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Public City Architecture Inc
Cornish Library Addition
Riverbank Stabilization Measures
Hydraulic Engineering and Assessment

Prepared for:

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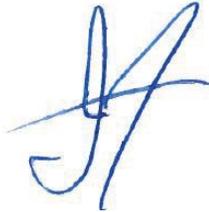
**RE: Cornish Library Addition Riverbank Stabilization Measures
Hydraulic Engineering and Assessment**

TREK Geotechnical Inc. is pleased to submit our Final Report for the Hydraulic Engineering Assessment for the above noted project. This report will include recommendations for rock riprap sizing, layout and extent on the riverbank located at the Cornish Library in Winnipeg, MB.

Please contact the undersigned if you have any questions. Thank you for the opportunity to serve you on this assignment.

Sincerely,

TREK Geotechnical Inc.
Per:



Jim Friesen, P. Eng.
Manager, Water Resource Engineering
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Encl.

Revision History

Revision No.	Author	Issue Date	Description
0	MK	August 21, 2017	Draft Report
1	MK	October 12, 2017	Final Report

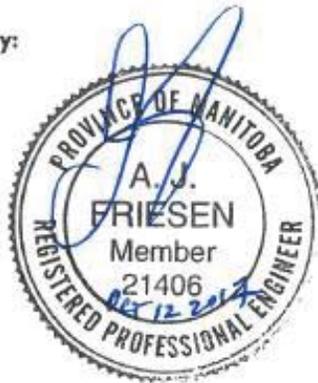
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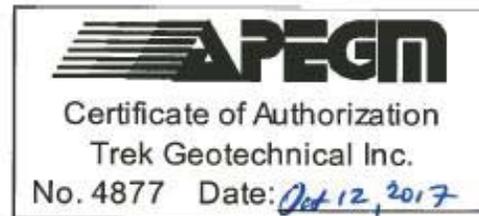


Table of Contents

Letter of Transmittal

Revision History and Authorization Signatures

1.0	Introduction	1
2.0	Project Background	1
3.0	Assiniboine River Hydrology	1
3.1	Flood Hydrology	1
4.0	Hydraulic Assessment	2
4.1	Existing Conditions	2
4.2	Proposed Riprap Stabilization	3
4.3	Hydraulic Simulation Results.....	3
5.0	Conclusion and Recommendations	5
6.0	Closure.....	5

Appendices

List of Tables

Table 1: Assiniboine River Flows at Cornish Library.....	2
Table 2: Assiniboine River Hydraulic Summary at the Cornish Library	4

List of Appendices

Appendix A Figures and Photos

1.0 Introduction

This report summarizes the results of the hydrotechnical analysis completed by TREK Geotechnical Inc. (TREK) for the proposed riverbank stabilization measures as part of the Cornish Library addition project, located at 20 West Gate in Winnipeg, MB. The scope of work included topographic and bathymetric survey to determine site geometry, and hydraulic modelling to make recommendations for rock riprap sizing, layout and extent on the lower north riverbank. The report also summarizes the minor hydraulic impact of the rock riprap blanket as modelled in HEC-RAS under several typical flow conditions.

2.0 Project Background

TREK understands that an addition to the Cornish Library is proposed for construction on the south side of the structure, located between the existing building and the Assiniboine River. The addition will be an elevated single storey steel-framed structure above a partial basement. The main floor will be approximately 90 square metres in size. The basement will be approximately 29 square metres in size and will match the existing basement elevation which is approximately 1.8 m below ground surface. The Library is situated within the City of Winnipeg Waterways regulated zone between the Primary Dike and the Assiniboine River, therefore building the addition will require a riverbank stability assessment for a permit subject to the requirements of the City of Winnipeg.

In the time between TREK's site visit to determine subsurface conditions in December 2015 and site visits in 2017, the river bank experienced a slope failure on the east side of the property. This riverbank slope failure occurred before construction of the addition, further demonstrating the need for local geotechnical stabilization measures that could be provided by bank toe rock ballast or a rock riprap blanket. The area of the riverbank failure is shown in Figure 01.

3.0 Assiniboine River Hydrology

3.1 Flood Hydrology

The Assiniboine River is a meandering river with a relatively flat slope that is 1070 km running from eastern Saskatchewan to its confluence with the Red River in Winnipeg, MB. Design discharges were developed for the Assiniboine River reach at the Cornish Library by using the Water Survey of Canada (WSC) gauge, located in Headingley (05MJ001), and the developed flood frequency discharges for the contributing Sturgeon Creek (Sturgeon Creek near Perimeter Highway - WSC 05MJ011). The hydrology derived by Manitoba Water Stewardship is based on a detailed and comprehensive assessment of recorded flows in addition to the incorporation of estimates of extreme historical events. Table 1 summarizes the flood hydrology for the Assiniboine River at the Cornish Library.

Table 1: Assiniboine River Flows at Cornish Library

Flood Event	Assiniboine River Discharge (m ³ /s) *
50% Flood	231
10% Flood	368
1% Flood	620

* Assiniboine River discharge measured at Headingly (05MJ001) plus contributions from Sturgeon Creek near Perimeter Highway (05MJ011).

4.0 Hydraulic Assessment

4.1 Existing Conditions

The hydraulic conditions within the Assiniboine River were assessed to establish the baseline hydraulic regime. A steady-state backwater model of the Assiniboine River within the study reach was developed using the US Army Corps of Engineers Hydrologic Engineering Centre - River Analysis System (HEC RAS) model. The HEC RAS model is a one dimensional hydraulic model, which is considered to be the universal standard for computing steady-state water surface profiles. The backwater model extends along the Assiniboine River from the Red River (Forks) upstream to Headingly. The Cornish Library's project area is located approximately 3700 m upstream from the Red River at the Forks, extending from the Maryland Bridge for approximately 50 m downstream of the bridge. A plan of the study area is shown on Figure 02.

The framework for the backwater model, to allow for the assessment within the project area, was the hydraulic model developed for the December 2014 Assiniboine River Hydraulic Assessment Study prepared for the City of Winnipeg¹. Additional cross sections were incorporated into the December 2014 backwater model to provide additional detail within the project. The sections were assembled from topographic and bathymetric surveys undertaken by Wanless Geopoint Solutions in December 2015 and in July 2017, in addition to 2013 LiDAR data for the riverbank areas.

The estimated water surface profiles and channel velocity profile on the Assiniboine River for existing conditions are shown in Table 2 and Figures 03-05 at selected discharges throughout a range of downstream boundary conditions.

1 "Assiniboine River Hydraulic Assessment Study", December 2014, prepared for the City of Winnipeg, Water and Waste Department by Bruce Harding Consulting Ltd.

4.2 Proposed Riprap Stabilization

Geotechnical stability analysis suggested that rock rip rap should be placed along the lower riverbank at the Cornish Library to provide erosion protection measures and to increase overall bank stability. The proposed erosion protection consists of a Class 450 rock riprap blanket over approximately 50 m of riverbank reach. The rock material would be placed on heavy duty non-woven geotextile fabric. The geometric template for the erosion protection has been selected to closely match the existing site geometry minimizing potential encroachment into the river section. The erosion protection assumes an approximate 4:1 side slope at the upstream end of the protection (STA 37+50) and transitions to a 3:1 side slope at Sta 37+10 to the downstream end of the protection (STA 37+05). The rock riprap size and the resultant blanket thickness is larger than typically required to resist hydraulic tractive forces, but rather has been selected to provide increased bank stability through sufficient rock mass at the river bank toe.

Class 450 rock would be more than adequate to resist the noted stream velocities; however, it is recommended that the rock blanket be placed on a prepared riverbank slope, with minimal sub-cut and embedment, and thus requiring a taper or bevel-transition to meet the natural river bed. A self launching apron of rock will be placed at the toe of the slope to minimize toe erosion and the possible reduction in stability of the slope. A self launching apron provides extra rock material which will settle into any post-construction scour holes, thus providing continued protection to the toe and upper slope. Hydraulic velocities and shear forces are typically higher at the toe of a slope, particularly on an outside river bend, justifying the use of the self launching rock apron at the toe of the slope.

The top of rock elevation has been chosen at an elevation of 226 m to fill in the existing head scarps and smooth the curvature of the slope. This height of protection is slightly above the minimum City of Winnipeg requirements which state the top of rock elevation should be at the Normal Summer Controlled Level of 223.75 plus 1.0 m which yields an elevation of 224.75. The proposed layout of the erosion protection measures are presented in plan view on Figure 06, and typical sections are shown on Figure 07.

With this stabilization option, it is proposed that the riverbank is minimally sub-cut, so that riverbank stability will not be reduced during construction. Placement of rock on the riverbank without sub-cutting would have a very minor hydraulic influence, with slightly increased local velocities and water elevations in this section of river as detailed in Table 2.

4.3 Hydraulic Simulation Results

The HEC-RAS hydraulic model simulations were conducted for a range of Assiniboine River design flows and downstream boundary conditions. The downstream conditions chosen for the Red River are

the unregulated levels (typically occurring after fall drawdown), regulated summer levels, typical spring flood level (18 ft JAPSD²) and 1997 flood peak level (24.5 ft JAPSD²). The model results are presented in Table 2 for both the existing conditions, and with the proposed rock riprap blanket design section.

Table 2: Assiniboine River Hydraulic Summary at the Cornish Library

Flood Event (Discharge)	Downstream Condition (Red River Water Level)	Existing Water Surface Elevation (m)	Existing River Channel Velocities (m/s)	Water Surface Elevation with Stabilization Measures (m)	River Channel Velocities with Stabilization Measures (m/s)
50 % Flood (231 m ³ /s)	Unregulated Levels (222.00 m +/-)	224.48	1.26	224.47	1.32
	Regulated Summer Levels (223.70 m)	224.78	1.12	224.78	1.18
	18 ft JAPSD (227.40 m)	227.52	0.57	227.52	0.58
	24.5 ft JAPSD (229.45 m)	229.50	0.41	229.50	0.41
10 % Flood (368 m ³ /s)	Unregulated Levels (222.00 m +/-)	225.41	1.47	225.40	1.53
	Regulated Summer Levels (223.70 m)	225.56	1.41	225.55	1.46
	18 ft JAPSD (227.40 m)	227.69	0.88	227.69	0.89
	24.5 ft JAPSD (229.45 m)	229.57	0.64	229.57	0.65
1 % Flood (620 m ³ /s)	Unregulated Levels (222.00 m +/-)	226.75	1.77	226.74	1.82
	Regulated Summer Levels (223.70 m)	226.79	1.76	226.78	1.80
	18 ft JAPSD (227.40 m)	228.15	1.36	228.15	1.38
	24.5 ft JAPSD (229.45 m)	229.78	1.05	229.77	1.06

2 James Avenue Pumping Station Datum (JAPSD)- The normal winter Red River level measured at James Ave in Winnipeg (221.77 m).

The estimated water surface profiles and channel velocity on the Assiniboine River for existing and design conditions, are shown in Figures 03-05 at selected discharges and downstream conditions. The addition of the rock riprap without embedment into the riverbank will cause minimal changes to the average local velocity of the river and water levels. The change to river velocity is negligible, with less than a 0.06 m/s increase locally. Changes to the water surface profile would be imperceptible (less than 1 cm).

5.0 Conclusion and Recommendations

It is recommended that a continuous rock riprap blanket be provided for erosion protection and toe ballast along the riverbank within the project area. The proposed rock blanket will have minimal negative affect on the existing hydraulic regime of the Assiniboine River throughout this reach. Additionally, the riprap blanket as proposed would not be sub-cut or embedded into the existing embankment to ensure that local riverbank stability can remain as high as possible.

6.0 Closure

The technical information provided in this report is in accordance with current engineering principles and practices (Standard of Practice). The findings of this report were based on information collected by TREK during recent field survey (field investigation) and City of Winnipeg-provided hydraulic cross-sections. Hydrotechnical analysis is based on environmental characteristics assumed to extend uniformly throughout the contributing area and watershed-scale, temporally-discrete hydrologic events.

All information provided in this report is subject to our standard terms and conditions for engineering services, a copy of which is provided to each of our clients with the original scope of work, or a mutually executed standard engineering services agreement. If these conditions are not attached, and you are not already in possession of such terms and conditions, contact our office and you will be promptly provided with a copy.

This report has been prepared by TREK Geotechnical Inc. (the Consultant) for the exclusive use of Public City Architecture Inc. (the Client) and their agents for the work product presented in the report. Any findings or recommendations provided in this report are not to be relied upon by any third parties, except as agreed to in writing by the Client and Consultant prior to use.



Appendix A

Figures and Photos



Figure 01
Riverbank Slope Failure at Cornish Library



Z:\Projects\0015 City of Winnipeg\0015 016 00 Cornish Library\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\FIG 001 2017-08-18 General Site Plan_0_A_BT_0015 016 00.dwg, 8/18/2017 2:42:11 PM

0 5 10 15 20 25 m
SCALE = 1 : 600 (279 mm x 432 mm)

Figure 02
General Site Plan

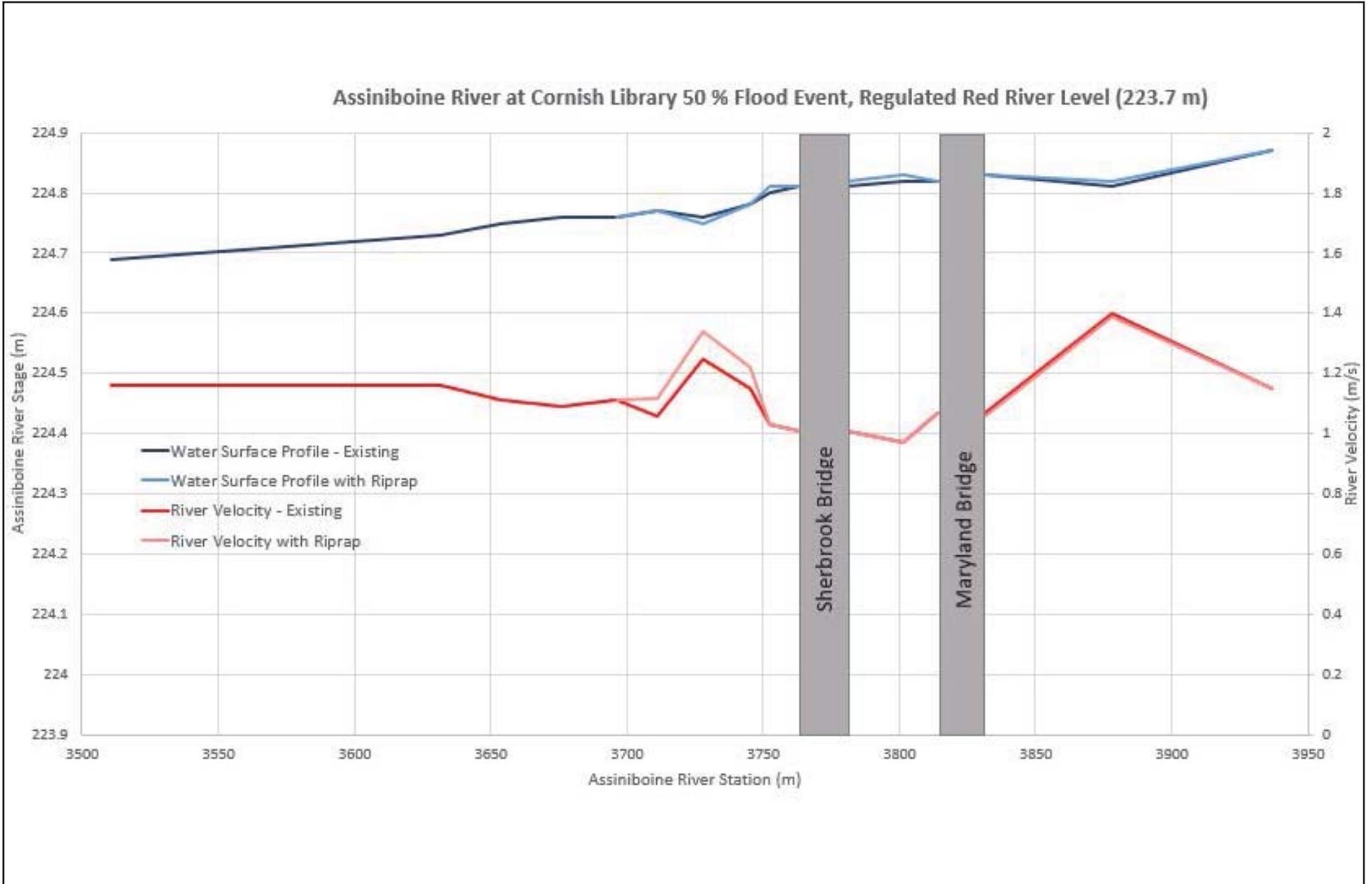


Figure 03
50% Flood Event

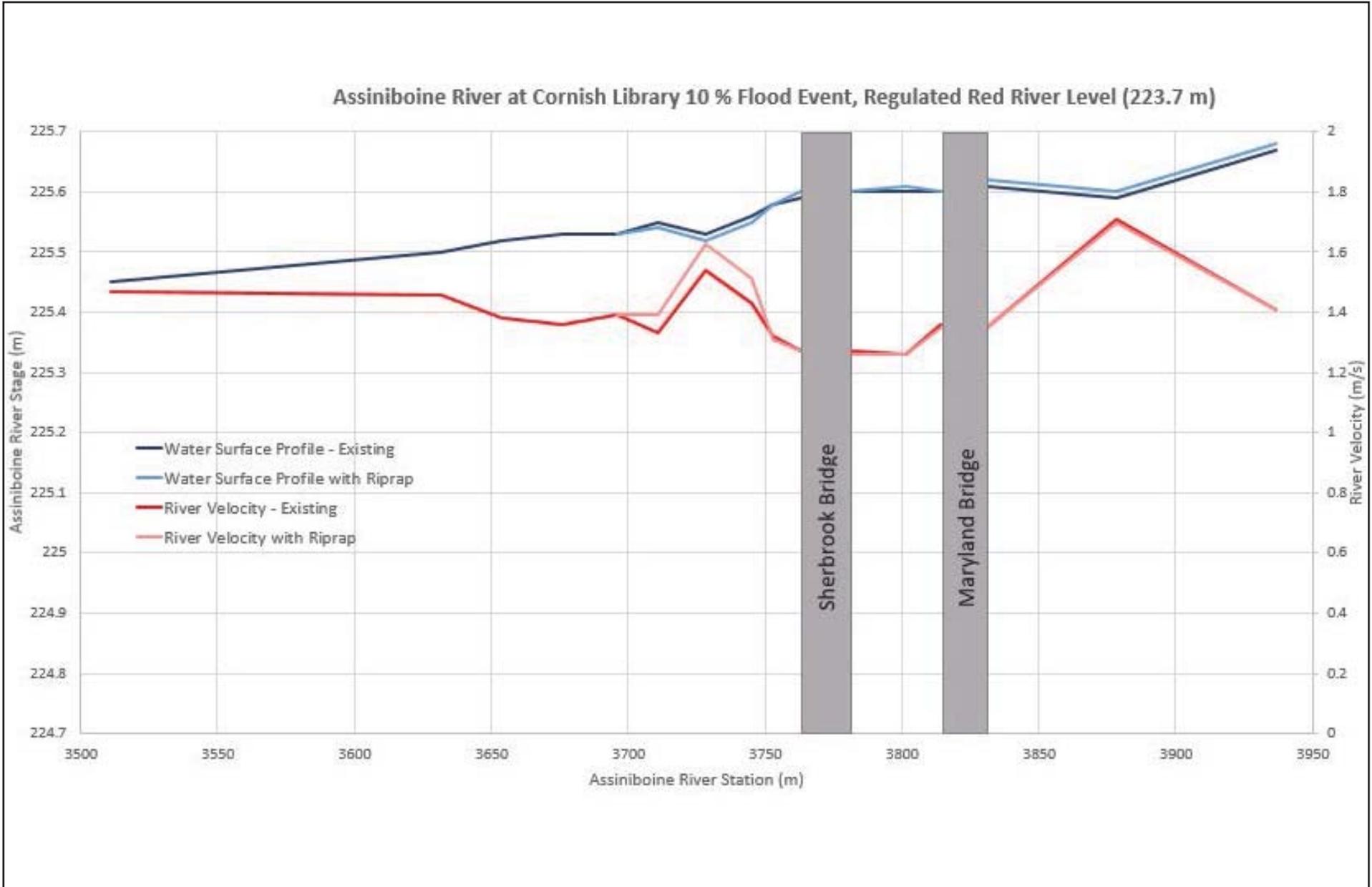


Figure 04
10% Flood Event

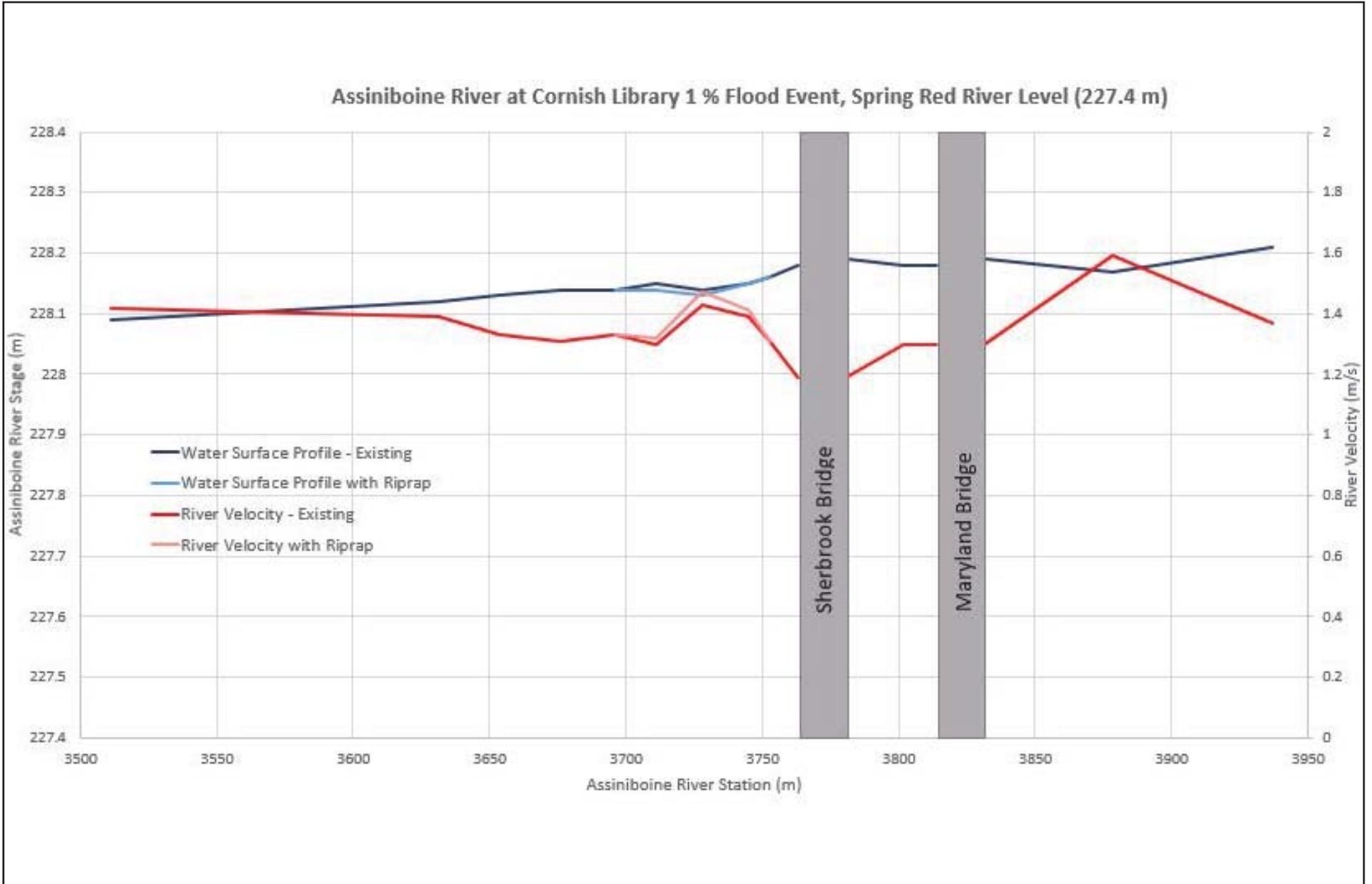
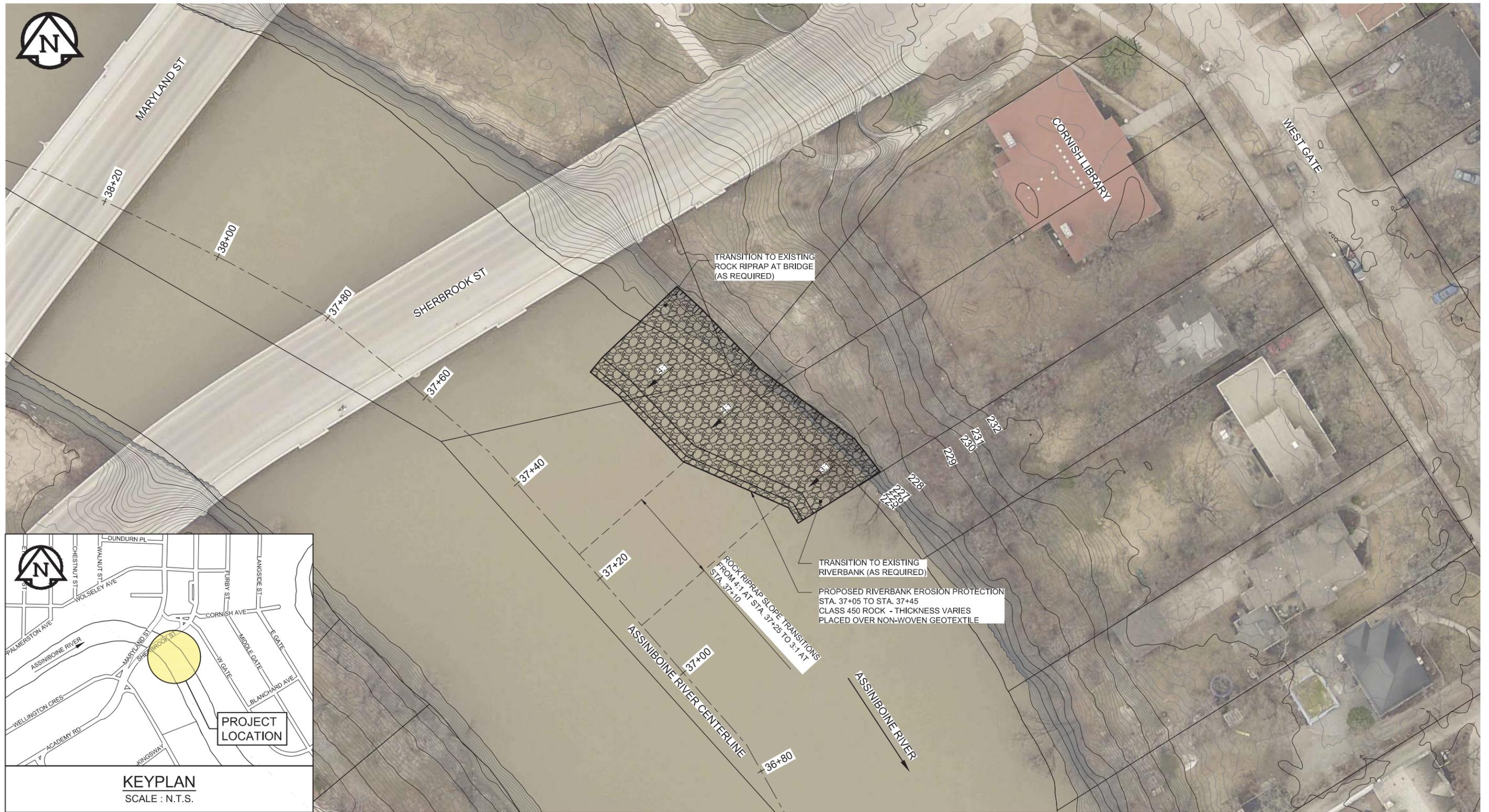


Figure 05
1% Flood Event

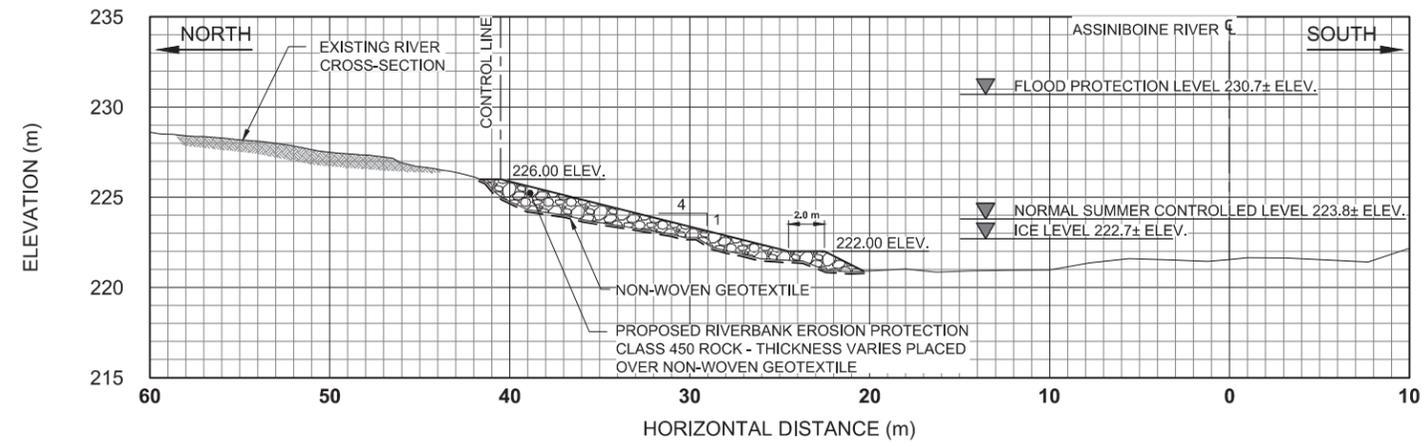
Z:\Projects\0015 016 00 Cornish Library\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\FIG 001 2017-08-18 General Site Plan_0_A_BT_0015 016 00.dwg, 8/18/2017 2:08:50 PM



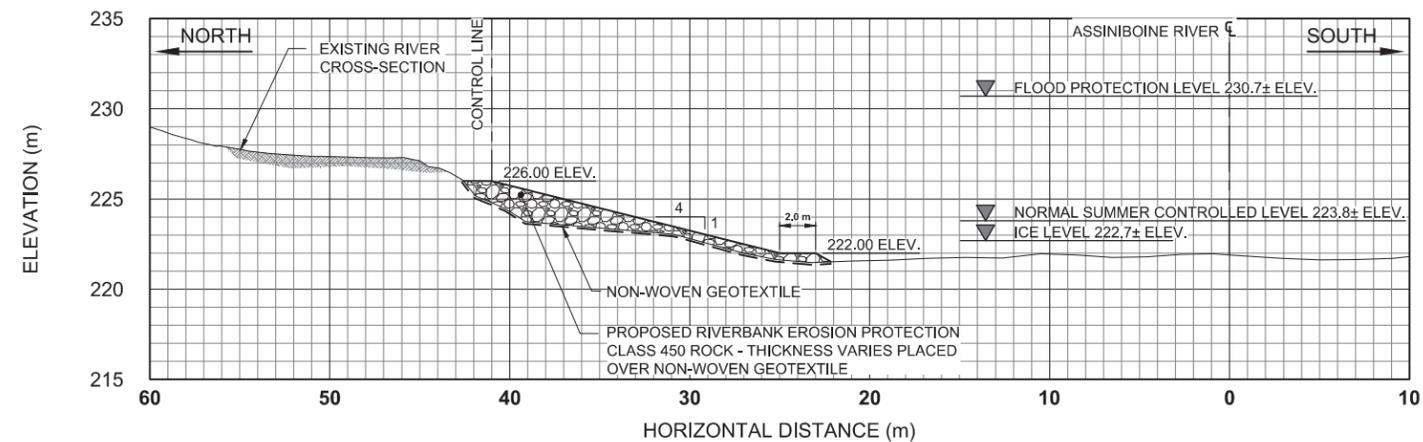
NOTES:

1. AERIAL IMAGE FROM CITY OF WINNIPEG, FALL 2016.
2. CADASTRAL MAPPING FROM MANITOBA LAND INITIATIVE, SUMMER 2012.
3. CONTOURS BASED ON 2013 LIDAR.

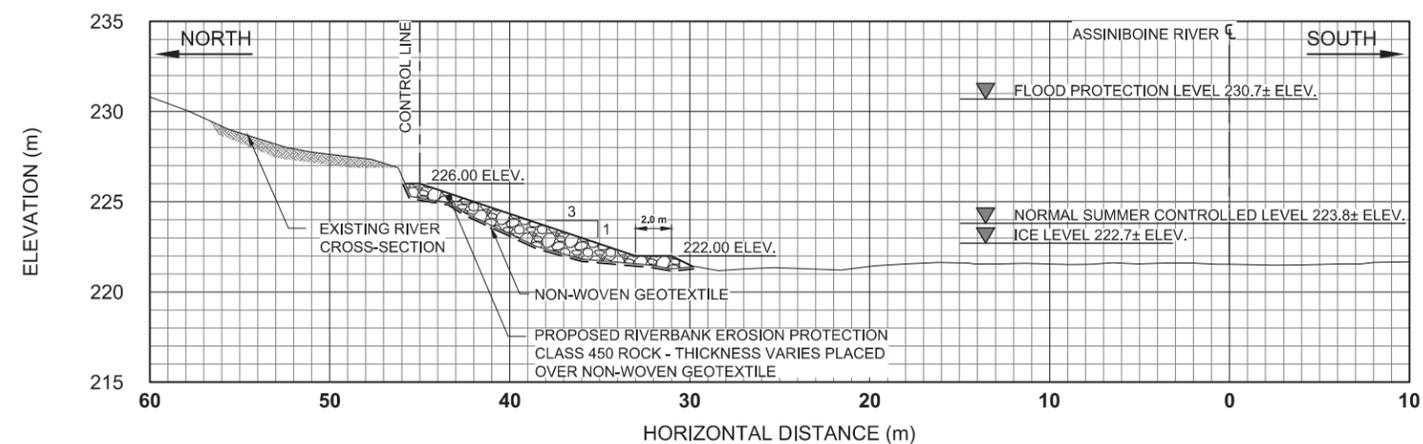
Figure 06
General Site Plan



01. CROSS SECTION A (STA. 37+45)

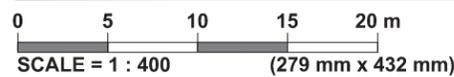


02. CROSS SECTION B (STA. 37+28)



03. CROSS SECTION C (STA. 37+11)

NOTES: 1. RIVER SECTIONS REFLECT BATHYMETRIC SURVEYS UNDERTAKEN BY WANLESS GEO-POINT SOLUTIONS (AUGUST 2017) AND LIDAR (2013)



Z:\Projects\0015 City of Winnipeg\0015 016 00 Cornish Library\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\FIG 001 2017-08-18 General Site Plan_0_A_BT_0015 016 00.dwg, 8/18/2017 2:38:33 PM

Figure 07
Cross Sections