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Memo

To:	Andrew Baryla Hatch	From:	David Morgan Stantec – Winnipeg
File:	Updated Preliminary Engineering Design of the Lake Manitoba Outlet Channel Outside Drain Stantec File: 111475107- Hatch Document Number: E358159-1000-221-030-0001, Rev. A	Date:	July 28, 2021

Reference: Updated Preliminary Engineering Design of the Lake Manitoba Outlet Channel Outside Drain

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1.0 INTRODUCTION

This memo updates the previous Preliminary Engineering Report for Local Surface Water Management for the Lake Manitoba Outlet Channel (LMOC) and documents the final preliminary design of the Outside Drain to be carried forward into the detailed design phase of the LMOC project.

1.1 OBJECTIVES

The objective of this memo is to describe the final preliminary design of the long-term surface water management infrastructure for the LMOC including preliminary sizing of drains and required culvert structures. This memo includes:

- Drainage design criteria
- A description of the general arrangement for managing surface water in the LMOC region
- A description of the design flows for use in design of new drainage infrastructure
- Hydraulic design of the Outside Drain and culverts

2.0 DRAIN DESIGN CRITERIA

Design criteria for the various stream crossings and the Outside Drain were developed based on experience with previous Manitoba Infrastructure (MI) projects in the Province of Manitoba.

A drainage management design criterion with capacity to convey runoff associated with a 10-year (10% exceedance probability) runoff event was selected as the design standard for the Outside Drain. Although other aspects of the LMOC project may include mitigation measures for the Outside Drain's interception of overland flows, no provisions will be incorporated in the Outside Drain for maintaining the pre-project flows from west to east towards Watchorn Creek and the Birch Creek/small lake system.

The hydraulic grade line in the Outside Drain will be designed to be at, or below, the adjacent prairie level. The Outside Drain cross-section will include a minimum 4H to 1V side slopes to allow for ditch maintenance. A minimum 4 m bottom width was also included in accordance with typical MI design standards for open channels.

Design of permanent structures for the Outside Drain will comply with the Water Control & Structures, Structures Design Manual (MIT 2011). Accordingly, permanent culvert roadway crossings for Township Line Rd and Iverson Rd will be designed for a 10% exceedance probability runoff event, while the PTH 6 crossing design will be designed for a 2% exceedance probability runoff event . A minimum clearance of 0.2 m will be maintained between the soffit or obvert of the culvert and the design water level for the entire length. Culverts will be designed to limit head loss through the culvert to 0.3 m or less. Adequate erosion protection, both upstream and downstream of the culvert structures will be provided including protection around the culvert inlets and outlets to a minimum height equal to the top of the culvert, and protection of roadway fills as required. The culvert inverts will be embedded 0.3 m in the drain bottom as per fish passage guidelines.

Erosion and sediment control measures will be installed and maintained throughout construction as needed until vegetation has been established.

3.0 OUTSIDE DRAIN GENERAL ARRANGEMENT

The location of the LMOC requires a drainage design that maintains or improves upon existing drainage standards so that the LMOC project doesn't exacerbate local surface water drainage issues. An Outside Drain is to be constructed along the west side of the LMOC to collect and convey intercepted runoff that would, under existing conditions, flow to the east of the LMOC. After consideration of a number of design concepts and construction factors along with potential drainage effects, the new PR 239 crossing (existing Carne Ridge Road) was selected as the highpoint location for the Outside Drain. North of the new PR 239 crossing, the Outside Drain will drain north to Lake St. Martin, while south of this crossing, the Outside Drain will drain south to Lake Manitoba. Culverts will be installed wherever the Outside Drain crosses a road. A map delineating the existing sub-watersheds and surface water flow directions to the LMOC Outside Drain is provided in Appendix A; Map 3-1. The Preliminary Design of the Outside Drain is further described in Section 5.0.

The Outside Drain will be constructed prior to construction of the LMOC main channel to allow for the interception of watershed flows originating from the west, thereby facilitating construction of the LMOC. The Outside Drain will convey the overland flows, as well as water from the construction dewatering works and the groundwater depressurization works to Lake Manitoba and Lake St. Martin. Existing drainage on the east side of the LMOC will continue to operate as it does at present.

4.0 DESIGN FLOWS

Flows for the outside drain were provided by MI, Water Management (pers. comm. Bin Lau 2021). The watershed was split into sub-basins with a flow divide located at the new PR 239 crossing. Watershed characteristics and design flows are presented in Table 4-1. The methodology used to estimate the sub-basin flows is consistent with that used by MI to design other Provincial drains and crossings in the Interlake region.

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Table 4-1 Sub-basin Characteristics and Design Flows (Provided by MI)

Sub-basin	Outside Drain Flow Direction	Cumulative Drainage Area (km^2)	Water Surface Area Percentage (%)	Cumulative 10% Daily Flow (cms)	Cumulative 2% Daily Flow (cms)
W840A-West S	South	3.05	4.2	0.53	0.92
W840-West	South	23.85	9.2	3.00	5.40
W150-West	South	26.55	9.4	3.10	5.70
W840A-West N	North	2.00	3.0	0.44	0.76
W610-West	North	19.84	12.9	2.20	4.00
W550-West	North	23.34	11.7	2.40	4.40
W530-West	North	42.80	14.5	2.60	5.40
W510-West	North	43.93	14.5	2.70	5.50
W490-West	North	54.53	13.0	3.60	7.20
W490A-West	North	54.96	12.9	3.60	7.30

5.0 HYDRAULIC DESIGN OF OUTSIDE DRAIN

5.1 HYDRAULIC MODEL

A HEC-RAS hydraulic model was used to develop a drain design that would convey the design flow for each segment of the Outside Drain. The appropriate Manning's roughness coefficient, n, was selected for the site based on proposed Outside Drain attributes and literature. A range of n values for channel types are reported in hydraulic literature, from which a normal n value was selected. The outside drain will be located on a plain, be straight and uniform, and maintained, however some vegetation growth is expected. Based on these characteristics a Manning's n of 0.040 (Chow 1959) was chosen for the design of the Outside Drain. An exception to this is the section between Lake Manitoba and Township Line Rd where the slope of the drain invert has been flattened out and significant vegetative growth is expected due to the shallow depth of water from Lake Manitoba that will be permanently present within this portion of the drain. While this has been done to help promote natural filtration of runoff prior to discharge into Lake Manitoba, this area may require more frequent maintenance to preserve the hydraulic function of the drain. Accordingly, a higher Manning's n of 0.06 was selected for the design of this portion of the drain.

5.2 DRAIN DESIGN

The preliminary designs of the South and North Outside Drain reaches are shown on Figure 5-1 and Figure 5-2 respectively. The resulting design parameters, the bottom slope and peak average velocities within each drain segment are shown in Table 5-1. Outside Drain inverts are shown on Table 5-2. The bottom width is constant along each segment and the side slopes were set at 4H to 1V for the entire length.

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Reference: **Updated Preliminary Engineering Design of the Lake Manitoba Outlet Channel Outside Drain**

The Outside Drain was designed to accommodate a 10% design flow with a maximum average flow velocity below 1.0 m/s to reduce erosion potential (Table 5-1) with Lake Manitoba and Lake St. Martin at the lower end of their normal operation ranges (i.e., el. 247.04 m [810.5 ft] and el. 242.93 m [797.0 ft], respectively).

The invert of the drain was selected such that the hydraulic grade line (see Figures 5-1 and 5-2) during the 10% event would be at or below the adjacent prairie, as well as the inverts of the existing incoming municipal drains so as to not result in backwater effects in the incoming drains during the design event with Lake Manitoba and Lake St. Martin at the upper end of their normal operating ranges (i.e., el. 247.65 m [812.5 ft] and el. 243.84 m [800.0 ft], respectively). No diking is required to accommodate the passage of the 10% design flow. All water is contained to the drain.

Table 5-1 Key Design Parameters and Peak Average Velocity for the Outside Drain

Drain Section		Bottom Width (m)	Side Slopes	Bottom Slope	Peak Average Velocity (m/s) (10% event)
South Reach	Lake Manitoba to Township Line Road	25	4 to 1	0% to 0.0265%	0.37
	Township Line Road to W150-west Incoming Drain	12	4 to 1	0.01%	0.25
	W150-west Incoming Drain to W810-west Incoming Drain	12	4 to 1	0.01%	0.24
	W810-west Incoming Drain to New PR 239	6	4 to 1	0.01%	0.209
North Reach	New PR 239 to Existing PR 239	4	4 to 1	0.01%	0.21
	PR 239 to PTH 6	4	4 to 1	0.01%	0.24
	PTH 6 to Iverson Road/Control Structure	4	4 to 1	0.01%	0.44
	Iverson Road/Control Structure to W490-west Incoming Drain	4	4 to 1	0.01% to 0.54%	0.93
	W490-west Incoming Drain to Lake St. Martin	4	4 to 1	0.02% to 1.0% (By Lake St. Martin Drop Off)	0.96

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Reference: **Updated Preliminary Engineering Design of the Lake Manitoba Outlet Channel Outside Drain**

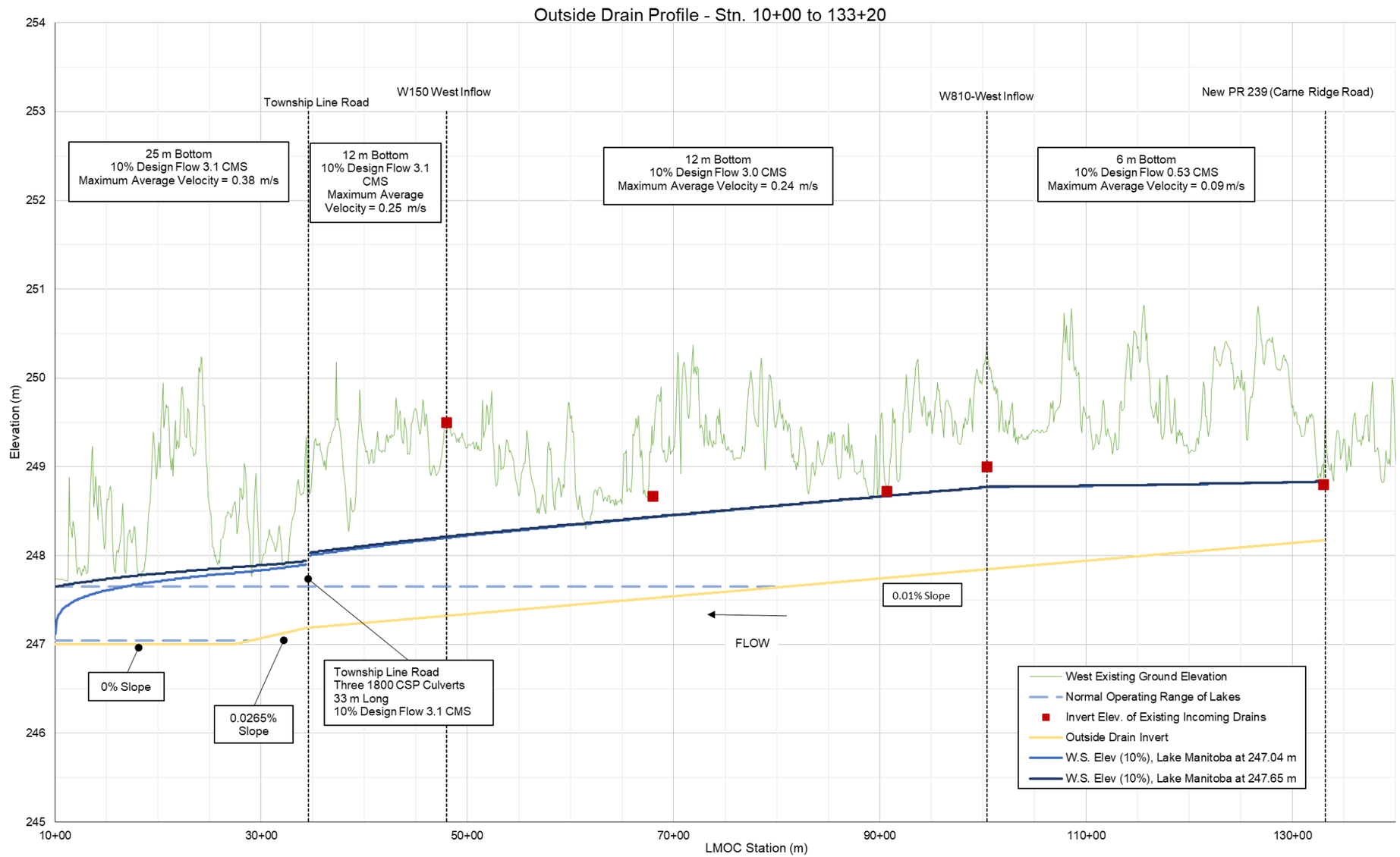

Figure 5-1 **Outside Drain Design Profile - Lake Manitoba to new PR 239**

Reference: **Updated Preliminary Engineering Design of the Lake Manitoba Outlet Channel Outside Drain**

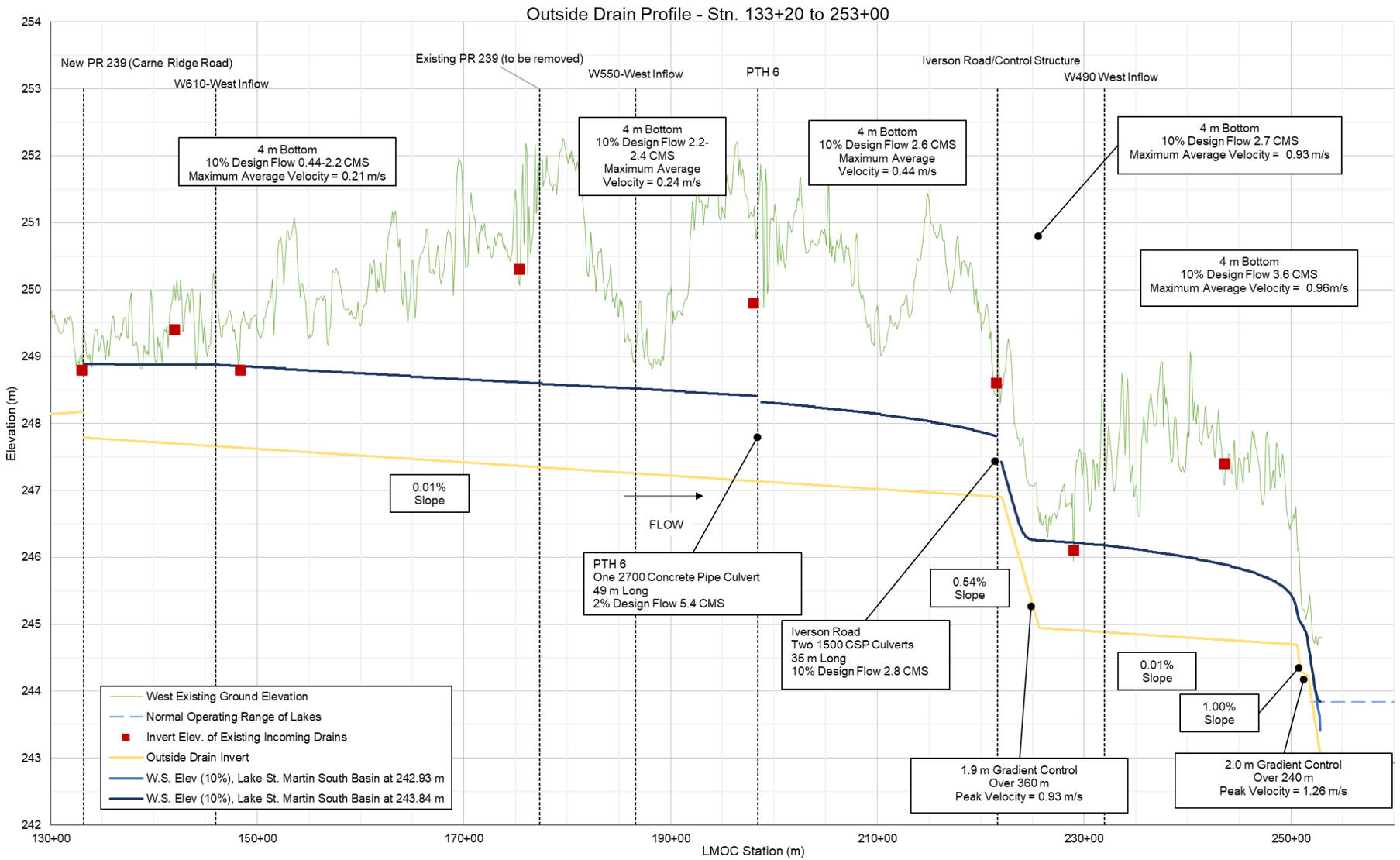

Figure 5-2 **Outside Drain Design Profile – New PR 239 to Lake St. Martin**

Table 5-2 Invert Elevations along Outside Drain

Location	LMOC Station	Invert (m asl)
Lake Manitoba	10+00	247.000
Grade Break (0 to 0.0265%)	27+38	247.000
Township Line Road	34+58	247.188
W150-west Incoming Drain	47+98	247.322
W810-west Incoming Drain	100+38	247.846
New PR 239 (South)	132+98	248.172
New PR 239 (North)	133+38	247.786
Existing PR 239	177+28	247.347
PTH 6 (South)	198+18	247.138
PTH 6 (North)	198+78	247.132
Iverson Road/Control Structure (South)	221+48	246.905
Iverson Road/Control Structure (North)	221+88	246.901
Grade Break (0.01% to 0.54%)	222+08	246.889
Grade Break (0.54% to 0.01%)	225+68	244.945
W490-west Incoming Drain	231+98	244.882
Grade Break (0.1% to 1.0%)	250+58	244.696
Grade Break (1.0% to 0.1%)	250+98	244.296
Grade Break (0.1% to 1.0%)	251+68	244.226
Lake St. Martin	252+88	243.026

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5.3 GRADIENT CONTROL STRUCTURES

Flow velocities will be above 1.0 m/s near the Iverson Road crossing and at the downstream end of the north reach of the Outside Drain near Lake St. Martin due to the steep longitudinal slopes in these areas. Permanent gradient control structures (which may consist of rockfill and/or sheet piles depending on the situation) will be installed in these areas to reduce the velocities below 1.0 m/s and thus reduce the potential for erosion. The height and spacing of the gradient control structures will vary depending on the longitudinal slope and MI requirements for fish exclusion. The design of these gradient control structures will be developed during detailed design. Gradient control structures will not be needed where the drain has sufficiently low longitudinal slopes, flow velocities and shear stresses.

5.4 INCOMING DRAINS

The approximate location and elevation of incoming drain inverts are shown as red squares on the profiles in Figure 5-1 and Figure 5-2. The incoming drain inverts enter the Outside Drain either above or slightly below

the 10% design hydraulic grade line and, in all cases, enter above the proposed Outside Drain invert. As such the hydraulics of the incoming drains should not be affected by the passage of the 10% design flow in the Outside Drain.

The details of the transition from the existing drains into the Outside Drain will be determined in detailed design and will likely consist of installing riprap erosion protection on the Outside Drain side slope and/or cutting back the slope of the existing drains. An additional assessment of the potential for backwater in the drains that enter the Outside Drain below the 10% design hydraulic grade line will be performed in detailed design. If required, diking and/or flap gates could be used to limit the potential for flooding in incoming drains and fields adjacent to the Outside Drain, should they be at risk of being impacted by backwater from the Outside Drain during passage of the design event.

5.5 CULVERT DESIGN

Permanent culvert crossings have been designed for a 10-year return event (10%) with the exception of the PTH 6 crossing, which will be designed for a 50-year return event (2%) as required by the Water Control & Structures, Structures Design Manual (MIT 2011). The drain crossings at Township Line Road, PTH 6, and Iverson Road were hydraulically designed using a HEC-RAS model. The number of culverts and sizes were determined based on the Drain Design Criteria discussed earlier in this memo.

The required culvert configurations are summarized in Table 5-3. The 0.2 m clearance requirement between the water surface in the culvert and its obvert can be met for all crossings. The culvert inverts will be embedded 0.3 m into the Outside Drain bed. The proposed culvert locations and sizes are presented in Appendix A; Map 5-1. After discussion with MI, the culvert configuration at Township Line Road was increased to three 1800 mm diameter culverts to reduce the risk of ice blockage due to the permanent depth of water present at this location.

Table 5-3 Culvert Design

Location	Culverts Required		Culvert Length (m)	Design Flow (m^3/s)	Minimum Clearance (m)	Head loss (m)	Material (m^3/s)	Comment
	Diameter (mm)	Number						
Township Line Road	1800	3	33	3.1	0.66	0.10	CSP	10% Design Flow
PTH 6	2700	1	49	5.4	0.55	0.18	Concrete	2% Design Flow
Iverson Road	1500	2	35	2.8	0.29	0.09	CSP	10% Design Flow

As the Outside Drain will be constructed prior to the decommissioning of existing PR 239, temporary culverts will be installed at this location, as well as at other construction detours. These temporary culverts will be sized as part of detailed design.

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6.0 REFERENCES

Chow, Ven, T. 1959. Open-Channel Hydraulics. New York: McGraw-Hill Book Company.

Manitoba Infrastructure and Transportation (MIT). 2011. Water Control & Structures Design Manual. Version 1. February 18, 2011.

Pers. Comm., June 10, 2021. Email from Bin Luo Senior Hydrologic Engineer, Hydrologic Operations Section, Planning and Standards Branch, Manitoba Infrastructure to Seifu Guangul, Senior Water Resources Engineer, Stantec Consultants Ltd.

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Attachment: Appendix A, Maps

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Reference: **Updated Preliminary Engineering Design of the Lake Manitoba Outlet Channel Outside Drain**

Appendix A MAPS

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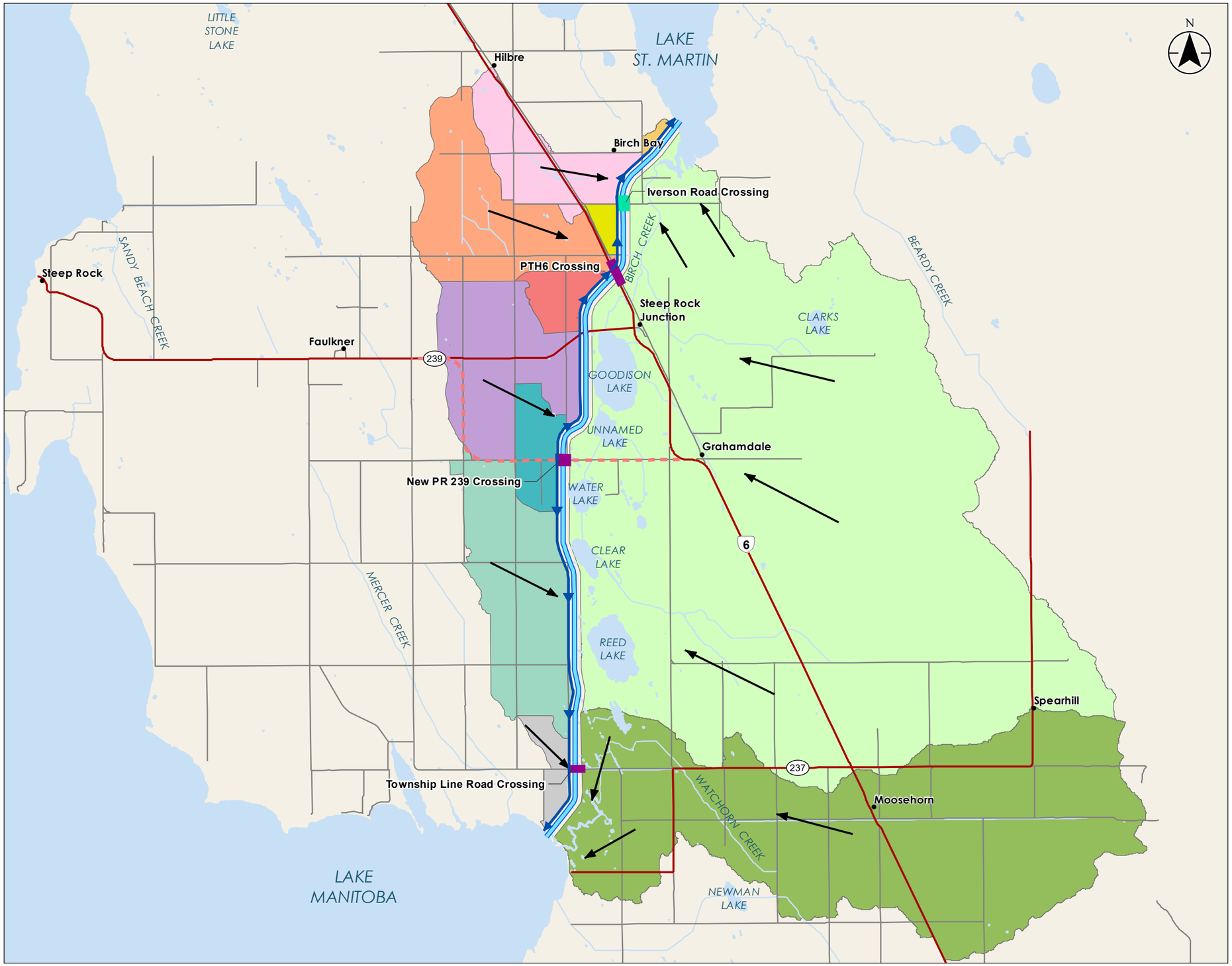

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Project Infrastructure

- Proposed Lake Manitoba Outlet Channel
- Proposed PR 239 Realignment
- Proposed Bridge
- Proposed Water Control Structure

Study Area

- Proposed Outside Drain
- Surface Water Flow Direction

Subwatershed

- W150-West
- W490-West
- W490A-West
- W510-West
- W530-West
- W550-West
- W610-West
- W840-West
- W840A-West
- Birch Creek drainage area not affected by LMOC
- Watchorn Creek drainage area not affected by LMOC

Landbase

- Community
- Highway
- Major Road
- Watercourse
- Waterbody

0 2.5 5 Kilometres

1:125,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 14N
2. Base features provided by the Government of Manitoba, Government of Canada, Manitoba Infrastructure, Stantec Consulting.

Project Location
Lake Manitoba and Lake St. Martin Outlets

111475107

Prepared by JHiebert on 2021-07-25
Technical Review by SBiswanger on 2021-07-25

Client/Project
MANITOBA INFRASTRUCTURE
Lake Manitoba Outlet Channel

Map No.
3-1

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Title
LMOC Outside Drain Arrangement

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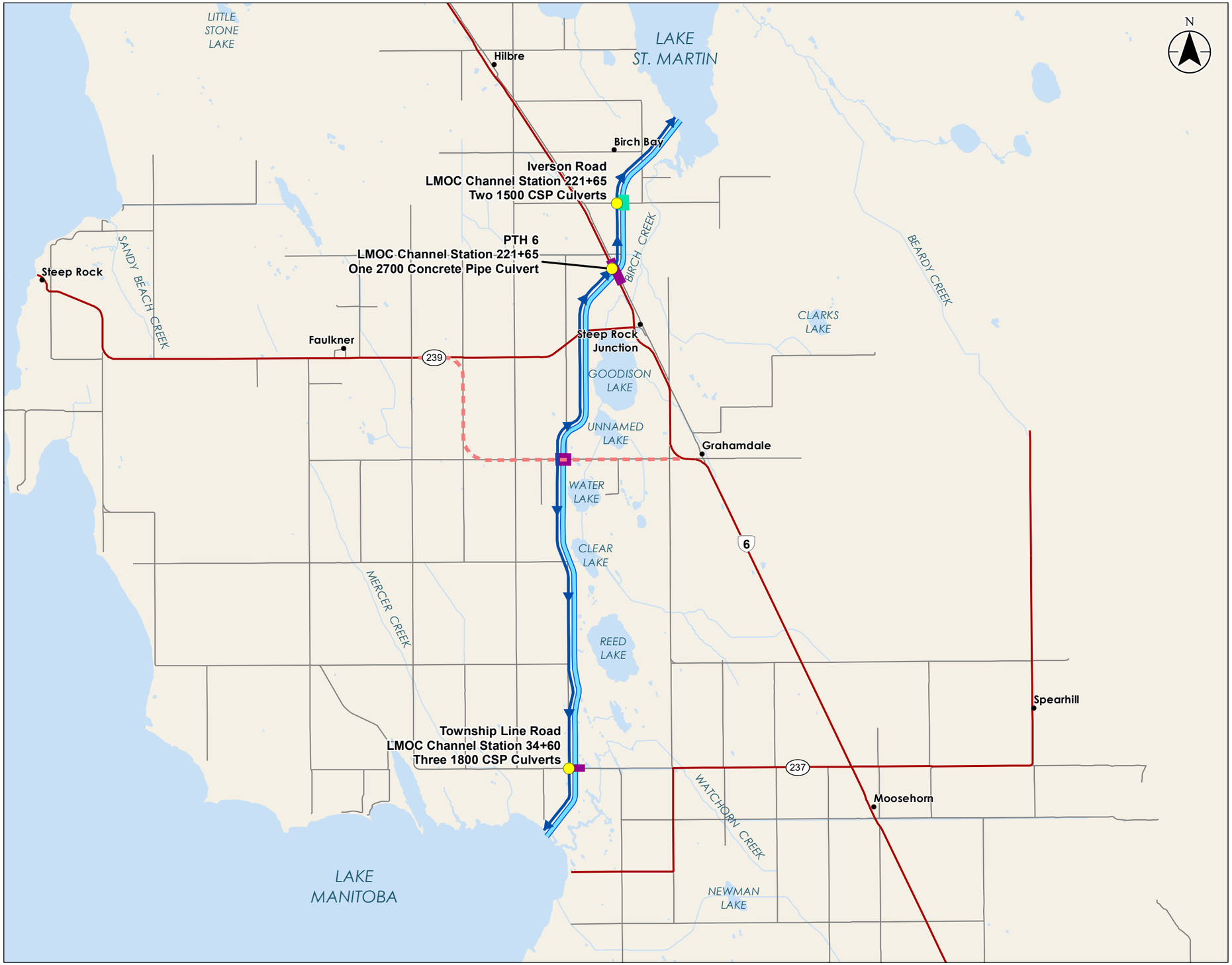

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Project Infrastructure

- Proposed Lake Manitoba Outlet Channel
- Proposed PR 239 Realignment
- Proposed Bridge
- Proposed Water Control Structure

Study Area

- Proposed Outside Drain Crossing Location
- Proposed Outside Drain

Landbase

- Community
- Highway
- Major Road
- Watercourse
- Waterbody

0 2.5 5 Kilometres

1:125,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 UTM Zone 14N
2. Base features provided by the Government of Manitoba and the Government of Canada.

Project Location
Lake Manitoba and Lake St. Martin Outlets

111475107

Prepared by ACampigotto on 2021-07-28
Technical Review by SBiswanger on 2021-07-28

Client/Project
MANITOBA INFRASTRUCTURE
Lake Manitoba Outlet Channel

Map No.
5-1

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Title
Proposed Outside Drain Crossing Locations and Sizes

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