVIOUS FLOODWAY
	DEPTH ≥ 1 M
	100-YEAR DESIGN FLOOD EXTENT
	VELOCITY ≥ 1 M/S
DESIGN DISCHARGE CLEARWATER RIVER ABOVE HANGINGSTONE RIVER CONFLUENCE = 900 M ³ /S	



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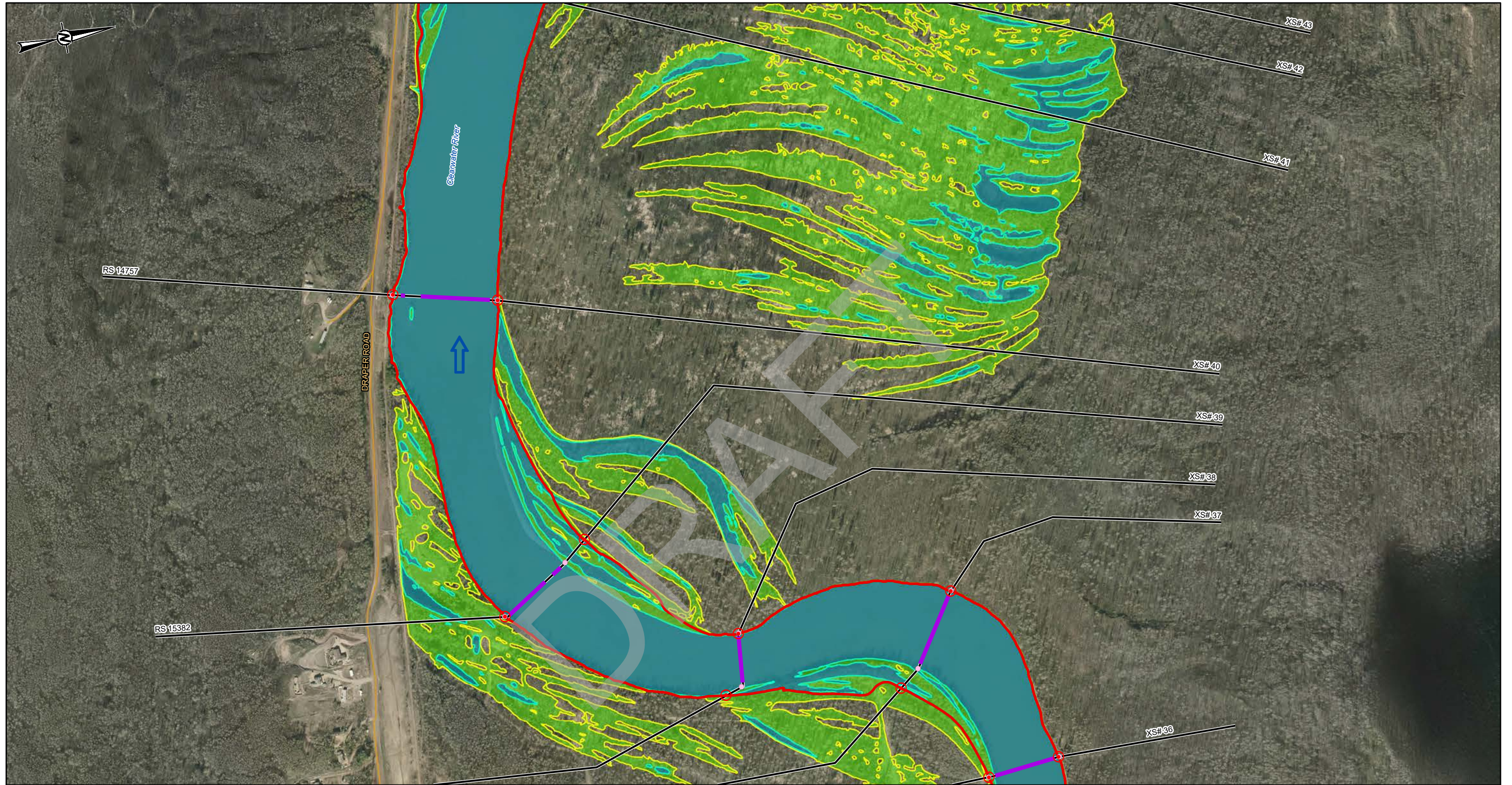
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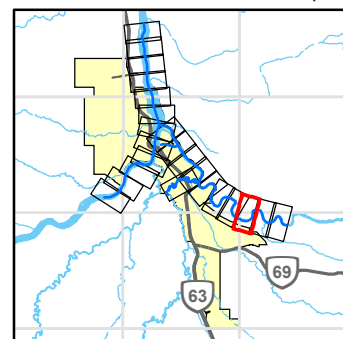
PROJECT
FORT McMURRAY RIVER HAZARD STUDY

TITLE
OPEN WATER FLOODWAY CRITERIA MAP

PROJECT NO.	CONTROL	REV.	FIGURE
1662603	5000	0	Sheet 14 of 23



LEGEND	
—	CROSS SECTION
XS#110	CROSS SECTION NUMBER
RS57085	RIVER STATION
➔	FLOW DIRECTION
—+—	BRIDGE
—	LOCAL ROAD
—	PRIMARY HIGHWAY
—	STUDY BOUNDARY
—	FLOOD CONTROL STRUCTURE
—	PROPOSED FLOODWAY BOUNDARY
●	BANK STATION
⊙	PROPOSED FLOODWAY STATION
- - -	PREVIOUS FLOODWAY
■	DEPTH ≥ 1 M
■	100-YEAR DESIGN FLOOD EXTENT
■	VELOCITY ≥ 1 M/S
DESIGN DISCHARGE	
CLEARWATER RIVER ABOVE HANGINGSTONE RIVER CONFLUENCE = 900 M ³ /S	



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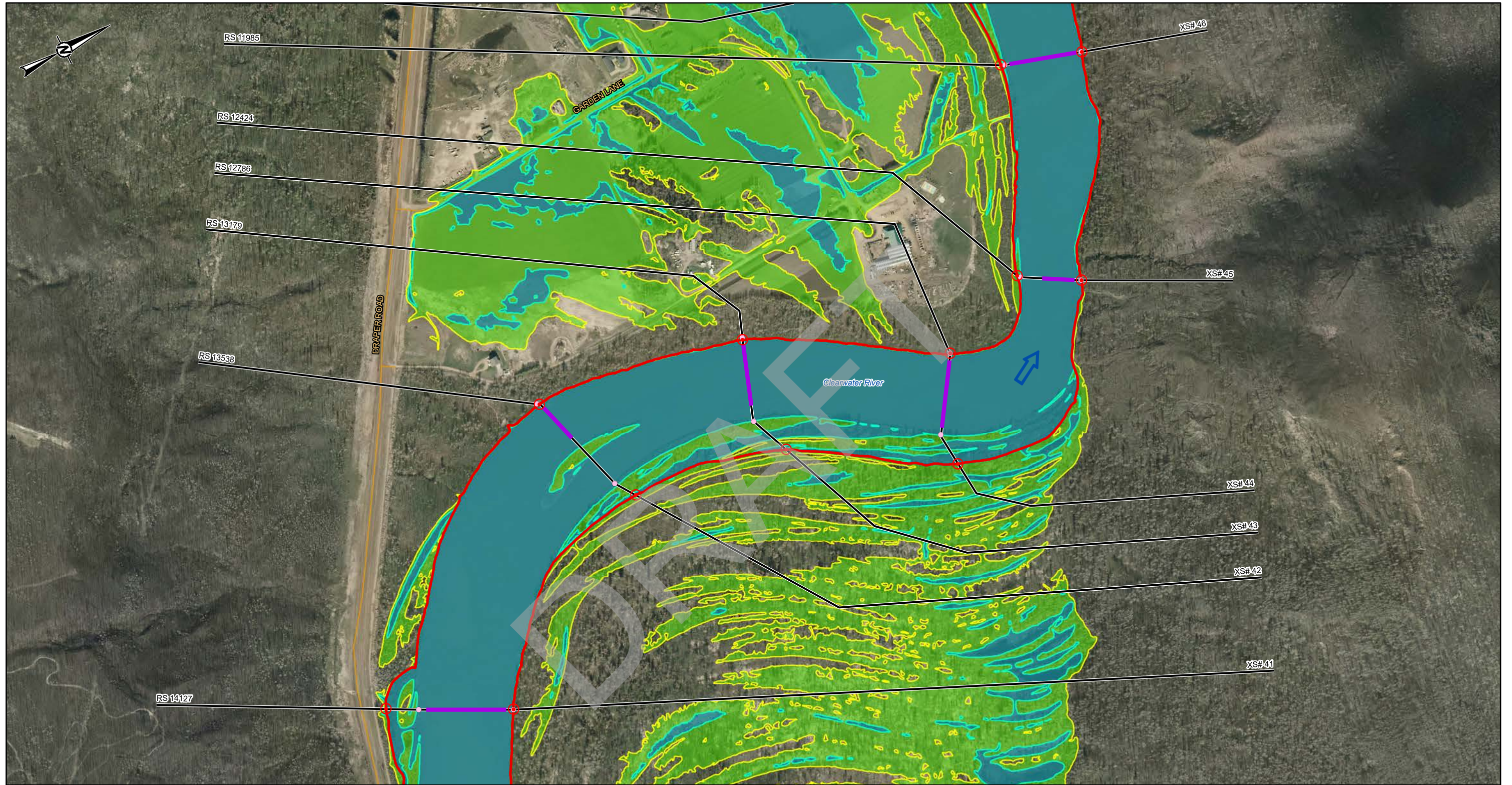
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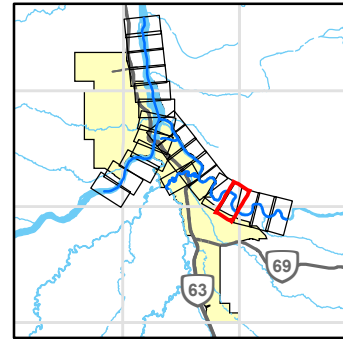
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TITLE OPEN WATER FLOODWAY CRITERIA MAP	
PROJECT NO. 1662603	CONTROL 5000
REV. 0	FIGURE Sheet 15 of 23

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LEGEND	
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XS#110	CROSS SECTION NUMBER
RS57085	RIVER STATION
➔	FLOW DIRECTION
—+—	BRIDGE
—	LOCAL ROAD
—	PRIMARY HIGHWAY
—+—+—	STUDY BOUNDARY
—+—+—+—	FLOOD CONTROL STRUCTURE
—	PROPOSED FLOODWAY BOUNDARY
●	BANK STATION
⊙	PROPOSED FLOODWAY STATION
- - -	PREVIOUS FLOODWAY
■	DEPTH ≥ 1 M
■	100-YEAR DESIGN FLOOD EXTENT
■	VELOCITY ≥ 1 M/S
DESIGN DISCHARGE	
CLEARWATER RIVER ABOVE HANGINGSTONE RIVER CONFLUENCE = 900 M ³ /S	



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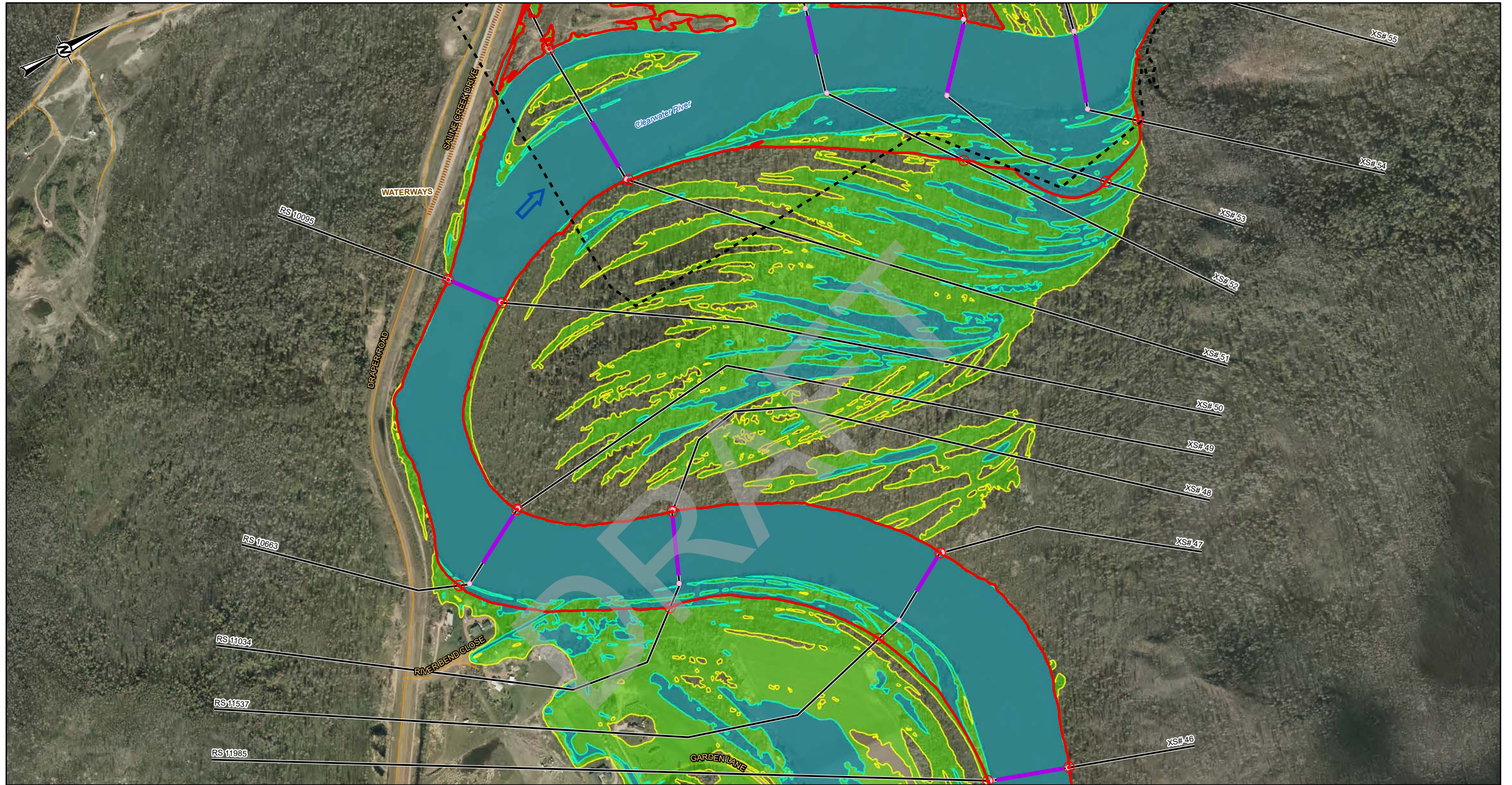
PROJECT
FORT McMURRAY RIVER HAZARD STUDY

TITLE
OPEN WATER FLOODWAY CRITERIA MAP

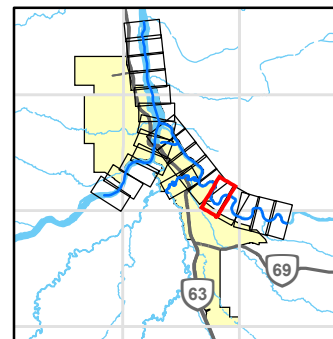
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LEGEND	
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	CROSS SECTION NUMBER
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	FLOW DIRECTION
	BRIDGE
	LOCAL ROAD
	PRIMARY HIGHWAY
	STUDY BOUNDARY
	FLOOD CONTROL STRUCTURE
	PROPOSED FLOODWAY BOUNDARY
	BANK STATION
	PROPOSED FLOODWAY STATION
	PREVIOUS FLOODWAY
	DEPTH ≥ 1 M
	100-YEAR DESIGN FLOOD EXTENT
	VELOCITY ≥ 1 M/S
DESIGN DISCHARGE CLEARWATER RIVER ABOVE HANGINGSTONE RIVER CONFLUENCE = 900 M ³ /S	



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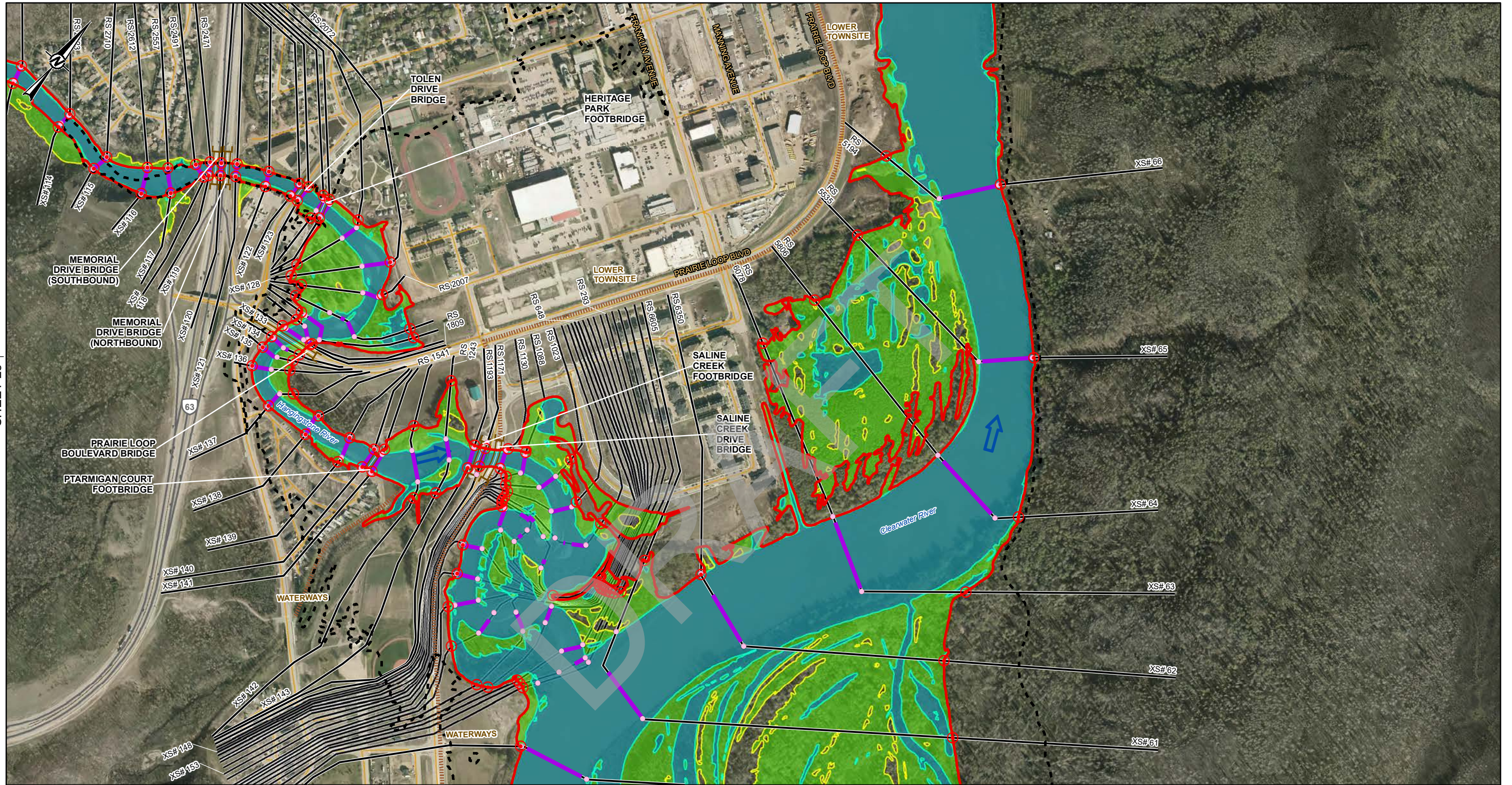
PROJECT
FORT McMURRAY RIVER HAZARD STUDY

TITLE
OPEN WATER FLOODWAY CRITERIA MAP

PROJECT NO.	CONTROL	REV.	FIGURE
1662603	5000	0	Sheet 17 of 23

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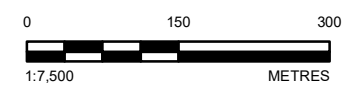
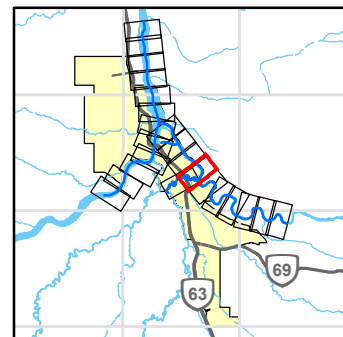
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SHEET 23 ↑

SHEET 18 ↓

LEGEND	
—	CROSS SECTION
XS#110	CROSS SECTION NUMBER
RS57085	RIVER STATION
➔	FLOW DIRECTION
⌈	BRIDGE
—	LOCAL ROAD
—	PRIMARY HIGHWAY
▬▬▬	STUDY BOUNDARY
▬▬▬	FLOOD CONTROL STRUCTURE
▭	PROPOSED FLOODWAY BOUNDARY
●	BANK STATION
⊙	PROPOSED FLOODWAY STATION
▭	PREVIOUS FLOODWAY
■	DEPTH ≥ 1 M
■	100-YEAR DESIGN FLOOD EXTENT
■	VELOCITY ≥ 1 M/S
DESIGN DISCHARGE	
CLEARWATER RIVER ABOVE HANGINGSTONE RIVER CONFLUENCE = 900 M ³ /S	
HANGINGSTONE RIVER = 206 M ³ /S	
CLEARWATER RIVER BELOW HANGINGSTONE RIVER CONFLUENCE = 949 M ³ /S	



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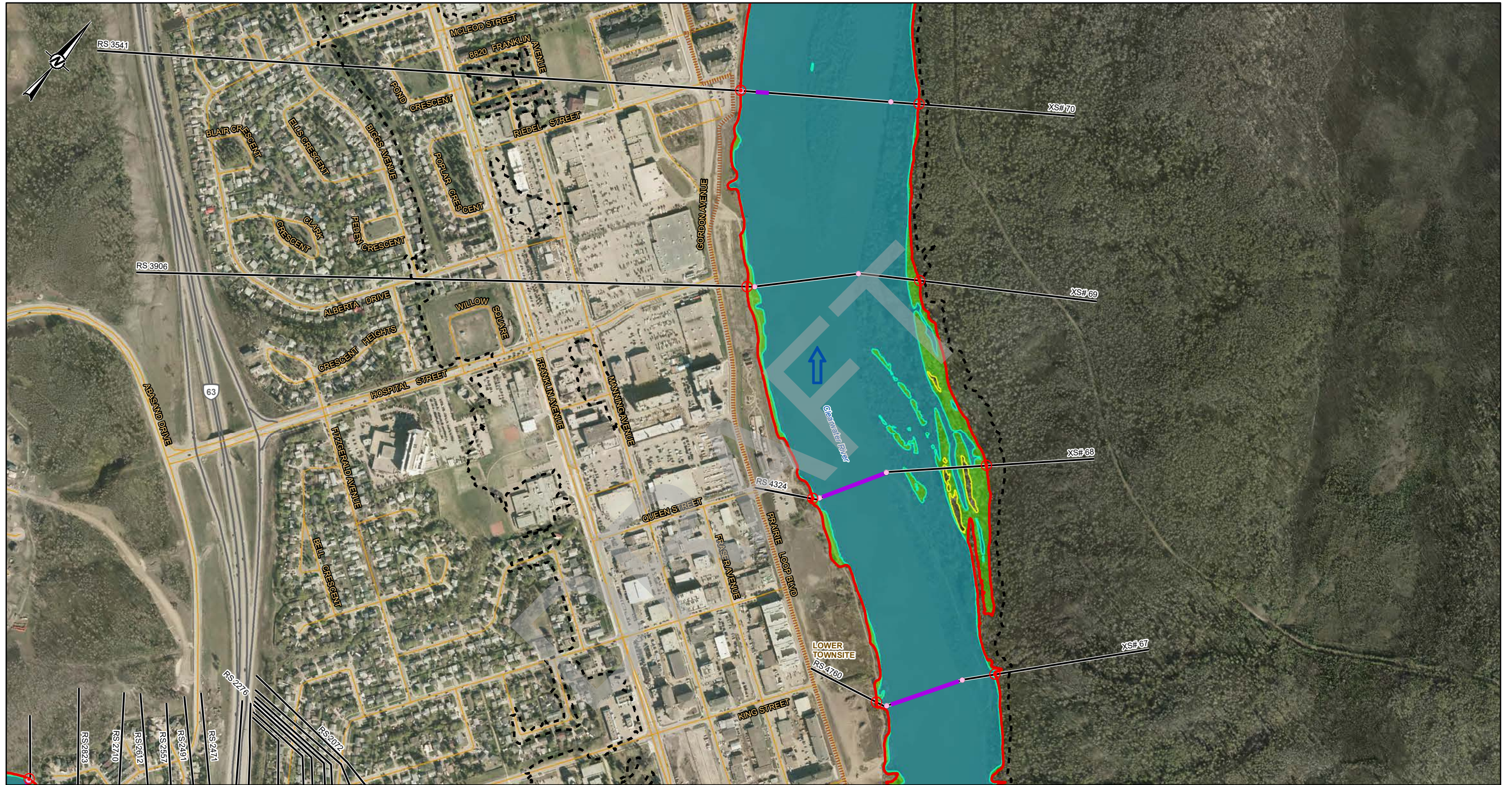
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PREPARED	PT
REVIEWED	WP
APPROVED	WP

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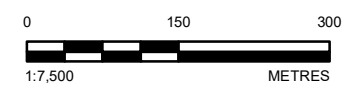
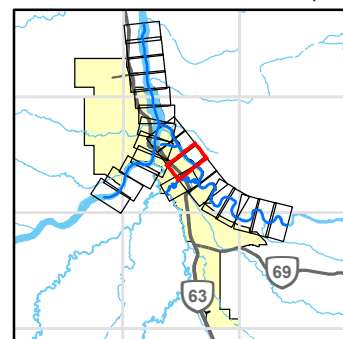
PROJECT
FORT McMURRAY RIVER HAZARD STUDY

TITLE
OPEN WATER FLOODWAY CRITERIA MAP

PROJECT NO.	CONTROL	REV.	FIGURE
1662603	5000	0	Sheet 19 of 23



LEGEND	
	CROSS SECTION
	XS#110 CROSS SECTION NUMBER
	RS57085 RIVER STATION
	FLOW DIRECTION
	BRIDGE
	LOCAL ROAD
	PRIMARY HIGHWAY
	STUDY BOUNDARY
	FLOOD CONTROL STRUCTURE
	PROPOSED FLOODWAY BOUNDARY
	BANK STATION
	PROPOSED FLOODWAY STATION
	PREVIOUS FLOODWAY
	DEPTH ≥ 1 M
	100-YEAR DESIGN FLOOD EXTENT
	VELOCITY ≥ 1 M/S
DESIGN DISCHARGE CLEARWATER RIVER BELOW HANGINGSTONE RIVER CONFLUENCE = 949 M ³ /S	



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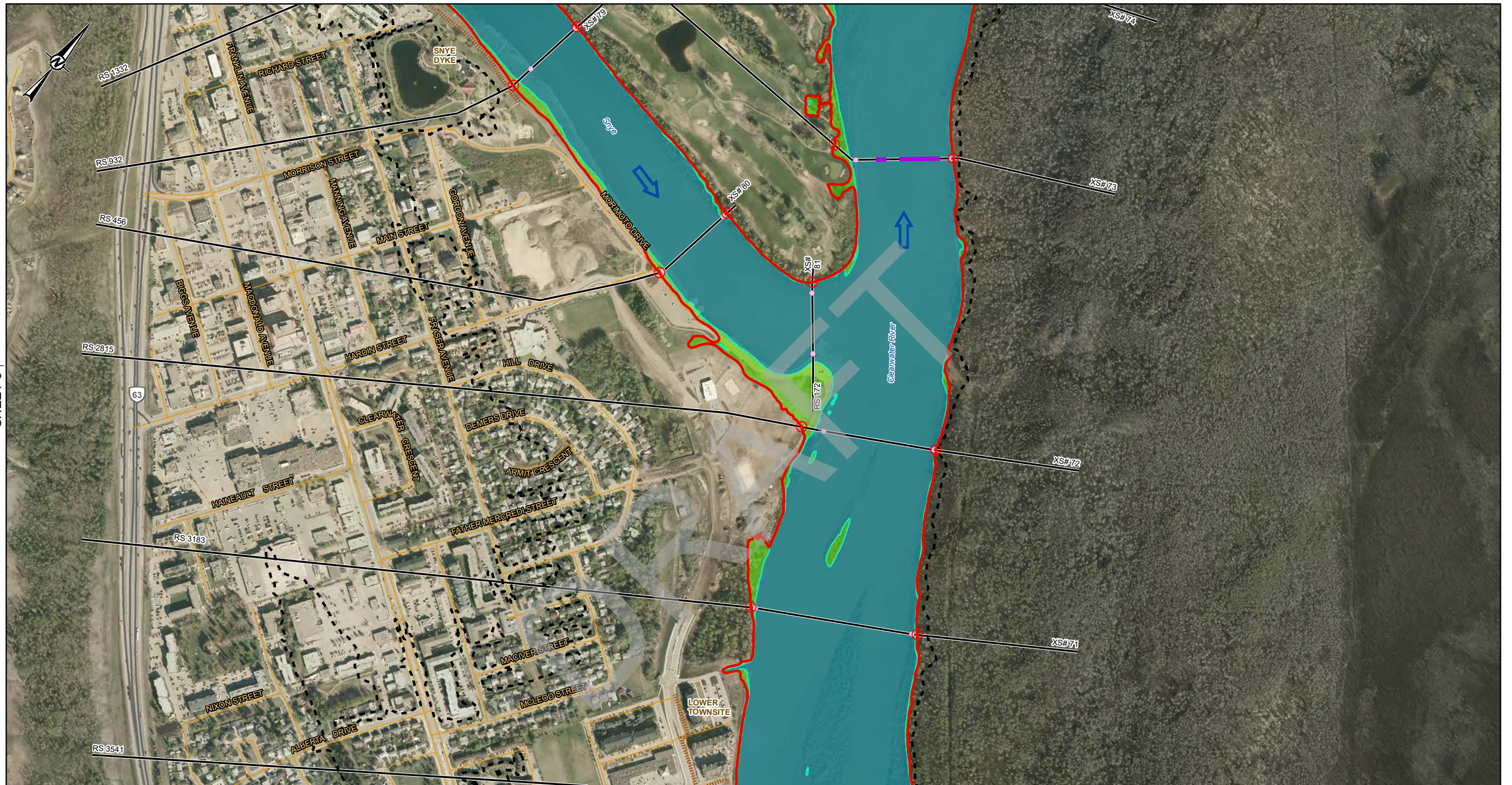
PROJECT
FORT McMURRAY RIVER HAZARD STUDY

TITLE
OPEN WATER FLOODWAY CRITERIA MAP

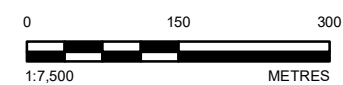
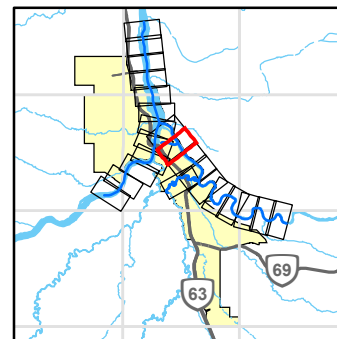
PROJECT NO.	CONTROL	REV.	FIGURE
1662603	5000	0	Sheet 20 of 23

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LEGEND	
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	XS#110 CROSS SECTION NUMBER
	RS57085 RIVER STATION
	FLOW DIRECTION
	BRIDGE
	LOCAL ROAD
	PRIMARY HIGHWAY
	STUDY BOUNDARY
	FLOOD CONTROL STRUCTURE
	PROPOSED FLOODWAY BOUNDARY
	BANK STATION
	PROPOSED FLOODWAY STATION
	PREVIOUS FLOODWAY
	DEPTH ≥ 1 M
	100-YEAR DESIGN FLOOD EXTENT
	VELOCITY ≥ 1 M/S
DESIGN DISCHARGE CLEARWATER RIVER BELOW HANGINGSTONE RIVER CONFLUENCE = 949 M ³ /S	



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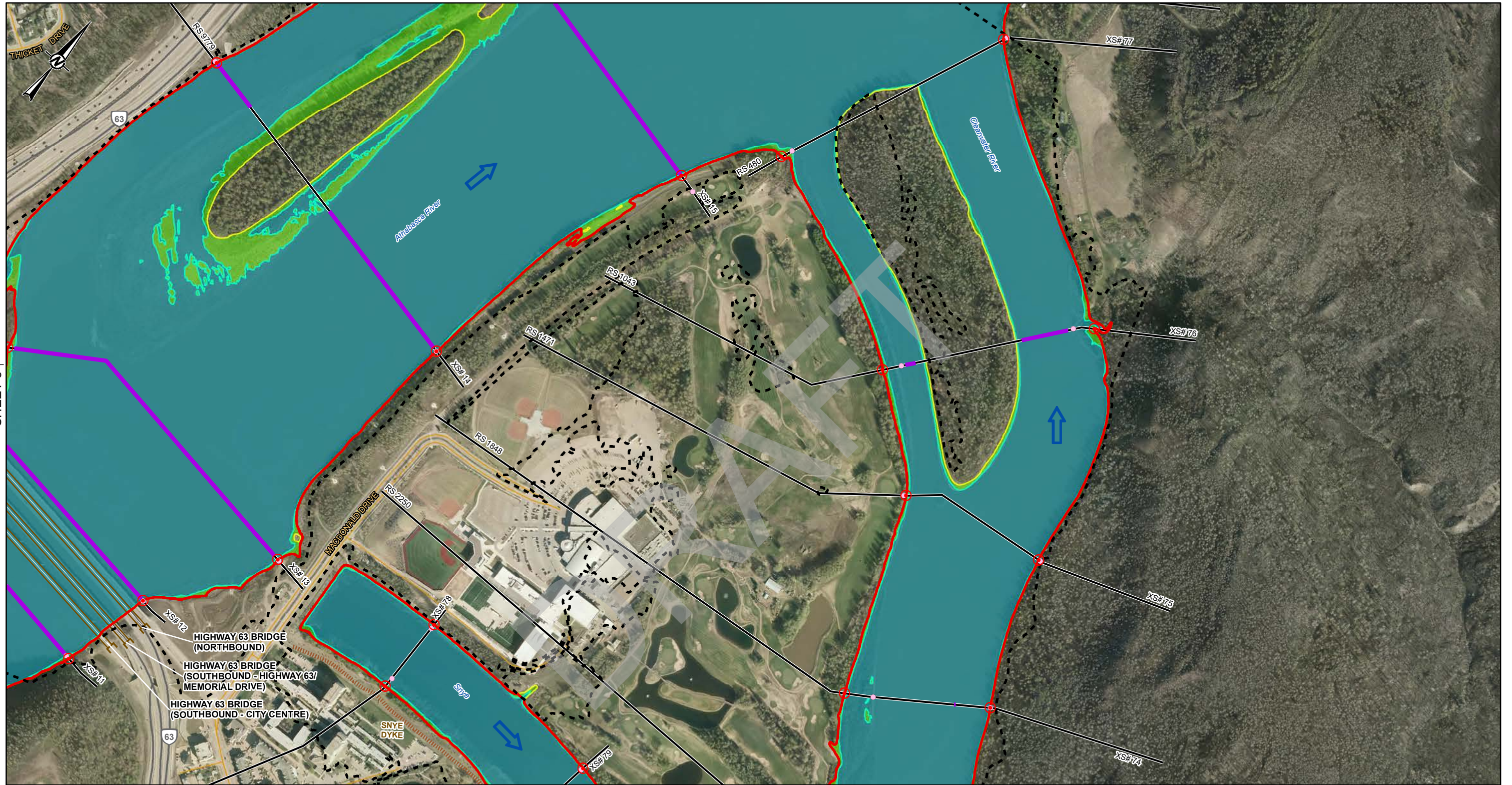
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APPROVED	WP

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PROJECT
FORT McMURRAY RIVER HAZARD STUDY

TITLE
OPEN WATER FLOODWAY CRITERIA MAP

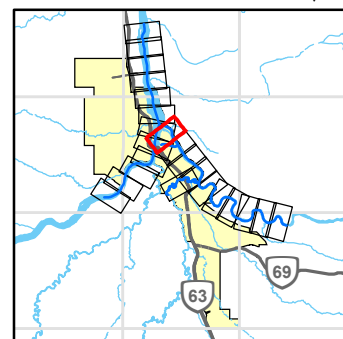
PROJECT NO.	CONTROL	REV.	FIGURE
1662603	5000	0	Sheet 21 of 23



SHEET 5 ↑

SHEET 21 ↓

LEGEND	
—	CROSS SECTION
XS#110	CROSS SECTION NUMBER
RS57085	RIVER STATION
➔	FLOW DIRECTION
—	BRIDGE
—	LOCAL ROAD
—	PRIMARY HIGHWAY
—	STUDY BOUNDARY
—	FLOOD CONTROL STRUCTURE
—	PROPOSED FLOODWAY BOUNDARY
●	BANK STATION
⊙	PROPOSED FLOODWAY STATION
- - -	PREVIOUS FLOODWAY
■	DEPTH ≥ 1 M
■	100-YEAR DESIGN FLOOD EXTENT
■	VELOCITY ≥ 1 M/S
DESIGN DISCHARGE	
ATHABASCA RIVER ABOVE CLEARWATER RIVER CONFLUENCE = 5480 M ³ /S	
CLEARWATER RIVER BELOW HANGINGSTONE RIVER CONFLUENCE = 949 M ³ /S	
ATHABASCA RIVER BELOW CLEARWATER RIVER CONFLUENCE = 5920 M ³ /S	



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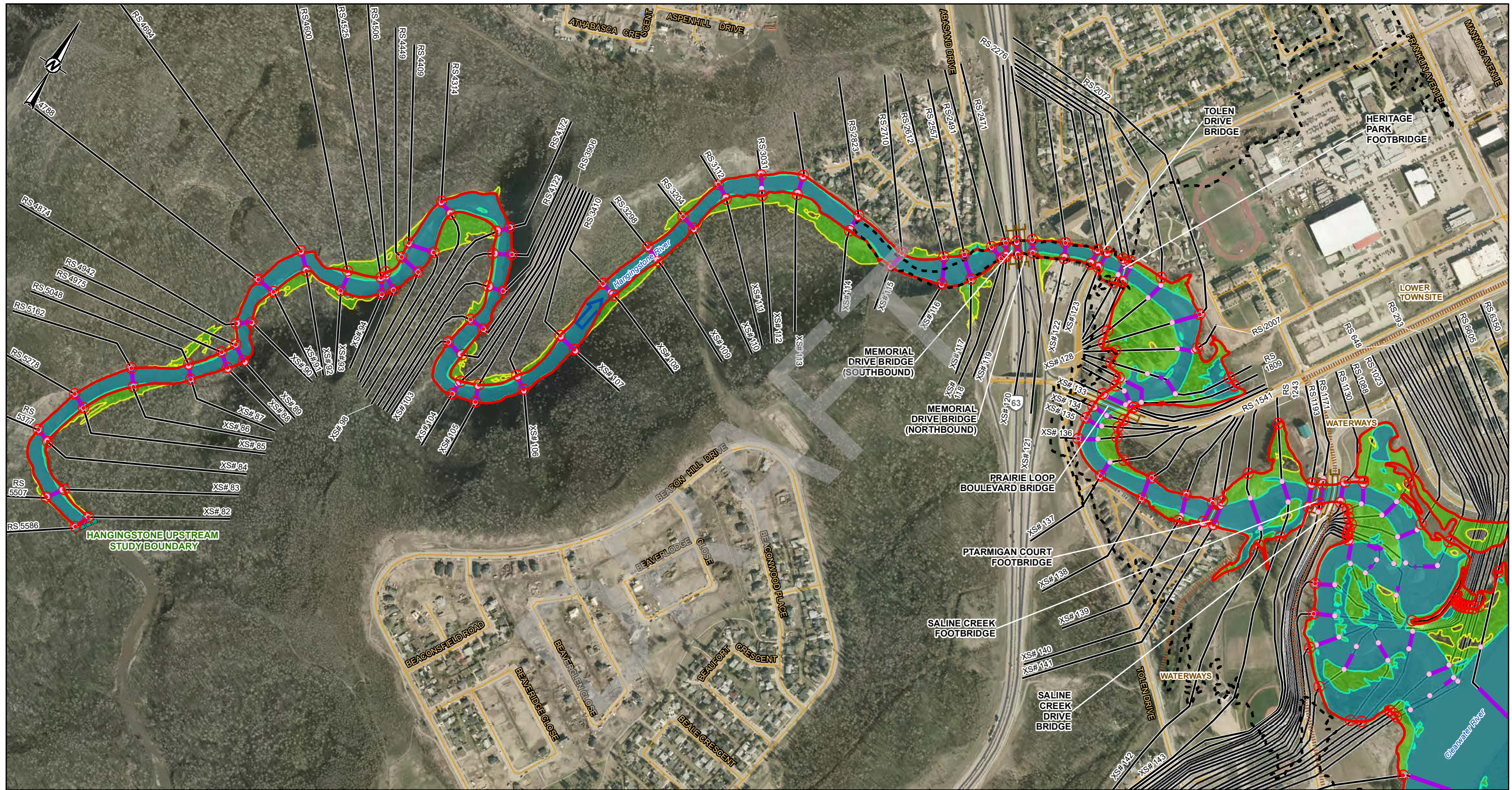
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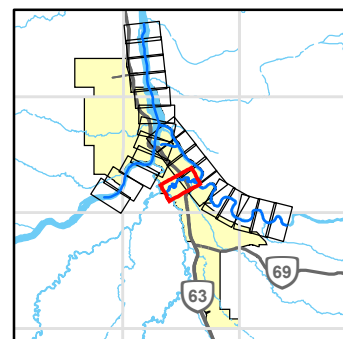
TITLE
OPEN WATER FLOODWAY CRITERIA MAP

PROJECT NO.	CONTROL	REV.	FIGURE
1662603	5000	0	Sheet 22 of 23



LEGEND

CROSS SECTION	PROPOSED FLOODWAY BOUNDARY	
XS#110 CROSS SECTION NUMBER	BANK STATION	
RS57085 RIVER STATION	PROPOSED FLOODWAY STATION	
FLOW DIRECTION	PREVIOUS FLOODWAY	
BRIDGE	DEPTH ≥ 1 M	
LOCAL ROAD	100-YEAR DESIGN FLOOD EXTENT	
PRIMARY HIGHWAY	VELOCITY ≥ 1 M/S	
STUDY BOUNDARY	DESIGN DISCHARGE	
FLOOD CONTROL STRUCTURE	CLEARWATER RIVER ABOVE HANGINGSTONE RIVER CONFLUENCE = 900 M ³ /S	
	HANGINGSTONE RIVER = 206 M ³ /S	
	CLEARWATER RIVER BELOW HANGINGSTONE RIVER CONFLUENCE = 949 M ³ /S	



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PROJECT
FORT McMURRAY RIVER HAZARD STUDY

TITLE
OPEN WATER FLOODWAY CRITERIA MAP

PROJECT NO.	CONTROL	REV.	FIGURE
1662603	5000	0	Sheet 23 of 23

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