

RED RIVER FLOODWAY OPERATION REPORT

SPRING 2019

June 28, 2019

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



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EXECUTIVE SUMMARY

The 2019 Red River spring flood resulted from above normal to well above normal winter snow fall in the upper Red River basin, including significant late season snowfall in the Fargo area, combined with normal soil moisture going into freeze-up in the fall. The March Outlook published by Manitoba's Hydrologic Forecast Center estimated that the peak flow at Emerson could exceed the flow seen in the 2011 flood under favorable conditions, and exceed the 2009 flood under normal conditions. Under unfavorable conditions, the 2019 flow at Emerson was forecast to be second only to 1997 in the last 60 years of records. The observed peak at Emerson for the 2019 spring flood was approximately 60,700 cfs (1720.0 m³/s), and occurred on April 25. This is similar to the peak flow observed at Emerson in 2010. The 2019 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 1:6 year flood.

The 2019 Red River spring flood was driven primarily by significant winter precipitation in the upper portion of the basin, and most of the tributaries on the Canadian side of the border had peaked long before the flood crest arrived. Ice was not a major concern on the Red or Assiniboine rivers in 2019, however, some ice jamming did occur north of the City of Winnipeg in the Selkirk and Netley Creek areas. Floodway operation began at 12 noon on April 14, and the gates were operated for 31 days ending at 11:15 a.m. on May 15. During this period of operation, 40 discrete gate adjustments were made, as required at various times, to regulate the water level at the floodway inlet. In the spring of 2019, approximately 580,000 acre-feet (715.4 million m³) of water was diverted around the City of Winnipeg by the Red River Floodway, with a peak flow of 14,400 cfs (407.7 m³/s). The Red River Floodway has been operated in 33 of the past 50 years to prevent spring flooding since its first year of operation in 1969.

The Assiniboine River flow during the spring flood of 2019 was average for the spring freshet. The natural (unregulated) peak flow along the Assiniboine River at Portage la Prairie occurred on April 10, and was computed to be 8,300 cfs (235.0 m³/s). The observed flow along the Assiniboine River at Headingley reached a maximum of 6,200 cfs (175.6 m³/s) due to the operation of the Shellmouth Dam and Portage Diversion.

In spring 2019, 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 0.31 ft (0.09 m) below computed natural water levels at the floodway inlet throughout the 31 days of floodway operation. In concert with the operation of the Portage Diversion and Shellmouth Reservoir, the operation of the floodway reduced the flood crest in the City of Winnipeg by 3.68 ft (1.12 m) at the peak natural flow.

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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 2019 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 flows used in this report.

2.0 2019 SPRING RUNOFF

The 2019 Red River spring flood resulted from above normal (115% - 150%) to well above normal (150% - 200%) winter snow fall in the upper Red River basin, including significant late season snowfall in the Fargo area, combined with normal (85% - 115%) soil moisture going into freeze-up in the fall. The March Outlook published by Manitoba’s Hydrologic Forecast Center estimated that the peak flow at Emerson could exceed the flow seen in the 2011 flood under favorable conditions, and exceed the 2009 flood under normal conditions. Under unfavorable conditions, the 2019 flow at Emerson was forecasted to be second only to 1997 in the last 60 years of records.

The 2019 Red River spring flood was driven primarily by significant winter precipitation in the upper portion of the basin. Low winter precipitation and antecedent moisture conditions in the Assiniboine, Souris and Pembina river basins were beneficial in reducing the total volume of flow seen in the Red River at Winnipeg. The City of Winnipeg also benefitted from a relatively slow melt, which began in the northern part of the basin first. The spring melt in the northern

portion of the Red River Basin began around March 20, and occurred over several weeks. The melt in the southern portion of the basin began around April 1. Consequently, many of the tributaries in the lower portion of the basin had already peaked when the flood waters from the upper basin arrived. The observed peak at Emerson for the 2019 spring flood occurred on April 25, and was approximately 60,700 cfs (1720.0 m³/s). This was well below the favourable condition forecast of 85,000 cfs (2406.9 m³/s) published in the Hydrologic Forecast Center March Outlook. The Red River crested at the floodway inlet on April 30, with a peak flow of approximately 60,000 cfs (1699.0 m³/s).

The 2019 natural spring flood was a significant event in the upper portion of the basin. The 2019 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 1:6 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 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 2019 spring floodway operation, the natural water levels upstream of the inlet were calculated with 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 2019 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 2019

4.1 General Observations

Floodway operation began at noon on April 14. Water had begun to spill into the floodway on April 11, however, ice was still in place until the next day. River levels remained flat on April 12 and 13 before resuming their rise on April 14. 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 2019 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 17.67 ft (227.15 m) under open water conditions on the morning of April 30. The peak natural flow at James Avenue in Winnipeg would have occurred at the same time, and was calculated to be approximately 64,660 cfs (1831.0 m³/s). This peak flow would have resulted in a James Avenue level of 21.41 ft (228.29 m). Operation of the floodway, Portage Diversion and Shellmouth Dam lowered the James Avenue water level during the peak natural flow by 3.74 ft (1.14 m).

Overall, in the spring of 2019, approximately 580,000 acre-feet (715.4 million m³) of water was diverted around the City of Winnipeg by the Red River Floodway, with a peak flow of 14,400 cfs (407.7 m³/s). The peak recorded level at the floodway entrance (Water Survey Canada station 05OC026) was 757.02 ft (230.74 m) on April 30—0.30 ft (0.09 m) lower than the computed natural level of 757.31 ft (230.83 m). The recorded river level at the floodway entrance was maintained at an average of 0.31 ft (0.09 m) below the computed natural level throughout the 31 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 2019. On May 14, after consultation with the City of Winnipeg, the floodway gates were transitioned out of service over the course of 24 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 11:15 a.m. on May 15.

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 2019 Flood

During the 2019 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 10 at 10:30 a.m., providing notice of conditions at the floodway inlet, advising of imminent flow into the floodway, and estimating the date of floodway gate operation. The final operation notification email was distributed at 11:30 a.m., May 15, informing stakeholders on the contact list that floodway operations were complete for the spring 2019 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 2019 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/rff/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 2019

Ice was intact on the Red River upstream of the floodway inlet until April 12. Ice had no impact on floodway operations in 2019 as the ice had cleared two days before operation of the floodway gates was necessary. North of Winnipeg, minor ice jams caused some temporary road closures and overland flooding but no property damage. A drone was deployed on April 13 to evaluate conditions, but the ice was running by that time.

Ice jamming was not a major issue along the Assiniboine River upstream of the Portage Diversion. The Portage Diversion was operated from April 8 to April 16 to maintain flows on the Lower Assiniboine to less than 5,000 cfs. 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 2019 were average for the spring freshet. The computed peak natural Assiniboine flow at Portage la Prairie was 8,300 cfs (235.0 m³/s) on April 10. The natural Assiniboine River contribution at James Avenue peaked at 9,700 cfs (274.7 m³/s). The recorded flow along the Assiniboine River at Headingley reached a maximum of 6,200 cfs (175.6 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 April 28, when the Red River flow at James Avenue was reduced by approximately 1,800 cfs (51.0 m³/s).

The flow at the Portage Diversion peaked on April 10, at 3,800 cfs (107.6 m³/s). Combined with the impacts of the Shellmouth Dam, this resulted in a reduction in peak flow contribution to the Red River of 3,340 cfs (94.6 m³/s). Outflow at Shellmouth Reservoir was still higher than inflow, reducing the net benefit at Winnipeg at the time of 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 2019, the Red River Floodway was operated for 31 days and, in combination with other related flood control 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 3.74 ft (1.14 m) during the peak natural flow.
- The operation of the Red River Floodway began at 12 noon on April 14, 2019, and concluded at 11:15 a.m. on May 15, 2019. During this period, 40 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 2019. On average, water levels were 0.31 ft (0.09 m) lower than natural levels.
- The crest at the floodway inlet was 757.02 ft (230.74 m), 0.30 ft (0.09 m) lower than the computed natural peak level of 757.31 ft (230.83 m).
- Ice break-up did not delay floodway operations in 2019. Some ice jamming occurred north of the City of Winnipeg, resulting in some temporary road closures and overland flooding but no property damage.
- During spring 2019, the Red River Floodway diverted 580,000 acre-feet (715.4 million m³) of water around the City of Winnipeg with a peak flow of 14,400 cfs (407.7 m³/s).

Table 1 - 2019 Floodway Gate Operations

Date	Time*	Gate Elevation (ft)	
		Start of Operation	End of Operation
April 14, 2019	12:05 PM	728.04	734.08
April 14, 2019	6:57 PM	734.08	735.58
April 15, 2019	8:00 AM	735.58	736.62
April 15, 2019	12:27 PM	736.62	737.76
April 15, 2019	4:41 PM	737.76	738.71
April 21, 2019	8:37 PM	738.71	739.38
April 22, 2019	4:57 PM	739.38	740.14
April 23, 2019	9:01 PM	740.14	740.62
April 24, 2019	4:03 PM	740.62	741.10
April 26, 2019	3:53 PM	741.10	741.39
May 1, 2019	10:56 AM	741.39	741.10
May 2, 2019	3:00 PM	741.10	740.91
May 4, 2019	9:00 PM	740.91	740.72
May 6, 2019	8:14 AM	740.72	740.53
May 6, 2019	1:58 PM	740.53	740.05
May 6, 2019	8:20 PM	740.05	739.76
May 7, 2019	9:20 PM	739.76	739.48
May 8, 2019	11:35 AM	739.48	739.29
May 8, 2019	4:18 PM	739.29	739.00
May 8, 2019	10:01 PM	739.00	738.81
May 9, 2019	3:52 PM	738.81	738.62
May 9, 2019	9:57 PM	738.62	738.33
May 10, 2019	10:21 AM	738.33	738.14
May 10, 2019	3:52 PM	738.14	737.95
May 10, 2019	9:55 PM	737.95	737.66
May 11, 2019	12:17 PM	737.66	737.38
May 11, 2019	6:17 PM	737.38	737.19
May 11, 2019	10:01 PM	737.19	736.81
May 12, 2019	10:48 AM	736.81	736.52
May 12, 2019	2:58 PM	736.52	736.24
May 12, 2019	8:25 PM	736.24	735.77
May 13, 2019	7:15 AM	735.77	735.29
May 13, 2019	1:20 PM	735.29	734.83
May 13, 2019	5:00 PM	734.83	734.36
May 13, 2019	10:32 PM	734.36	733.89
May 14, 2019	8:17 AM	733.89	733.15
May 14, 2019	11:59 AM	733.15	732.42
May 14, 2019	3:39 PM	732.42	731.51
May 14, 2019	9:57 PM	731.51	730.18
May 15, 2019	11:15 AM	730.18	728.04

*Time at start of gate operation

Figure 1 - Recorded and Natural Levels at James Avenue 2019

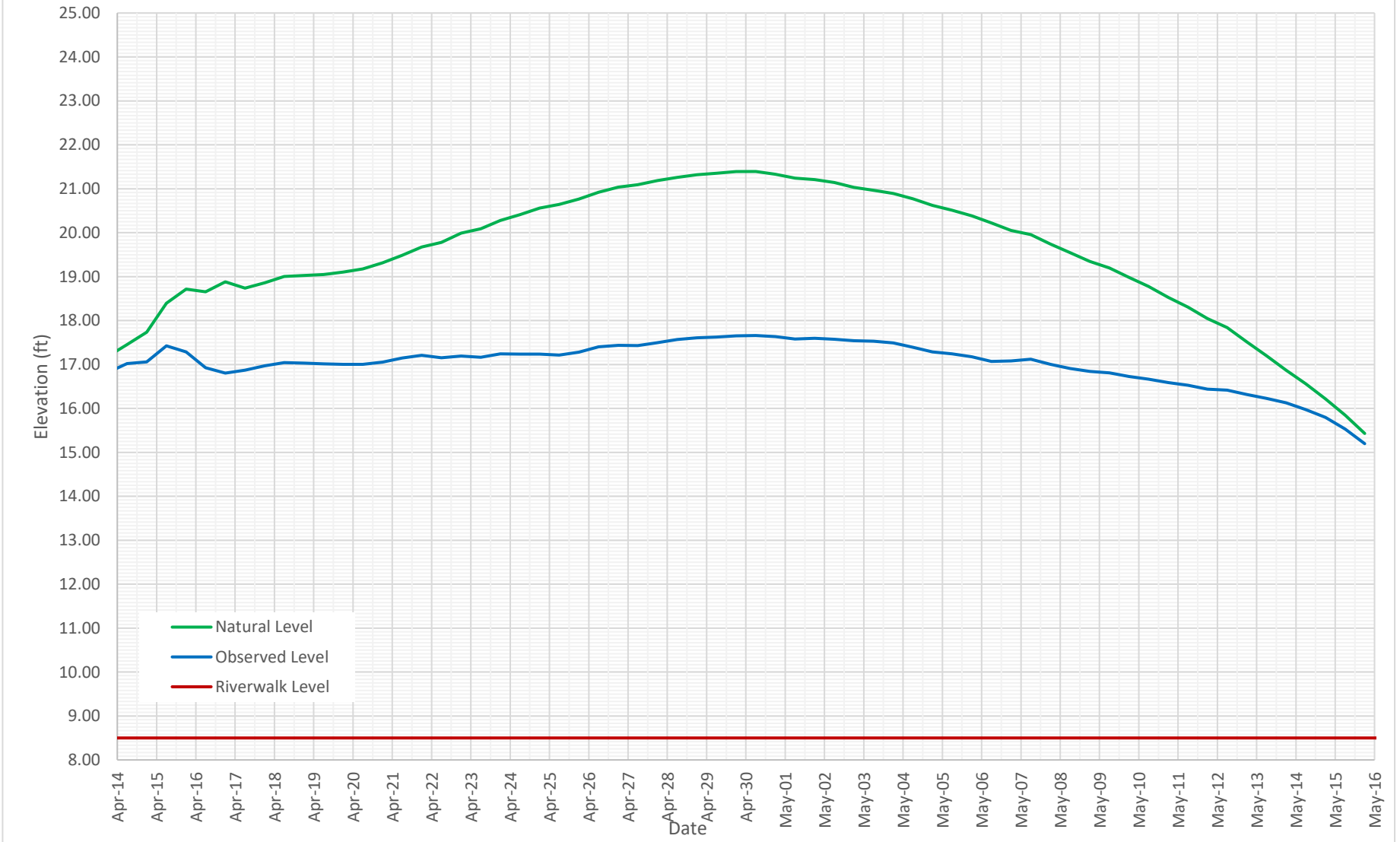
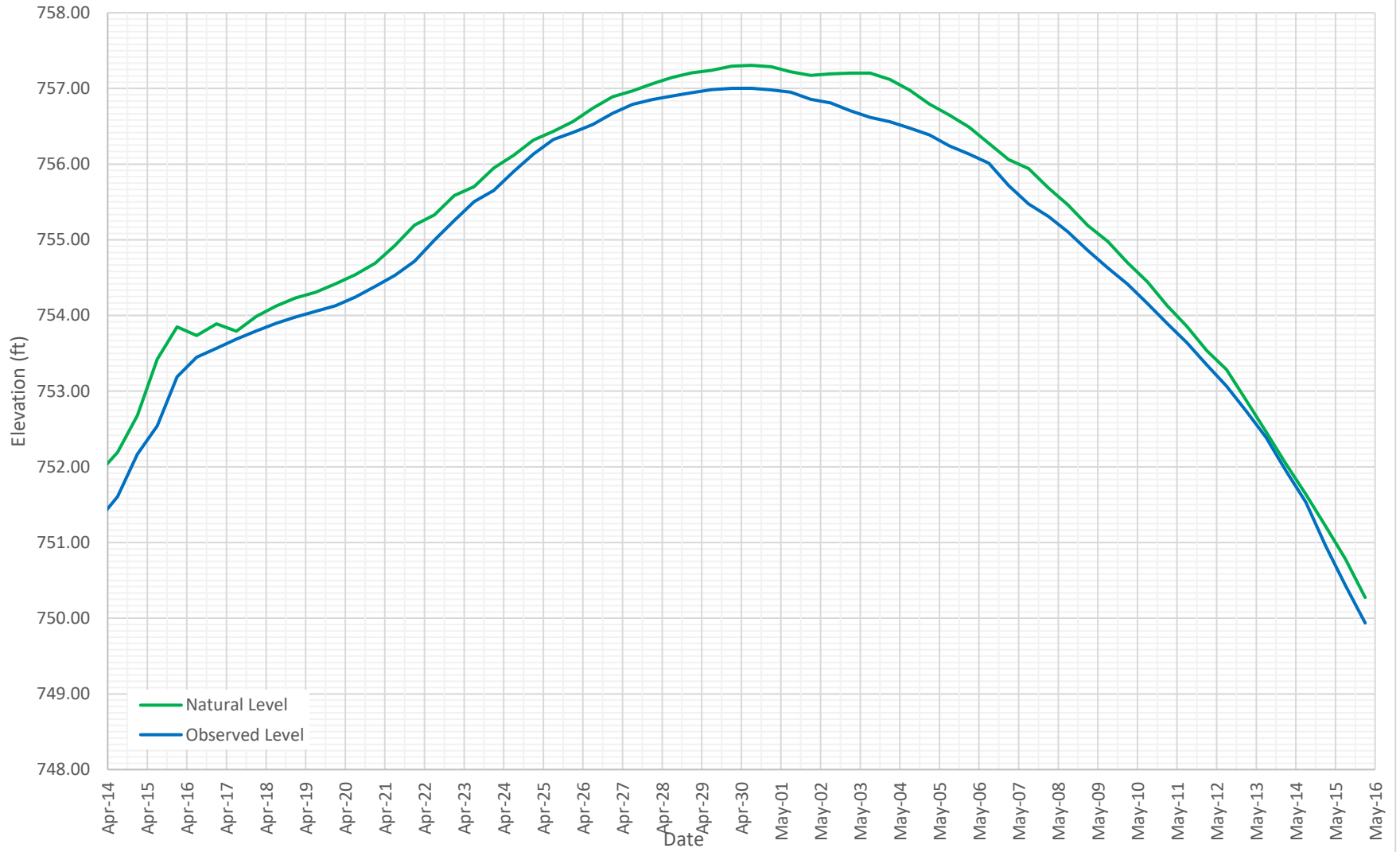


Figure 2 - Recorded and Natural Levels at Floodway Entrance 2019



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 backup;
 - (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 2019 Flows and Levels

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	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 Rec. & Est.	Natural Assiniboine River Flow into Red River	Red River Flow U/S of Floodway	Red River Floodway Flow	La Salle River Flow	Red River Flow at James Ave.	Natural Red River Flow at James Ave.	Natural Water Level on Red River at James Ave. (ft)	Recorded Water Level on Red River at James Ave. (ft)	Natural Water Level on Red River at Floodway Inlet (ft)	Recorded Water Level on Red River at Floodway Inlet (ft)	Below Natural at Floodway Inlet (ft)
Date	Recorded	Recorded	Recorded	Computed	=1+2+3-4		=5+6	Computed	Recorded	Recorded	Recorded	=1+2-4+9+10	Computed	Recorded	Computed	Recorded	Computed
April 11, 2019 AM	-256	494	5,564	0	5,802	676	6,478	31,888	0	1,911	40,038	40,277	13.99	13.92	748.94	748.99	-0.05
April 11, 2019 PM	-160	789	5,426	0	6,055	556	6,612	35,519	275	1,789	43,016	43,921	15.26	15.02	750.21	750.65	-0.44
April 12, 2019 AM	-109	521	5,456	0	5,868	503	6,370	39,017	611	1,645	46,010	47,033	16.79	16.52	751.37	751.23	0.14
April 12, 2019 PM	-7	468	5,533	0	5,995	465	6,460	40,269	718	1,420	46,970	48,149	17.08	16.77	751.75	751.22	0.53
April 13, 2019 AM	45	427	5,592	0	6,065	442	6,507	40,416	867	1,164	46,746	48,086	17.06	16.71	751.72	751.18	0.53
April 13, 2019 PM	150	254	5,587	0	5,991	411	6,402	41,147	1,012	995	47,128	48,544	17.18	16.81	751.90	751.29	0.62
April 14, 2019 AM	202	242	5,978	0	6,422	384	6,806	41,885	1,210	897	47,934	49,588	17.45	17.02	752.19	751.60	0.59
April 14, 2019 PM	306	240	5,348	0	5,894	360	6,255	43,742	2,103	725	48,073	50,722	17.74	17.06	752.68	752.17	0.51
April 15, 2019 AM	357	282	5,852	0	6,490	354	6,845	45,932	3,293	631	49,476	53,408	18.39	17.43	753.42	752.54	0.88
April 15, 2019 PM	459	405	5,599	0	6,462	331	6,793	47,386	4,932	538	48,921	54,717	18.71	17.29	753.85	753.19	0.66
April 16, 2019 AM	507	626	5,548	0	6,682	310	6,992	46,990	5,833	496	47,510	54,477	18.66	16.93	753.73	753.45	0.29
April 16, 2019 PM	605	1,556	5,229	0	7,390	298	7,688	47,240	6,245	472	46,995	55,400	18.88	16.81	753.89	753.57	0.32
April 17, 2019 AM	652	344	5,271	0	6,267	298	6,564	47,357	6,503	467	46,890	54,388	18.74	16.87	753.79	753.69	0.10
April 17, 2019 PM	746	110	5,233	0	6,090	299	6,388	48,007	6,752	491	47,278	54,886	18.86	16.97	753.99	753.79	0.19
April 18, 2019 AM	792	169	5,000	0	5,961	299	6,260	48,452	6,967	524	47,308	55,236	19.00	17.04	754.12	753.90	0.23
April 18, 2019 PM	883	43	4,582	0	5,508	253	5,762	49,029	7,134	477	47,207	55,267	19.03	17.03	754.23	753.98	0.25
April 19, 2019 AM	928	0	4,256	0	5,185	203	5,388	49,478	7,290	396	47,044	55,262	19.05	17.02	754.31	754.05	0.25
April 19, 2019 PM	1,018	0	3,892	0	4,910	176	5,086	50,018	7,451	321	46,955	55,425	19.10	17.01	754.42	754.13	0.29
April 20, 2019 AM	1,063	0	3,673	0	4,736	174	4,909	50,515	7,739	264	46,887	55,688	19.17	17.00	754.54	754.24	0.30
April 20, 2019 PM	1,151	0	3,704	0	4,855	173	5,028	50,990	8,052	217	47,032	56,234	19.31	17.05	754.69	754.38	0.31
April 21, 2019 AM	1,194	0	3,629	0	4,823	166	4,988	51,772	8,389	181	47,359	56,941	19.49	17.15	754.92	754.53	0.40
April 21, 2019 PM	1,279	0	3,406	0	4,685	155	4,840	52,703	8,876	156	47,544	57,699	19.68	17.21	755.19	754.72	0.48
April 22, 2019 AM	1,319	0	3,308	0	4,627	144	4,771	53,180	9,497	134	47,268	58,085	19.78	17.15	755.33	755.00	0.33
April 22, 2019 PM	1,399	0	3,357	0	4,756	132	4,888	53,952	10,201	114	47,354	58,955	19.99	17.19	755.59	755.26	0.33
April 23, 2019 AM	1,435	0	3,337	0	4,772	121	4,893	54,330	10,678	97	47,206	59,319	20.09	17.17	755.70	755.50	0.20
April 23, 2019 PM	1,508	0	3,282	0	4,790	99	4,889	55,127	11,141	83	47,451	60,099	20.28	17.24	755.95	755.65	0.29
April 24, 2019 AM	1,539	0	3,212	0	4,751	80	4,831	55,743	11,742	72	47,366	60,646	20.41	17.24	756.12	755.90	0.22
April 24, 2019 PM	1,601	0	3,064	0	4,665	68	4,734	56,482	12,369	65	47,310	61,281	20.56	17.24	756.32	756.13	0.19
April 25, 2019 AM	1,627	0	2,941	0	4,568	66	4,633	56,913	12,822	62	47,160	61,608	20.65	17.21	756.43	756.32	0.11
April 25, 2019 PM	1,678	0	2,994	0	4,672	64	4,736	57,328	13,066	59	47,379	62,123	20.77	17.28	756.56	756.42	0.14
April 26, 2019 AM	1,698	0	3,054	0	4,752	63	4,815	57,911	13,288	56	47,796	62,782	20.92	17.40	756.74	756.52	0.22
April 26, 2019 PM	1,737	0	2,949	0	4,686	58	4,744	58,461	13,656	55	47,867	63,260	21.04	17.44	756.89	756.67	0.22
April 27, 2019 AM	1,750	0	2,816	0	4,567	53	4,620	58,777	13,901	51	47,796	63,447	21.09	17.43	756.97	756.79	0.18
April 27, 2019 PM	1,777	0	2,879	0	4,656	51	4,707	59,072	14,047	51	48,005	63,829	21.18	17.50	757.06	756.85	0.21
April 28, 2019 AM	1,783	0	2,902	0	4,686	50	4,736	59,343	14,119	47	48,224	64,126	21.26	17.57	757.14	756.90	0.24
April 28, 2019 PM	1,796	0	2,912	0	4,708	49	4,757	59,553	14,221	46	48,338	64,356	21.32	17.61	757.21	756.95	0.26
April 29, 2019 AM	1,796	0	2,869	0	4,665	48	4,713	59,688	14,302	43	48,345	64,444	21.35	17.62	757.24	756.98	0.26
April 29, 2019 PM	1,796	0	2,837	0	4,633	44	4,677	59,884	14,372	39	48,432	64,600	21.39	17.65	757.29	757.00	0.29

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Date	Assiniboine River							Red River									
	Shellmouth Flow Reduction (Routed to Headingley)	Portage Diversion Flow (Routed to Headingley)	Actual Assiniboine River Flow at Headingley	Natural Breakouts from River	Natural Assiniboine River low at Headingley	Sturgeon Cr. Flow Plus Other Local Inflows Rec. & Est.	Natural Assiniboine River Flow into Red River	Red River Flow U/S of Floodway	Red River Floodway Flow	La Salle River Flow	Red River Flow at James Ave.	Natural Red River Flow at James Ave.	Natural Water Level on Red River At James Ave. (ft)	Recorded Water Level on Red River at James Ave. (ft)	Natural Water Level on Red River at Floodway Inlet (ft)	Recorded Water Level on Red River at Floodway Inlet (ft)	Below Natural at Floodway Inlet (ft)
	Recorded	Recorded	Recorded	Computed	=1+2+3-4		=5+6	Computed	Recorded	Recorded	Recorded	=1+2-4+9+10	Computed	Recorded	Computed	Recorded	Computed
April 30, 2019 AM	1,790	0	2,780	0	4,571	39	4,610	59,956	14,356	37	48,456	64,603	21.39	17.66	757.31	757.00	0.30
April 30, 2019 PM	1,778	0	2,626	0	4,404	37	4,441	59,960	14,283	35	48,375	64,437	21.33	17.64	757.29	756.98	0.31
May 1, 2019 AM	1,767	0	2,519	0	4,286	37	4,323	59,770	14,194	32	48,164	64,125	21.24	17.58	757.22	756.95	0.27
May 1, 2019 PM	1,745	0	2,524	0	4,269	34	4,304	59,618	13,978	30	48,229	63,952	21.21	17.60	757.17	756.86	0.31
May 2, 2019 AM	1,729	0	2,454	0	4,184	32	4,215	59,724	13,843	28	48,395	63,967	21.14	17.58	757.19	756.81	0.38
May 2, 2019 PM	1,698	0	2,456	0	4,154	51	4,206	59,765	13,564	26	48,734	63,997	21.03	17.54	757.20	756.70	0.50
May 3, 2019 AM	1,680	0	2,435	0	4,115	76	4,191	59,780	13,379	24	48,936	63,995	20.97	17.53	757.20	756.62	0.59
May 3, 2019 PM	1,642	0	2,413	0	4,055	79	4,134	59,504	13,215	26	48,807	63,664	20.90	17.49	757.12	756.56	0.56
May 4, 2019 AM	1,621	0	2,294	0	3,915	68	3,983	59,077	13,056	25	48,409	63,086	20.77	17.39	756.98	756.48	0.50
May 4, 2019 PM	1,579	0	2,245	0	3,824	60	3,884	58,481	12,786	23	48,023	62,388	20.62	17.29	756.79	756.38	0.41
May 5, 2019 AM	1,556	0	2,231	0	3,787	55	3,842	57,996	12,451	23	47,854	61,861	20.51	17.24	756.65	756.24	0.41
May 5, 2019 PM	1,510	0	2,222	0	3,733	49	3,781	57,469	12,171	22	47,592	61,272	20.39	17.17	756.49	756.13	0.35
May 6, 2019 AM	1,487	0	2,185	0	3,672	45	3,717	56,760	11,805	20	47,205	60,497	20.22	17.07	756.28	756.01	0.26
May 6, 2019 PM	1,439	0	2,142	0	3,580	38	3,619	56,079	11,020	19	47,259	59,717	20.05	17.08	756.06	755.71	0.34
May 7, 2019 AM	1,414	0	2,096	0	3,511	34	3,544	55,738	10,475	18	47,411	59,300	19.95	17.12	755.94	755.47	0.47
May 7, 2019 PM	1,365	0	1,968	0	3,334	28	3,362	54,998	10,040	18	46,971	58,377	19.74	17.00	755.69	755.31	0.38
May 8, 2019 AM	1,341	0	1,781	0	3,122	24	3,146	54,369	9,588	16	46,602	57,530	19.55	16.91	755.46	755.11	0.36
May 8, 2019 PM	1,291	0	1,822	0	3,113	18	3,131	53,500	8,993	16	46,363	56,647	19.35	16.84	755.19	754.86	0.33
May 9, 2019 AM	1,267	0	1,870	0	3,137	14	3,151	52,820	8,480	15	46,240	55,986	19.20	16.81	754.98	754.63	0.35
May 9, 2019 PM	1,218	0	1,872	0	3,090	11	3,101	51,941	7,910	14	45,929	55,056	18.98	16.73	754.70	754.42	0.28
May 10, 2019 AM	1,194	0	1,855	0	3,049	10	3,059	51,147	7,320	13	45,705	54,219	18.78	16.67	754.44	754.16	0.29
May 10, 2019 PM	1,146	0	1,868	0	3,013	8	3,021	50,162	6,649	13	45,401	53,196	18.53	16.59	754.13	753.89	0.24
May 11, 2019 AM	1,122	0	1,847	0	2,970	8	2,978	49,293	5,987	12	45,172	52,282	18.31	16.53	753.86	753.64	0.22
May 11, 2019 PM	1,076	0	1,830	0	2,906	11	2,917	48,282	5,283	12	44,851	51,210	18.05	16.44	753.54	753.35	0.19
May 12, 2019 AM	1,054	0	1,800	0	2,854	13	2,867	47,495	4,544	11	44,775	50,373	17.84	16.42	753.28	753.07	0.22
May 12, 2019 PM	1,010	0	1,756	0	2,765	10	2,776	46,301	3,643	8	44,432	49,085	17.52	16.32	752.87	752.73	0.14
May 13, 2019 AM	989	0	1,715	0	2,705	8	2,713	45,137	2,743	6	44,124	47,856	17.20	16.23	752.46	752.39	0.07
May 13, 2019 PM	948	0	1,701	0	2,649	7	2,657	43,934	1,897	6	43,752	46,597	16.87	16.13	752.04	751.95	0.09
May 14, 2019 AM	929	0	1,671	0	2,600	7	2,607	42,788	1,268	5	43,203	45,399	16.56	15.98	751.64	751.54	0.10
May 14, 2019 PM	891	0	1,615	0	2,506	7	2,513	41,593	680	2	42,539	44,109	16.22	15.79	751.21	750.96	0.26
May 15, 2019 AM	873	0	1,445	0	2,318	7	2,325	40,403	279	0	41,576	42,729	15.84	15.53	750.78	750.43	0.35
May 15, 2019 PM	839	0	1,390	0	2,228	13	2,241	38,952	8	0	40,346	41,193	15.43	15.20	750.27	749.94	0.33

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
NATURAL RED RIVER AT JAMES AVENUE FLOW (cfs)	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)