

RED RIVER FLOODWAY OPERATION REPORT

SPRING 2020

June 30, 2020

Manitoba Infrastructure
Hydrologic Forecasting and Water Management Branch
Water Management and Structures Division



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EXECUTIVE SUMMARY

The 2020 Red River spring flood resulted from normal to above normal winter snow fall in the upper Red River basin, including significant late season snowfall in the Fargo area, combined with above normal to record high soil moisture going into freeze-up in the fall. Significant precipitation in September and October of 2019 prompted the use of the Red River Floodway in October for the first time since its construction. The March Outlook published by Manitoba's Hydrologic Forecast Center estimated that the peak flow at Emerson would be similar to the flow seen in the spring of 2019 under favorable conditions, and exceed the 2006 flood under normal conditions. Under unfavorable conditions, the 2020 flow at Emerson was forecast to be greater than 2011. Due to a long and favourable thaw with minimal spring precipitation, the observed peak at Emerson for the 2020 spring flood was approximately 69,600 cfs (1970 m³/s), and occurred over April 19 and 20. This is slightly lower than the peak flow observed at Emerson in 2006. The 2020 peak flow measured at Emerson equated to a 1:15 year flood.

Ice was not a major concern on the Red or Assiniboine rivers in 2020; however, some ice jamming did occur north of the City of Winnipeg in the Selkirk and Netley Creek areas. Floodway operation began at 7:00 p.m. on April 10, and the gates were operated for 28 days ending at 6:00 p.m. on May 8. During this period of operation, 50 discrete gate adjustments were made, as required at various times, to regulate the water level at the floodway inlet. In the spring of 2020, approximately 757,300 acre-feet (934.1 million m³) of water was diverted around the City of Winnipeg by the Red River Floodway, with a peak flow of 19,400 cfs (549.3 m³/s). The Red River Floodway has been operated in 34 of the past 51 years to reduce high water levels in the City of Winnipeg since its first year of operation in 1969.

The Assiniboine River flow during the spring flood of 2020 was average for the spring freshet. The natural (unregulated) peak flow along the Assiniboine River at Portage la Prairie occurred on April 12, and was computed to be 13,600 cfs (385.1 m³/s). The observed flow along the Assiniboine River at Headingley reached a maximum of 6,000 cfs (169.9 m³/s) due to the operation of the Shellmouth Dam and Portage Diversion.

In spring 2020, the operation of the floodway was successful in protecting the City of Winnipeg from flooding, while minimizing upstream impacts through normal floodway operation under Rule 1 of the Red River Floodway Rules of Operation, which sets out the conditions by which the floodway can be used to protect Winnipeg. Rule 1 requires that natural water levels are maintained on the Red River at the floodway inlet. On average, the operation of the Red River Floodway maintained river levels 0.28 ft (0.09 m) below computed natural water levels at the floodway inlet throughout the 28 days of floodway operation. In concert with the operation of the Portage Diversion and Shellmouth Dam, the operation of the floodway reduced the flood crest in the City of Winnipeg by 4.02 ft (1.22 m) at the peak natural flow. The recorded peak water level at James Avenue was 18.94 ft (5.77 m).

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1.0 INTRODUCTION

On April 20, 2005, The Red River Floodway Act was proclaimed into force. Subsection 11(1) of this act states that:

“On or before June 30 of any year in which the government operates the floodway during spring flooding to regulate the river level, the director must provide the minister with a report about the operation containing the information the minister requires.”

The following report details operation of the Red River Floodway in the spring runoff period of 2020 as required by section 11(1) of The Red River Floodway Act and includes the information specified in section 3(1) of The Red River Floodway Regulation.

Within the charts and tables in this report, all flows and levels are shown in imperial units. Flows can be converted from cubic feet per second (cfs) to cubic metres per second (m³/s) by dividing by 35.3147. River levels can be converted from feet to metres by dividing by a factor of 3.28084. Water levels within the City of Winnipeg reference the James Avenue Pumping Station Datum (JAPSD), which is based on the normal winter ice level in the city. This datum has been the traditional reference for water levels used by the City of Winnipeg, and is the datum used for reference water levels specified in the Red River Floodway Rules of Operation. Geodetic elevations can be converted to the James Avenue datum by subtracting 727.57 ft (221.763 m).

This report refers to “natural” flows and water levels. Natural flows are the flows that would have occurred in the absence of flood control works (unregulated conditions). Natural water levels refer to the water levels that would have occurred in the absence of flood control and with the level of urban development in place at the time of the construction of these various works.

Manitoba Infrastructure gratefully acknowledges Water Survey Canada for providing the provisional and approved flow data used in this report.

2.0 2020 SPRING RUNOFF

The 2020 Red River spring flood resulted from above normal (115% - 150%) to extremely above normal (200% - 300%) soil moisture in the Red River basin, combined with normal (85% - 115%) to extremely above normal (200% - 300%) winter precipitation in the southern portion of the basin. The northern part of the basin, including most of Manitoba, Saskatchewan, and some parts of North Dakota saw Well Below Normal (<50%) to Below Normal (50% - 85%) precipitation over winter. The March Outlook published by Manitoba’s Hydrologic Forecast Center estimated that the peak flow at Emerson could be similar to the flow seen in the 2019 spring flood under favorable conditions, and exceed the 2006 flood under normal conditions. Under unfavorable conditions, the 2020 flow at Emerson was forecasted to exceed the 2011 flow.

The recorded peak flow was similar to the forecast peak for normal melt conditions published in the March Outlook, aided by a long and favourable thaw with minimal spring precipitation, low winter precipitation, and low antecedent moisture conditions in the Assiniboine, Souris and Pembina River basins. The observed peak at Emerson for the 2020 spring flood occurred on April 19 and 20, and was approximately 69,600 cfs (1970 m³/s). The Red River crested at the floodway inlet on April 23, with a peak flow of approximately 67,900 cfs (1922.7 m³/s).

The 2020 natural spring flood was a significant event in the upper portion of the basin, with extensive flooding in North Dakota. The 2020 peak flow measured at Emerson equated to a 1:15 year flood. However, due to the small contributions of tributaries in the lower portion of the basin, the peak natural flood flow at James Avenue only equated to a 1:8 year flood.

3.0 THE RED RIVER FLOODWAY

Following the historic flood of 1950 in the City of Winnipeg, work began on the design and construction of a series of flood control measures including the Shellmouth Dam and Reservoir, the Portage Diversion, and the Red River Floodway to protect the City of Winnipeg from significant flood events. All were intended to be operated in concert to reduce flood flows and thus, minimize flood damage within the City of Winnipeg.

Operation of the floodway is guided by the Red River Floodway Rules of Operation (Appendix A), a set of rules intended to provide balanced flood protection to the City of Winnipeg without artificially affecting properties south (e.g., upstream) of the inlet. Rule 1 requires that natural levels not be exceeded upstream of the Floodway Inlet Control Structure as long as water levels within the City of Winnipeg are less than 24.5 ft (7.47 m) at James Avenue or if the water level anywhere along the Red River within the City of Winnipeg is less than two feet below the Flood Protection Level of 27.83 ft (8.48m). The natural water level on the Red River at the floodway entrance is defined as the water level that would have occurred at this location in the late 1950s if the Shellmouth Reservoir, Portage Diversion, Assiniboine River dikes, Winnipeg dikes and Red River Floodway were not in place.

During the 2020 spring floodway operation, the natural water levels upstream of the inlet were calculated using the relationship developed by Acres Manitoba Limited in 2004 [*“Re-Computation of Natural Water Levels at the Floodway Inlet (Final Report),” April 2004*]. This relationship requires two input values: the natural flow in the Red River downstream of the Assiniboine River (at James Avenue) and the natural flow of the Assiniboine River into the Red River. These data along with the natural and actual water levels on the Red River at the floodway inlet are shown for the 2020 spring flood in Appendix B, Table 2. Real-time water level and flow data to guide the operations are obtained at a number of sites, including the Red River at James Avenue, Red River above and below the Inlet Control Structure, Floodway Channel, Assiniboine River at Headingley, Portage Diversion, Sturgeon Creek, and La Salle River along with estimates of un-gauged flow from small streams or overland runoff in the Winnipeg area.

4.0 OPERATION OF THE FLOODWAY IN SPRING 2020

4.1 General Observations

Floodway operation began at 7:00 p.m. on April 10. Water had begun to spill into the floodway on April 7; however, ice was still in place immediately upstream of the Floodway Control Structure until approximately mid day on the 10th. The Red River Floodway gates were operated in accordance with normal operating procedures to reduce river levels in the City of Winnipeg. Operation of the floodway during open water in 2020 followed normal protocol and was consistent with experience in past spring floods.

The computation of natural water levels at the Red River Floodway Inlet Control Structure requires calculation of the natural flow at James Avenue. Natural flow is determined by adjusting the actual flow for the effects of the flood control works. Under open water conditions, the actual flow is determined from an established water level-flow relationship for the Red River at James Avenue using water levels collected at Water Survey of Canada water monitoring station 05OC015. This water level-flow relationship is verified multiple times throughout the spring through manual flow measurements.

The recorded peak water level at James Avenue was 18.94 ft (227.53 m) under open water conditions on the morning of April 23. The peak natural flow at James Avenue in Winnipeg would have occurred at the same time, and was calculated to be approximately 67,900 cfs (1922.71 m³/s). This peak flow would have resulted in a James Avenue level of 22.95 ft (228.76 m). Operation of the floodway, Portage Diversion and Shellmouth Dam lowered the James Avenue water level during the peak natural flow by 4.02 ft (1.22 m).

Overall, in the spring of 2020, approximately 757,300 acre-feet (934.1 million m³) of water was diverted around the City of Winnipeg by the Red River Floodway, with a peak flow of 19,400 cfs (549.3 m³/s). The peak recorded level at the floodway entrance (Water Survey Canada station 05OC026) was 759.29 ft (231.43 m) on April 30, 0.32 ft (0.10 m) lower than the computed natural level of 759.62 ft (231.53m). The recorded river level at the floodway entrance was maintained at an average of 0.28 ft (0.09 m) below the computed natural level throughout the 28 days of floodway operation.

After the initial operation, the floodway gates were adjusted in small increments to follow the natural rise and drop in water levels. This was done to avoid large gate raises and drops that may have caused sudden changes in water levels above and below the floodway control structure. Table 1 lists the gate operations that occurred during the operation of the floodway in the spring of 2020. On May 8, after consultation with the City of Winnipeg, the floodway gates were transitioned out of service over the course of 10 hours. Gate changes were no longer having an observable impact on the river level at James Avenue by this time. The final gate operation occurred at 15:42 p.m. on May 8.

Figure 1 shows the recorded and natural water levels for the Red River in Winnipeg at James Avenue during the period of operation. Figure 2 shows the recorded and natural water levels for the Red River upstream of the floodway entrance.

4.2 Public Communication in 2020 Flood

During the 2020 flood, public communication was achieved by direct email to stakeholders, the publication of gate change notices and water level plots on Manitoba Infrastructure's website, and through updates to the floodway operations info line.

An email database has been developed and maintained in accordance with the recommendations of the 2010 Public Review of the Red River Floodway Rules of Operation. The database includes municipal staff from the City of Winnipeg, Town of Morris, R.M. of Morris, R.M. of West St. Paul, City of Selkirk, R.M. of St. Clements, R.M. of St. Andrews, R.M. of Springfield, R.M. of MacDonald, and R.M. of Ritchot. Email notifications were distributed after each gate change operation. The first email was distributed April 2 at 7:20 p.m., providing notice of conditions at the floodway inlet, advising that flow could begin to enter the floodway naturally within days. A second notification was sent on April 8 indicating that flow had begun to enter the floodway naturally, but that ice was delaying floodway gate operation. The initial operation notification was sent April 10 at 3:00 p.m. indicating that ice had cleared, and that the gate operation was planned for 7:00 p.m. that evening. The final operation notification email was distributed at 5:50 p.m., May 8, informing stakeholders on the contact list that floodway operations were complete for the spring 2020 flood.

Prior to the initial operation of the floodway, Manitoba Infrastructure (MI) hosted an annual pre-flood meeting of the Red River Floodway Operation Advisory Board. At this meeting, it was requested that Manitoba Infrastructure provide more advanced notification of initial floodway operation. River ice break-up conditions in 2020 allowed for this advanced notification to take place.

MI published the Red River Floodway gate change logs and hydrographs to the floodway information website (www.manitoba.ca/mit/wms/r/f/information.html). The hydrographs showed natural and observed water levels at the floodway inlet, flow in the Red River upstream of the inlet, and flow in the floodway. These plots were updated on a daily basis during the operating period. The gate change logs were updated as gate changes were made.

An information phone line (204-284-4550) was also maintained with the most recent information on the operation of the Red River Floodway.

4.3 Ice Conditions in 2020

Ice was intact on the Red River immediately upstream of the floodway inlet until April 10. Ice delayed floodway operations in 2020 by approximately 2 days. Flow had begun to enter the Floodway naturally on the 7th, and by the 8th the level at James Avenue was above 16.5 ft (5.03 m). North of Winnipeg, minor ice jams caused some temporary road closures and overland flooding. Drone footage was used to evaluate ice jam activity north of the City of Winnipeg.

Ice jamming was not a major issue along the Assiniboine River upstream of the Portage Diversion. The Portage Diversion was operated from April 9 to April 19 to maintain flows on the Lower Assiniboine to less than 5,000 cfs (141.6 cms). Minor ice jamming occurred downstream of Portage la Prairie but did not cause any damages.

4.4 Assiniboine River Flow Contribution

The Assiniboine River flows during the spring flood of 2020 were average for the spring freshet. The computed peak natural Assiniboine flow at Portage la Prairie was 13,600 cfs (385.1 m³/s) on April 12. The natural Assiniboine River contribution at James Avenue peaked at 14,000 cfs (396.4 m³/s). The recorded flow along the Assiniboine River at Headingley reached a maximum of 6,000 cfs (169.9 m³/s) due to the operation of the Shellmouth Dam and Portage Diversion.

The greatest reduction in flow at James Avenue due to Shellmouth Dam operations occurred on May 8, when the Red River flow at James Avenue was reduced by approximately 2,000 cfs (56.6 m³/s).

The flow at the Portage Diversion peaked on April 12, at 8,400 cfs (237.9 m³/s). Combined with the impacts of the Shellmouth Dam, this resulted in a reduction in peak flow contribution to the Red River of 8,500 cfs (240.7 m³/s). Outflow at Shellmouth Reservoir was only slightly higher than inflow at the time, providing a negligible increase to the net benefit at Winnipeg during peak Portage Diversion Operation.

4.5 Floodway Maintenance and Efficiency

The floodway channel is maintaining acceptable levels of efficiency due to annual brush clearing in the floodway channel by Manitoba Infrastructure regional maintenance staff.

5.0 CONCLUSIONS

In summary:

- During the spring of 2020, the Red River Floodway was operated for 28 days and, in combination with other related flood protection measures such as operation of the Portage Diversion and the storage of flood waters in the Shellmouth Reservoir, these efforts reduced the flood crest in the City of Winnipeg by 4.02 ft (1.22 m) during the peak natural flow. The recorded peak water level at James Avenue was 18.94 ft (5.77 m).
- The operation of the Red River Floodway began at 7:00 pm on April 10, 2020, and concluded at 5:42 p.m. on May 8, 2020. During this period, 50 discrete gate adjustments were made as required.
- Recorded water levels upstream of the inlet were maintained below natural levels throughout the operation of the floodway in the spring of 2020. On average, water levels were 0.28 ft (0.09 m) lower than natural levels.

- The crest at the floodway inlet was 759.29 ft (231.43 m), 0.32 ft (0.10 m) lower than the computed natural peak level of 759.62 ft (231.53m).
- Ice break-up delayed floodway operations in 2020. However, the river level within the City was not a cause for concern due to this delay. Minor ice jamming occurred north of the City of Winnipeg, resulting in some temporary road closures and overland flooding.
- During spring 2020, the Red River Floodway diverted 757,300 acre-feet (934.1 million m³) of water around the City of Winnipeg with a peak flow of 19,400 cfs (549.3 m³/s).

Table 1 - 2020 Floodway Gate Operations

Date	Time *	Gate Elevation	
		Start of Operation	End of Operation
April 10, 2020	7:00 PM	728.04	738.04
April 11, 2020	6:10 AM	738.04	740.34
April 11, 2020	9:54 AM	740.34	742.34
April 11, 2020	2:40 PM	742.34	742.72
April 11, 2020	6:45 PM	742.72	743.19
April 12, 2020	7:58 AM	743.19	742.90
April 12, 2020	11:00 AM	742.90	742.53
April 16, 2020	10:15 AM	742.53	742.24
April 16, 2020	6:30 PM	742.24	742.62
April 16, 2020	11:00 PM	742.62	742.81
April 18, 2020	12:00 AM	742.81	743.00
April 19, 2020	10:17 PM	743.00	743.28
April 20, 2020	4:33 PM	743.28	743.57
April 21, 2020	9:55 PM	743.57	743.28
April 25, 2020	3:11 PM	743.28	743.09
April 26, 2020	10:08 AM	743.09	742.82
April 26, 2020	9:03 PM	742.82	742.62
April 27, 2020	8:54 PM	742.62	742.43
April 28, 2020	10:46 AM	742.43	742.15
April 28, 2020	8:56 PM	742.15	741.86
April 29, 2020	9:00 PM	741.86	741.48
April 30, 2020	11:15 AM	741.48	741.29
April 30, 2020	8:41 PM	741.29	741.00
May 1, 2020	10:52 AM	741.00	740.81
May 1, 2020	9:14 PM	740.81	740.53
May 2, 2020	10:48 AM	740.53	740.24
May 2, 2020	3:15 PM	740.24	739.95
May 2, 2020	9:13 PM	739.95	739.76
May 3, 2020	6:02 PM	739.76	739.48
May 3, 2020	10:23 PM	739.48	739.19
May 4, 2020	12:02 PM	739.19	738.90
May 4, 2020	4:19 PM	738.90	738.71
May 4, 2020	9:05 PM	738.71	738.33
May 5, 2020	8:03 AM	738.33	738.14
May 5, 2020	6:30 PM	738.14	737.95
May 5, 2020	10:23 PM	737.95	737.38
May 6, 2020	7:57 AM	737.38	736.90

*Time at start of gate operation

Table 1 Continued - 2020 Floodway Gate Operations

Date	Time *	Gate Elevation	
		Start of Operation	End of Operation
May 6, 2020	12:13 PM	736.90	736.43
May 6, 2020	3:50 PM	736.43	736.14
May 6, 2020	9:47 PM	736.14	735.58
May 7, 2020	1:23 AM	735.58	734.92
May 7, 2020	7:27 AM	734.92	734.54
May 7, 2020	12:04 PM	734.54	734.08
May 7, 2020	3:34 PM	734.08	733.61
May 7, 2020	7:08 PM	733.61	733.06
May 7, 2020	11:00 PM	733.06	732.33
May 8, 2020	7:38 AM	732.33	731.69
May 8, 2020	11:19 AM	731.69	730.98
May 8, 2020	3:36 PM	730.98	729.57
May 8, 2020	5:42 PM	729.57	728.04

*Time at start of gate operation

Figure 1 - Recorded and Natural Levels at James Avenue 2020

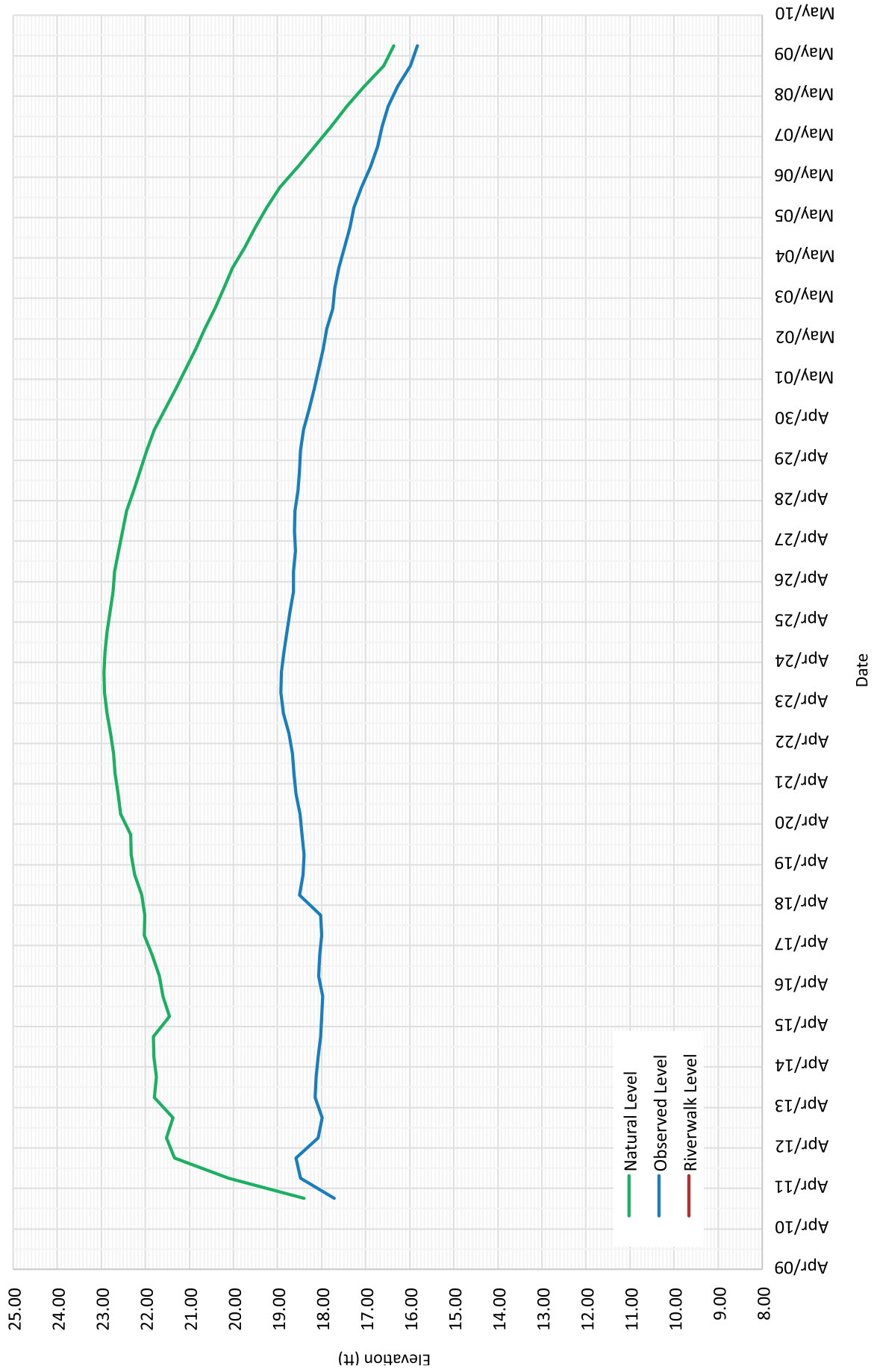


Figure 2 - Recorded and Natural Levels at Floodway Entrance 2



APPENDIX A

Red River Floodway Rules of Operation

Rules of Operation

Red River Floodway Control Structure

Normal Operation:

1. Maintain natural¹ water levels on the Red River at the entrance to the floodway channel, until the water surface elevation at James Avenue reaches 24.5 ft (7.46 m), or the river level anywhere along the Red River within the City of Winnipeg reaches two feet below the Flood Protection Level of 27.83 ft (8.48 m).

Major Flood Operation:

2. Once the river levels within Winnipeg reach the limits described in Rule 1, the level in Winnipeg should be held constant while levels south of the control structure continue to rise. Furthermore, if forecasts indicate that levels at the entrance to the floodway channel will rise more than two feet (0.6 m) above natural, the City of Winnipeg must proceed with emergency raising of the dikes and temporary protection measures on the sewer systems in accordance with the flood level forecasts within Winnipeg. The levels in Winnipeg should be permitted to rise as construction proceeds, but not so as to encroach on the freeboard of the dikes or compromise the emergency measures undertaken for protecting the sewer systems. At the same time, the Province should consider the possibility of an emergency increase in the height of the floodway embankments and the West Dike. At no time will the water level at the floodway channel's entrance be allowed to rise to a level that infringes on the allowable freeboard on the floodway west embankment (Winnipeg side) and the West Dike.

Extreme Flood Operation:

3. For extreme floods, where the water level at the floodway channel's entrance reaches the maximum level that can be held by the floodway west embankment and the West Dike, the river level must not be permitted to exceed that level. All additional flows must be passed through Winnipeg.

Initial Gate Operation with Ice:

The floodway gates should not be operated until ice on the river is flowing freely, unless flooding in Winnipeg is imminent.

Final Drop of Gates:

To minimize bank slumping along the river in Winnipeg and at the same time reduce the probability of sewer backup problems, final gate operations, once the level at the entrance to the floodway channel recedes to elevation 752 ft (229 m), shall be carried out in consultation with the City of Winnipeg.

Emergency Operation to Reduce Sewer Backup in Winnipeg

- 4(1) This rule defines the circumstances under which the Minister of Manitoba Infrastructure ("the Minister") may determine that emergency operation of the floodway is necessary to prevent widespread basement flooding and resulting risk to health and damage to property within the City of Winnipeg.
- 4(2) This rule applies after the spring crest from snowmelt runoff at Winnipeg, whenever high river levels substantially impair the capacity of Winnipeg's combined sewer system.
- 4(3) As long as the Department of Manitoba Infrastructure ("the Department") forecasts that river levels for the next 10 days will be below 14 ft James Avenue Pumping Station Datum (JAPSD), the Department will not operate the floodway control structure.

¹ The term natural refers to the level that would have occurred in the absence of the flood control works, with the level of urban development in place at the time of the construction of these works.

- 4(4) When the Department forecasts that river levels for the next 10 days are expected to rise to 14 feet JAPSD or higher, the Department will prepare a report that describes:
- (a) The basis of the Department's river level forecasts and its risk assessment;
 - (b) The risk of basement flooding in Winnipeg, including the following factors:
 - (i) The predicted peak river level in the next 10 days;
 - (ii) The length of time the Department forecasts the river level will be at 14 ft JAPSD or higher;
 - (iii) The risk of an intense rainfall event in Winnipeg in the next 10 days;
 - (c) The benefits and costs of floodway operation, including:
 - (i) The extent of basement flooding and damage to property expected from various combinations of intense rainfall events and high river levels;
 - (ii) The risk to the health of Winnipeg residents from sewer bup;
 - (iii) Economic loss and damage caused by artificial flooding south of the Inlet Control Structure;
 - (iv) Impacts of operation on fish and wildlife and their habitat and on water quality;
 - (v) The risks and potential costs of riverbank instability that may be caused by artificial river level changes, both upstream and downstream of the Inlet Control Structure;
 - (vi) During construction of the floodway expansion, costs and risks associated with any resulting delays of that construction, including the potential average annual expected damages associated with an additional period of risk of a flood event that would exceed the current capacity of the floodway;
 - (vii) Such other benefits and costs of operation of which the Department is aware at the time of the preparation of the report, excluding benefits associated with recreational or tourism activities or facilities; and
 - (d) measures that may be taken to mitigate the costs and impacts of the operation under consideration, including:
 - (i) minimizing the rate at which river levels are changed both upstream and downstream of the floodway Inlet Control Structure;
 - (ii) providing means to assure fish passage.
- 4(5) The Department will present a draft of the report prepared under Rule 4(4) to the Floodway Operation Review Committee and provide an opportunity for the Committee to provide input, before finalizing the report and making recommendations respecting floodway operation.
- 4(6) The Department will not recommend operation of the floodway unless the expected benefits of doing so clearly and substantially outweigh the expected costs.
- 4(7) The Department will present its report and recommendations to the Minister, who, subject to Rule 4(8), will make a decision respecting floodway operation based on his or her consideration of the report.

- 4(8) The Department will not operate the floodway control structure under this rule:
- (a) to raise river levels immediately upstream of the control structure to an elevation higher than 760 ft above sea level;
 - (b) to achieve a river level of less than 9 ft JAPSD; or
 - (c) except in circumstances of extreme urgency, to lower river levels more than one foot per day.
- 4(9) The Department will issue a news release announcing a decision to operate the floodway at least 24 hours before commencing operation.
- 4(10) The Department will ensure every reasonable effort is made to personally notify landowners who may be directly affected by flooding due to floodway operation in advance of the operation.
- 4(11) The Department will sound the horn at the floodway Inlet Control Structure one-half hour before operation commences.
- 4(12) The Department will maintain a program of compensation for damages suffered by landowners arising from flooding caused by floodway operation under this rule.

APPENDIX B

Computation of Natural Flows and Levels

Computation of Natural Flows and Levels On the Red and Assiniboine Rivers

Figure 1 and Figure 2 in the main report show the natural and observed levels at the floodway inlet and James Avenue. This Appendix describes how these levels were determined, and explains how the relationships developed in the Acres 2004 study were applied to compute the natural level at the floodway entrance.

Table B-1 lists the recorded and computed flows and levels for each time step. Columns 1 to 7 list the flows used in computing the natural flows on the Assiniboine River, and columns 8 to 10 list the flows used for computing the natural flows on the Red River.

Natural Assiniboine River Flow

The natural (unregulated) flows on the Assiniboine River are altered by operation of the Shellmouth Dam, the Portage Diversion, and by the presence of dikes along the Assiniboine River.

The Shellmouth Dam can decrease flows below natural levels by adjusting the control gates so that reservoir outflows are lower than inflows. In this case, the reservoir levels rise, and excess water is stored behind the dam.

The Portage Diversion can be used to reduce flows in the lower Assiniboine River by diverting some of the river flow north to Lake Manitoba.

The Assiniboine River dikes were constructed to prevent overflows from the river onto the surrounding lands. Much of this overflow would not return to the Assiniboine River because of the height of the river and the slope of the land. Therefore, the dikes have the effect of increasing flows entering Winnipeg on the Assiniboine River during periods of high flow.

Referring to Table B-1, column 1 lists the flow reductions at Winnipeg resulting from storage behind the Shellmouth Dam. It is important to recognize that these flow changes at the dam take some time to reach Winnipeg. The department uses the Muskingum routing procedure to compute this flow attenuation.

Column 2 shows the flows diverted to Lake Manitoba via the Portage Diversion. Again the flows are routed to Winnipeg to apply the time delay.

Column 3 shows the recorded flows at the hydrometric station at Headingley.

Column 4 lists the computed breakouts that would have occurred at those flows if the dikes had not been constructed.

Column 5 lists the computed natural flows at Headingley. These are computed by adding the values in columns 1 to 3 (Shellmouth flow reduction, recorded Portage Diversion flow, and recorded Headingley flow) and subtracting by the computed Assiniboine River natural breakouts.

There is some additional local inflow entering the Assiniboine River between Headingley and the Forks. Most of this flow is recorded on Sturgeon Creek. However, in column 6 the recorded flows on Sturgeon Creek are increased to include the estimated unmeasured local inflows.

Finally columns 5 and 6 are added together to give the computed natural flows of the Assiniboine River at the Forks, as listed in column 7.

Natural Red River Flow

On the Red River the primary flow adjustment is caused by the Red River Floodway. During periods of extensive flooding there can also be a flow change resulting from changes in the storage of floodwaters on the land, but as long as flood levels at the floodway entrance are held at natural that change would be negligible.

Column 8 lists the recorded flows in the floodway channel, and column 9 shows the recorded flows at James Avenue. Column 10 sums the flows in columns 1, 2, 8 and 9, and subtracts column 4 to give the total natural flow on the Red River at James Avenue, which is downstream of the Forks.

Natural River Levels at the Floodway Inlet

Table B-2 is a reproduction of Table 4-7 from the Acres report “*Re-Computation of Natural Water Levels at the Floodway Inlet (Final Report), April 2004.*” The table provides natural elevations at the inlet based upon the relative contribution of natural flow at the Forks from the Red and Assiniboine Rivers. The *combined* flow is represented by the values in the left-hand column entitled Natural Red River at James Avenue Flow. The Natural Assiniboine River Flow Contribution amount is shown across the top and is the flow in the Assiniboine River at the Forks.

The natural water level at the inlet can vary by a few feet dependent upon the amount of flow coming from the Assiniboine River (Assiniboine River Contribution). This phenomenon is referred to as a variable backwater effect.

This concept can be illustrated by using the example of 100,000 cfs flow for the Red River at James Avenue in various combinations of Red and Assiniboine river flows. One combination could have 95,000 cfs as Red River flow upstream of the Forks, and 5,000 cfs as the Assiniboine River Contribution. This combination results in a level at the inlet of 765.6 ft as shown in Table B-2. Similarly, another combination, while still yielding a total James Avenue flow of 100,000 cfs, could be 70,000 cfs as the Red River flow upstream of the Forks, and 30,000 cfs as the Assiniboine River Contribution. The resulting inlet level would be 762.9 ft (232.53 m). The difference in the inlet water elevation between these two flow combinations is 2.7 ft (0.82 m), with the lower elevation occurring when there is relatively more flow on the Assiniboine River.

Natural water levels are determined by using the natural Red River flows at James Avenue listed in column 10 of Table B-1, and the natural Assiniboine River flows listed in column 7 of Table B-1, and interpolating between the values listed in Table B-2 to determine the natural levels. These natural levels are listed in column 13 of Table B-1. For comparison, column 14 of Table B-1 lists the recorded levels at the floodway inlet (station 05OC026). Similar levels for James Avenue in Winnipeg are provided in columns 11 and 12.

Table B-1 - Spring 2020 Flows and Levels

Date	Assiniboine River							Red River									
	Shellmouth Flow Reduction (Routed to Headingley) Recorded	Portage Diversion flow (Routed to Headingley)	Actual Assiniboine R. flow at Headingley	Natural breakouts from river	Natural Assiniboine River flow at Headingley	Sturgeon Cr. Flow plus other local inflows	Natural Assiniboine R. flow into Red River	Red River flow U/S of Floodway	Red River Floodway flow	La Salle flow	Red River flow at James Ave.	Natural Red River flow at James Avenue	Natural water level on Red R. At James Ave (feet)	Recorded Water level on Red R. at James Ave (feet)	Natural water level on Red R. at Floodway Inlet (feet)	Recorded Water level on Red R. at Floodway Inlet (feet)	Below Natural at Floodway Inlet (feet)
	Recorded	Recorded	Recorded	Computed	=1+2+3-4	Rec. & Est.	=5+6	Computed	Recorded	Recorded	Recorded	=1+2-4+9+10	Computed	Recorded	Computed	Recorded	Computed
April 10, 2020 AM	-508	217	5,757	800	4,666	1,112	5,778	42,114	2,903	2,118	48,197	50,009	17.97	17.50	753.38	753.20	0.18
April 10, 2020 PM	-433	256	5,872	800	4,895	869	5,764	43,635	3,709	2,389	49,057	51,788	18.39	17.71	753.50	753.17	0.34
April 11, 2020 AM	-390	205	5,913	800	4,928	788	5,716	50,581	7,932	2,404	51,754	58,701	20.11	18.48	755.33	755.01	0.32
April 11, 2020 PM	-303	1,995	5,950	800	6,841	705	7,546	55,312	11,411	2,418	52,973	65,276	21.34	18.58	756.99	756.51	0.48
April 12, 2020 AM	-256	3,246	5,930	800	8,120	633	8,754	56,800	13,409	2,344	52,299	67,898	21.53	18.08	757.56	757.33	0.23
April 12, 2020 PM	-141	2,495	5,933	800	7,487	474	7,961	57,079	13,676	2,320	52,129	67,360	21.37	17.99	757.53	757.37	0.16
April 13, 2020 AM	73	3,640	5,933	800	8,846	397	9,243	57,481	13,702	2,370	52,479	69,094	21.79	18.15	757.84	757.33	0.51
April 13, 2020 PM	75	3,542	5,903	800	8,721	299	9,020	57,128	13,667	2,484	52,147	68,632	21.75	18.12	757.73	757.34	0.39
April 14, 2020 AM	71	3,586	5,876	796	8,736	247	8,984	57,298	14,038	2,360	51,743	68,641	21.80	18.07	757.75	757.38	0.37
April 14, 2020 PM	63	3,869	5,827	754	9,004	181	9,185	57,215	13,983	2,196	51,435	68,596	21.81	18.02	757.70	757.41	0.29
April 15, 2020 AM	53	2,016	5,712	716	7,065	206	7,271	57,875	14,112	1,934	51,615	67,080	21.45	18.00	757.56	757.48	0.09
April 15, 2020 PM	34	2,628	5,565	700	7,527	195	7,722	58,536	14,373	1,609	51,533	67,867	21.61	17.98	757.72	757.52	0.20
April 16, 2020 AM	19	2,660	5,260	696	7,244	198	7,441	59,621	14,410	1,204	51,874	68,267	21.69	18.06	757.89	757.59	0.30
April 16, 2020 PM	-10	3,178	4,898	654	7,412	178	7,590	60,493	14,707	931	51,794	69,015	21.84	18.04	758.09	757.70	0.39
April 17, 2020 AM	-28	3,688	4,874	616	7,918	172	8,089	61,090	15,323	783	51,595	69,962	22.03	18.00	758.29	757.95	0.34
April 17, 2020 PM	-64	3,121	5,211	600	7,667	169	7,837	61,888	15,841	695	52,122	70,419	22.01	18.02	758.46	758.14	0.33
April 18, 2020 AM	-82	1,160	5,436	596	5,917	168	6,085	65,082	16,405	614	54,895	71,781	22.08	18.50	759.12	758.33	0.80
April 18, 2020 PM	-118	1,740	5,188	554	6,255	162	6,417	65,499	16,982	554	54,421	72,470	22.24	18.42	759.26	758.52	0.74
April 19, 2020 AM	-133	1,671	5,084	516	6,106	159	6,265	65,343	17,345	488	53,730	72,096	22.32	18.40	759.18	758.65	0.53
April 19, 2020 PM	-163	1,200	5,037	500	5,574	154	5,728	65,818	17,662	448	53,796	71,995	22.33	18.44	759.24	758.75	0.49
April 20, 2020 AM	-171	1,715	5,278	500	6,322	150	6,472	66,081	18,131	452	53,830	73,005	22.56	18.49	759.41	758.90	0.51
April 20, 2020 PM	-187	1,117	5,577	500	6,006	150	6,156	66,401	18,606	463	53,984	73,021	22.62	18.58	759.46	759.04	0.42
April 21, 2020 AM	-186	722	5,694	489	5,742	154	5,896	66,736	19,071	459	53,972	73,090	22.68	18.63	759.52	759.20	0.32
April 21, 2020 PM	-183	428	5,759	363	5,640	150	5,790	66,997	19,285	422	54,043	73,209	22.72	18.66	759.57	759.25	0.32
April 22, 2020 AM	-172	327	5,894	248	5,801	154	5,954	67,234	19,261	373	54,394	73,561	22.79	18.75	759.64	759.26	0.39
April 22, 2020 PM	-151	130	5,996	200	5,776	152	5,928	67,519	19,266	317	54,718	73,763	22.88	18.87	759.71	759.24	0.46
April 23, 2020 AM	-131	7	5,865	200	5,541	149	5,690	67,715	19,346	264	54,648	73,670	22.93	18.93	759.72	759.26	0.45
April 23, 2020 PM	-92	0	5,546	200	5,254	148	5,402	67,811	19,381	220	54,343	73,432	22.94	18.91	759.70	759.27	0.43
April 24, 2020 AM	-67	0	5,219	198	4,954	146	5,100	67,660	19,387	186	53,824	72,946	22.92	18.86	759.61	759.26	0.35
April 24, 2020 PM	-16	0	4,940	177	4,748	136	4,883	67,604	19,345	167	53,501	72,654	22.86	18.78	759.56	759.23	0.33
April 25, 2020 AM	13	0	4,734	158	4,589	137	4,726	67,470	19,272	155	53,223	72,350	22.81	18.71	759.51	759.21	0.30
April 25, 2020 PM	70	0	4,615	150	4,536	138	4,674	67,150	19,127	140	52,918	71,964	22.73	18.64	759.41	759.15	0.26
April 26, 2020 AM	100	0	4,565	150	4,515	132	4,647	66,623	18,853	125	52,591	71,395	22.70	18.64	759.25	759.05	0.20
April 26, 2020 PM	159	0	4,549	150	4,558	124	4,683	65,731	18,384	112	52,132	70,526	22.60	18.60	759.00	758.92	0.09

Table B-1 - Spring 2020 Flows and Levels

Date	Assiniboine River							Red River									
	Shellmouth Flow Reduction (Routed to Headingley)	Portage Diversion flow (Routed to Headingley)	Actual Assiniboine R. flow at Headingley	Natural breakouts from river	Natural Assiniboine River flow at Headingley	Sturgeon Cr. Flow plus other local inflows	Natural Assiniboine R. flow into Red River	Red River flow U/S of Floodway	Red River Floodway low	La Salle flow	Red River flow at James Ave.	Natural Red River flow at James Avenue	Natural water level on Red R. At James Ave (feet)	Recorded Water level on Red R. at James Ave (feet)	Natural water level on Red R. at Floodway Inlet (feet)	Recorded Water level on Red R. at Floodway Inlet (feet)	Below Natural at Floodway Inlet (feet)
	Recorded	Recorded	Recorded	Computed	=1+2+3-4	Rec. & Est.	=5+6	Computed	Recorded	Recorded	Recorded	=1+2-4+9+10	Computed	Recorded	Computed	Recorded	Computed
April 27, 2020 AM	189	0	4,535	148	4,576	119	4,695	65,333	17,818	103	52,271	70,131	22.51	18.62	758.89	758.73	0.16
April 27, 2020 PM	249	0	4,532	127	4,653	113	4,767	65,023	17,378	92	52,383	69,882	22.42	18.60	758.81	758.60	0.21
April 28, 2020 AM	280	0	4,521	108	4,693	109	4,801	64,410	16,833	86	52,292	69,297	22.27	18.54	758.63	758.45	0.18
April 28, 2020 PM	341	0	4,516	100	4,757	110	4,867	63,700	16,205	80	52,201	68,647	22.12	18.50	758.43	758.25	0.18
April 29, 2020 AM	375	0	4,463	100	4,738	104	4,842	62,980	15,474	72	52,145	67,894	21.97	18.48	758.22	757.99	0.23
April 29, 2020 PM	442	0	4,391	100	4,733	101	4,834	62,147	14,860	68	51,848	67,049	21.80	18.41	757.97	757.78	0.20
April 30, 2020 AM	481	0	4,304	100	4,685	97	4,782	60,983	14,099	68	51,353	65,833	21.55	18.28	757.63	757.51	0.12
April 30, 2020 PM	559	0	4,274	100	4,732	91	4,824	59,821	13,340	68	50,913	64,712	21.32	18.17	757.30	757.23	0.06
May 1, 2020 AM	605	0	4,279	98	4,786	85	4,871	58,711	12,646	63	50,492	63,645	21.09	18.07	756.98	756.93	0.05
May 1, 2020 PM	698	0	4,315	77	4,936	74	5,010	57,749	12,007	59	50,191	62,818	20.86	17.96	756.72	756.66	0.05
May 2, 2020 AM	753	0	4,351	58	5,046	68	5,114	56,849	11,366	62	49,964	62,026	20.65	17.88	756.47	756.37	0.10
May 2, 2020 PM	863	0	4,395	50	5,208	60	5,268	56,052	10,745	71	49,833	61,391	20.42	17.75	756.25	756.03	0.22
May 3, 2020 AM	927	0	4,508	50	5,385	56	5,441	54,952	9,900	79	49,694	60,471	20.22	17.70	755.95	755.67	0.28
May 3, 2020 PM	1,054	0	4,629	50	5,633	51	5,683	53,823	9,258	85	49,329	59,591	20.02	17.61	755.63	755.41	0.22
May 4, 2020 AM	1,124	0	4,655	49	5,730	46	5,776	52,559	8,477	85	48,869	58,420	19.75	17.49	755.24	755.04	0.20
May 4, 2020 PM	1,264	0	4,662	41	5,885	41	5,927	51,323	7,732	81	48,374	57,330	19.50	17.36	754.86	754.69	0.17
May 5, 2020 AM	1,337	0	4,625	33	5,929	37	5,966	50,141	6,859	74	48,019	56,181	19.24	17.26	754.48	754.25	0.23
May 5, 2020 PM	1,482	0	4,521	30	5,973	35	6,008	48,837	6,080	69	47,382	54,914	18.95	17.10	754.07	753.88	0.19
May 6, 2020 AM	1,552	0	4,304	30	5,825	34	5,859	47,314	5,148	64	46,568	53,237	18.54	16.88	753.56	753.42	0.14
May 6, 2020 PM	1,690	0	4,342	30	6,002	32	6,034	45,548	4,013	60	45,970	51,643	18.15	16.72	753.02	752.88	0.14
May 7, 2020 AM	1,750	0	4,464	30	6,184	32	6,216	43,835	2,779	53	45,605	50,104	17.78	16.63	752.49	752.31	0.17
May 7, 2020 PM	1,868	0	4,571	30	6,410	31	6,441	42,234	1,792	49	45,093	48,723	17.42	16.49	751.96	751.74	0.22
May 8, 2020 AM	1,912	0	4,560	30	6,442	30	6,472	40,682	1,013	43	44,302	47,197	17.03	16.27	751.41	751.13	0.28
May 8, 2020 PM	1,999	0	4,656	30	6,626	29	6,655	38,816	311	39	43,229	45,509	16.59	15.98	750.77	750.52	0.25
May 9, 2020 AM	1,999	0	4,720	30	6,690	29	6,719	37,858	0	37	42,644	44,613	16.36	15.83	750.43	750.14	0.29

Table B-2 - Red River Floodway Inlet Natural Water Level Rating Table

		NATURAL ASSINIBOINE RIVER FLOW CONTRIBUTION (cfs)												
	cfs	0	5,000	10,000	15,000	20,000	25,000	30,000	35,000	40,000	45,000	50,000		
	20,000	742.1	740.4	738.7	737.4									
	30,000	746.6	745.2	743.9	742.6	741.5								
	40,000	750.4	749.2	748.0	746.9	745.8	744.9							
	50,000	753.8	752.7	751.7	750.7	749.7	748.8	747.9						
	60,000	756.8	755.9	754.9	754.0	753.1	752.2	751.4						
	70,000	759.7	758.8	758.0	757.1	756.3	755.5	754.7						
	80,000	762.4	761.6	760.8	760.1	759.3	758.5	757.8						
	90,000		763.9	763.2	762.6	761.9	761.2	760.6	759.9					
	100,000		765.6	765.3	764.8	764.1	763.5	762.9	762.3					
	110,000		766.7	766.3	765.9	765.5	765.2	764.7	764.2					
	120,000		767.6	767.5	767.2	766.8	766.5	766.1	765.7	765.4				
	130,000		768.5	768.2	768.0	767.7	767.5	767.3	767.0	766.6				
	140,000			768.7	768.7	768.6	768.4	768.1	767.9	767.6	767.4			
	150,000			769.1	769.0	768.8	768.7	768.6	768.5	768.5	768.3			
	160,000			769.6	769.4	769.2	769.1	768.9	768.8	768.7	768.5	768.5		
	170,000			770.1	769.9	769.8	769.6	769.5	769.3	769.2	769.0	768.8		
	180,000			770.5	770.4	770.3	770.2	770.0	769.9	769.7	769.5	769.4		
	190,000				770.5	770.5	770.5	770.5	770.3	770.2	770.1	769.9		
	200,000				770.7	770.6	770.6	770.5	770.5	770.5	770.5	770.5		
	210,000				770.9	770.8	770.7	770.7	770.6	770.6	770.5	770.5		
	220,000				771.1	771.0	770.9	770.8	770.7	770.7	770.6	770.5		
	230,000				771.2	771.2	771.1	771.0	770.9	770.8	770.7	770.7		
	240,000					771.5	771.4	771.3	771.2	771.1	771.0	770.9		
	250,000					771.8	771.7	771.6	771.6	771.5	771.4	771.3		
	260,000					772.1	772.0	772.0	771.9	771.8	771.7	771.6		
	270,000					772.4	772.4	772.3	772.2	772.1	772.1	772.0		
	280,000					772.8	772.7	772.6	772.5	772.5	772.4	772.3		
	290,000					773.1	773.0	772.9	772.8	772.8	772.7	772.6		
	300,000					773.3	773.3	773.2	773.1	773.1	773.0	772.9		

Note: Open water conditions under steady state (no ice)