

# **RED RIVER FLOODWAY OPERATION REPORT**

## **FALL 2019**

December 31, 2019

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



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## EXECUTIVE SUMMARY

Fall conditions in the Red River basin were much wetter than normal in 2019. Heavy rains occurred throughout the Red River basin in September, with some locations receiving as much as 400% of normal precipitation for the month September. Above normal precipitation continued into the month of October with most of the Red River basin receiving over 200% normal precipitation. The near record wet conditions produced record high fall season water levels on the Red River and its tributaries. The weather event that triggered the necessity to operate the Floodway was a Colorado Low that occurred over a period of three days from October 10<sup>th</sup> -12<sup>th</sup>. This severe weather event caused 40-70 mm of snow water equivalent to fall over much of the Red River valley.

The Red River floodway was operated under Rule 4 in the fall of 2019 to manage river levels within the City of Winnipeg and reduce the risk of basement flooding due to sewer backup. Rule 4 applies any time after the spring crest from snowmelt runoff at Winnipeg, when high river levels substantially impair the capacity of Winnipeg's combined sewer system. Operation under Rule 4 can only be considered when river levels are forecasted to rise to 14 feet James Avenue Datum or higher for the next 10 days and there is risk of an intense rainfall event in Winnipeg. Both of these conditions were met leading up to the mid-October severe weather event.

In accordance with the requirements of Rule 4, a report was prepared for the Minister summarizing the forecasted river levels within the City of Winnipeg, the nature of the approaching weather event, the risks this severe weather event presented to the City's infrastructure, and the cost-benefit of operating the floodway to reduce river levels in the City. This report was presented to the Red River Floodway Operation Advisory Board for input and feedback, and operation was recommended. On October 8, the Minister accepted the recommendation to operate the floodway, and the control gates were raised on October 9, initiating flow in the floodway.

The floodway gates were operated for 29 days, ending at 8:15 a.m. on November 7, 2019. During this period, 57 discrete gate adjustments were made as required at various times, to regulate the water level within the City. After the severe weather extent had passed, the river level in the City was allowed to rise, but was maintained below 17 ft for an additional week, as additional precipitation events were forecast. The gates began to be lowered on October 20<sup>th</sup>, and James Avenue peaked on October 23<sup>rd</sup>, at 17.19 ft. The final gate operation was made on November 7<sup>th</sup>, concluding the fall 2019 operation. In this time, the floodway diverted approximately 440,500 acre-feet (543.3million m<sup>3</sup>) of water around the City of Winnipeg with a peak flow of 11,000 cfs (311.5 m<sup>3</sup>/s). The Red River Floodway has been operated in 33 of the past 50 years to reduce high water levels in the City of Winnipeg since its first year of operation in 1969. Of these 33 years it has been operated five times under Rule 4.

Operation under Rule 4 causes artificial flooding, since the activation of the floodway gates raises the water level at the inlet above the natural level. All locations along the main stem of the Red River upstream of the floodway inlet were subject to artificial flooding to some degree. The depth and duration of artificial flooding are site specific, but are more significant closer to the inlet control structure. The maximum depth of artificial flooding calculated at the artificial flood crest was 3.16 ft (0.96 m), but this occurred two days before the natural flood crest would have arrived at the inlet. The river would naturally have reached an elevation only 1.73 ft (0.53 m) lower than the observed crest. Operation of the floodway gates also caused river levels to rise faster than they would naturally have risen. Flood hydrographs and inundation maps have been appended to this report.

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## 1.0 INTRODUCTION

In October 2019 the Red River Floodway was operated outside of the spring flooding period, under Rule 4 of the Red River Floodway Control Structure Rules of Operation (Appendix A), to reduce sewer backup in Winnipeg. The following report details this operation during the extreme weather event of October 2019, and includes the required information specified in sections 3(1) and 3(2) of The Red River Floodway Regulation (R32 – R.M. 208/2009) .

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 (m<sup>3</sup>/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 defined in the Red River Floodway act as “the scientifically demonstrable water level that would be expected in the Red River at a given time during spring flooding in the absence of the floodway, the Assiniboine River Diversion, the Assiniboine River dykes, the Shellmouth Dam, the primary dykes in the City of Winnipeg, and urban development in the area protected by the floodway since its design was finalized”.

The recorded water level flow data shown in this report is provided by Water Survey of Canada and is considered provisional. An amended version of this report will be issued once the provisional data has been finalized by Water Survey of Canada.

## 2.0 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 Control Structure Rules of Operation (Appendix A). Non-spring emergency operation to reduce sewer backup in Winnipeg is governed by Rule 4. Under Rule 4, the Department:

- Must not operate if river levels for the next ten days are forecast to be under 14 feet James Avenue Pumping Station Datum (JAPSD)
- Must not operate to raise river levels immediately upstream of the control structure to an elevation higher than 760 feet, and
- Must not operate to achieve a river level of less than 9 feet James Avenue.
- Must maintain a program of compensation for damages suffered by landowners arising from flooding caused by Floodway operation,

During the 2019 fall flood, 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 2019 spring flood in Appendix B, Table B-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.

### 3.0 2019 Fall Conditions

The Red River Basin experienced near record accumulated rainfall amounts in September 2019. Accumulated precipitation amounts varied from Above Normal to Extremely Above Normal, with some parts of the basin receiving in excess of 400% of normal precipitation for the month of September (Figure 1).

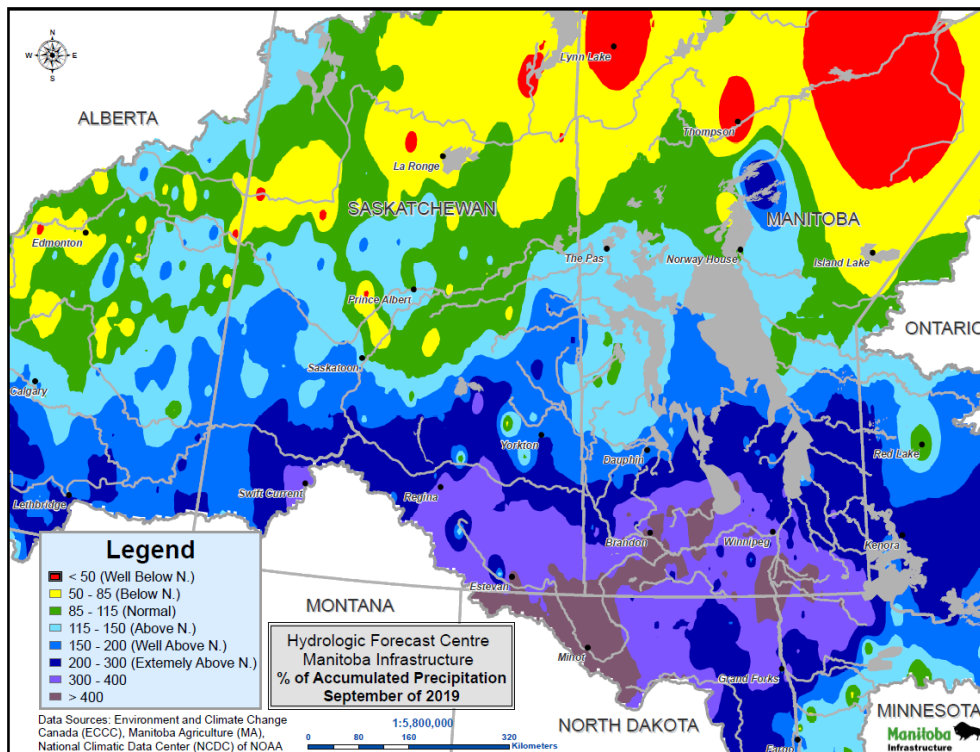


Figure 1: Percent Accumulated Precipitation September 2019

This trend continued into the month of October with regular rainfall events causing further saturation in the Red River watershed. Conditions came to a head in mid-October when a series of two low pressure systems brought accumulated totals of 40-70 mm of snow water equivalent over much of the Red River valley from October 10<sup>th</sup> – 12<sup>th</sup> (Figure 2). The majority of this

precipitation fell as heavy wet snow but some fell as rain in Eastern Manitoba, specifically in the Roseau River watershed and in the Whiteshell region. The heavy precipitation totals over September and October resulted in record flows and water levels for the Fall season in the Red River and its tributaries.

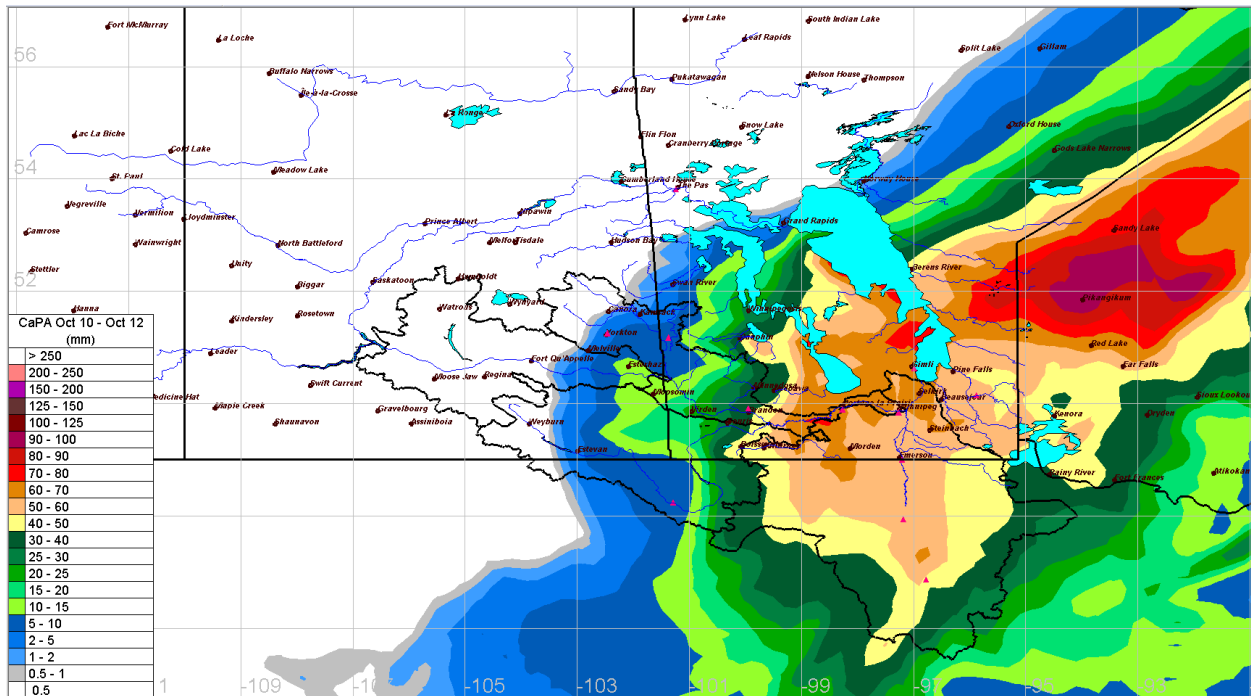


Figure 2: Accumulated Precipitation Totals October 10-12, 2019

#### 4.0 Rule 4 Risk Analysis

Floodway operation Rule 4 applies any time after the spring crest from snowmelt runoff at Winnipeg when high river levels substantially impair the capacity of Winnipeg's combined sewer system. Operation under Rule 4 can only be considered when river levels are forecasted to rise to 14 feet James Avenue Datum or higher for the next 10 days and there is risk of an intense rainfall event during that time. Once these conditions occur, the department must prepare a risk analysis report that describes:

- The basis of the river level forecasts and risk assessment.
- The risk of an intense rainfall event in Winnipeg
- The risk of basement flooding in Winnipeg.
- The benefits and costs of Floodway operation.
- Measures that may be taken to mitigate the costs and impacts of the operation under consideration.

The risk analysis report for the Fall 2019 Rule 4 Operation was prepared by Manitoba Infrastructure on October 8<sup>th</sup>. Some key excerpts from the report are as follows:

- The level at James Avenue was expected to remain above 14 ft JAPDS for more than 10 days based on forecasted Red River flows in North Dakota

- There was a high risk of two concurrent major precipitation events over the next 10 days based on the forecasts from both the Canadian and American global weather models
  - Forecasted precipitation amounts for the City of Winnipeg were in the range of 75 – 100 mm from October 10-12
- There was significant uncertainty as to whether the precipitation would fall as rain, immediately impacting the city sewer system, or as snow
- The benefit-cost ratios for the evaluated scenarios ranged from 2.9 to 7.6
- Operation of the floodway under Rule 4 was recommended to manage river levels within the City of Winnipeg and reduce the risk of basement flooding due to sewer backup

As required under the operating rules, the risk analysis report was circulated to the Red River Floodway Operation Advisory Board for input and feedback before a final recommendation was made to operate the floodway. The Operation Advisory Board is made up of representatives from the City of Winnipeg, and the rural municipalities of Ritchot, Macdonald, and Morris. The Operation Advisory Board collectively accepted the conclusions of the risk analysis report and agreed with the recommendation to operate the Floodway under Rule 4.

Subsequently the risk analysis report was submitted to the Minister of Infrastructure and the recommendation to operate the floodway under Rule 4 to reduce the risk of widespread sewer backup and basement flooding in the City of Winnipeg was approved.

## **5.0 OPERATION OF THE FLOODWAY IN THE FALL OF 2019**

### **5.1 General Observations**

Floodway operation began at 6:30 pm on October 9. Prior to operation, the water level at the inlet of the floodway channel was approximately 1.5 ft below the inlet lip. The Red River Floodway gates were operated in accordance with the requirements under Rule 4 to reduce river levels in the City of Winnipeg. Operation of the floodway dropped the level at James Avenue by approximately 2 ft in the first 2 days of operation.

The river level at James Avenue was reduced to approximately 12.14 ft (225.46 m) for the duration of the October 11-12 severe weather event. During this time, the natural water level at James Avenue would have been 14.36 ft (226.14 m); this represents a 2.22 ft (0.68 m) water level decrease due to operation of the floodway.

After the initial operation, the floodway gates were held relatively stable for the week of October 13<sup>th</sup> as the water levels in the City of Winnipeg were allowed to rise as flow on the Red River continued to increase. The floodway gates were held over this period as there was risk of another major precipitation event occurring on October 21<sup>st</sup>. Once it was clear that the risk of this event occurring had passed, the floodway gates were gradually lowered over a period of two and a half weeks from October 20<sup>th</sup> to November 7<sup>th</sup>. Based on consultation with the City of Winnipeg, the James avenue level was maintained close to 17ft JAPSD for the duration of the gate lowering process. This was done to provide the City with relief from pumping operations, and reduce sandbagging requirements. The City was required to sandbag one residence and a community center, but sandbagging requirements and pumping costs increase noticeably above 17 ft JAPSD.

The recorded peak water level at James Avenue was 17.19 ft (227.00 m) on October 23. The peak natural flow at James Avenue in Winnipeg would have occurred on the same day, and was calculated to be approximately 59,500 cfs (1684.8 m<sup>3</sup>/s).

Overall, in the fall of 2019, approximately 440,500 acre-feet (543.3million m<sup>3</sup>) of water was diverted around the City of Winnipeg by the Red River Floodway, with a peak flow of 11,000 cfs (311.5 m<sup>3</sup>/s). The peak recorded level at the floodway entrance (Water Survey Canada station 05OC026) was 757.26 ft (230.81 m) on October 20, approximately 3.16 ft (0.96 m), higher than the computed natural level of 754.10 ft (229.85 m). Table 1 lists the gate operations that occurred during the operation of the floodway in the fall of 2019. The final gate operation occurred at 8:15 a.m. on November 7.

Figure 3 shows the recorded and natural water levels for the Red River in Winnipeg at James Avenue during the period of operation. Figure 4 shows the recorded and natural water levels for the Red River upstream of the floodway entrance.

## 5.2 Public Communication in 2019 Flood

A requirement of Rule 4 operation is that the department must prepare a report describing the weather forecast and the risk assessment, including a benefit/cost analysis, for floodway operation, when water levels are forecasted to exceed and remain at greater than 14 feet JAPSD for 10 days or more. This report was distributed and discussed with the members of the Red River Floodway Operation Advisory Board on October 8<sup>th</sup> and incorporated their feedback. A follow up meeting with Advisory Board was held during operations, on October 16<sup>th</sup> to discuss impacts that river levels were having on stakeholders.

During the Fall 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. Daily flood forecasts were issued for the Red River main stem as would have been done under spring operation. A press release was issued October 8, advising the public that operation of the floodway was likely to occur within the next 24 hours. A coordination conference call was held on October 9<sup>th</sup> for Emergency Coordinators of the affected RMs.

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 October 9 at 5:30 p.m., providing notice of imminent operation of the floodway that evening. The final operation notification email was distributed at 8:30 a.m., November 7, informing stakeholders on the contact list that floodway operations were complete for the fall 2019 flood.

The Red River Floodway gate change logs and hydrographs were published to the floodway information website ([www.manitoba.ca/mit/wms/rrf/information.html](http://www.manitoba.ca/mit/wms/rrf/information.html)). The gate change logs were updated as gate changes were made. 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.

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

## 6.0 ARTIFICIAL FLOODING

Operation under Rule 4 creates artificial flooding, since the activation of the floodway gates raises the water level at the inlet above the natural level. The natural level is determined by calculating the flows that would have occurred without the benefit of the existing flood control infrastructure, including the Shellmouth Reservoir, Portage Diversion, Assiniboine River Dikes, and Red River Floodway, and using those flows to compute a level at the Floodway Inlet. During the fall 2019 operation, operation of the Shellmouth Dam was providing a negligible positive benefit to the Actual level at the floodway inlet, and the Portage Diversion was providing no benefit. The floodway, at the time that operation was initiated, was not providing a benefit, so the actual and natural levels were approximately equal. Raising the gates immediately raised the river above the natural level.

Operation of the floodway increased river levels upstream of the inlet faster than they would otherwise have risen, and increased the maximum observed water level above what would have been observed. The maximum difference between the Actual and Natural water levels at the floodway inlet occurred on October 12, when the difference was 6.82 ft (2.08 m). The maximum observed water level at the inlet was 757.26 ft (230.81 m), and occurred on October 20, at which point the Actual water level was only 3.16 ft (0.96 m) above the Natural level. The computed natural flood crest would have occurred on October 23, and was 755.53 ft (230.29 m), 1.40 ft (0.43 m) below the actual observed water level at the time. The absolute depth of artificial flooding, represented as the difference between the recorded flood peak and the natural flood peak, at the floodway inlet during this operation was 1.73 ft (0.53 m). See Figure 3 – Recorded and Natural Levels at the Floodway Entrance 2019.

Artificial flooding can be observed at all points upstream of the floodway inlet along the main stem of the Red River and on some tributaries to a degree, but is most prominent north of Letellier. Likewise, the duration of artificial flooding was for the entire period of floodway operation, however, only locations north of Morris saw significant artificial flooding periods for the duration of the operation. See Figure 4 for a summary natural and actual water levels at selected gauge locations. The depth and duration of artificial flooding is represented by the area between the natural and actual water levels and is site specific.

Inundation maps showing the extent of artificial flooding have been prepared based on the recorded water levels, and can be found in Appendix C.

Detailed hydrographs at the Floodway Inlet and gauge locations along the Red River can be found in Appendix D.

## 7.0 CONCLUSIONS

In summary:

- During the fall of 2019, the Red River Floodway was operated under Rule 4 for 29 days and reduced the flood crest in the City of Winnipeg by 2.22 ft (0.68 m) during the mid-October severe weather event.
- The operation of the Red River Floodway began at 7:00 pm on October 9, 2019, and concluded at 8:15 a.m. on November 7, 2019. During this period, 57 discrete gate adjustments were made as required.
- The operation of the floodway under Rule 4 created artificial flooding upstream of the floodway inlet. The absolute depth of artificial flooding, represented as the difference between the recorded flood peak and the natural flood peak, at the floodway inlet during this operation was 1.73 ft (0.53 m). The operation also raised the river level faster than it would otherwise have risen.
- During fall of 2019, the Red River Floodway diverted 440,500 acre-feet (543.3million m<sup>3</sup>) of water was diverted around the City of Winnipeg by the Red River Floodway, with a peak flow of 11,000 cfs (311.5 m<sup>3</sup>/s).

**Table 1 - 2019 Floodway Gate Operations**

Date	Time *	Gate Elevation	
		Start of Operation	End of Operation
October 9, 2019	7:00 PM	728.04	740.62
October 10, 2019	4:57 PM	740.62	744.50
October 11, 2019	3:04 PM	744.50	744.97
October 14, 2019	8:29 AM	744.97	745.16
October 14, 2019	7:57 PM	745.16	744.69
October 15, 2019	8:25 AM	744.69	744.41
October 20, 2019	10:47 AM	744.41	744.22
October 20, 2019	8:20 PM	744.22	744.04
October 21, 2019	8:45 AM	744.04	743.94
October 21, 2019	7:32 PM	743.94	743.75
October 22, 2019	1:48 PM	743.75	743.57
October 22, 2019	9:30 PM	743.57	743.28
October 23, 2019	8:05 PM	743.28	743.09
October 24, 2019	8:13 PM	743.09	742.90
October 25, 2019	10:34 AM	742.90	742.72
October 25, 2019	2:24 PM	742.72	742.53
October 26, 2019	9:20 AM	742.53	742.34
October 26, 2019	3:06 PM	742.34	742.15
October 27, 2019	12:11 AM	742.15	741.96
October 27, 2019	9:58 AM	741.96	741.77
October 27, 2019	1:20 PM	741.77	741.58
October 28, 2019	8:06 AM	741.58	741.39
October 29, 2019	8:35 AM	741.39	741.19
October 29, 2019	1:57 PM	741.19	740.91
October 30, 2019	11:51 AM	740.91	740.62
October 31, 2019	8:30 AM	740.62	740.43
October 31, 2019	3:18 PM	740.43	740.14
November 1, 2019	8:35 AM	740.14	739.95
November 1, 2019	3:15 PM	739.95	739.57
November 2, 2019	10:20 AM	739.57	739.19
November 2, 2019	5:06 PM	739.19	738.81
November 3, 2019	8:26 AM	738.81	738.62
November 3, 2019	3:43 PM	738.62	738.33

\*Time at start of gate operation

Date	Time *	Gate Elevation	
		Start of Operation	End of Operation
November 4, 2019	8:32 AM	738.33	737.85
November 4, 2019	3:53 PM	737.85	737.38
November 5, 2019	8:12 AM	737.38	736.81
November 5, 2019	12:06 PM	736.81	736.24
November 5, 2019	3:38 PM	736.24	735.58
November 5, 2019	10:18 PM	735.58	735.10
November 6, 2019	8:07 AM	735.10	734.17
November 6, 2019	12:34 PM	734.17	733.15
November 6, 2019	4:40 PM	733.15	731.69
November 6, 2019	9:48 PM	731.69	730.62
November 7, 2019	8:13 AM	730.62	728.04

\*Time at start of gate operation

Figure 3 - Recorded and Natural Levels at James Avenue 2019

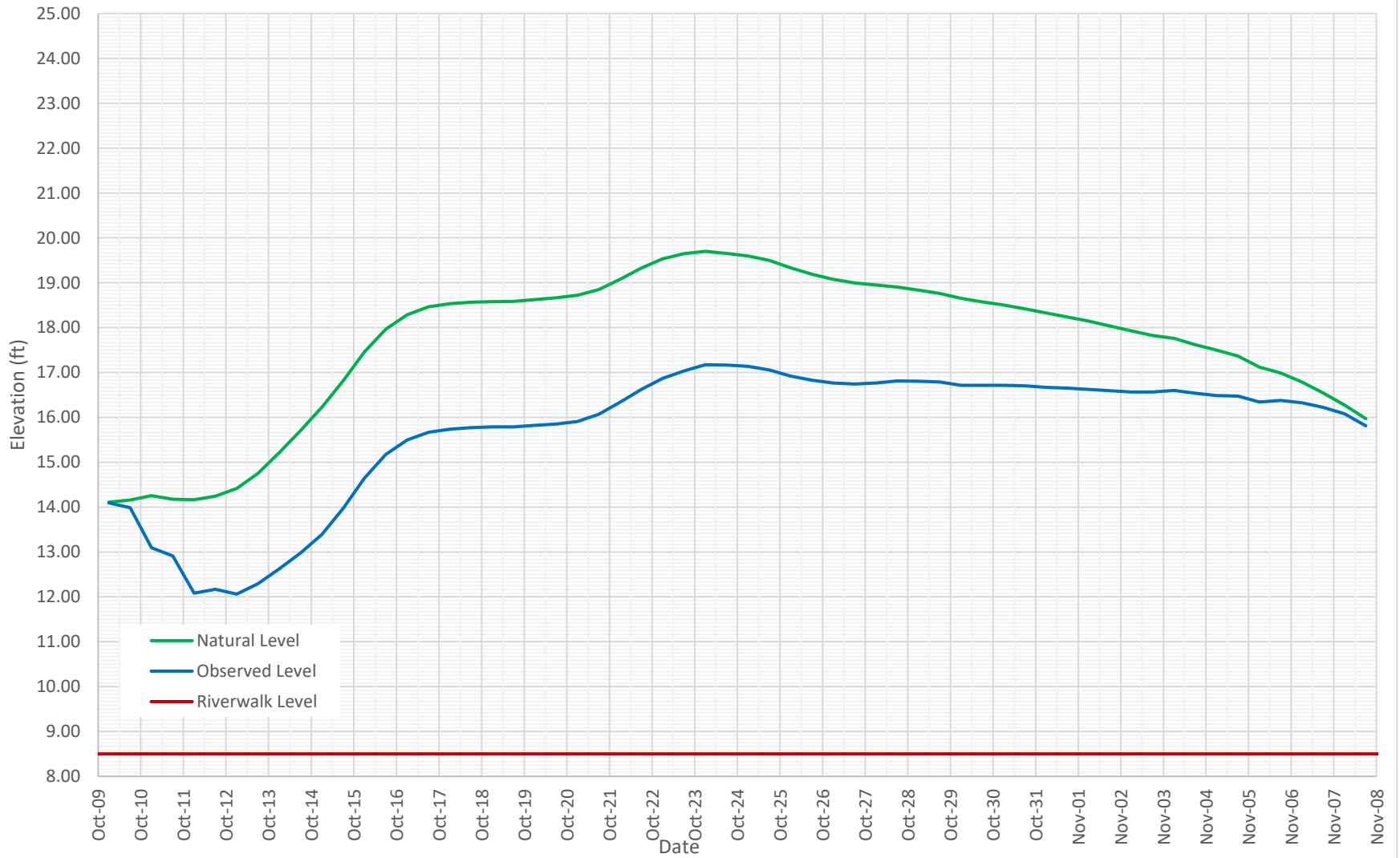


Figure 4 - Recorded and Natural Levels at Floodway Entrance 2019

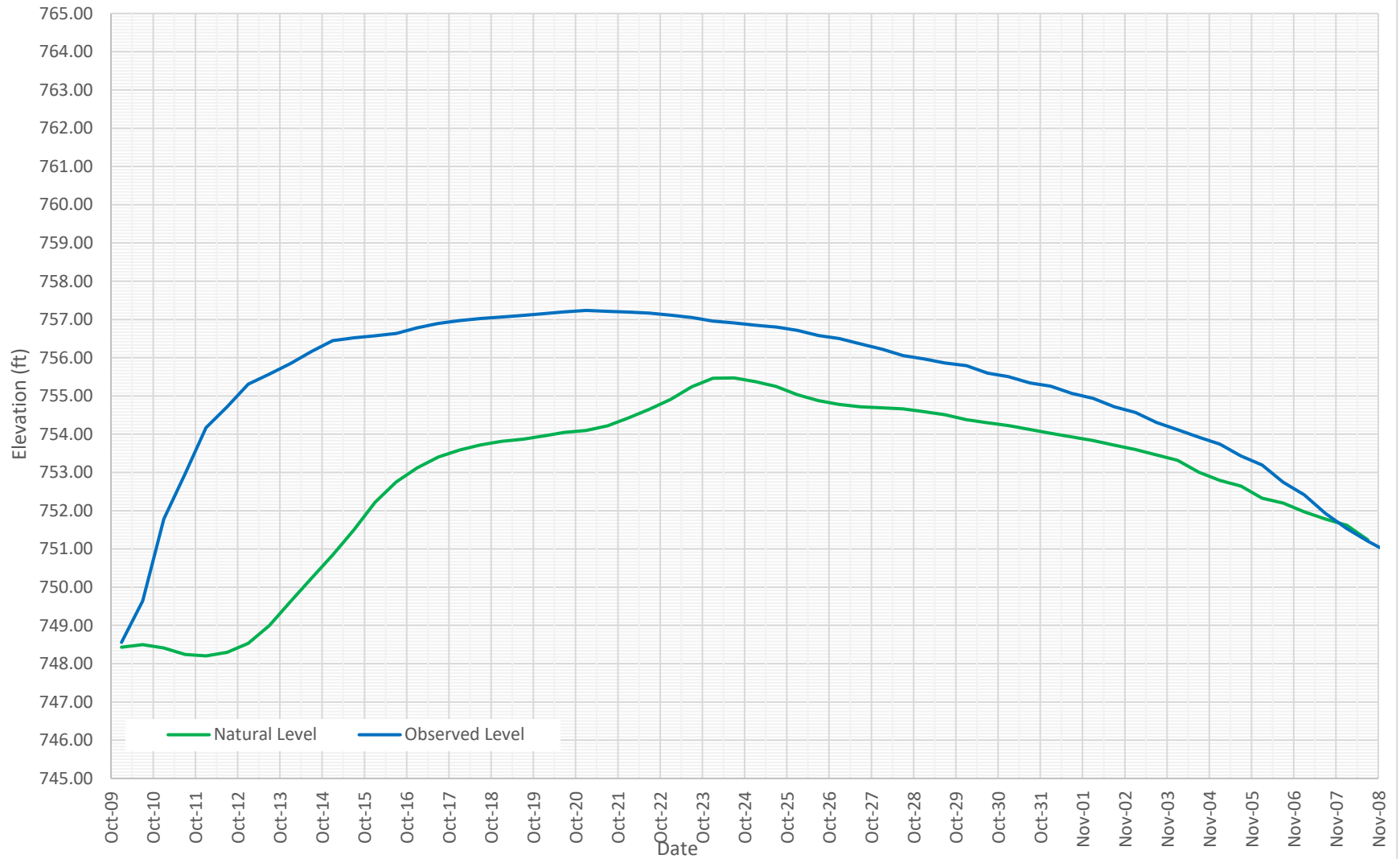
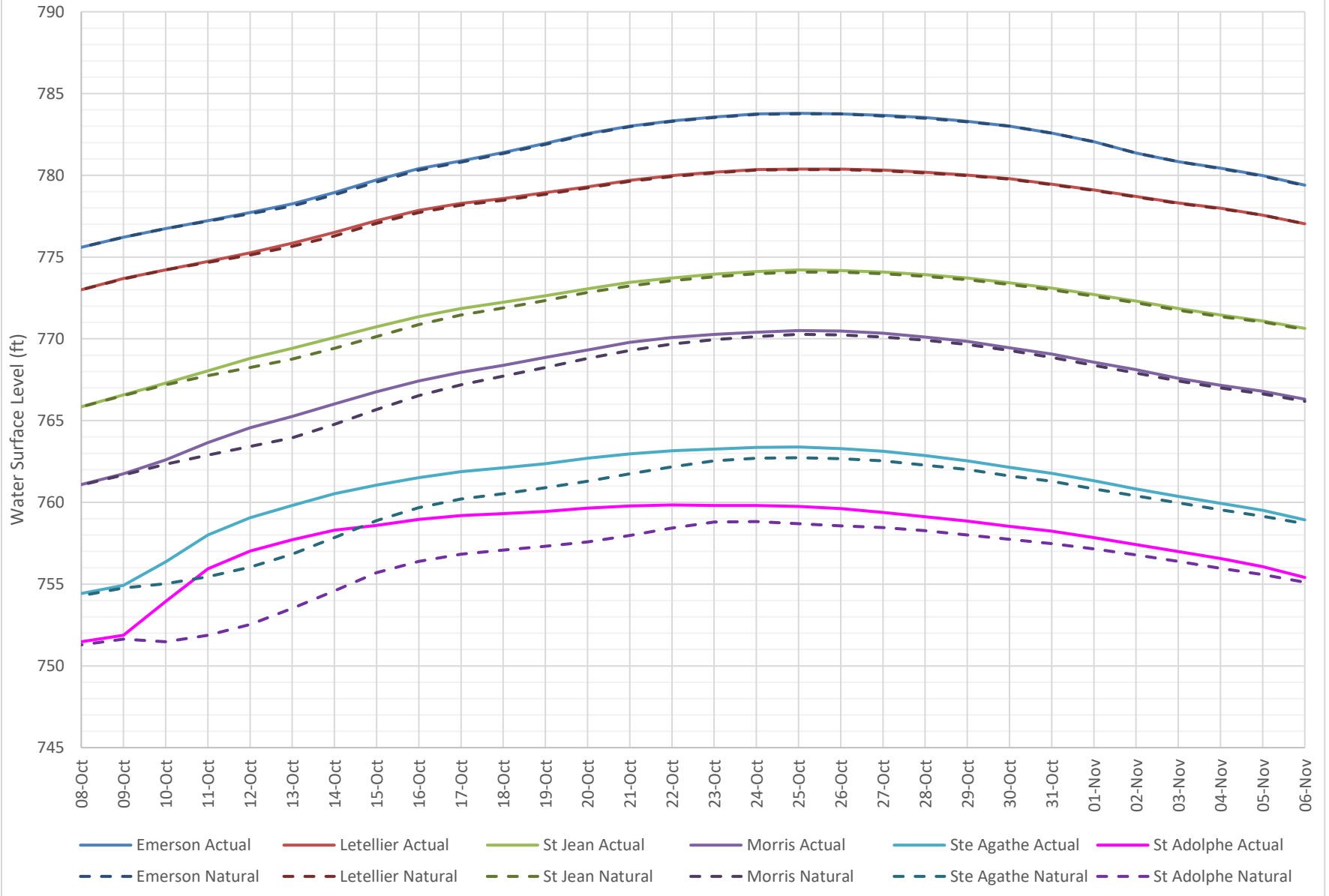


Figure 5 - Actual and Natural Water Levels at Select Red River Locations



**APPENDIX A**

**Red River Floodway Rules of Operation**



# **Rules of Operation**

## **Red River Floodway Control Structure**

### **Normal Operation:**

1. Maintain natural<sup>1</sup> 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.

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<sup>1</sup> 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 back up;
  - (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**

Column =>	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 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
October 9, 2019 AM	63	0	2,286	0	2,350	120	2,470	33,820	0	196	36,423	36,471	14.11	14.10	748.43	748.56	-0.13
October 9, 2019 PM	61	0	2,232	0	2,292	116	2,408	33,560	95	185	35,998	36,593	14.16	13.99	748.49	749.64	-1.15
October 10, 2019 AM	60	0	2,232	0	2,292	113	2,405	30,805	886	175	32,440	36,370	14.26	13.10	748.41	751.78	-3.37
October 10, 2019 PM	58	0	2,303	0	2,361	117	2,478	32,031	2,866	161	31,746	35,991	14.18	12.91	748.24	752.95	-4.71
October 11, 2019 AM	58	0	2,374	0	2,432	111	2,543	31,889	5,454	143	29,064	35,935	14.16	12.08	748.20	754.17	-5.96
October 11, 2019 PM	57	0	2,443	0	2,501	107	2,607	33,168	6,531	134	29,321	36,210	14.24	12.17	748.29	754.72	-6.42
October 12, 2019 AM	58	0	2,453	0	2,511	104	2,615	34,025	7,702	120	29,000	36,818	14.41	12.06	748.53	755.31	-6.78
October 12, 2019 PM	59	0	2,475	0	2,534	106	2,640	35,266	8,246	119	29,720	38,025	14.76	12.30	749.00	755.57	-6.57
October 13, 2019 AM	60	0	2,528	0	2,588	102	2,690	36,875	8,816	96	30,786	39,662	15.22	12.63	749.62	755.85	-6.23
October 13, 2019 PM	62	0	2,564	0	2,625	112	2,737	38,606	9,396	72	31,958	41,415	15.71	12.98	750.23	756.16	-5.93
October 14, 2019 AM	63	0	2,614	0	2,677	113	2,790	40,371	9,912	55	33,241	43,216	16.23	13.39	750.84	756.44	-5.60
October 14, 2019 PM	65	0	2,673	0	2,738	190	2,928	42,219	10,124	51	35,009	45,198	16.82	13.97	751.50	756.52	-5.03
October 15, 2019 AM	66	0	2,834	0	2,900	345	3,245	44,193	10,219	62	37,216	47,501	17.46	14.65	752.22	756.57	-4.35
October 15, 2019 PM	68	0	2,992	0	3,060	546	3,606	45,512	10,295	137	38,891	49,254	17.96	15.18	752.75	756.64	-3.89
October 16, 2019 AM	69	0	3,110	0	3,179	674	3,853	46,293	10,444	382	40,014	50,528	18.29	15.50	753.12	756.78	-3.67
October 16, 2019 PM	70	0	3,113	0	3,183	673	3,856	46,919	10,561	666	40,810	51,441	18.46	15.67	753.41	756.89	-3.49
October 17, 2019 AM	70	0	3,051	0	3,121	636	3,758	47,195	10,637	994	41,240	51,947	18.53	15.74	753.59	756.97	-3.39
October 17, 2019 PM	70	0	3,003	0	3,073	551	3,624	47,415	10,658	1,236	41,547	52,275	18.56	15.77	753.72	757.03	-3.31
October 18, 2019 AM	69	0	2,989	0	3,058	466	3,524	47,579	10,684	1,416	41,766	52,518	18.58	15.79	753.82	757.07	-3.25
October 18, 2019 PM	67	0	3,009	0	3,076	433	3,509	47,640	10,726	1,523	41,879	52,672	18.58	15.79	753.87	757.11	-3.24
October 19, 2019 AM	65	0	3,056	0	3,121	409	3,529	47,855	10,790	1,589	42,118	52,974	18.62	15.82	753.96	757.15	-3.19
October 19, 2019 PM	62	0	3,107	0	3,168	377	3,546	48,088	10,853	1,638	42,357	53,271	18.66	15.85	754.05	757.20	-3.15
October 20, 2019 AM	59	0	3,483	0	3,542	342	3,884	48,064	10,903	1,693	42,678	53,641	18.72	15.91	754.09	757.24	-3.14
October 20, 2019 PM	54	0	3,961	0	4,016	318	4,333	48,246	10,896	1,739	43,368	54,318	18.85	16.07	754.22	757.21	-3.00
October 21, 2019 AM	51	0	4,549	0	4,600	299	4,899	48,679	10,891	1,762	44,399	55,341	19.08	16.33	754.43	757.19	-2.77
October 21, 2019 PM	46	0	5,183	0	5,229	275	5,504	49,166	10,915	1,756	45,465	56,426	19.33	16.62	754.66	757.16	-2.51
October 22, 2019 AM	43	0	5,719	0	5,762	257	6,018	49,830	10,861	1,707	46,652	57,556	19.53	16.87	754.91	757.11	-2.20
October 22, 2019 PM	37	0	5,960	0	5,997	240	6,237	50,853	10,792	1,618	47,879	58,708	19.65	17.03	755.24	757.05	-1.81
October 23, 2019 AM	34	0	5,900	0	5,934	225	6,160	51,713	10,529	1,491	48,801	59,364	19.70	17.17	755.46	756.96	-1.49
October 23, 2019 PM	29	0	5,723	0	5,751	212	5,963	51,961	10,392	1,340	48,843	59,263	19.66	17.16	755.47	756.91	-1.44
October 24, 2019 AM	26	0	5,468	0	5,494	198	5,692	51,912	10,217	1,183	48,544	58,787	19.60	17.14	755.37	756.85	-1.47
October 24, 2019 PM	21	0	5,197	0	5,218	168	5,386	51,785	10,096	1,027	48,081	58,198	19.50	17.06	755.25	756.80	-1.55
October 25, 2019 AM	19	0	4,937	0	4,956	137	5,093	51,373	9,896	881	47,431	57,347	19.33	16.92	755.03	756.71	-1.68
October 25, 2019 PM	15	0	4,685	0	4,700	125	4,826	51,126	9,611	757	47,082	56,708	19.19	16.83	754.88	756.58	-1.70
October 26, 2019 AM	14	0	4,431	0	4,445	120	4,565	51,015	9,389	650	46,827	56,230	19.08	16.76	754.78	756.50	-1.72
October 26, 2019 PM	11	0	4,208	0	4,218	115	4,333	50,996	9,137	562	46,744	55,892	19.00	16.74	754.72	756.36	-1.64
October 27, 2019 AM	10	0	4,018	0	4,028	111	4,139	51,062	8,841	494	46,843	55,694	18.95	16.77	754.69	756.22	-1.53
October 27, 2019 PM	8	0	3,869	0	3,876	107	3,984	51,081	8,469	437	47,025	55,501	18.91	16.81	754.66	756.06	-1.39

Column =>	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	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)
Date	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
October 28, 2019 AM	7	0	3,758	0	3,765	104	3,869	50,952	8,201	380	46,993	55,201	18.84	16.80	754.59	755.97	-1.38
October 28, 2019 PM	7	0	3,678	0	3,685	97	3,782	50,761	7,941	337	46,932	54,880	18.76	16.79	754.51	755.86	-1.36
October 29, 2019 AM	7	0	3,598	0	3,605	89	3,694	50,431	7,771	306	46,653	54,431	18.65	16.71	754.38	755.79	-1.41
October 29, 2019 PM	8	0	3,521	0	3,529	85	3,614	50,220	7,437	280	46,669	54,113	18.57	16.72	754.30	755.60	-1.30
October 30, 2019 AM	9	0	3,466	0	3,475	72	3,547	50,028	7,156	255	46,664	53,829	18.50	16.72	754.22	755.50	-1.28
October 30, 2019 PM	11	0	3,423	0	3,434	71	3,505	49,745	6,853	229	46,615	53,479	18.42	16.70	754.12	755.34	-1.22
October 31, 2019 AM	13	0	3,360	0	3,373	61	3,434	49,475	6,621	205	46,481	53,114	18.33	16.67	754.02	755.26	-1.23
October 31, 2019 PM	16	0	3,237	0	3,253	65	3,319	49,235	6,291	178	46,424	52,731	18.23	16.65	753.93	755.07	-1.14
November 1, 2019 AM	18	0	3,098	0	3,117	60	3,176	49,028	6,023	150	46,313	52,354	18.14	16.62	753.84	754.94	-1.10
November 1, 2019 PM	22	0	3,034	0	3,056	57	3,113	48,665	5,673	143	46,225	51,920	18.04	16.60	753.72	754.72	-1.00
November 2, 2019 AM	24	0	2,906	0	2,930	50	2,980	48,356	5,334	128	46,105	51,464	17.92	16.56	753.60	754.57	-0.96
November 2, 2019 PM	27	0	2,957	0	2,984	51	3,035	47,898	4,904	118	46,120	51,052	17.82	16.57	753.46	754.30	-0.84
November 3, 2019 AM	29	0	2,898	0	2,927	47	2,974	47,455	4,506	108	46,002	50,536	17.76	16.60	753.31	754.12	-0.80
November 3, 2019 PM	32	0	2,784	0	2,816	47	2,862	46,570	4,178	98	45,321	49,531	17.62	16.53	753.01	753.92	-0.92
November 4, 2019 AM	33	0	2,870	0	2,903	46	2,949	45,922	3,877	88	45,049	48,959	17.50	16.49	752.79	753.74	-0.95
November 4, 2019 PM	35	0	2,756	0	2,791	42	2,833	45,548	3,424	80	45,003	48,462	17.37	16.47	752.64	753.43	-0.79
November 5, 2019 AM	35	0	2,711	0	2,746	39	2,785	44,647	2,951	76	44,522	47,508	17.12	16.34	752.33	753.19	-0.87
November 5, 2019 PM	37	0	2,521	0	2,558	37	2,596	44,349	2,317	70	44,661	47,015	16.99	16.38	752.20	752.75	-0.55
November 6, 2019 AM	37	0	2,344	0	2,381	34	2,414	43,768	1,722	61	44,485	46,244	16.79	16.33	751.97	752.41	-0.44
November 6, 2019 PM	38	0	1,766	0	1,804	31	1,834	43,413	1,144	56	44,121	45,303	16.54	16.23	751.78	751.93	-0.15
November 7, 2019 AM	38	0	1,006	0	1,044	28	1,072	43,190	690	51	43,585	44,312	16.28	16.08	751.62	751.53	0.08
November 7, 2019 PM	38	0	1,014	0	1,052	25	1,076	42,070	553	48	42,604	43,194.86	15.97	15.81	751.23	751.20	0.03



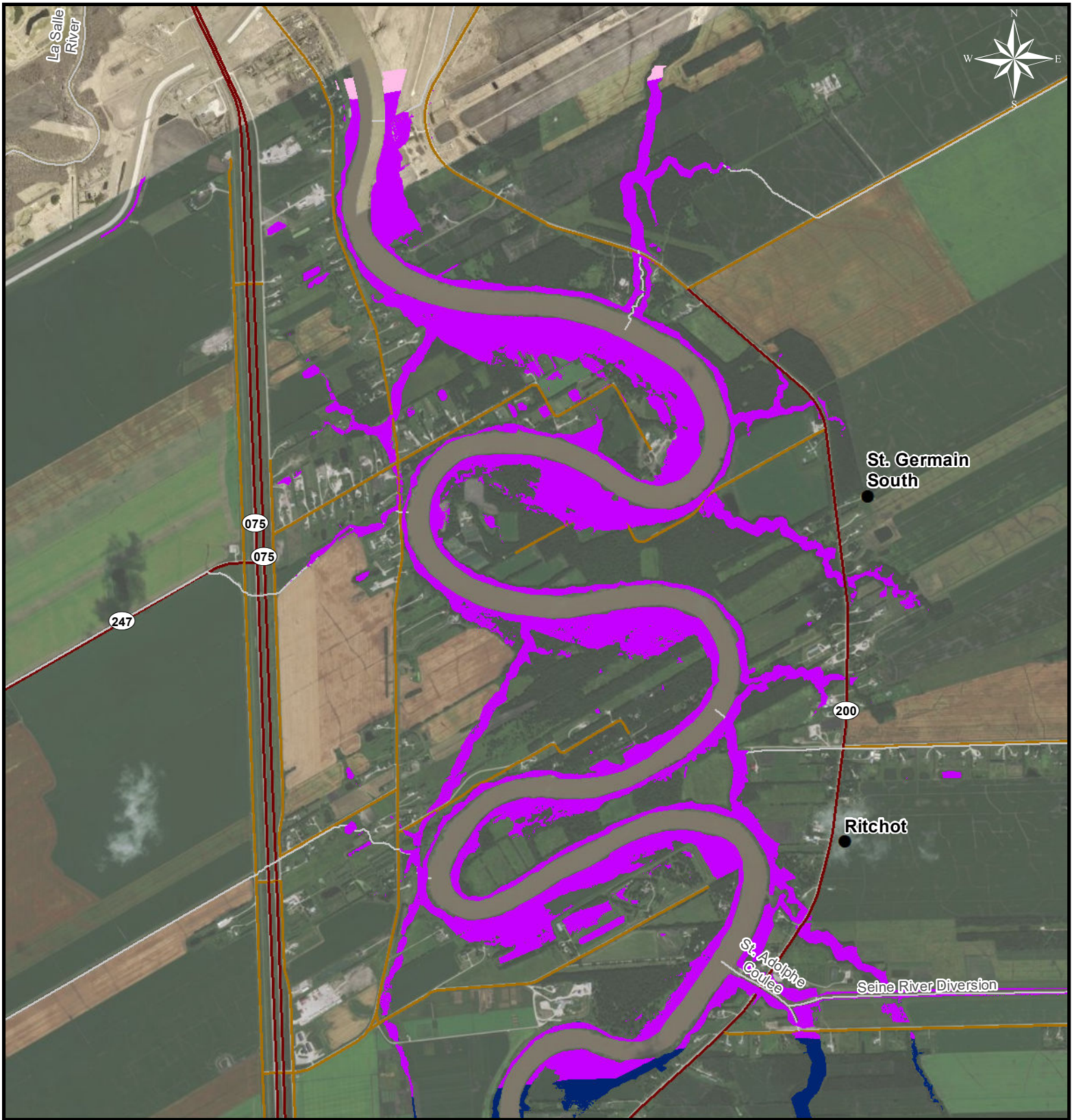
**Table B-2 - Red River Floodway Inlet Natural Water Level Rating Table**

		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	

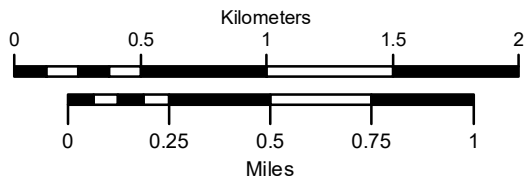
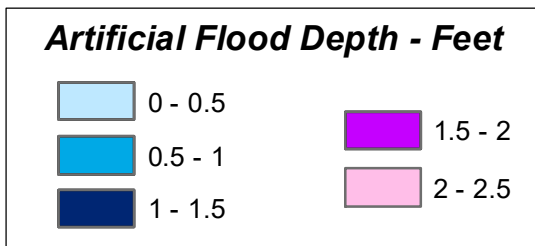
Note: Open water conditions under steady state (no ice)

## **APPENDIX C**

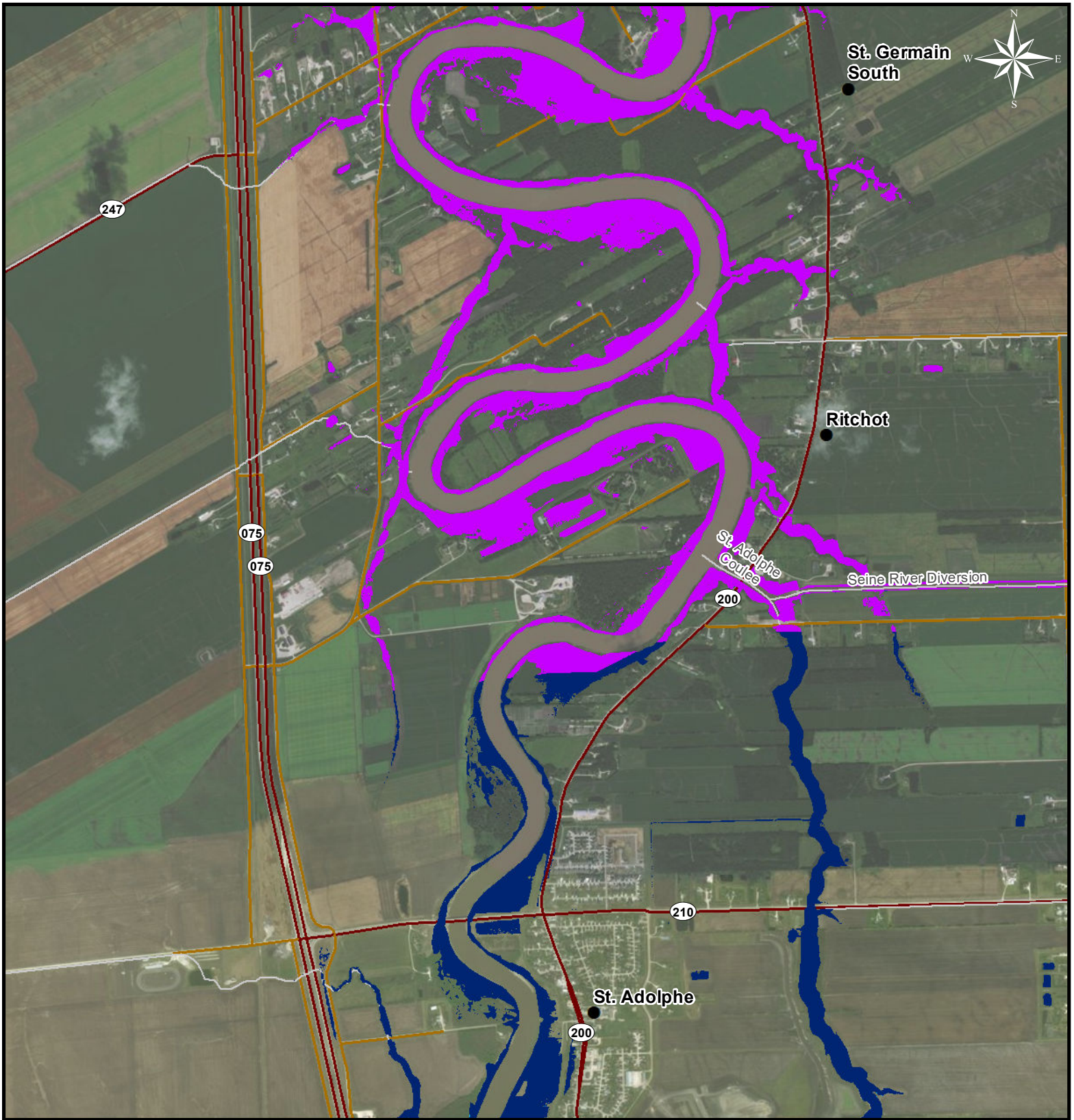
### Inundation Maps



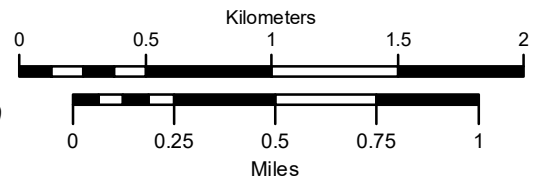
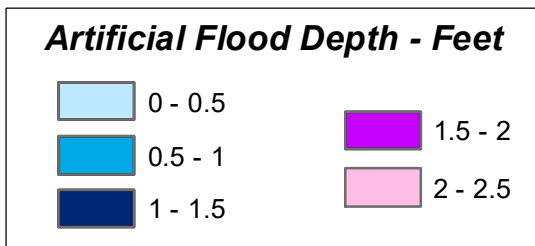
**Red River Floodway - Fall 2019 Operation**  
**Maximum Extent and Depth of Artificial Flooding - Map 1**  
*Artificial Flooding occurred between October 9 and November 6, 2019*



Meta Data:  
 Lidar: Aeroscan International  
 Base Layers: GeoManitoba  
 Base Map: ESRI Canada



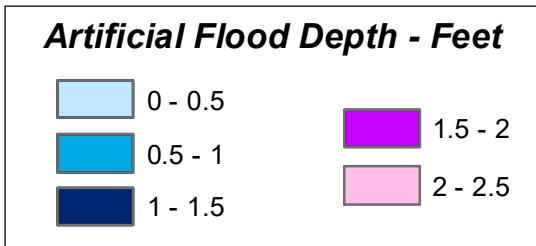
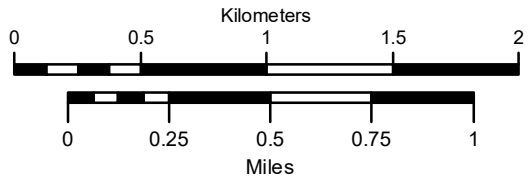
**Red River Floodway - Fall 2019 Operation**  
**Maximum Extent and Depth of Artificial Flooding - Map 2**  
*Artificial Flooding occurred between October 9 and November 6, 2019*



Meta Data:  
 Lidar: Aeroscan International  
 Base Layers: GeoManitoba  
 Base Map: ESRI Canada



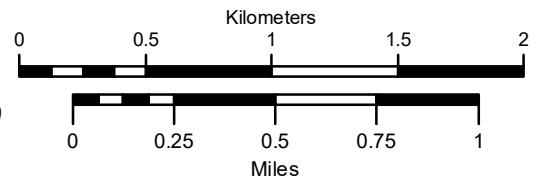
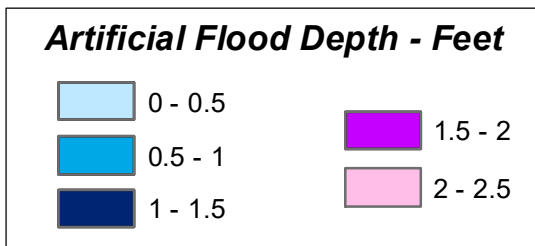
**Red River Floodway - Fall 2019 Operation**  
**Maximum Extent and Depth of Artificial Flooding - Map 3**  
*Artificial Flooding occurred between October 9 and November 6, 2019*



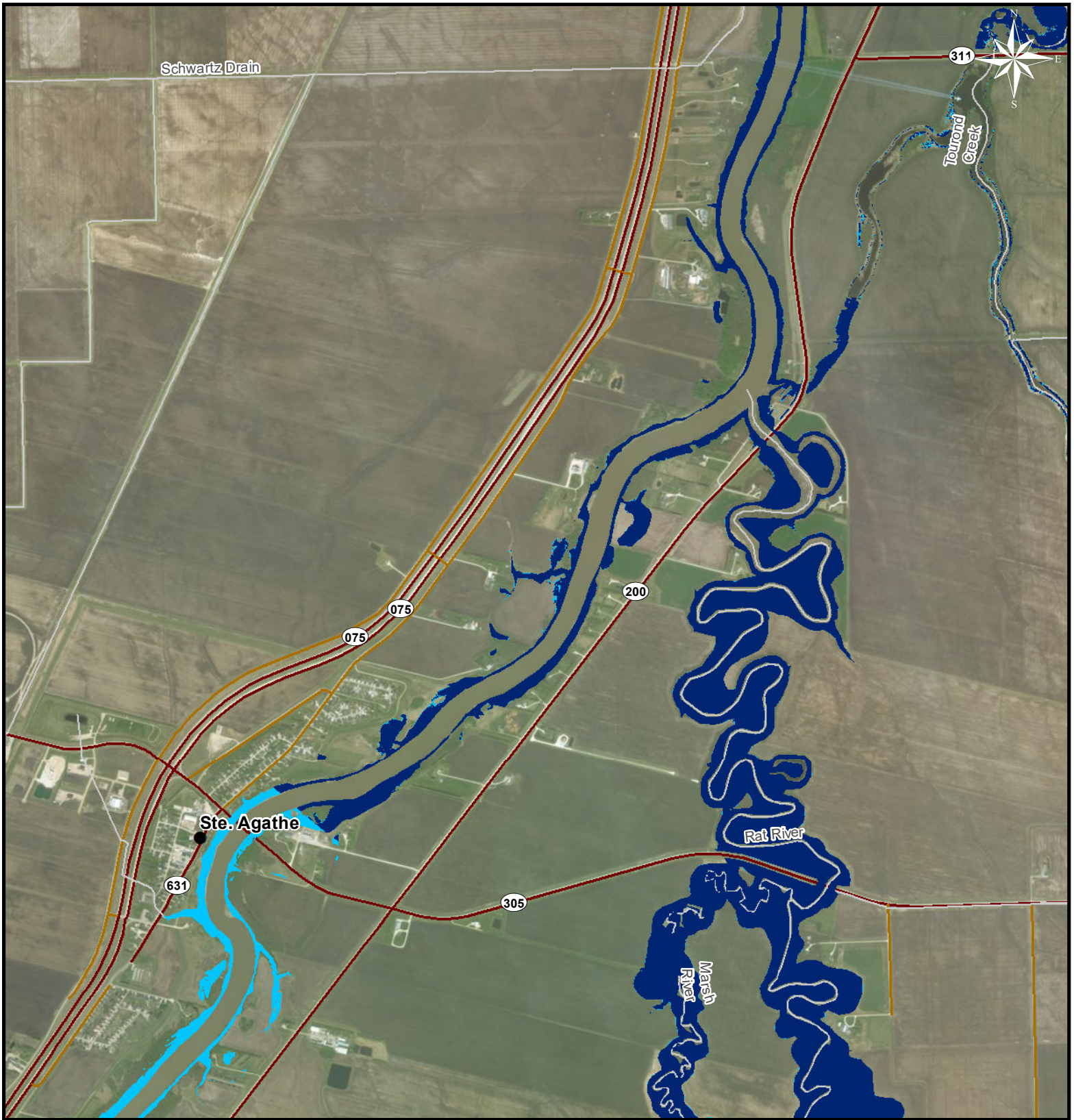
Meta Data:  
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 Base Layers: GeoManitoba  
 Base Map: ESRI Canada



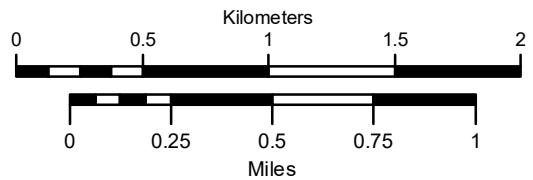
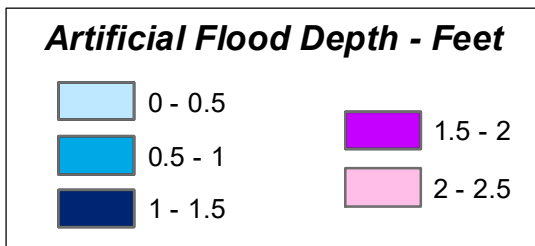
**Red River Floodway - Fall 2019 Operation**  
**Maximum Extent and Depth of Artificial Flooding - Map 4**  
*Artificial Flooding occurred between October 9 and November 6, 2019*



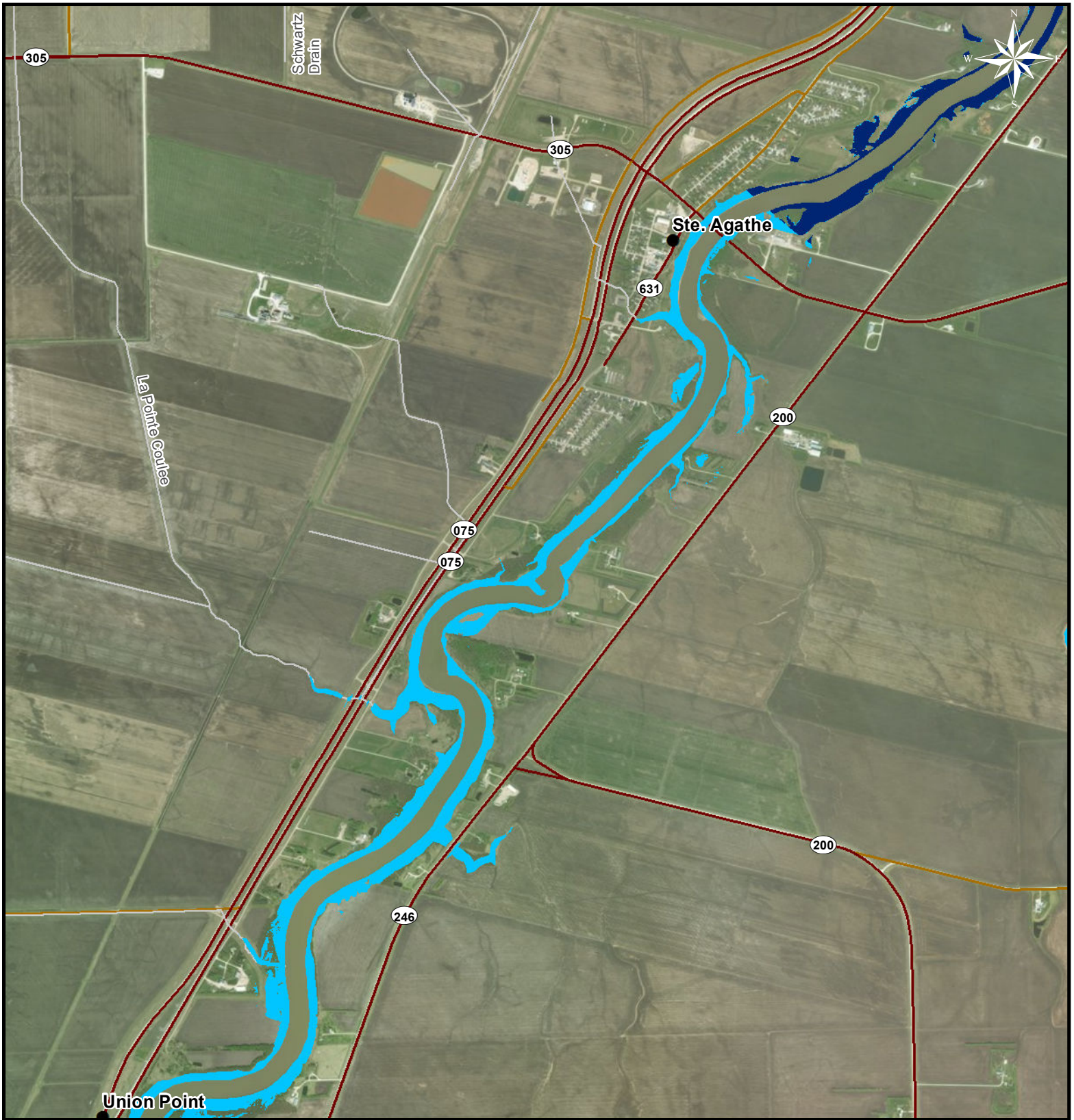
Meta Data:  
 Lidar: Aeroscan International  
 Base Layers: GeoManitoba  
 Base Map: ESRI Canada



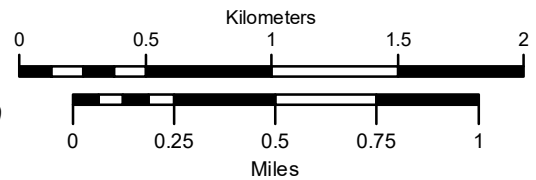
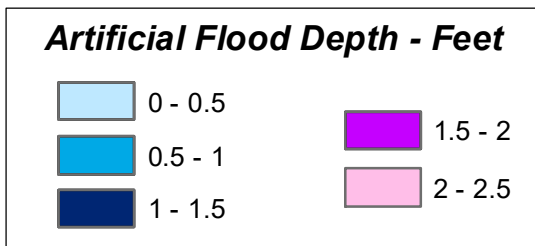
**Red River Floodway - Fall 2019 Operation**  
**Maximum Extent and Depth of Artificial Flooding - Map 5**  
*Artificial Flooding occurred between October 9 and November 6, 2019*



Meta Data:  
 Lidar: Aeroscan International  
 Base Layers: GeoManitoba  
 Base Map: ESRI Canada



**Red River Floodway - Fall 2019 Operation**  
**Maximum Extent and Depth of Artificial Flooding - Map 6**  
*Artificial Flooding occurred between October 9 and November 6, 2019*

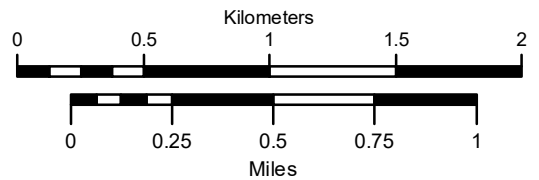
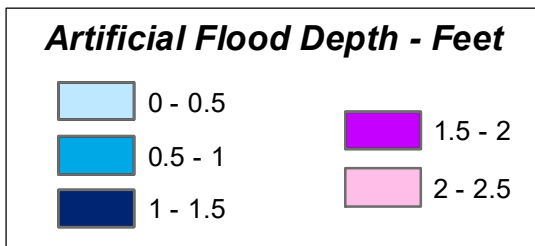


Meta Data:  
 Lidar: Aeroscan International  
 Base Layers: GeoManitoba  
 Base Map: ESRI Canada

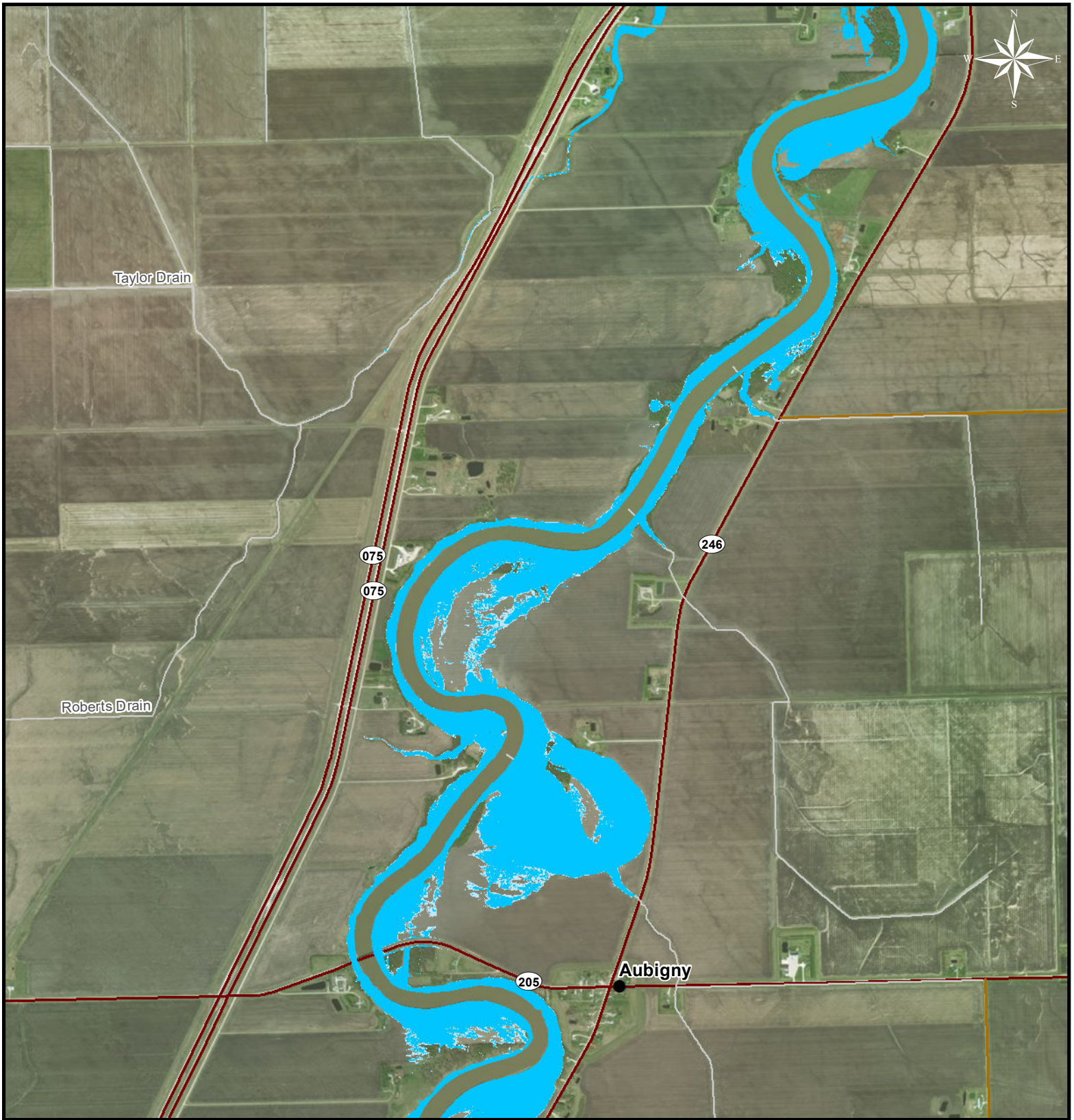




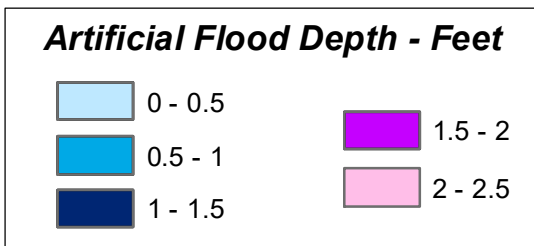
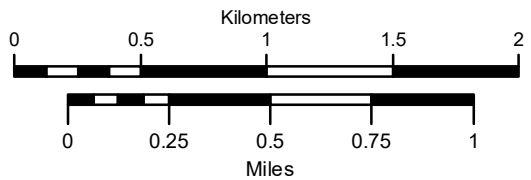
**Red River Floodway - Fall 2019 Operation**  
**Maximum Extent and Depth of Artificial Flooding - Map 7**  
*Artificial Flooding occurred between October 9 and November 6, 2019*



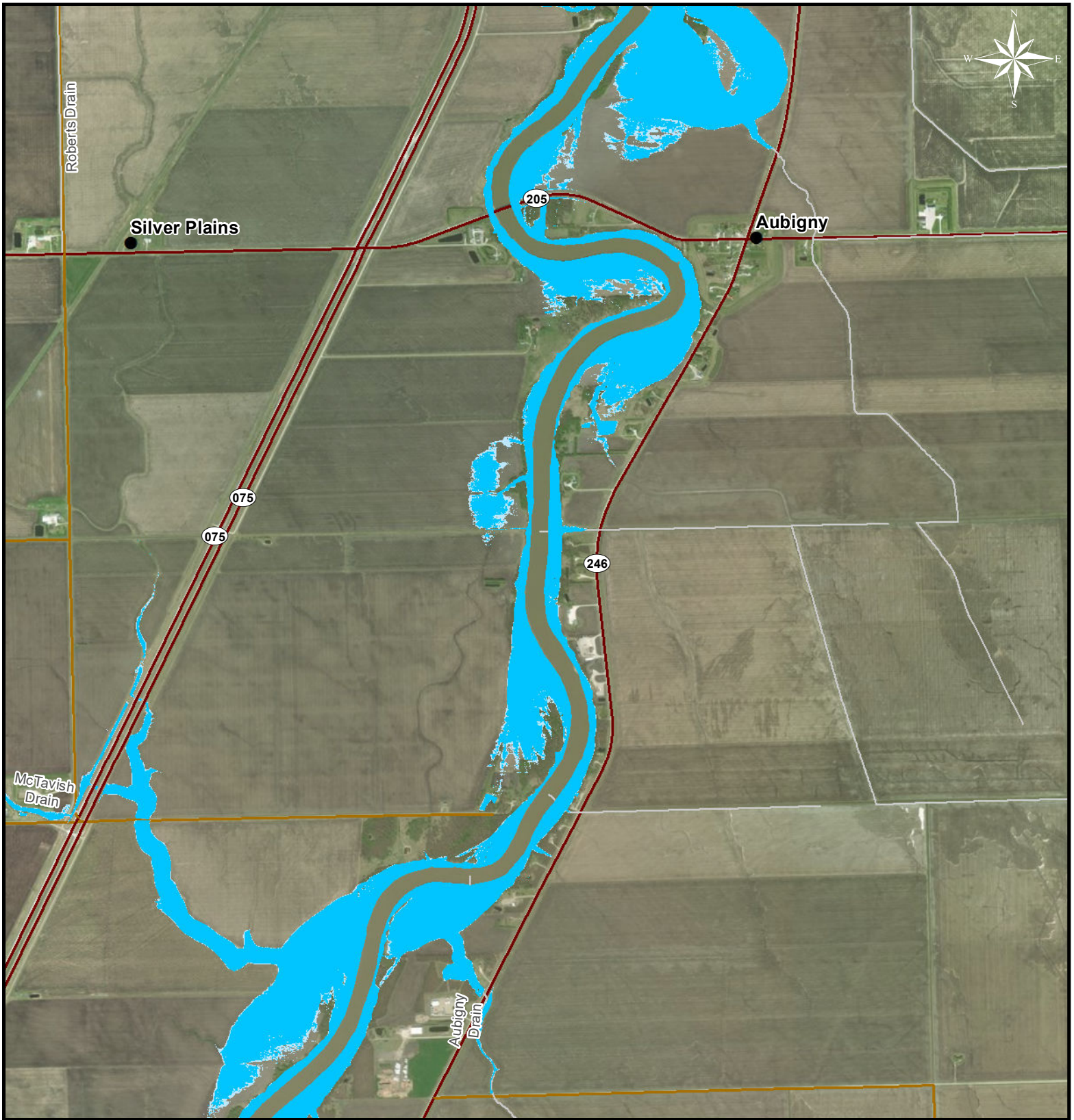
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 Base Layers: GeoManitoba  
 Base Map: ESRI Canada



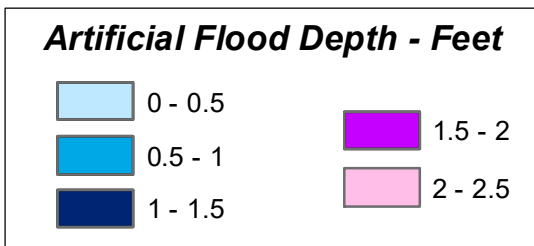
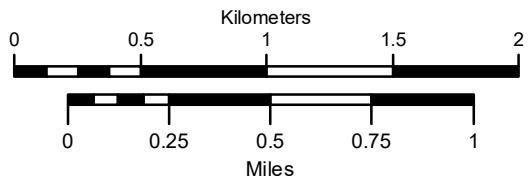
**Red River Floodway - Fall 2019 Operation**  
**Maximum Extent and Depth of Artificial Flooding - Map 8**  
*Artificial Flooding occurred between October 9 and November 6, 2019*



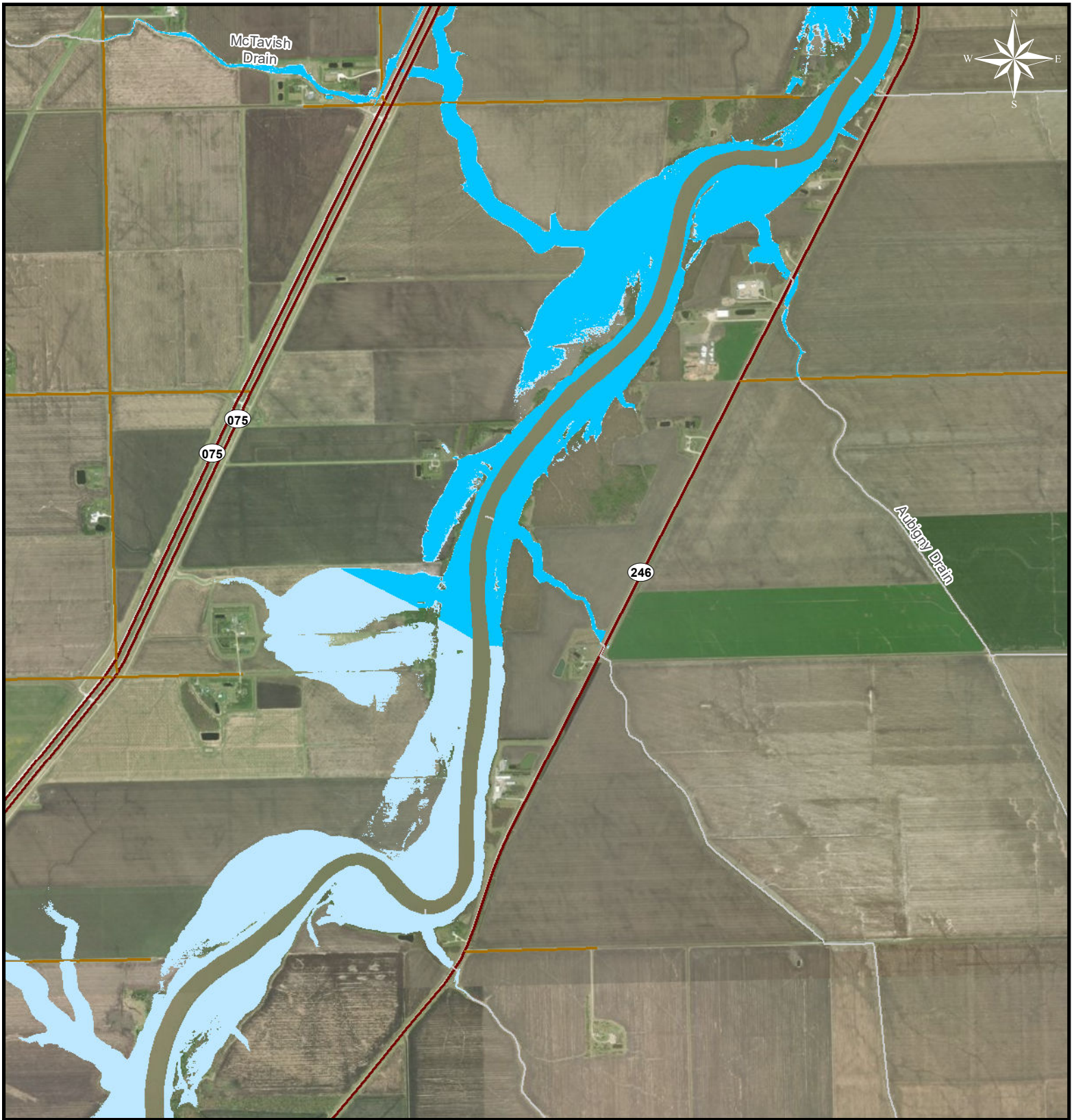
Meta Data:  
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 Base Layers: GeoManitoba  
 Base Map: ESRI Canada



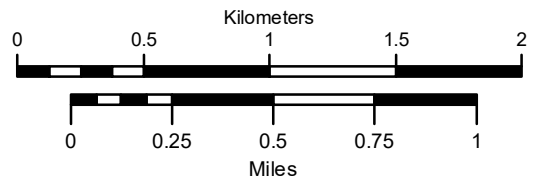
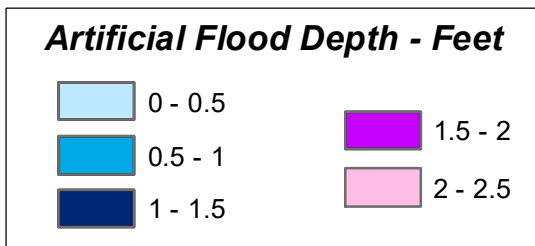
**Red River Floodway - Fall 2019 Operation**  
**Maximum Extent and Depth of Artificial Flooding - Map 9**  
*Artificial Flooding occurred between October 9 and November 6, 2019*



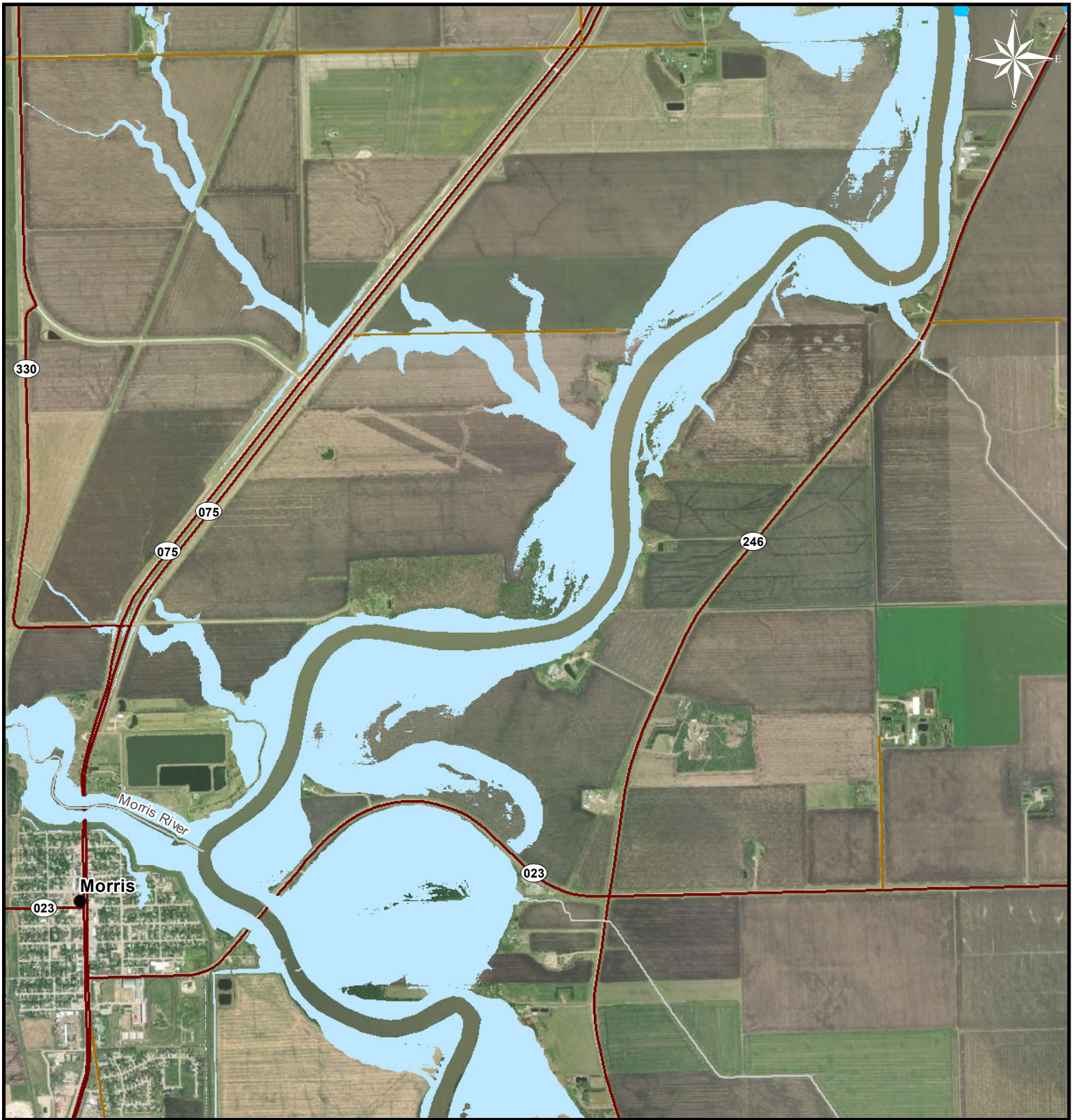
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 Base Layers: GeoManitoba  
 Base Map: ESRI Canada



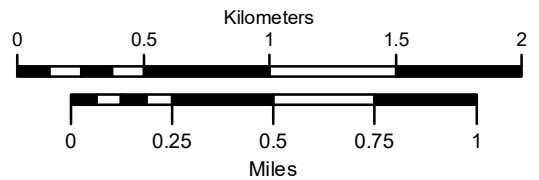
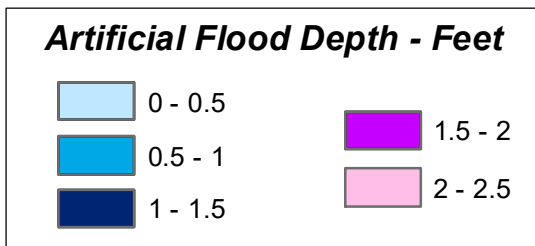
**Red River Floodway - Fall 2019 Operation**  
**Maximum Extent and Depth of Artificial Flooding - Map 10**  
*Artificial Flooding occurred between October 9 and November 6, 2019*



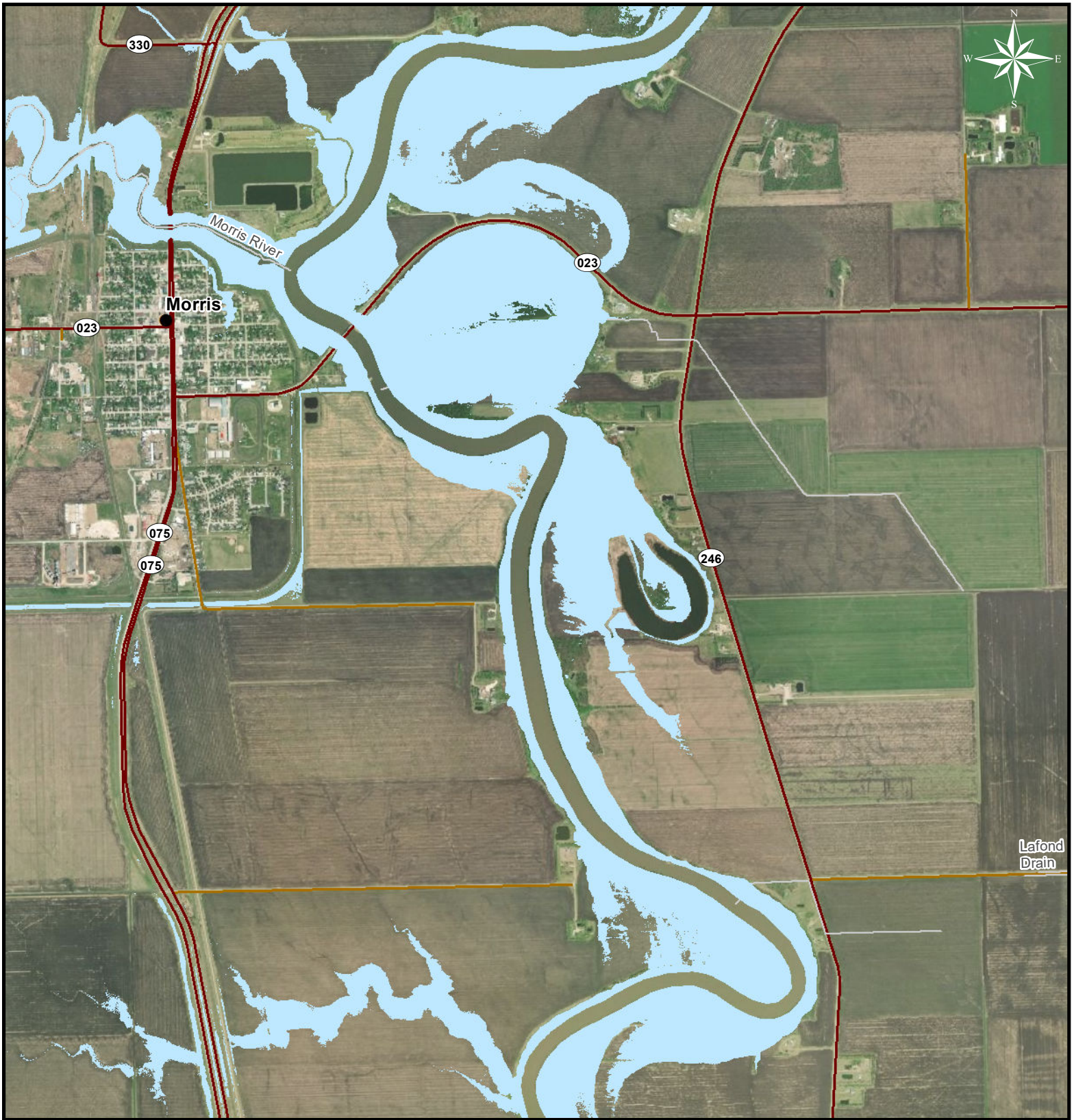
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 Base Layers: GeoManitoba  
 Base Map: ESRI Canada



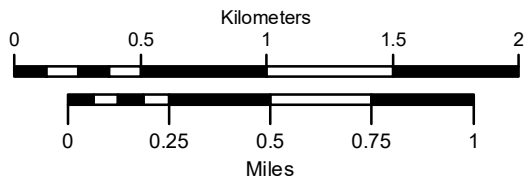
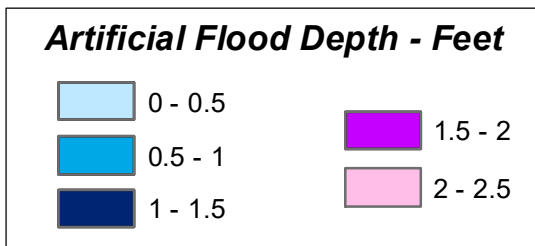
**Red River Floodway - Fall 2019 Operation**  
**Maximum Extent and Depth of Artificial Flooding - Map 11**  
*Artificial Flooding occurred between October 9 and November 6, 2019*



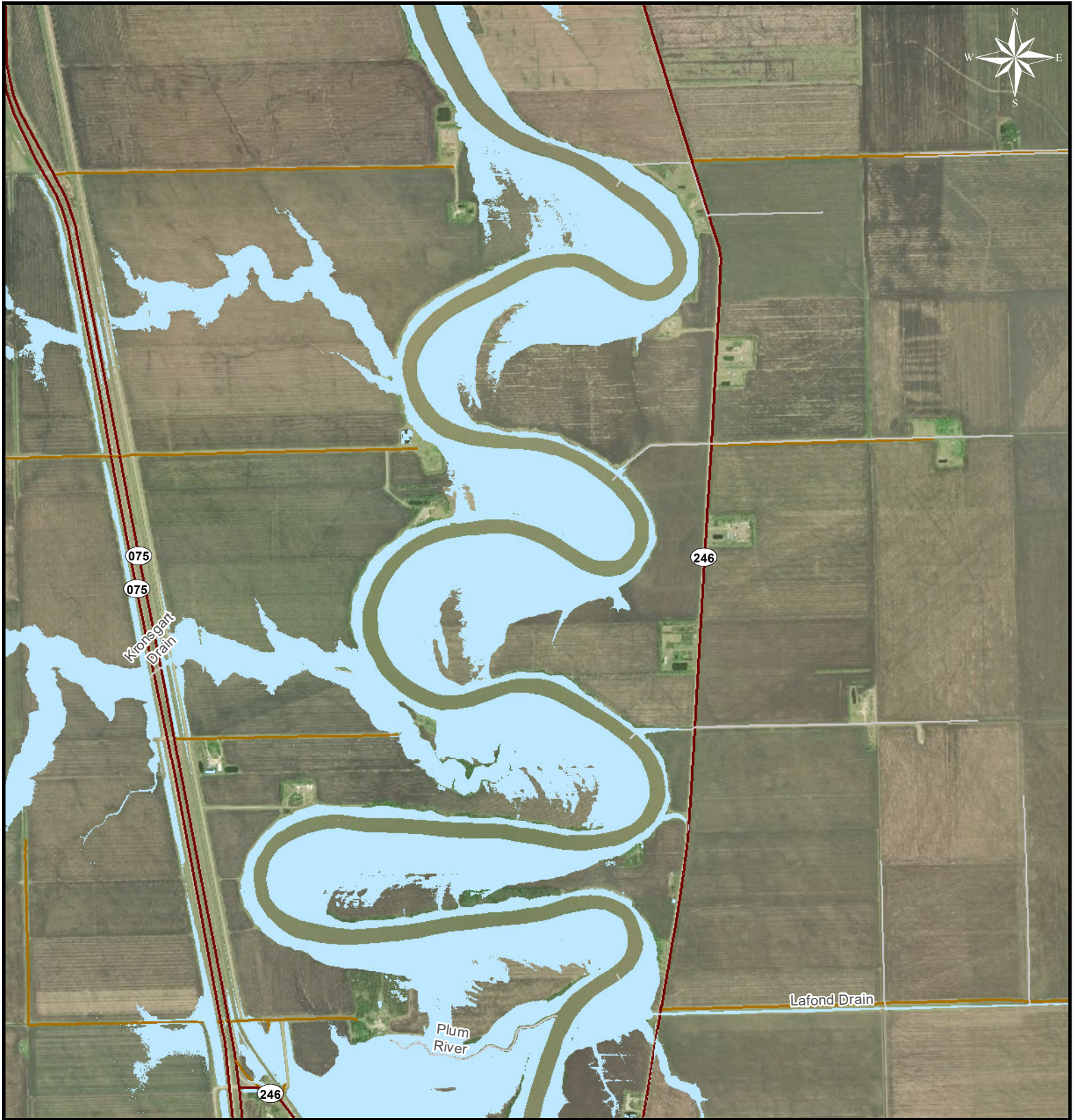
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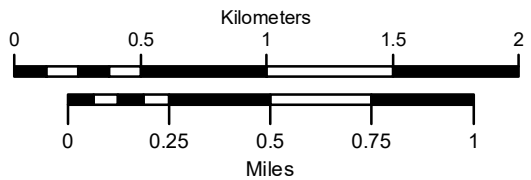
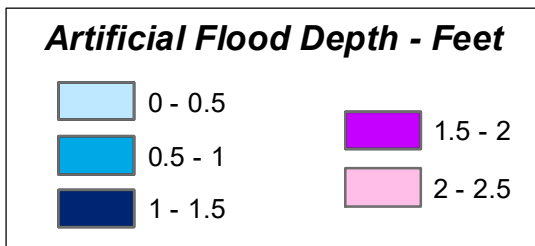
**Red River Floodway - Fall 2019 Operation**  
**Maximum Extent and Depth of Artificial Flooding - Map 12**  
*Artificial Flooding occurred between October 9 and November 6, 2019*



Meta Data:  
 Lidar: Aeroscan International  
 Base Layers: GeoManitoba  
 Base Map: ESRI Canada



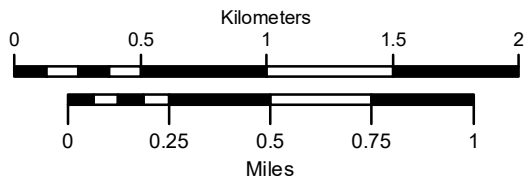
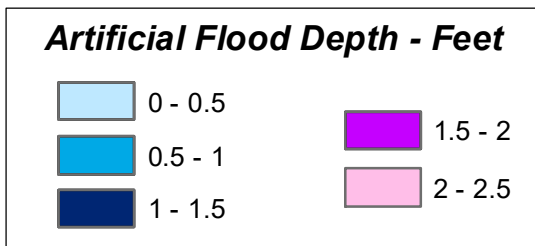
**Red River Floodway - Fall 2019 Operation**  
**Maximum Extent and Depth of Artificial Flooding - Map 13**  
*Artificial Flooding occurred between October 9 and November 6, 2019*



Meta Data:  
 Lidar: Aeroscan International  
 Base Layers: GeoManitoba  
 Base Map: ESRI Canada



**Red River Floodway - Fall 2019 Operation**  
**Maximum Extent and Depth of Artificial Flooding - Map 14**  
*Artificial Flooding occurred between October 9 and November 6, 2019*

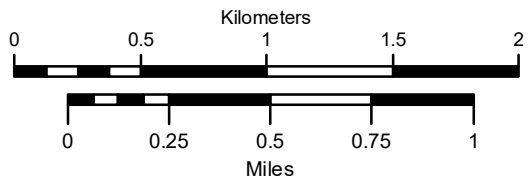
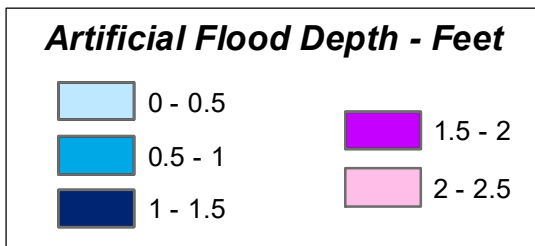


Meta Data:  
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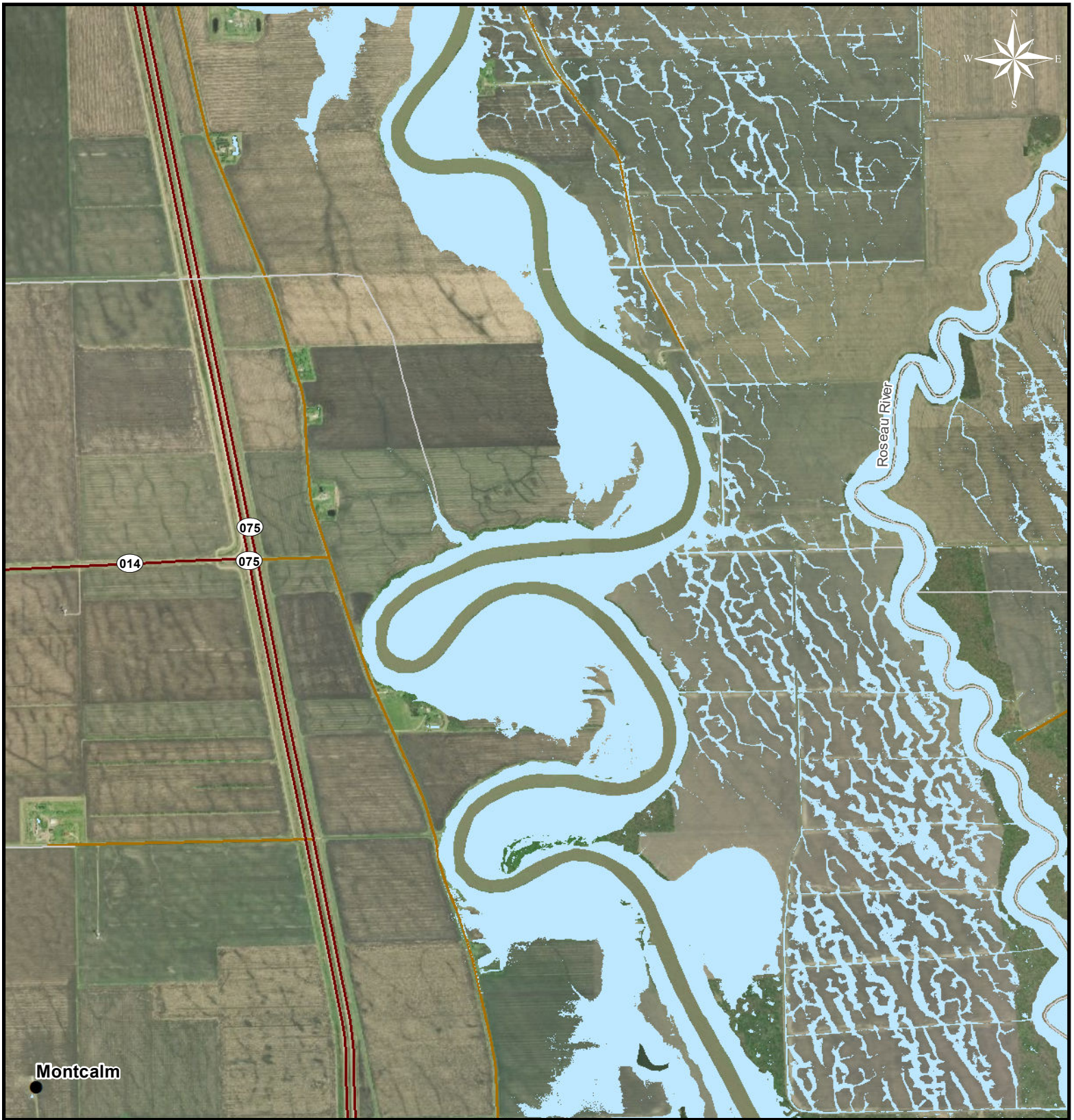




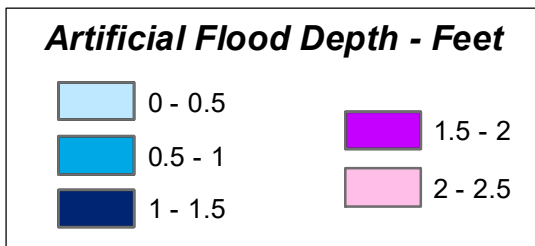
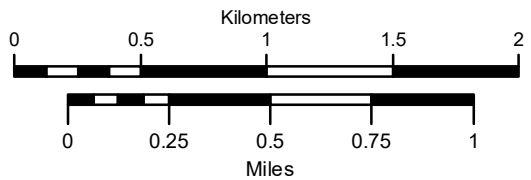
**Red River Floodway - Fall 2019 Operation**  
**Maximum Extent and Depth of Artificial Flooding - Map 15**  
*Artificial Flooding occurred between October 9 and November 6, 2019*



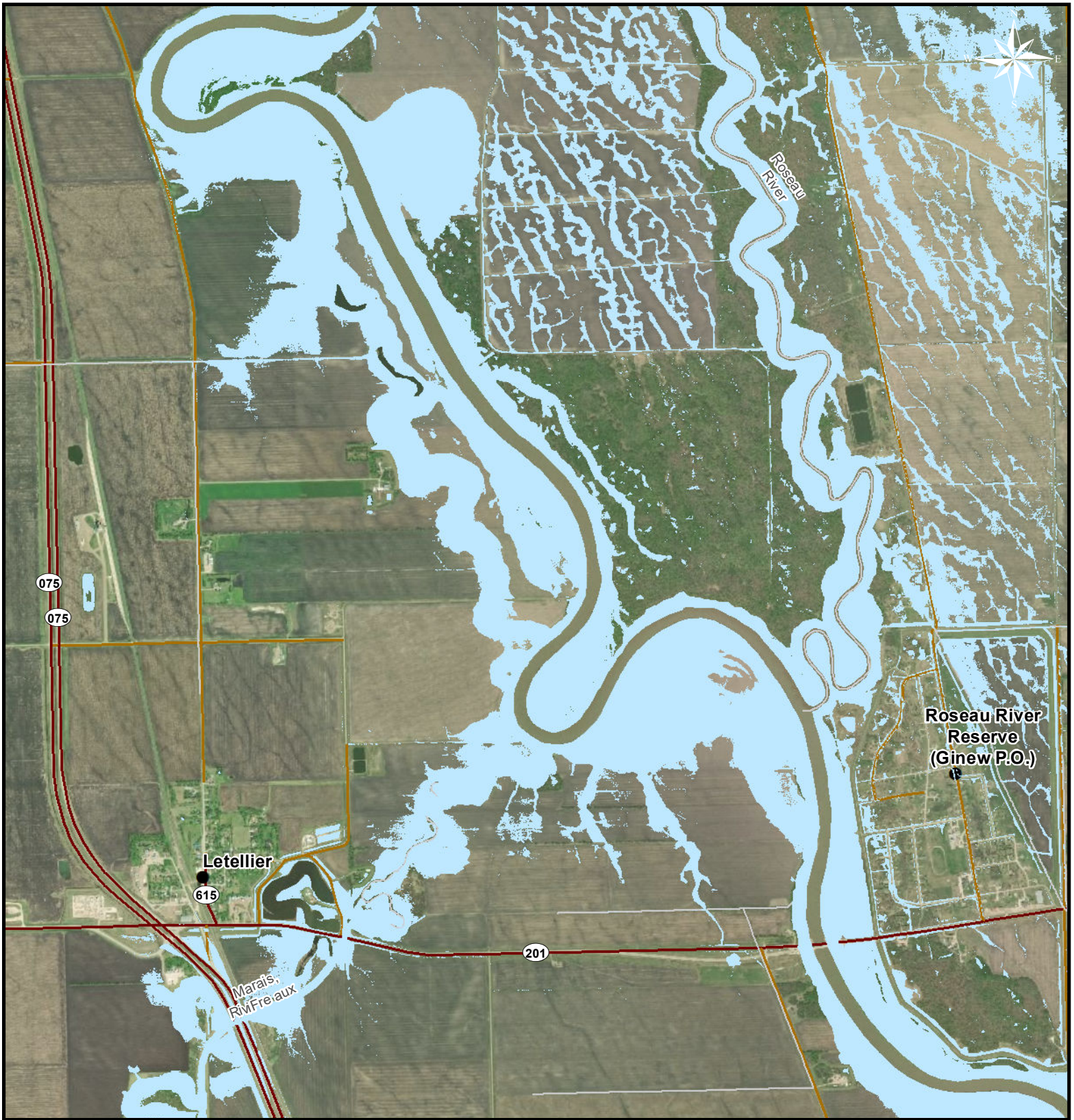
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 Base Map: ESRI Canada



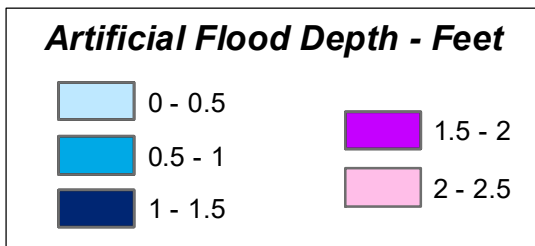
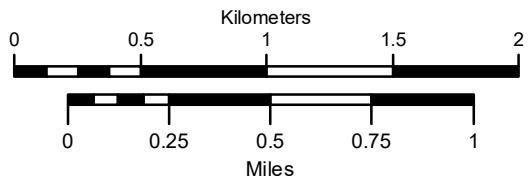
**Red River Floodway - Fall 2019 Operation**  
**Maximum Extent and Depth of Artificial Flooding - Map 16**  
*Artificial Flooding occurred between October 9 and November 6, 2019*



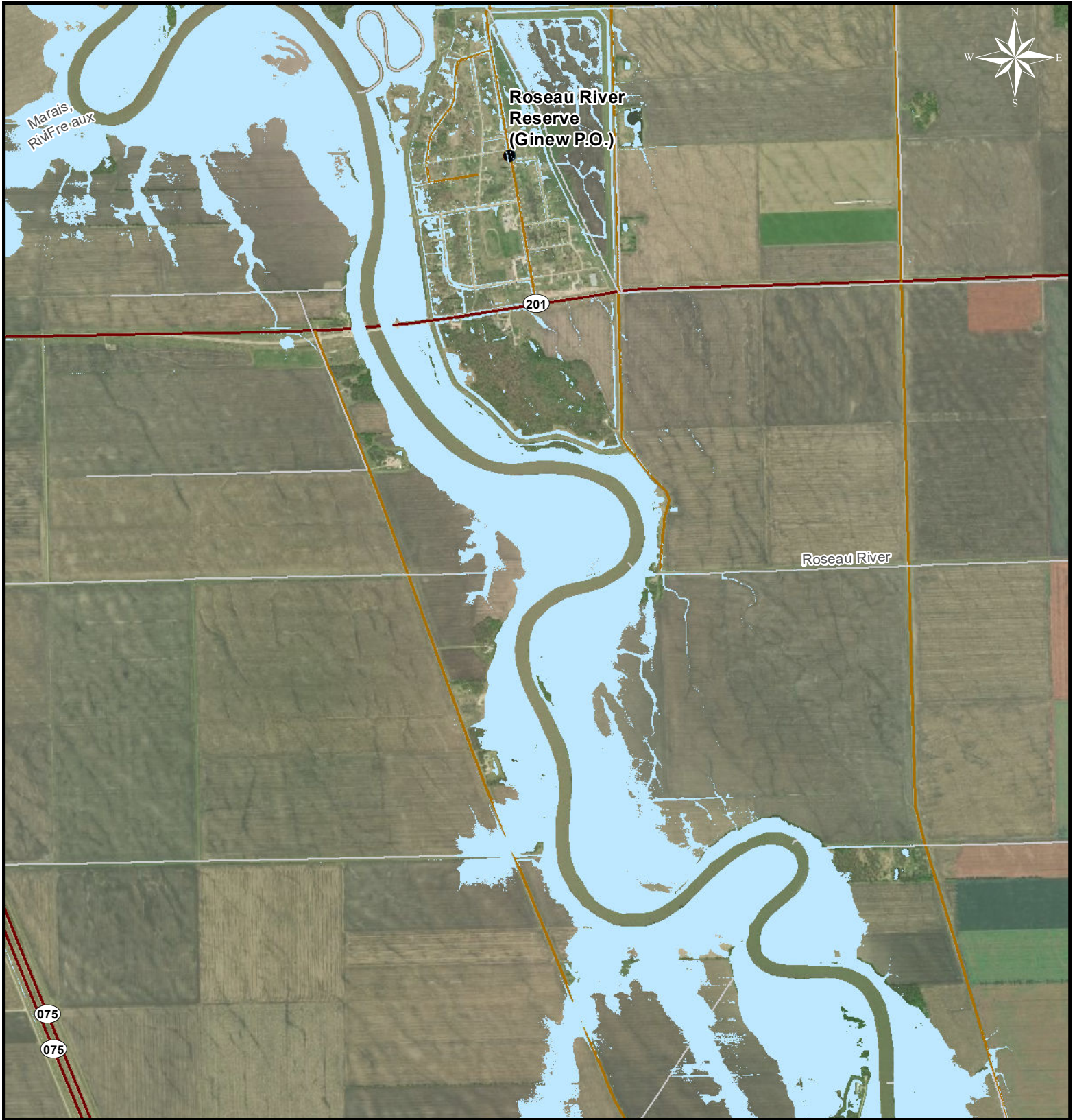
Meta Data:  
 Lidar: Aeroscan International  
 Base Layers: GeoManitoba  
 Base Map: ESRI Canada



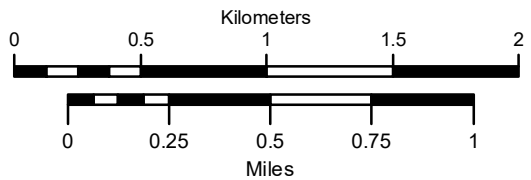
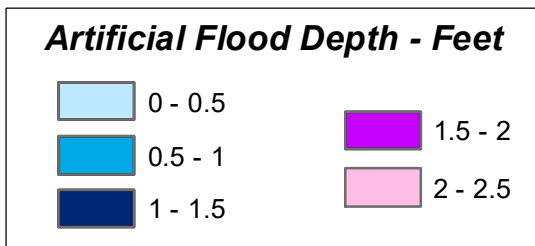
**Red River Floodway - Fall 2019 Operation**  
**Maximum Extent and Depth of Artificial Flooding - Map 17**  
*Artificial Flooding occurred between October 9 and November 6, 2019*



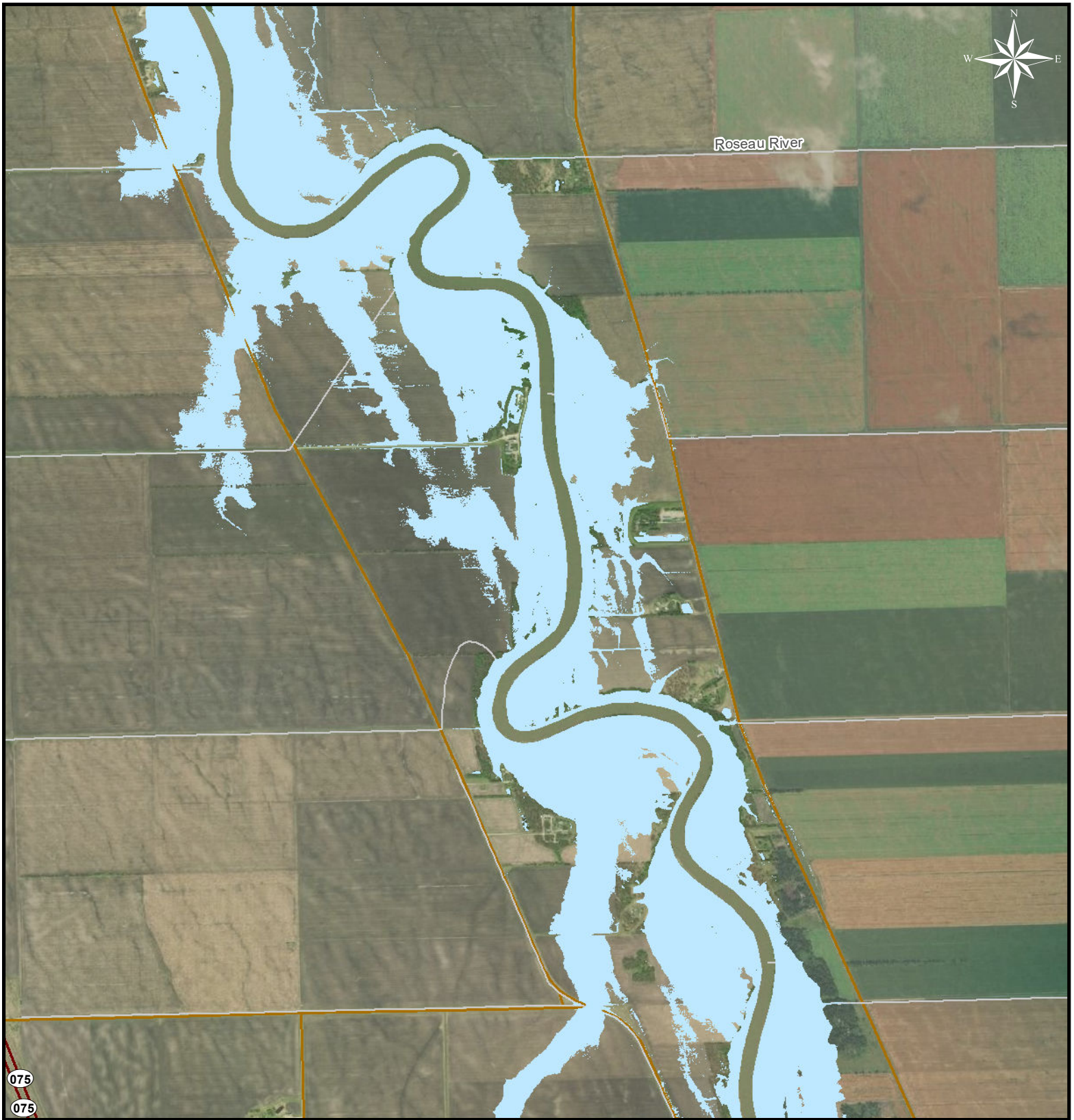
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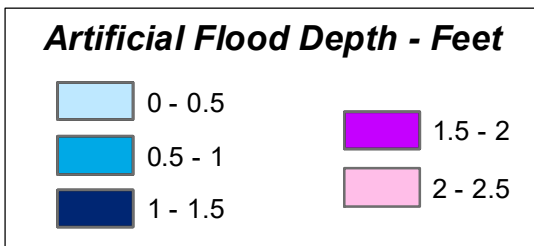
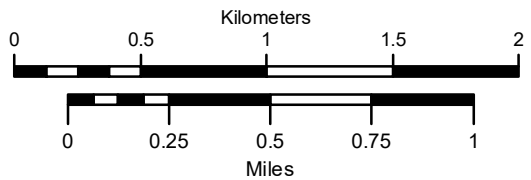
**Red River Floodway - Fall 2019 Operation**  
**Maximum Extent and Depth of Artificial Flooding - Map 18**  
*Artificial Flooding occurred between October 9 and November 6, 2019*



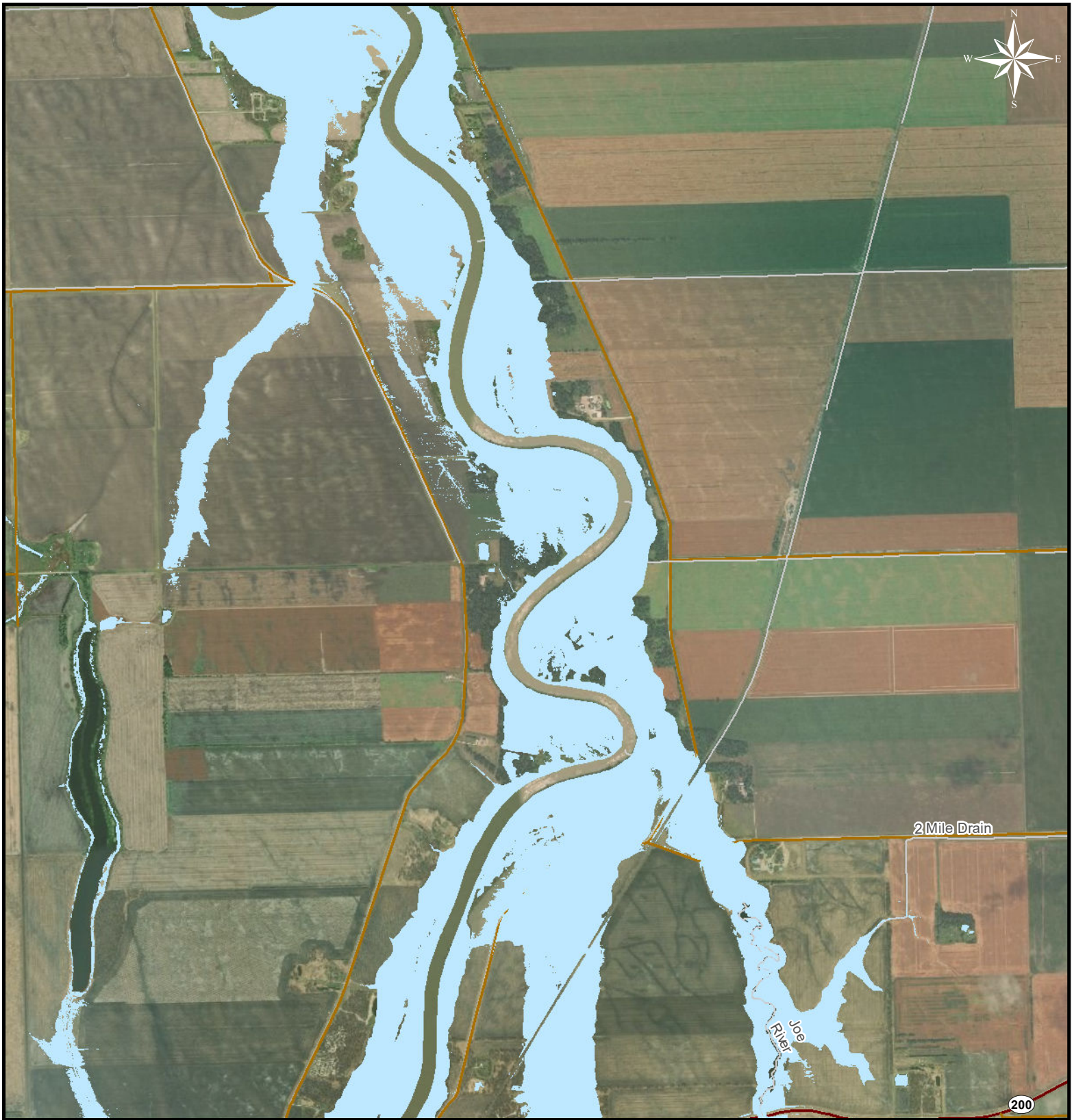
Meta Data:  
 Lidar: Aeroscan International  
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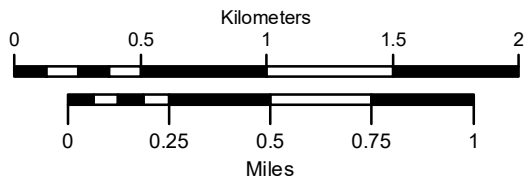
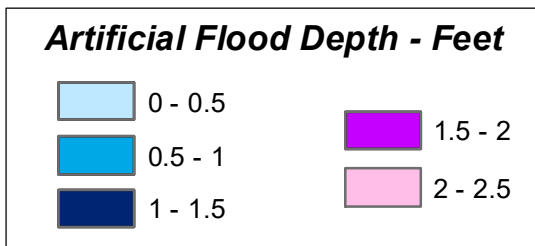
**Red River Floodway - Fall 2019 Operation**  
**Maximum Extent and Depth of Artificial Flooding - Map 19**  
*Artificial Flooding occurred between October 9 and November 6, 2019*



Meta Data:  
 Lidar: Aeroscan International  
 Base Layers: GeoManitoba  
 Base Map: ESRI Canada



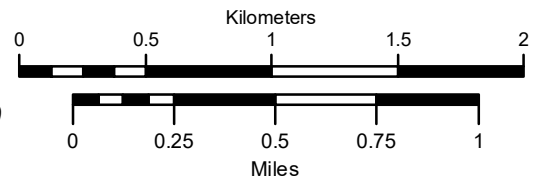
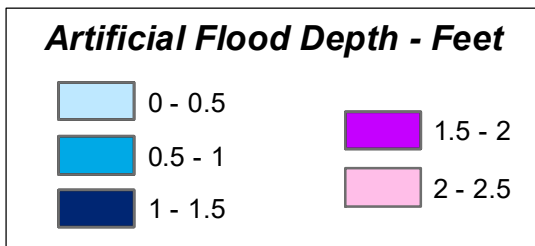
**Red River Floodway - Fall 2019 Operation**  
**Maximum Extent and Depth of Artificial Flooding - Map 20**  
*Artificial Flooding occurred between October 9 and November 6, 2019*



Meta Data:  
 Lidar: Aeroscan International  
 Base Layers: GeoManitoba  
 Base Map: ESRI Canada



**Red River Floodway - Fall 2019 Operation**  
**Maximum Extent and Depth of Artificial Flooding - Map 21**  
*Artificial Flooding occurred between October 9 and November 6, 2019*



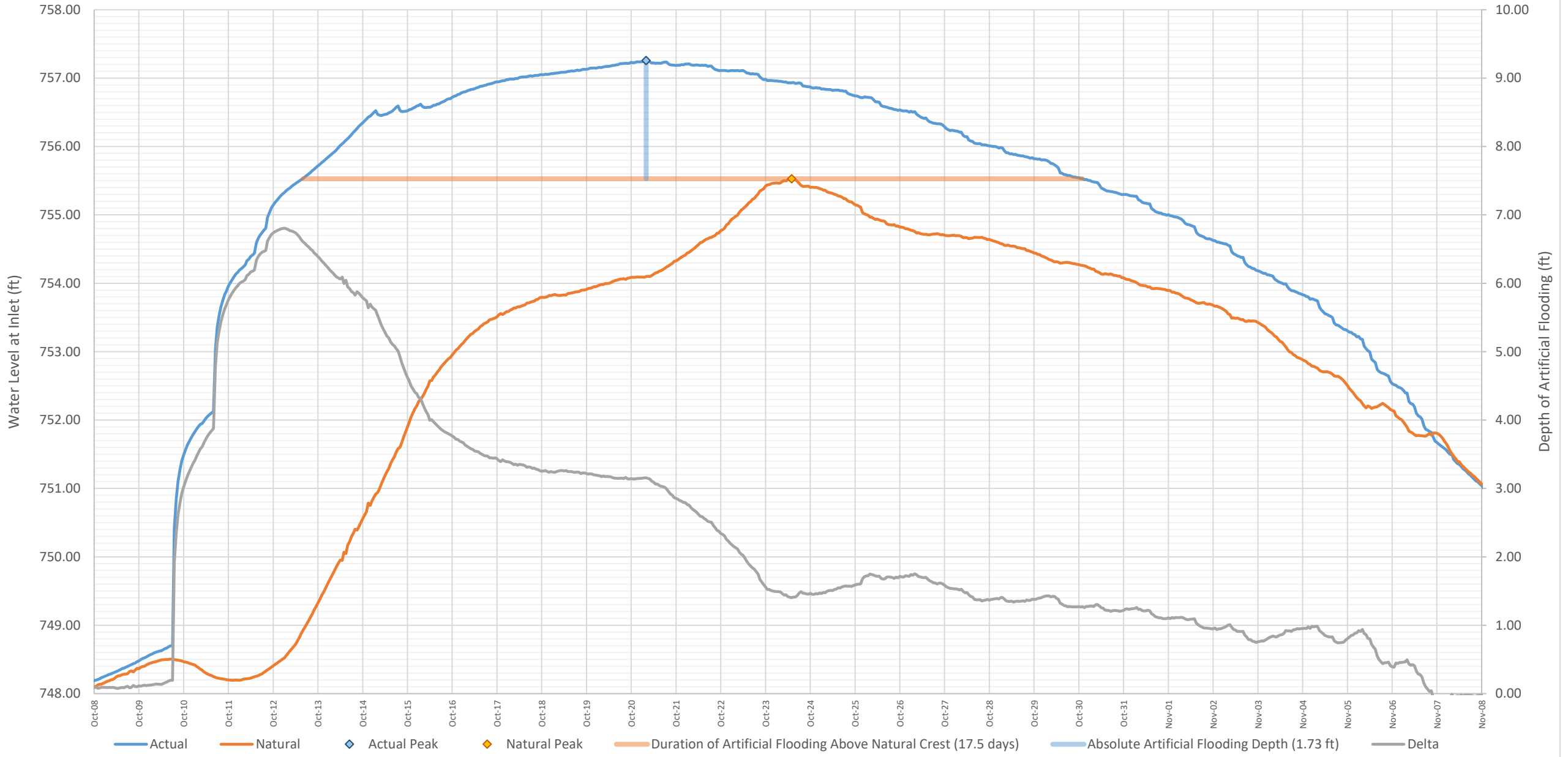
Meta Data:  
 Lidar: Aeroscan International  
 Base Layers: GeoManitoba  
 Base Map: ESRI Canada

## **APPENDIX D**

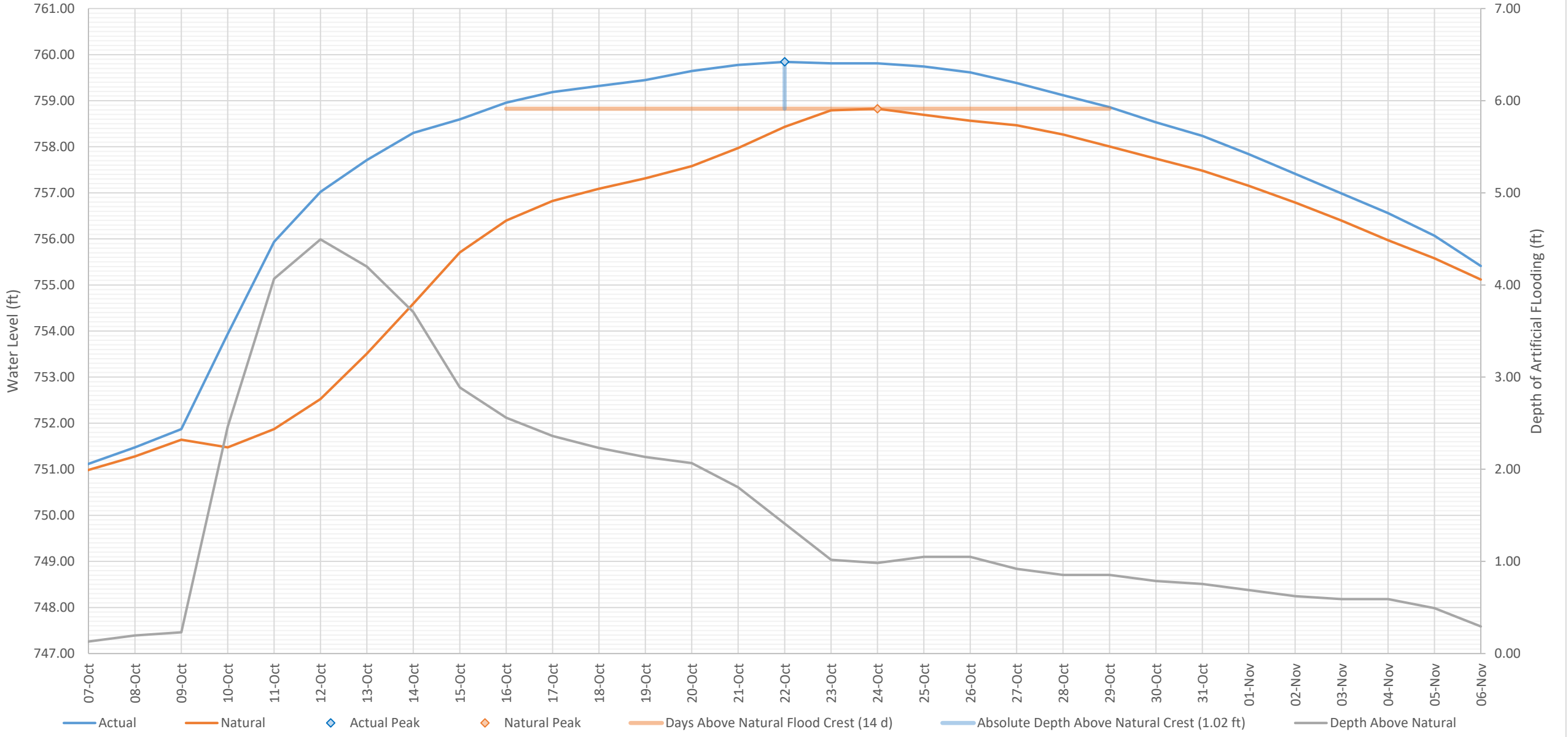
Level Hydrographs at Inlet and Gauge Locations



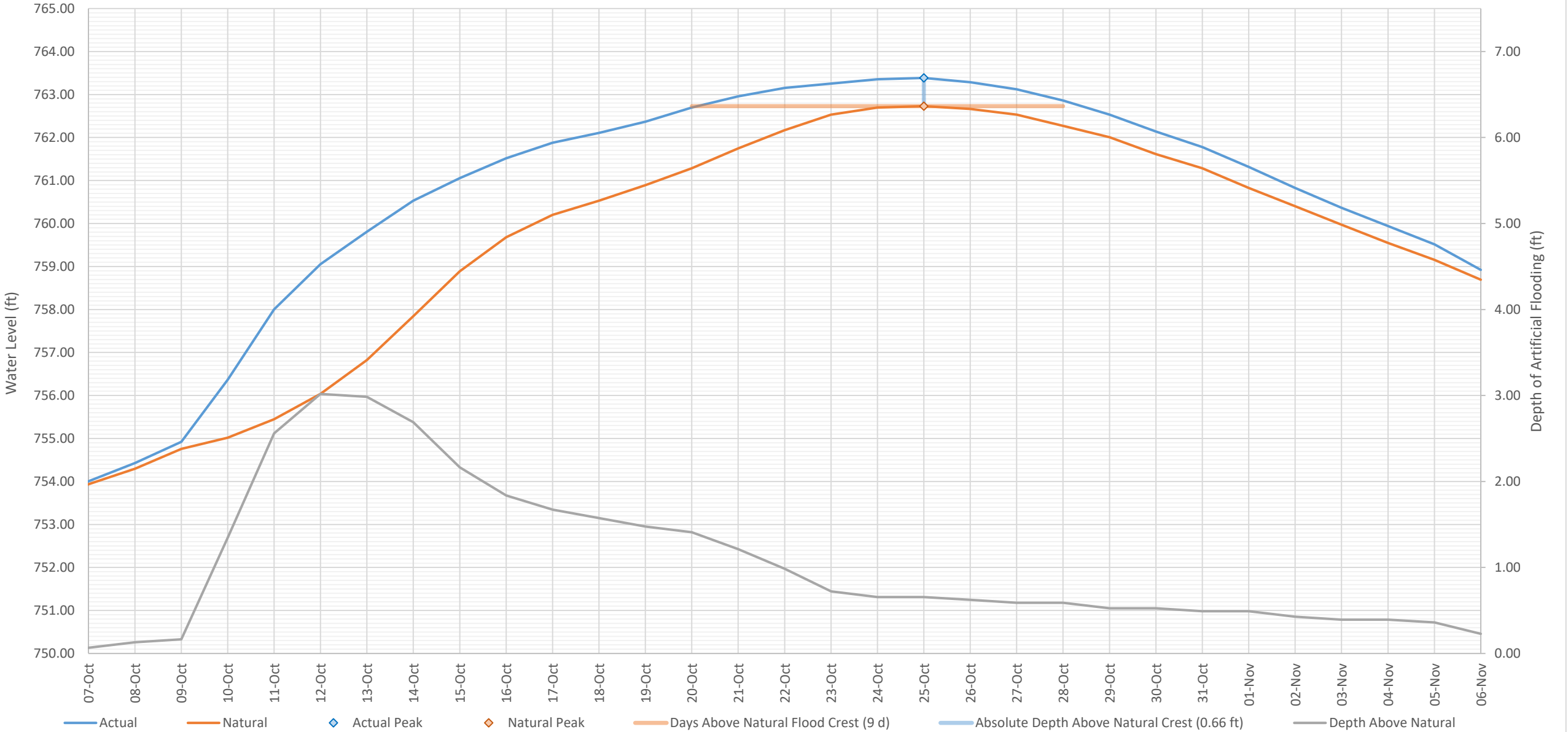
# Level Hydrographs at Floodway Inlet



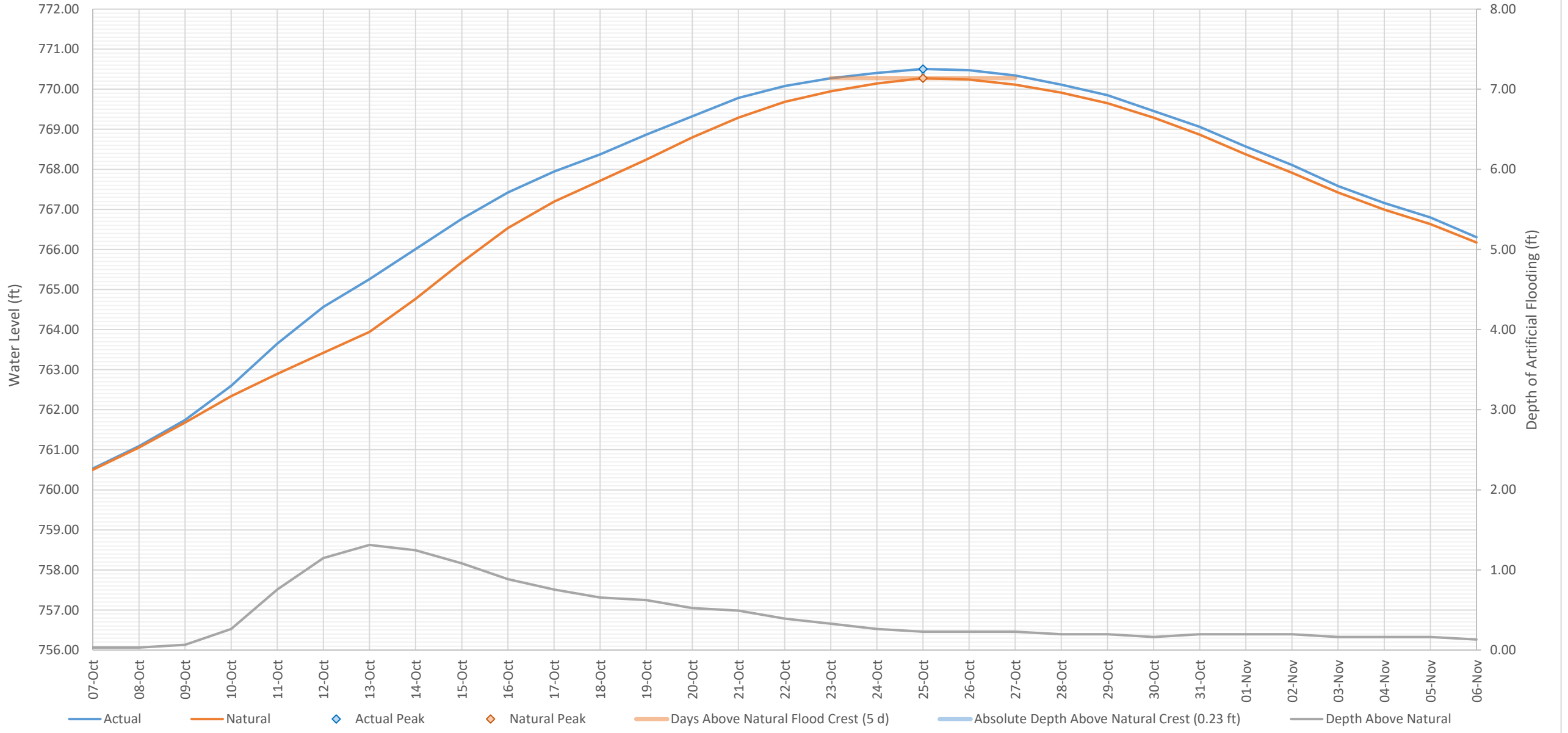
### Level Hydrographs at Saint Adolphe



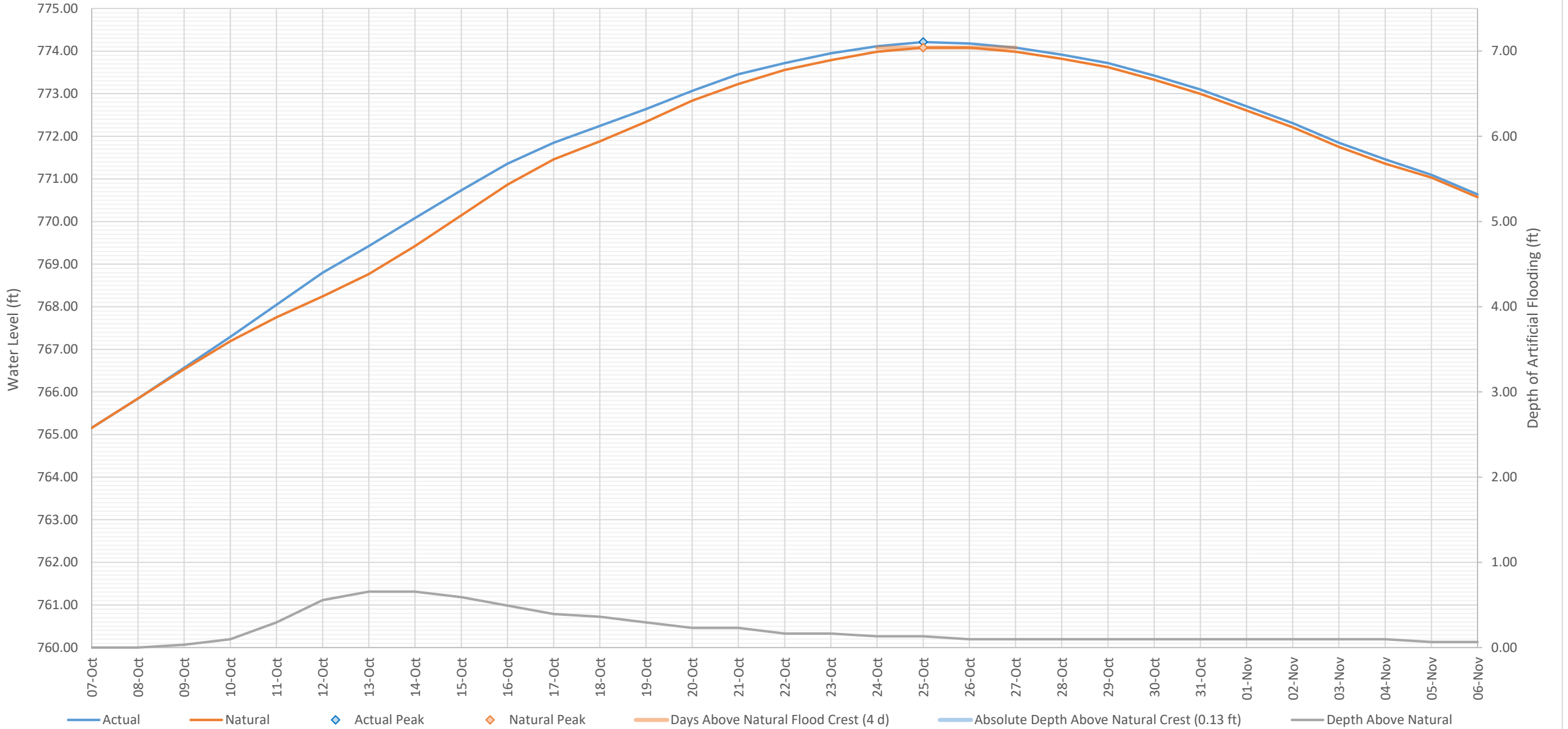
### Level Hydrographs at Ste Agathe



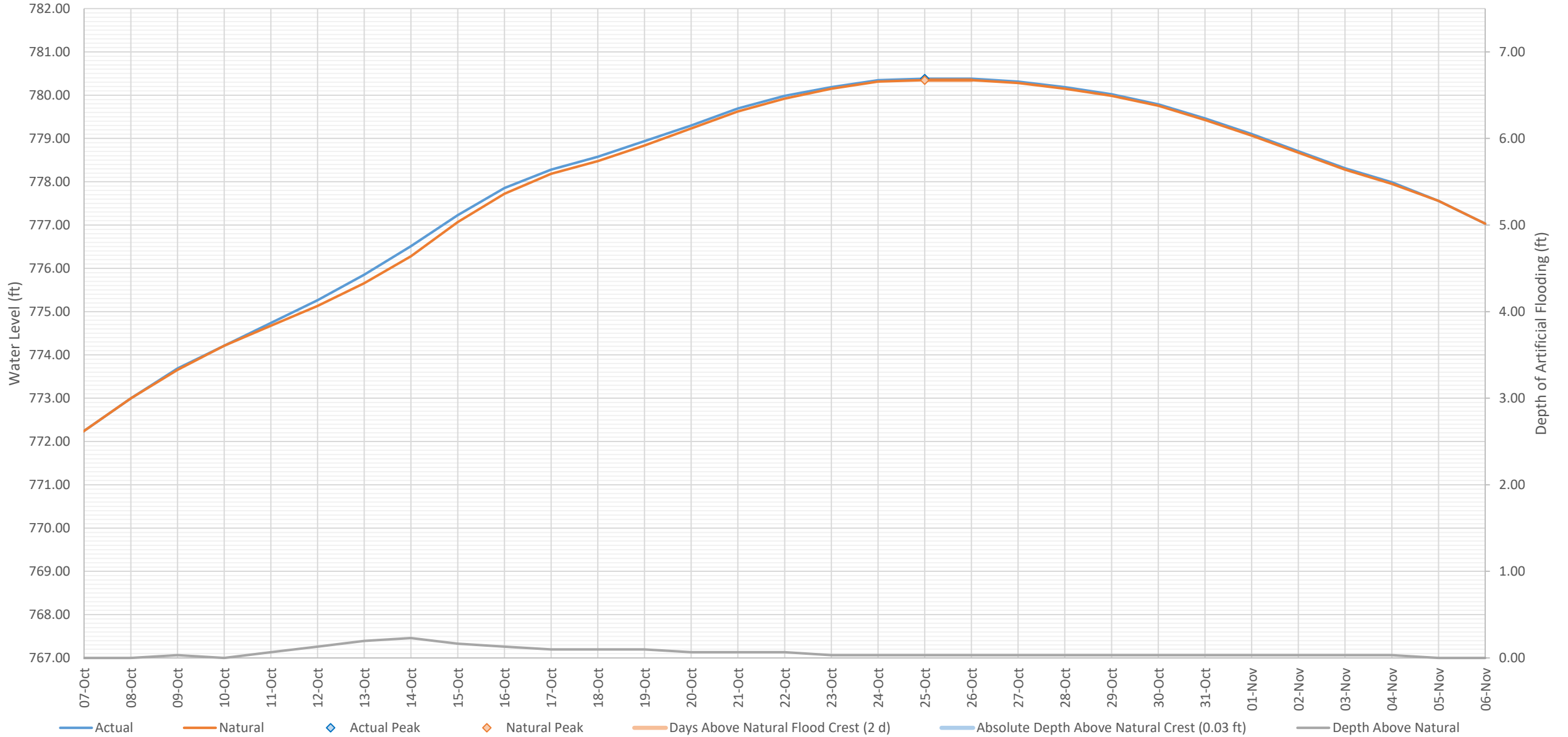
### Level Hydrographs at Morris



### Level Hydrographs St. Jean Baptiste



### Level Hydrographs at Letellier



### Level Hydrographs at Emerson

