



EMERGENCY REDUCTION OF LAKE MANITOBA AND LAKE ST. MARTIN WATER LEVELS



KGS GROUP REPORT
11-0300-18

November 2015

in association with



BINDER 2 OF 5



November 30, 2015

File No. 11-0300-18

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ATTENTION: Mr. Ron Kaatz
Senior Hydraulic Engineer

RE: Emergency Reduction of Lake Manitoba and Lake St. Martin Water Levels
Binder Series of Deliverables (Final) – November, 2015

Dear Mr. Kaatz:

KGS Group is pleased to provide the binder series representing Final deliverables produced for the Emergency Reduction of Lake Manitoba and Lake St. Martin Water Levels Project by the KGS Group Project Team, which included North/South Consultants.

On February 21, 2014, KGS Group provided MIT with a Mock-Up of the binder series for the project deliverables. The intent of the Mock-Up was for MIT to verify completeness of the data files used to produce figures and appendices and agree to the format of the binder series. MIT reviewed the binder series and provided comments on December 19, 2014. The comments included suggested changes to the text within several documents previously issued as Final. KGS Group compiled the comments from all MIT reviewers into a single summary document that included proposed changes to the text to address the comments and submitted to MIT on May 4, 2015. Through discussions and emails culminating on October 7, 2015, KGS Group received verification as to which comments should be incorporated into revised Final documents and which were not compulsory to include.

Any report that had technical content changed as a result of comments provided by MIT on the Mock-Up of the binder series were included in the Final binder series as a revision and assigned a new issue date. Documents that were left unchanged or had changes that were strictly non-technical, were included in the binder series with the original issue date. Details for reports in each binder that were modified for technical content, modified for non-technical content, or left unchanged are provided in the table below:

TABLE 1
STATUS OF REPORTS ISSUED WITH FINAL BINDER SERIES FOR PROJECT

Binder	Report	Update	Issued Final	Revised Final
1	1	Non-technical	Nov-13	-
2	1	Non-technical	Mar-14	-
3	1	Technical Content	Jan-13	Nov-15
	2	Unchanged	Jan-13	-
	3	Non-technical	Mar-12	-
	4	Unchanged	Nov-13	-
	5	Technical Content	Aug-12	Nov-15
4	1	Technical Content	Dec-13	Nov-15
	2	Unchanged	Mar-12	-
	3	Unchanged	Jan-13	-
5	1	Non-technical	Nov-13	-
	2	Technical Content	Nov-13	Nov-15
	3	Non-technical	Nov-13	-
	4	Non-technical	Feb-14	-
	5	Non-technical	Apr-13	-

All binders within the series contain a Table of Contents (TOC) indicating the names of the reports in the series and in which binder they can be located. The subsequent pages of the TOC for the binder series provide general details for each report.

Two DVDS are included with each binder within the series; one DVD with report(s) in PDF format attached to the front cover and a data files DVD attached to the back cover. The information on these DVDs only contain reporting/files for the specific binder in which they are located. The data files DVDs contain a geodatabase for figures/appendices created using GIS data and individual folders with background data for figures/appendices created using laboratory data, tables for modelling/Excel files, AutoCAD data, Grapher files, or Jpeg/PDF for photos/images. Any figures created in AutoCAD were converted into MicroStation and a copy of the MicroStation data was included in the data files DVD. Figures and appendices that do not require data files to reproduce are not included on the data files DVD.

Please contact the undersigned if you have any questions regarding the compilation of Final deliverables.

<original signed by>

Yours truly,

Colin Siepmann, P.Eng. 
Senior Project Manager

SO/
Enclosure

cc: Bert Smith – KGS Group

**EMERGENCY REDUCTION OF LAKE MANITOBA AND
LAKE ST. MARTIN WATER LEVELS
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**Emergency Reduction of Lake Manitoba and
Lake St. Martin Water Levels
Analysis & Monitoring of Discharges & Ice Processes
FINAL REPORT**

KGS File No. 11-0300-18
March 2014

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Review History	Date
Draft report issued to MIT	16-Aug-13
MIT comments received	3-Feb-14
Final report issued to MIT	7-Mar-14

EXECUTIVE SUMMARY

In June 2011, The Province of Manitoba commissioned Kontzamanis Graumann Smith Macmillan Inc. (KGS Group) and AECOM to urgently explore options to bring the water levels of Lake St. Martin and Lake Manitoba down to the desirable range on an emergency basis. In July 2011, KGS Group and AECOM issued the draft report, *"Analysis of Options for Emergency Reduction of Lake Manitoba and Lake St. Martin Levels"* with immediate actions to construct Reach 1 of the Lake St. Martin Emergency Outlet Channel (LSMEOC) to address the hydraulic flow restriction out of Lake St. Martin to Lake Winnipeg and to allow unrestricted maximum outflow of water from Lake Manitoba through the Fairford River Water Control Structure (FRWCS) throughout the winter of 2011/2012.

Following the decision to construct Reach 1, KGS Group provided assistance to Manitoba Infrastructure and Transportation (MIT) in the forecasting of water levels and outflows in Lake Manitoba and Lake St. Martin. Concurrent with the forecasts, KGS Group was also requested to provide assistance in the study of ice formation and processes within the various reaches of the Lake Manitoba and LSMEOC System. This report summarizes the various ice studies and the water level and discharge forecasts completed between August 2011 and December 2012 by KGS Group. It includes the results and findings of the river ice analyses, as well as a summary of all forecasts prepared for MIT during the study duration. The results of the flow metering and water level measurements that were surveyed between November 2011 and August 2012 are also summarized in this report.

Early in the project, MIT identified concerns with the potential of ice formation causing flooding. MIT established the "Frazil Ice Team" (FIT) to assess the potential impact of ice formation to the water levels and effects to the local communities along the system. The FIT consisted of senior engineers experienced in river ice conditions and hydraulic computer modeling. KGS Group's involvement in the FIT ice studies was led by Rick Carson.

For the winter of 2011-2012, unprecedented outflow magnitudes were predicted for Lake Manitoba and Lake St. Martin. Several issues related to the ice processes on the Fairford and Dauphin Rivers, as well as the LSMEOC and Buffalo Creek for these unprecedented conditions are identified and discussed in the report.

Spreadsheet routing models were developed to forecast water levels on Lake Manitoba and Lake St. Martin and outflows from these lakes. The models calculated daily changes in water levels and outflows based on predetermined stage-discharge relationships at the outlet of the lakes and available storage. Lake Manitoba inflow forecasts provided by MIT were used as input. A copy of all the forecasts formally issued to MIT is provided with the report.

Flow metering and water level measurements taken during operation of the LSMEOC were completed to calibrate flood routing and backwater models, and to confirm the true capacity of Reach 1 under open water conditions. An Acoustic Doppler Current Profiler (ADCP) mounted on a tethered miniature boat was used to measure flows in Reach 1 on four occasions. A cableway system was installed in March 2012 for the purpose of safely operating the ADCP. The data was processed according to the Water Survey of Canada (WSC) Procedure for the Review and Approval of ADCP Discharge Measurements. Measured flows ranged from 172 m³/s (6074 cfs) on November 18, 2011, to 115 m³/s (4061 cfs) on August 9, 2012.

Water levels were measured on Reach 1 and on Buffalo Creek using Global Positioning System (GPS) survey equipment, or from temporary benchmarks, during the flow metering trips and on five more occasions in February 2012. Water levels from WSC were also processed and compared to the surveyed water levels. A rating curve was developed for Reach 1 based on the flow metering data and the water levels recorded by WSC.

Combined results from the forecasts and the river ice simulations formed an integral part of the decision to construct dikes in the Dauphin River communities and also contributed to the decision to construct the Reach 3 Emergency Channel. A summary of the forecasted conditions, which led to those decisions, is discussed in the report.

KGS Group developed a numerical model of the Fairford River to simulate its winter characteristics. The model was developed based on a combination of old and new bathymetric data, historical observations, and experience of the Engineers involved. It was concluded that the worst case scenario of immediate ice generation within released flow from Lake Manitoba would be entirely possible.

Results of the analyses indicated that the Lake Manitoba level could rise approximately 0.25 m, compared to open water conditions without an ice jam. However, the winter of 2011-2012 was extremely mild. The formation of ice on the Fairford River was minimal and rises in water levels due to ice accumulation did not occur as had been predicted by the numerical models using conservatively severe assumptions.

On the Dauphin River, historical observations showed that frazil ice production on the river occurred every year and could cause significant water level rises in the Dauphin River communities. The ice cover also affects the discharge capacity from Lake St. Martin. A numerical model of the Dauphin River was developed to simulate the ice cover development. Data was collected to help generate the model including river bathymetry, water temperature data, historical observations and water level surveys.

Results of the simulations predicted that the water levels in the lower Dauphin River, as the ice cover developed, could increase by up to 4 m depending on the location along the river. The design elevation of the dikes in the Dauphin River communities was set based on the results of the numerical model simulations. In the upper Dauphin River, simulated ice conditions were used to predict the potential staging of water levels on Lake St. Martin with Reach 1 in operation. The forecast showed that the lake could stage up to 1.2 m.

In spite of the extremely mild winter conditions that occurred during 2011-2012, the observed peak levels along the dikes in the Dauphin River communities compared closely to the predicted levels for the ice formation event, and staging of 3 to 4 m was measured at some locations. The recorded water levels indicated that, had the dikes not been built, flooding would have occurred in the communities.

On the upper Dauphin River, ice conditions turned out to be less severe than had been expected. However, a review of the ice conditions that occurred in this reach during 2011-2012 indicated that without the LSMEOC in operation, significant staging would have occurred on Lake St. Martin, which could have exacerbated flood conditions around the Lake and on the Dauphin River. These conditions would have been worse if the winter conditions had been normal or more severe than normal.

A numerical model of Reach 1 was developed to simulate ice conditions in the channel. Similar assumptions adopted for the Fairford River were used in the Reach 1 model. Results from the analysis were used to assist with the prediction of ice staging on Lake St. Martin throughout the 2011-2012 winter period. However, ice conditions in Reach 1 did not occur as had been originally predicted; and it remained free of an ice cover. Only 0.2 m of staging occurred on Lake St. Martin.

On Buffalo Creek, the diversion of the flow through the LSMEOC from Lake St. Martin resulted in winter flows in the creek being several orders of magnitude greater than what would normally occur, which made previous information on ice conditions in the channel not relevant. It was, therefore, reasonable to consider the worst case scenario possible on the creek, based on experience with other rivers. A numerical model was developed using a combination of LiDAR data and survey data along the creek. The results showed that there was a significant risk of inundation during construction along many of the proposed Reach 3 alignment options. The final Reach 3 alignment was chosen, in part, to minimize this risk. Due to the extremely mild winter, ice conditions in Buffalo Creek did not occur as had been predicted by the numerical models.

The analysis and monitoring of discharges and ice processes was discontinued in December 2012, shortly after, the LSMEOC was closed as required under the federal terms and conditions for emergency operations. Additional analysis and monitoring may be required in the future if the LSMEOC is made permanent and/or a Lake Manitoba outlet channel is to be constructed.

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1.0 INTRODUCTION

The extremely wet conditions of 2010 and 2011 led to unprecedented flood inflows and rises in water levels on Lake Manitoba and Lake St. Martin. In June 2011, the Province of Manitoba commissioned Kontzamanis Graumann Smith Macmillan Inc. (KGS Group) to urgently explore options to bring the water levels of Lake St. Martin and Lake Manitoba down to the desirable range on an emergency basis. As part of this work, in collaboration with others as described below, KGS Group conducted river ice studies of the Lake Manitoba and Lake St. Martin Emergency Outlet Channel System from August 2011 to April 2012. This included the Fairford River, Dauphin River, Lake St. Martin Emergency Outlet Channel (LSMEOC) and Buffalo Creek. Concurrent with the ice studies and throughout operation of the LSMEOC, KGS Group prepared, at the request of MIT, water level and outflow forecasts from August 2011 to December 2012 for Lake Manitoba and Lake St. Martin.

To complete the ice studies, KGS Group and MIT developed river ice models of the various reaches of the system using computer software. Several scenarios were analyzed based on a range of assumptions on freeze-up dates and the rate of decline of the river flows in the system. The results from the simulations were analyzed to assess the potential extents of the effects from ice on flooding to local communities (e.g. Dauphin River First Nation (DRFN)), and the impacts on lake levels and outflows. Stage-discharge relationships for winter conditions were developed at the outlet of Lake St. Martin and at Lake Manitoba for forecasting purposes. Ice conditions in the various reaches of the system were monitored throughout the winter of 2011-2012 to compare model predictions to observations and surveys of actual conditions that occurred during the winter.

The water level and outflow forecasts were developed by KGS Group based on a numerical flood routing model of Lake Manitoba and Lake St. Martin. The numerical model was formulated as an Excel spreadsheet to enable rapid and efficient deployment during the course of the studies. The model was used to prepare forecasts that were used by the Province of Manitoba for planning and operating purposes of the Lake Manitoba and LSMEOC System. The forecasts were issued monthly or as requested by MIT and modified based on different operating conditions and river ice conditions in the system. The forecasts were also updated and adjusted as appropriate to best represent actual conditions as they were unfolding at the time.

This report focuses on the various ice studies and water level and discharge forecasts prepared between August 2011 and December 2012 by KGS Group for MIT. It includes the results and findings of the river ice analyses, as well as a summary of all forecasts prepared for MIT during the study duration.

To keep the overall structure of this report organized and easy to follow, the contents of the report are not presented in the order that they actually occurred. Section 2.0 includes background information. Section 3.0 provides an overview of ice processes and issues. Section 4.0 discusses the forecasts of water levels and discharges. Sections 5.0 to 8.0 discuss the results and findings of the river ice analyses organized by stream: Fairford River, Dauphin River, Reach 1 and Buffalo Creek. The four areas each have data sources / historical observations presented first, followed by numerical simulations and findings, and observations in 2011 – 2012 presented last.

2.0 BACKGROUND

In June 2011, the Province of Manitoba commissioned KGS Group and AECOM to urgently explore options to accelerate the rate of return of water levels of Lake St. Martin and Lake Manitoba to the desirable range. In July 2011, KGS Group and AECOM issued a draft report titled, “*Analysis of Options for Emergency Reduction of Lake Manitoba and Lake St. Martin Levels*”, which recommended the following actions to the Province of Manitoba:

- Begin immediate work on construction of an emergency channel (Reach 1) from Lake St. Martin towards Lake Winnipeg to address the hydraulic flow restrictions out of Lake St. Martin and to accommodate additional Lake Manitoba outflows over the winter; and
- Allow unrestricted maximum outflow of water from Lake Manitoba through the Fairford River Water Control Structure (FRWCS) throughout the winter of 2011-2012, allowing for several times more outflow than past typical winter flows.

Subject to the successful implementation of the above, KGS Group and AECOM also provided the following conditional recommendations for the Province of Manitoba to consider:

- Construct a bypass channel around the north side of the FRWCS to allow additional outflow from Lake Manitoba; and
- Expand the emergency channel from Lake St. Martin to offset the additional inflows from Lake Manitoba on the principle of “no net addition of water” to Lake St. Martin.

Due to logistical challenges associated with the development of Reach 1, the conditional recommendations were not implemented.

Following the decision to construct Reach 1, KGS Group provided assistance to MIT in the forecast of water levels and outflows in Lake Manitoba and Lake St. Martin for a range of possible conditions. These forecasts were requested to consider the most up to date hydrometric data and Lake Manitoba inflow forecast available at the time. Concurrent with the forecasts, KGS Group was also asked by MIT to provide assistance in the study of ice formation and processes within the various reaches of the Lake Manitoba and LSMEOC System. A range of ice formation scenarios were simulated to assess the potential flooding of communities and infrastructure adjacent to the water courses in the system.

As the design of Reach 1 evolved, results from the river ice studies and forecasting indicated that there was a significant risk of major flooding of the Dauphin River communities in the fall of 2011 and in the spring of 2012 due to ice jam formations and unprecedented flows, as discussed in Section 6.0. It was concluded that construction of the Reach 3 Emergency Channel should be carried out to divert flows away from the Dauphin River prior to spring break up. In combination with this, the dikes being constructed along the banks of the Dauphin River would significantly reduce the risk of flooding for the Dauphin River communities. Figure 1 shows the location plan of the project area.

2.1 FRAZIL ICE TEAM

Early during the project, MIT identified concerns with the potential of ice formation causing flooding. To address these concerns, MIT established the “Frazil Ice Team” (FIT) to assess the potential impacts of ice formation to the water levels and effects to the local communities along the system. The FIT consisted of the following senior engineers experienced in river ice conditions and hydraulic computer modeling:

- Steve Topping, P.Eng. – Chairman of FIT.
- Rick Carson, P.Eng. – Senior Consultant, KGS Group.
- Dr. Karl-Erich Lindenschmidt, P.Eng. – Associate Professor, University of Saskatchewan (formerly Hydrologic Modeling Research Engineer at Manitoba Water Stewardship at the time the FIT was established).
- Mike Morris, P.Eng. – Ice expert from Manitoba Hydro.

KGS Group’s involvement in the ice studies was led by Rick Carson who provided advice on the effective deployment of engineering software for the analysis of the ice conditions in the system. Dr. Karl-Erich Lindenschmidt prepared and ran the simulation models, with assistance provided by Maurice Sydor, a contract employee of KGS Group, and recently retired from Environment Canada. Mr. Sydor had been previously involved with KGS Group in the development of the software used in the studies and is highly skilled at model setup and trouble-shooting. Dr. Lindenschmidt ran the simulations for Manitoba Water Stewardship (MWS) until his departure to take a new position at the University of Saskatchewan in early 2012. He was then hired by KGS Group as a contract employee (concurrent with his responsibilities as an Associate Professor at the University of Saskatchewan) to complete his assignment as part of

the study. KGS Group also provided ongoing support throughout the study with surveys and continuous monitoring during the winter. KGS Group's involvement and the findings of the FIT are documented in this report.

At the request of MIT, an independent review and confirmation of the key aspects of the ice studies done by the FIT for the Fairford and Dauphin rivers was conducted by Jean-Philippe Saucet of the LaSalle Consulting Group of LaSalle, Quebec. The findings of Mr. Saucet are documented in this report.

3.0 OVERVIEW OF ICE PROCESSES AND ISSUES

3.1 FAIRFORD RIVER

Outflow from Lake Manitoba occurs at the Fairford River located at the northeast end of the lake. The Fairford River is approximately 17 km long and the desirable water level descends from 247.0 to 247.7 m (810.5 to 812.5 ft) at Lake Manitoba to 242.9 to 243.8 m (797 to 800 ft) at Lake St. Martin. This is consistent with the recommendations made in 2003 by the Lake Manitoba Regulation Review Advisory Committee that the “water level management regime should permit Lake Manitoba to fluctuate between El 810.5 to 812.5 ft asl over a period of years insofar as this may be reasonably possible, with the expectation that as a result of water level variations, the lake will rise to 813.0 ft asl in some years and drop to 810 ft asl in others”. Normally the outflows are quite limited in magnitude in the winter, and are controlled by the installation of stoplogs at the Fairford Dam, located a short distance along the river from the lake, to promote the formation of a stable ice cover in the Fairford River and the Dauphin River downstream. Under these conditions of low flow, the ice formations on the river both upstream or downstream from the dam do not have significant influence on the outflow discharge capacity from the lake.

However, the issue that was foreseen for the winter of 2011-2012 was that the lake outflow would be so large that hanging ice dams could form in the channels downstream of the Fairford Dam and in Lake Pineimuta. This would potentially cause high water levels along the Fairford River/Lake Pineimuta and conceivably constrict the outflow capacity from Lake Manitoba.

A mitigating aspect, however, that makes this phenomenon particularly difficult to analyze is the fact that the water stored in Lake Manitoba and released over the winter has some residual heat. Only the surface of the lake immediately below its ice cover has cold water that is consistently at zero degrees Celsius. The temperature of the water well below the surface may be above freezing. It may only be a few tenths of a degree Celsius above zero. However, the extent of heat that represents may still be capable of preventing ice forming in the water for some significant distance downstream from the lake outlet. Most outlets from lakes of this size have this characteristic “residual heat”.

The main issue foreseen was the generation of ice and how it could affect the outflow capacity from Lake Manitoba. However, addressing this had to be accompanied by consideration of how, and to what extent, the creation of ice dams would be mitigated by the natural effects from residual heat in Lake Manitoba.

3.2 DAUPHIN RIVER

The Dauphin River is the only natural outlet from Lake St. Martin. It traverses a distance of about 50 km from Lake St. Martin to its outlet into Lake Winnipeg and the desirable water descends from approximately El 242.9 to 243.8 m (El 797 to 800 ft) at Lake St. Martin to El 216.7 to 217.9 m (El 711 to 715 ft) at Lake Winnipeg. Over the first 25 km, the river gradient is relatively flat and the flow has a low velocity. The discharge capacity at the outlet from Lake St. Martin is dominated by the frictional effects of the flow in the upper Dauphin River. Winter conditions can cause formation of an ice cover in this reach and further affect the discharge capacity. Typically, it has been observed that the greater the outflow prior to formation of an ice cover, the larger the percentage of discharge capacity reduction due to ice relative to what would be possible with fully open water conditions (i.e. ice formation is proportional to outflow).

The lower 30 km of the river is steeply inclined, with a gradient of about 25 m over the relatively short length of the lower river. Velocities are relatively high. The formation of a smooth ice cover is rarely possible. In most years, the ice cover forms as the result of an accumulation of frazil ice pans formed in the fast flowing lower river. Rises in water level in the freeze-up period have, prior to 2011, been observed to be in the range of 1 to 2 m. The higher the flow, the higher the river water level must rise to create a stable ice cover. Conditions in the lower Dauphin River do not affect Lake St. Martin water levels or outflow.

In spring, the sudden increase in flow due to resumption of open water conditions at the outlet of Lake St. Martin could trigger ice jams in the lower river. This is not known to be a concern in most years but the carryover of high flows from 2011 could have brought this phenomenon forward and could have raised water levels to an undesirable extent.

The issues pertaining to river ice were:

- When and by how much the open water outflow capacity into the upper Dauphin River would be reduced by ice formation.
- The extent to which the increased water levels during freeze-up would threaten the Dauphin River communities and PR 513 that leads to it from the west. Predictions were required to form the basis of design of flood protection dikes in the Dauphin River communities.
- The extent to which ice jams could form in the spring thaw and cause rises in water level in the lower river.

3.3 LAKE ST. MARTIN EMERGENCY OUTLET CHANNEL AND BUFFALO CREEK

Normally Buffalo Creek is a small stream with little or no flow in winter. However, the LSMEOC planned to release excess water from Lake St. Martin through Buffalo Creek, into the Dauphin River and onwards into Lake Winnipeg. The increased flows in Buffalo Creek would create the potential for production of frazil ice and the accumulation of hanging ice dams and ice jams along the creek. There could ultimately have been a backwater effect onto the LSMEOC due to ice on Buffalo Creek.

The LSMEOC would have velocities low enough to permit the formation of ice and the potential establishment of an ice cover that would affect the discharge capacity from the lake and slow the response of declining flood levels in Lake St. Martin. That could be exacerbated by the effect of an ice cover on Buffalo Creek.

The issue with ice was to what extent it could affect the discharge capacity at the outlet from Lake St. Martin.

3.4 LAKE WINNIPEG AT THE MOUTH OF THE DAUPHIN RIVER

The outflow from the Dauphin River releases into Lake Winnipeg adjacent to the Community of Dauphin River. The river flow is swift in the river channel upstream of the community and continues with little reduction in intensity until it expands into the lake. In theory, if the ice that is carried down from the river could spread under the ice cover in the lake, the accumulation of an ice cover and the rise in water levels on the river in the community would not occur. Prior to 2011, this potential stalling of the ice cover advance from Lake Winnipeg had not occurred, and the ice historically was always able to back up the river water levels to the extent that the ice cover could develop and advance upstream from the lake.

The issue in 2011-2012 was whether the unprecedented flow magnitudes in the Dauphin River, supplemented by the inflow from Reach 1 through Buffalo Creek, would be large enough to prevent an ice cover formation. Furthermore, if the ice could advance, it would be necessary to estimate the rise in water level at the bay, and how it would influence the backwater profile along the river in the community.

4.0 FORECASTS OF WATER LEVELS AND DISCHARGES

4.1 ROUTING MODEL

KGS Group developed a spreadsheet routing model to forecast water levels on Lake Manitoba and Lake St. Martin and discharges from these lakes. The routing model consisted of two individual water balance models: one for Lake Manitoba, and the other for Lake St. Martin. The water balance models calculated changes in water levels and outflows during a time period when inflows to the lakes are known (i.e. $\text{Inflow} = \text{Change in Storage} + \text{Outflow}$). A 1-day simulation window was used for the time period in the model. Output from the Lake Manitoba model was used as input for the Lake St. Martin model.

The following steps outline the computation process, as well as the inputs and outputs of the Lake Manitoba model:

1. Daily inflows were input into the Lake Manitoba model based on the inflow forecasts provided on a regular basis by the Hydrologic Forecast Center, MIT (formerly MWS). The inflow forecasts were updated by KGS Group as deemed necessary to reflect actual conditions observed at the time. Each forecast provided by MIT considered all sources of inflow to the lake including precipitation and evaporation and all other miscellaneous inputs such as seepage and groundwater inflow. Copies of the Lake Manitoba inflow forecasts provided by MIT are available in Appendix A, Annex A1.
2. A starting water level on Lake Manitoba was input into the model. The water level was based on observed lake levels as reported by Water Survey of Canada (WSC). The starting water level was used to define the beginning-of-day water level for the first day of simulation in the model.
3. Based on the beginning-of-day water level, the Lake Manitoba storage was computed. The storage was calculated using a stage-storage relationship developed from the surface area of the lake for water levels ranging from approximately EI 247.0 to 249.2 m (810.4 to 817.6 ft).
4. An outflow was computed for the lake based on the beginning-of-day water level. Outflow from Lake Manitoba is through the Fairford River. The outflow was calculated using a predetermined stage-discharge relationship from the Fairford River. The open water stage-discharge relationship for the Fairford River was based on historical water levels on Lake Manitoba and corresponding measured Fairford River discharges by WSC at Station 05LM001, supplemented with results from a backwater model of the Fairford River. The backwater model considered that the Fairford River Water Control Structure (FRWCS) would be fully open. The stage-discharge relationship for winter ice conditions was based on results from numerical backwater models in the river. A discussion on winter ice conditions in the Fairford River and inherent assumptions is

- provided in Section 5.0 of this report. A copy of the open water and winter rating curves is also provided in Section 5.0.
5. An end-of-day water level was computed for this water level using the same stage-discharge relationship that was outlined in Step 4. The final value for the end-of day wl was computed by trial and error following steps 6 to 10.
 6. A mean outflow was computed for the day based on the outflows computed in steps 4 and 5.
 7. The daily change in storage was then computed based on the known inflow outlined in step 1 and the mean daily outflow outlined in step 6 (Change in Storage = [inflow – Outflow] x change in time).
 8. The daily change in storage computed in Step 7 was added to the beginning-of-day storage computed in Step 3 to compute the end-of-day storage and the corresponding end-of-day water level from the storage curve.
 9. The actual end of day water level from step 8 was compared to the assumed end-of-day water level in Step 5.
 10. Steps 5 to 9 were repeated until the assumed end-of-day water level equaled the computed end-of-day water level.
 11. The end of day water level was used as the starting water level for the next day.
 12. Steps 3 to 11 were then repeated for each day of simulation in the model.

The computed Lake Manitoba mean outflow values were used as input into the Lake St. Martin Water Balance Model and were adjusted to account for additional inflow sources such as precipitation and evaporation. The same computation process, as outlined above, was then applied for the Lake St. Martin model.

The stage-discharge relationship for outflow from Lake St. Martin for open water conditions in the Dauphin River was based on historical water level and flow data available from WSC. The stage-discharge relationship used for 2011-2012 winter ice conditions was based on results from numerical models in the river developed by the FIT. The stage-discharge relationship was then modified in the late spring of 2012 following observations of actual conditions that occurred during the winter of 2011-2012. A discussion on winter ice conditions in the Dauphin River and inherent assumptions is provided in Section 6.0 of this report. Copies of the open water and winter stage-discharge relationships are also provided in Section 6.0.

The stage-discharge relationship for outflow from Lake St. Martin into Reach 1 under open water conditions was based on a numerical backwater model of the channel and was calibrated and adjusted based on flow meterings. Flow metering results and the estimated stage-discharge relationship for Reach 1 are provided in Appendix B in the report titled, *"Flow Metering and Water Level Measurement of the Lake St. Martin Emergency Channel System"*. The stage-discharge relationship for Reach 1 that was developed for winter conditions was also based on a numerical model of the channel and was adjusted based on observations of actual conditions in Reach 1. A discussion on winter ice conditions in Reach 1 is provided in Section 7.0 of this report.

The stage-storage relationship for Lake St. Martin was developed from the surface area of the lake for water levels ranging from approximately El 243.2 to 247.0 m (797.9 to 810.4 ft).

4.2 SUMMARY OF FORECASTS AND RESULTS

A copy of all the forecasts formally issued to MIT is provided in Appendix A, Annex A2. The forecast figures are organized by issue date and include a copy of e-mails issued with the forecast. A table summarizing all of the forecasts that were issued and date of issue is included at the front of the Annex (Table A2-1).

Results from the forecasts formed the basis of the river ice simulations described in this report. Combined results from the forecasts and the river ice simulations formed an integral part of the decision to construct dikes in the Dauphin River communities. They also contributed to the decision to construct the Reach 3 Emergency Channel. A summary of the forecasted conditions, which led to those decisions, is discussed in Sections 4.2.1, 4.2.2 and 4.2.3.

4.2.1 Scenarios for Dauphin River Ice Simulations

A total of seven discharge scenarios were considered for the Lower Dauphin River ice simulations as follows.

1. Early Freeze Up (2011) at $Q = 500 \text{ m}^3/\text{s}$ (17,620 cfs).
2. Best Estimate Freeze Up (2011) at $Q = 400 \text{ m}^3/\text{s}$ (14,160 cfs).

3. Late Freeze Up (2011) at $Q = 365 \text{ m}^3/\text{s}$ (12,900 cfs).
4. Spring Break Up at $Q = 700 \text{ m}^3/\text{s}$ (24,720 cfs).
5. Spring Break Up at $Q = 1000 \text{ m}^3/\text{s}$ (35,310 cfs).
6. Spring Break Up at $Q = 444 \text{ m}^3/\text{s}$ (15,680 cfs).
7. Early Freeze Up (2012) - $269 \text{ m}^3/\text{s}$ (9,500 cfs).

On August 30, 2011, three ice freeze-up scenarios with ice jam formation at the Dauphin River communities were identified. The forecast indicated that the estimated discharge in the lower Dauphin River for early, best estimate and late freeze up conditions on Lake Winnipeg was approximately $500 \text{ m}^3/\text{s}$ (17,620 cfs), $400 \text{ m}^3/\text{s}$ (14,160 cfs), and $365 \text{ m}^3/\text{s}$ (12,900 cfs) respectively. These discharges formed the basis for Scenarios 1, 2 and 3 for the simulations of the lower Dauphin River described in Section 6.4.

On September 20, 2011, the model results indicated that the discharge in the lower Dauphin River during ice breakup would be approximately $1000 \text{ m}^3/\text{s}$ (35,310 cfs). This condition formed the basis of Scenario 5 since the potential for an ice jam formation during a rapid spring melt could cause the water levels to exceed the water levels for the spring ice formation phase. However, due to construction limitations, the Dauphin River dykes could not be raised to the maximum level; and, therefore, a discharge of $700 \text{ m}^3/\text{s}$ (24,720 cfs) for spring ice breakup was also selected for modeling (Scenario 4).

Due to the extremely mild winter conditions that occurred in the winter of 2011-2012, the ice jam conditions on both Reach 1 and the Dauphin River outlet, as well as the effects on outflow from Lake St Martin, were much less severe than forecasted in early winter (Scenario 4 and 5). A discussion on the extremely mild winter conditions that occurred is provided in Section 5.3. By February 22, 2012, the revised forecast model runs predicted that the peak outflow from Lake St Martin during the spring would be between $410 \text{ m}^3/\text{s}$ (14,480 cfs) and $476 \text{ m}^3/\text{s}$ (16,810 cfs). At the request of MIT, Scenario 6 for the average discharge of $444 \text{ m}^3/\text{s}$ (15,680 cfs) was analyzed.

The February 22, 2012 forecast also indicated that the discharge in the lower Dauphin River during the early winter 2012 ice formation period would be approximately $269 \text{ m}^3/\text{s}$ (9,500 cfs).

This formed the basis of the Scenario 7 simulation, which was requested by MIT to determine if the Dauphin River dikes could be removed or lowered.

4.2.2 Basis for Design of the Dikes in the Dauphin River Communities

The computed water level profile for Scenario 1, which was comprised of an early date for the start of the ice formation with a predicted discharge of $500 \text{ m}^3/\text{s}$ (17,620 cfs), was initially used for the design of the crest level for the dikes in the Dauphin River communities. A freeboard of 0.6 m above the computed water level was included in the design. However, due to the potential that an ice jam during a rapid severe spring melt season could cause water levels to exceed those estimated for the ice formation phase, an additional 0.7 m was added to the Scenario 1 profile for the design of the dikes.

As discussed in Section 4.2.1, the September 20 forecast indicated that the discharge in the lower Dauphin River during ice breakup could reach approximately $1000 \text{ m}^3/\text{s}$ (35,310 cfs). The model results for Scenarios 4 and 5 later showed that the design level of the dikes was too low in some areas. The details and results of the spectrum of simulations of the Dauphin River are discussed in depth in Section 6.0 of this report.

Scenario 4, $700 \text{ m}^3/\text{s}$ (24,720 cfs) for spring ice breakup was, therefore, selected for the design of the dikes, with due consideration of the limited capacity for emergency raising of dikes at the Dauphin River communities. Scenario 4 required a top-up above the Scenario 1 profile (plus 0.7 m allowance) of up to 0.4 m in some locations to maintain 0.6 m of freeboard. This elevation was deemed to be the maximum feasible to suit the area for the proposed dike footprints. It would also require volumes of soil that would be the maximum that could be placed during the available construction period prior to winter freeze-up.

The risk of overtopping of the dikes was still deemed unacceptable by MIT. The following options were considered to protect against the severe spring breakup scenario with a potential flow of $1000 \text{ m}^3/\text{s}$ (35,310 cfs).

1. Widen and raise the dikes even higher at the Dauphin River communities utilizing a winter access road and winter construction techniques. This option had constructability concerns due to access and winter conditions and high construction costs for the temporary works.

2. Temporarily close off Reach 1 by constructing a temporary cofferdam across Reach 1 approximately two weeks prior to spring breakup to reduce Dauphin River flows during the spring ice staging period. However, it was concluded that the cofferdam would not be practical due to constructability concerns; and it would be difficult to judge the optimal timing for the closure. It would also have resulted in increased Lake St. Martin water levels.
3. Reduce water levels on Lake St Martin by reducing flows at the FWRCS during the winter. Installing stoplogs in the winter would have been very difficult and the reduced Lake Manitoba outflows would have increased the water level on Lake Manitoba.
4. Construct Reach 3 of the Lake St. Martin Emergency Outlet Channel during the winter to divert Reach 1 flows away from the Dauphin River directly to Lake Winnipeg, thereby reducing Dauphin River flows at the communities in the spring. This option was considered the most favorable and was ultimately adopted for construction.

4.2.3 Basis for Hydraulic Design of Reach 3

Based on the September 20, 2011 water level and discharge forecasts, a discharge of 240 m³/s (8,500 cfs) was selected for the hydraulic design of the Reach 3 Emergency Channel to divert Reach 1 flows away from the Dauphin River directly to Lake Winnipeg. Also, the September 20, 2011 forecasts showed that the predicted peak flow of 1000 m³/s (35,310 cfs), ice simulation Scenario 5, in the lower Dauphin River was only expected to exceed 700 m³/s (24,720 cfs), ice simulation Scenario 4, for a brief period during ice breakup. It was, therefore, concluded that the Reach 3 Emergency Channel would only need to be operated for a period of approximately four weeks. The Reach 3 Emergency Channel tender package was prepared based on these design assumptions and issued on the following dates:

- November 17, 2011: issued for tender.
- November 25, 2011: issued for tender with Amendment No.1.

Contract 6178 for the construction of the Reach 3 Emergency Channel was awarded to Hugh Munro in December 2011. However, the January 5, 2012 forecast revised downward the predicted discharge in the Dauphin River communities from 1000 m³/s (35,310 cfs) to 765 m³/s (27,000 cfs) during ice breakup. This reduction was due to reduced staging on Lake St. Martin resulting from the extremely mild winter conditions. Therefore, based on recommendations from KGS Group, MIT requested on January 13, 2012 that the design discharge for Reach 3 Emergency Channel be reduced by half to 120 m³/s (4250 cfs). The Reach 3 Emergency Channel design was correspondingly revised and re-issued on the following dates:

- February 3, 2012: issued for construction (IFC).
- March 1, 2012: re-issued for construction (RFC).

Due to continuing extremely mild winter conditions, the February 22, 2012 “worst case” forecast for the spring breakup discharge in the Dauphin River communities had decreased to 475 m³/s (16,800 cfs). The revised forecasted spring breakup flow was well below the 700 m³/s (24,720 cfs) capacity of the dikes in the communities. Operation of the Reach 3 Emergency Channel was therefore no longer required. Design and construction details of the Reach 3 Emergency Channel are included in “*Reach 3 Design and Construction Report*” by KGS Group. Table 1 summarizes the evolution of the predicted peak discharge in the Dauphin River communities and the proposed design discharge of Reach 3

TABLE 1
SUMMARY OF PREDICATED PEAK SPRING DISCHARGE IN DAUPHIN RIVER
COMMUNITIES AND CORRESPONDING DESIGN DISCHARGE OF REACH 3

Date of Forecast	Predicted Peak Discharge in Dauphin River communities	Corresponding Design Discharge of Reach 3
September 20, 2011	1000 m ³ /s (35,310 cfs)	240 m ³ /s (8,500 cfs)
January 5, 2012	765 m ³ /s (27,000 cfs)	120 m ³ /s (4250 cfs)
February 22, 2012	475 m ³ /s (16,800 cfs)	No longer required
Actual Peak	307 m ³ /s (10,800 cfs)	n/a

5.0 FAIRFORD RIVER

5.1 DATA SOURCES

5.1.1 River Bathymetry

Previous bathymetric surveys of the Fairford River were provided to KGS Group by MIT dating from 1980. The surveyed cross sections only extended over a short length of the river from Lake Manitoba approximately 1 km upstream of the Fairford River Water Control Structure (FRWCS) to the mouth of Lake Pineimuta approximately 800 m downstream of the old railway bridge. A copy of the data is provided in Appendix C, Annex C1. Typical cross sections are provided with the Fairford River HEC-RAS backwater model attached in Appendix L.

Additional field surveys were carried out by KGS Group on August 31 and September 1, 2011 covering the river from the FRWCS to Lake St. Martin. Plan drawings showing the extent of the survey are provided in Appendix C, Annex C2. Typical cross sections are provided with the Fairford River HEC-RAS backwater model attached in Appendix L. The raw bathymetric data is provided on the Data DVD.

5.1.2 Historical Observations and Relevance

Historical photographic records of the Fairford River in winter are not extensive. Photos from January 26, 2004 as well as November 30, 2007, which show ice conditions in the Fairford River, were provided by MIT and are attached in Appendix D, Annex D1 and D2.

Of particular interest were the photographs from November 30, 2007, which showed ice forming on the surface of the open water early in the winter season. This showed that there was strong evidence that ice could form on the surface of the outflow from Lake Manitoba almost immediately upon its release from under the lake ice. It was deduced from the evidence that residual heat content normally occurring in other lakes is typically suppressed in Lake Manitoba due to its shallow depth. It is recognized that the conditions shown in the few photos available may not prevail throughout the entire winter. However, it was not possible with the data available to predict the extent to which the residual heat may be relied upon.

5.1.3 Water Temperature Data

Two water temperature loggers were installed on the Fairford River to monitor the ice producing potential and the residual heat in the water released from Lake Manitoba. The loggers were installed in December 2011 and removed in March 2012. One logger was installed at the Fairford Dam and the other was installed at the old railway bridge. Data obtained from the loggers is provided in Appendix E, Annex E1.

5.2 NUMERICAL SIMULATIONS

5.2.1 Models Applied

VARY-ICE Model

KGS Group applied its in-house numerical model “VARY-ICE” to simulate the winter characteristics of the Fairford River. VARY-ICE was selected due to its ability to model hydrodynamic conditions in a river and account for the upstream progression of an ice cover or jam. A brief description of VARY-ICE is provided in Appendix F.

La Salle Model

The ice studies done by the FIT for the Fairford/Dauphin River system used leading edge techniques and relied to a large extent on the experience of the engineers involved. MIT also requested an independent review and confirmation of the methodology and results of the ice studies. MIT selected, for these purposes, the services of a specialist consultant, Jean-Philippe Saucet, of LaSalle Consulting Group of LaSalle, Quebec.

Mr. Saucet has diverse experience with river ice problems, primarily in Quebec. He used this experience in parallel with the application of a proprietary numerical model of ice processes. That software had been previously developed jointly by the Danish Hydraulic Institute and LaSalle Consulting Group. It operates as a subroutine of the well-known software called Mike 11.

The LaSalle Consulting Group concluded in their November 2, 2011 report entitled, "*Ice Effects on the Fairford River during the Coming Winter*" that "the VARY-ICE model used by KGS incorporated the main ice processes which would control the winter flow of the Fairford River".

The LaSalle Consulting Group concluded in their November 17, 2011 report entitled, "*Numerical Modelling of the Fairford River Ice Conditions during the 2011 – 2012 Winter Season*", that "the results differ somewhat from those presented by KGS. The change of flow is more gradual in early winter and spring, and the minimum flow in the middle of winter is larger. The total volume of water leaving the lake is, however, comparable; and the minimum level reached during winter is the same".

The complete findings of Mr. Saucet on the Fairford River are described in Appendix G, Annex G1. A copy of the model files from Mr. Saucet are provided in Appendix G, Annex G3.

5.2.2 Assumptions Adopted

As described above, the most critical assumption for any calculation of potential ice generation in the Fairford River is how much heat is in the lake outflow. Observation of almost all other major lakes shows that there is some residual heat in the water that must be released into the cold air before ice can begin to form. Examples include the Nelson River at the outlet of Lake Winnipeg, the Churchill River Diversion at the outlet of South Indian Lake, the Reindeer River at the outlet of Reindeer Lake in northern Saskatchewan, the Niagara River at the outlet of Lake Erie, and the Winnipeg River at the outlet of Lake of the Woods.

A parallel assumption is at what point the surface layers of the river flow can begin to form ice. Surface ice generation can occur even though the main body of the flow beneath it is still at temperatures above the freezing point. Flow depths and turbulence of the river flow of course influence this phenomenon significantly.

There are no data records of water temperature in Lake Manitoba, nor are there records of water temperature in the Fairford River. Due to the emergent nature of the project, the water temperature loggers discussed in Section 5.1.3 could only be installed later in the modeling

process, and therefore assumptions for the calculation of ice generation had to be selected from experience elsewhere and from indirect anecdotal evidence.

Three key points influenced the development of this assumption:

1. Photographs from early-winter 2007 indicated that the water exiting from Lake Manitoba showed clear signs of surface ice generation almost immediately below the exit point from under the lake ice cover. This indicated that on the days that the photographs were taken the water temperature was so close to freezing that surface ice formation was immediate.
2. Manitoba Hydro's experience of the Nelson River at the outlet of Lake Winnipeg was that open water can persist for some distance below Warren Landing, but eventually it becomes ice covered later in the winter. This indicates that the residual heat in the water at that point is negligible.
3. Lake Manitoba is shallow. Based on Lake Manitoba depth charts, the average normal depth in the lake is approximately only 5 m. The shallow depths reduce the possibility of stratification of the water body and allow for cooling of the water body to lower temperatures.

It was concluded that the worst case scenario of immediate ice generation within released flow from Lake Manitoba would be entirely possible. Consequently, it was necessary to assume that the temperature of the water releasing from Lake Manitoba would be at the freezing point throughout the winter. Based on past experience, the ice front was assumed to be at the upstream end of Lake Pineimuta on January 1, 2012. This assumption formed the cornerstone of all the numerical analyses done to predict the response of the river to ice formation.

Other assumptions used in the ice model included:

- **Air Temperature** – The air temperature is used to determine the daily volume of ice produced in the area of open water upstream from the ice front. The monthly average air temperature in January and February was assumed to range between approximately -7° and -17° Celsius, which was similar to historic air temperatures recorded in the area.
- **Maximum Froude Number at Ice Jam for Ice Juxtaposition** – The maximum Froude Number at the leading edge of the ice jam required for juxtaposition of ice at the ice front typically ranges from 0.08 to 0.12. The lower Froude Number applies when the incoming ice is comprised of frazil ice particles, and the higher value typically used when the incoming ice is primarily ice pans or floes. A Froude number of 0.08 was used for the Fairford River ice model.
- **The Maximum Velocity for Deposition under the Ice Cover** – The maximum velocity for deposition under the ice cover is 0.6 m/s. Incoming ice is carried under the ice cover when

the Froude Number at the leading edge is greater than the critical Froude Number. That submersed ice is deposited only when the velocity is less than the maximum deposition velocity. The ice cover is scoured out when the velocity exceeds 1.2 m/s.

- **Roughness Coefficient for Ice Jam Cover** – The roughness coefficient for the ice cover varies according to the thickness of the ice cover. The Manning's n-value for the ice cover varied from 0.035 when the ice cover was 0.6 m thick to 0.054 when the ice cover thickness was 4.25 m.
- **Channel Bed Manning's Roughness** – The Manning's n-value for the channel bed was assumed as 0.030.

The VARY-ICE model was run using a constant discharge of 300 m³/s (10,600 cfs). This discharge corresponded to the estimated average outflow from Lake Manitoba during the winter without ice effects in the Fairford River. The VARY-ICE model was used to compute the ice jam progression starting on January 1, 2012. The model assumed a constant discharge throughout the ice simulation period. Since storage routing was not included in the VARY-ICE model, Lake Manitoba water levels continued to rise in response to the increasing head loss from the advancing ice jam. The model was not capable of reducing the discharge due to the increased backwater. The ice thicknesses in the model computed at the end of each day were used in a HEC-RAS backwater model to develop end-of-day stage discharge relationships that were input into the Lake Manitoba flood routing model discussed in Section 4.1. The routing model was then used to determine the storage effects in Lake Manitoba.

5.2.3 Findings

The computed Lake Manitoba water level based on an ice cover forming on the Fairford River starting on January 1, 2012 was included in the November 8, 2011 forecast. The effect of the ice jam on the Fairford River caused the level on Lake Manitoba to rise approximately 0.8 feet, compared to the open water conditions without the ice jam. The results of the simulations showed a reduction in Lake Manitoba outflow from approximately 370 m³/s (13,070 cfs) for the open water conditions to 105 m³/s (3,710 cfs) by January 24, 2012, for the ice jam conditions. Figure 2 shows the stage-discharge relationships for open water conditions and maximum winter ice conditions on the Fairford River. The computed water surface profile of the Fairford River under winter ice conditions at the end of January 2012 is provided on Figure 3.

5.3 OBSERVATIONS IN 2011–2012

The winter of 2011-2012 was extremely mild. Figure 4 shows the trace of degree-days of freezing at Fisher Branch located approximately 90 km south-east of the Lake Manitoba outlet, compared to other recorded years of data, and clearly shows the extent of warm weather that prevailed through the entire season. Water temperature data collected on the Fairford River (Appendix E) showed that the water in the river never declined to zero degrees for extended periods. This had profound effects on the ice development downstream. The formation of ice was minimal and rises in water levels due to ice accumulation did not occur as had been predicted by the numerical models using conservatively severe assumptions.

To document ice conditions during the winter of 2011-2012, a time lapse camera was installed on the Fairford River at the old railway bridge and collected photos every 30 min between November 29, 2011 and March 22, 2012. The photos are provided in Appendix H, Annex H1. Air photos and Satellite Imagery were also collected periodically during the winter. The air photos are provided in Appendix H, Annex H1. The satellite imagery is provided in Appendix H, Annex H2.

6.0 DAUPHIN RIVER

6.1 ICE REGIME AND HISTORICAL OBSERVATIONS

The Dauphin River slopes relatively gently over the first 40 km from its source at Lake St. Martin, with a gradient of about 0.3 m per 1000 m. This is comparable to many slowly moving streams in the flat topography of central Manitoba. However, it then steepens significantly over the next 10 km to a gradient that averages about 1 m per 1000 m of length, and in short portions of that reach, approaches 1 m per 700 m of length. Even in the last few kilometres where the river enters Lake Winnipeg the river slope remains steep. Flow velocities typically range between 0.5 to 1.5 m/s, irrespective of flow, over the first 40 km and increase to approximately 2 m/s over the next 10 km.

This wide variation in slope of the river results in widely varying ice conditions. In the upper river, the sluggish flow can develop an ice cover due to border ice advancement, skim ice formation, and bridging of moving slush ice between border ice edges, even before the ice cover advances from downstream.

In the steep lower part of the river where the velocities are high, the river surface typically cools to freezing in early November. At that point, frazil ice begins to generate and coalesce into slush ice pans that travel down into Lake Winnipeg. The surface of Lake Winnipeg typically ices over in the area of the Dauphin River mouth by early November. At that point, the slush ice being delivered by the Dauphin River begins to amass at the river mouth and back up the water levels. This is the classic formation of a hanging ice dam, and would be expected to occur at this location when river flows are greater than about 70 m³/s (2,470 cfs) and velocities are greater than approximately 0.5 m/s.

In the late fall of 2010, the river flow was in the order of 200 m³/s (7,060 cfs). The ice cover advanced from Lake Winnipeg, being supplied continuously by a steady inflow of slush ice. Water levels were estimated to have risen over 2 m as the ice cover formed and stabilized. Photographs of the river ice were supplied by local residents and are shown in Appendix D, Annex D3. These photos showed recognizable landmarks such as roads, therefore, the water levels occurring at that time could be estimated. In addition, MIT provided notes on ice

conditions in the Dauphin River taken from 2007 to 2011. It was reported that the road near Cranberry Creek was overtopped by November 21, 2010, which provided more evidence of the rising stage of the river with the ice cover advancement. A copy of the notes on Dauphin River ice conditions is provided in Appendix D, Annex D4.

In spite of the high flow in the Dauphin River, the water and ice levels did not exceed the bankfull stage in the Dauphin River communities and no serious damages occurred in 2010. Upstream, water did exceed bankfull stage and flooded part of PR 513 and an access road west of the Dauphin River community, but only at a few minor locations.

MIT reported that the river developed a full ice cover extending from Lake Winnipeg to Lake St. Martin by mid-December in 2010. Only minor short reaches of open water remained by that time.

This mode of ice formation and advancement, or variations of it, occurs every year, and affects the discharge capacity from Lake St. Martin. MWS has estimated that in previous years, with normal river flow conditions, the stage-discharge relationship at the outlet of Lake St. Martin rises approximately 60 cm due to the formation of the ice cover.

A further remark from local residents was also important. It was stated that there had been no flooding in the communities due to ice jams or ice cover formations in the recorded history of the communities.

There are no records available on conditions during spring ice breakup. However, local observers have indicated to KGS Group that the ice typically releases slowly and ice jams are not of particular concern in spring.

6.2 INFLUENCE BY RECORD FLOOD FLOWS AND LSMEOC

The record-setting flood runoff in the spring and summer of 2011 caused severe flood conditions on Lake Manitoba, the Fairford River, Lake Pineimuta and on Lake St. Martin. The effects had not subsided by the early fall of 2011 and flows were still in excess of 600 m³/s (21,190 cfs) in the Dauphin River.

The Government of Manitoba took proactive steps to plan and construct an emergency outlet channel from the northeast end of Lake St. Martin to Big Buffalo Lake at the headwaters of Buffalo Creek. The flow from Big Buffalo Lake and Buffalo Creek discharged into the Dauphin River approximately 5 km upstream of Lake Winnipeg. This channel (called "Reach 1") was constructed and opened to pass flow on November 1, 2011. The increase in the total outflow from Lake St. Martin via Reach 1 assisted in the lowering of the high Lake St. Martin water levels.

The lower Dauphin River was already exposed to unprecedented early winter flows prior to the opening of Reach 1. The releases from Reach 1 were only expected to temporarily increase the flow in the lower river during the first few weeks of operation until Lake St. Martin water levels receded to a level where its outflow was approximately equal to its inflow. Regardless of the opening of Reach 1, the projected flows in the lower Dauphin River would result in unprecedented water and ice levels within the Dauphin River communities. The Frazil Ice Team predicted that water and ice staging levels could potentially cause flooding in the Dauphin River communities in 2011.

Protection of the infrastructure at the Dauphin River communities would be required. A dike was planned to be built in parallel with the Reach 1 construction so that by the time the ice conditions commenced, there would be preventive measures in place to minimize damage along the river. It was this scenario that formed the main focus of the ice studies and is described in the sections that follow.

6.3 DATA SOURCES

6.3.1 River Bathymetry

Field surveys were carried out on the Dauphin River by KGS Group from June 29 to July 2, 2011 to capture bathymetry data for the model. The surveys covered the entire river extending from the Lake St. Martin outlet to the mouth at Lake Winnipeg. Plan drawings showing the extent of the survey are provided in Appendix C, Annex C3. The raw bathymetric data is provided on the Data DVD.

6.3.2 Water Temperature Data

Water temperature loggers were installed on October 19, 2011 in the Dauphin River and Lake Winnipeg near the Dauphin River community to be used as an indicator of when ice would start to be generated and accumulated. Data obtained from the loggers as well as a plan showing their location is provided in Appendix E, Annex E2. The loggers were removed while ice developed on the lake and in the river in late November.

6.3.3 River Observations

Open Water

Prior to 2011 open water levels along the Dauphin River were not recorded, except at the Water Survey of Canada gauge located at approximately the midpoint between Lake Winnipeg and Lake St. Martin.

During the 2011 event, MIT regularly surveyed water levels along the Fairford and Dauphin Rivers at over 15 separate locations. A copy of the data provided by MIT is attached in Appendix I, Annex I1. The data provided was collected from October 2011 to March 2012, during open water conditions and also during the winter when ice effects were present. Additional data collected on May 19, 2011 was also provided when the estimated flow in the River was approximately 420 m³/s (14,830 cfs) and was used for the calibration of the model. Table 2 shows the water levels measured on May 19, 2011. The measured water levels are also plotted on the profile provided on Figure 7 and discussed in Section 6.4.2.

TABLE 2
MEASURED DAUPHIN RIVER WATER LEVELS ON MAY 19, 2011
420 M³/S (14,830 CFS)

Location ID	Dauphin R. Station (m)	Water Surface Elevation (m)
Gauge 8	0	244.97
Gauge 9	7251	244.54
Gauge 10	11780	243.77
Gauge 11	26721	238.78
Gauge 12	31319	237.04
Gauge 13	32295	236.96
Gauge 14	35579	235.65
Gauge 15	38692	234.83
Gauge "Reserve"	52015	218.12

KGS Group also undertook field surveys in June and July of 2011 that included both the bathymetric surveys described in Section 6.3.1 and water surface profiles that could be linked to river discharge measurements. Figure 5 shows the river profile measured during the June and July 2011 survey. The flow at the time of the survey was approximately 565 m³/s (19,950 cfs).

Winter

As described in Section 6.1 above, KGS Group used photographic and anecdotal evidence to reconstruct the water levels that occurred in the winter of 2010-2011. Table 3 shows the estimated maximum water levels that occurred at five different locations in November 2010 at a river flow of approximately 190 m³/s (6,710 cfs).

TABLE 3
ESTIMATED MAXIMUM DAUPHIN RIVER WATER LEVELS WITH ICE
190 M³/S (6,710 CFS)

Station (m)	Elevation (m)
2000	244.85
27700	238.5
48200	224.8
49300	222.3
49700	221.8

Water levels were also surveyed by KGS Group along the Dauphin River communities during the ice formation period between November 20 and December 17, 2011 as well as January 6, 2012. A copy of the data is provided in Appendix I, Annex I2. Three monitoring stations were initially selected for the survey, which was increased to nine stations as ice conditions developed in the river. Due to impeding ice formations, water levels could not be surveyed daily at all locations. Water levels could not be surveyed after January 6, 2012, due to restricted access and flooding of PR 513.

Spring Breakup

There are no known water level observations of ice conditions in spring.

6.3.4 Historical Stage-Discharge Relationship

Open Water

Figure 6 shows the estimated stage-discharge relationship for the Dauphin River at the outlet of Lake St. Martin under open water conditions. This was developed over years of observations by MWS and formed a sound basis for the studies of the flood conditions of 2011.

Winter

As described in Section 6.1, ice can significantly affect the open water levels displayed in Figure 6. The estimated winter stage-discharge relationship for the Dauphin River at the outlet

of Lake St. Martin is also shown on Figure 6, and was developed by MWS based on years of winter observations. The historical flows used to develop the winter stage discharge relationship were much lower than the flows that were expected during the winter of 2011-2012.

6.4 NUMERICAL MODELING OF RIVER ICE CONDITIONS

6.4.1 Model(s) Applied

RIVICE

History

In late 1989, a group of consulting engineering firms prepared an unsolicited proposal for the development of a non-proprietary numerical model of river ice processes. A group of client companies and agencies formed a Steering Committee to administer the process of program development. A “design report” was submitted in 1992 that outlined the basic intent of the computer model, and after discussions with the Steering Committee, preparation of programming instructions defining the implementation of the new software commenced. A subsequent report was submitted including flowcharts and detailed line-by-line programming instructions. The development of the program code was undertaken by the programming group at Environment Canada. Individual subroutines were developed first, and were tested with sample input. However, the amalgamation of the entire program proved to be difficult and by 1995, a successfully working model had not yet been developed. At that point, the project went into abeyance, although some funds remained in the pooled financial support that had been raised for the project by the client organizations.

In 2003, KGS Group was approached by Environment Canada to complete the software. One of KGS Group’s lead engineers had participated in the original development work and had a working knowledge of the software.

By late 2008, the concept was essentially proven to be workable and several test cases had been run. The version of RIVICE that emerged from this process was similar in functionality to what had been envisaged by the original developers, but differed in one major aspect. This was the abandonment of a separate “driver” for the program and adoption of the driver logic that was

already embodied in the parent software “ONED”, which had been in use at Environment Canada for several decades.

Manitoba Water Stewardship has been experimenting with the “beta-version” of RIVICE since 2007. MWS’s experience with this model was reasonably successful for their studies of ice jams during breakup and formation in the lower Red River. As a result MWS promoted the use of the model for studies of the Dauphin River, in collaboration with KGS Group.

Model Objectives

The basic objectives of RIVICE are to:

- Permit the simulation of river ice cover development, primarily in swift rivers that do not permit the formation of a smooth, stable, thermally developed ice cover like that on a lake.
- Apply the most current understanding of the ice processes involved, and allow the user the flexibility of choosing optional means of representing ice development.
- Permit representation of the hydrodynamic effects of changing flows and the influence of the ice cover evolution on the changes in river flow.
- Provide a framework for the insertion of user developed subroutines that could be adopted in lieu of the logic that has been developed for RIVICE. Specific examples would be:
 - o heat loss from open water,
 - o rate of ice generation, or rate of ice cover melting when the incoming water temperature exceeds zero degrees Celsius,
 - o criteria for the stability of ice approaching the leading edge of an ice cover, the mechanism that governs whether ice entrained in the flow beneath an established ice cover will deposit on the ice under-surface, or continue to be transported downstream with the flow,
 - o border ice formation and breakup,
 - o estimation of roughness characteristics of the under surface of the ice cover,
 - o estimation of transport characteristics of entrained ice within the flow under an ice cover,
 - o calculation of the ability of a fragmented ice cover to resist the hydraulic loads imposed upon it, and thickening to become stable.

Numerical Model Used by LaSalle Consulting Group

As discussed in Section 5.2.1, the ice studies done by the FIT for the Fairford/Dauphin River system used leading edge techniques and relied to a large extent on the experience of the study engineers on that committee. MIT retained the services of Jean-Philippe Saucet, of LaSalle Consulting Group, to conduct an independent review and confirmation of the key aspects of the ice studies.

The findings of Mr. Saucet on the Dauphin River are described in Appendix G, Annex G2. A copy of the model files from Mr. Saucet are provided in Appendix G, Annex G3.

6.4.2 Assumptions for Modeling

Lake Winnipeg Water Levels

Water levels on Lake Winnipeg during the late fall 2011 were obtained from Water Survey of Canada. Projections of the water levels during the winter were provided by Manitoba Hydro.

At the time the studies were being conducted in September, 2011, the water level on Lake Winnipeg was approximately El 218.5 m (717 ft). The projection by Manitoba Hydro was that the lake levels would subside to approximately El 217.5 m (714 ft) by the spring of 2012. This range of the levels became the basis for the simulations at the lower end of the Dauphin River.

Hanging Ice Dam at Dauphin River Outlet

Even with the relatively high water level on Lake Winnipeg, the velocity of flow in the river at the outlet of the Dauphin River was expected to be much greater than 1 m/s in the fall of 2011. This could prevent the normal formation of a stable ice cover. An ice cover would, however, be able to develop on the quiet waters of Lake Winnipeg beyond the river release point. Incoming slush ice from the swift turbulent river would be driven under the lake ice. The submersed ice would be carried to points in the lake where the lower velocity would allow the ice to deposit on the underside of the lake ice. This is the classic formation process for a “hanging ice dam”. Hanging ice dams typically develop to such an extent as to impede the flow under the ice and cause

significant rises in the upstream water levels at the leading edge of the ice cover. As the water level at the leading edge of the ice cover rises, the local velocity at the leading edge is reduced below the critical value for upstream progression of the cover, which then allows the ice cover to advance in an upstream direction.

Examples of hanging ice dams at other locations include the hanging ice dam that typically forms in winter in the deep pool of the Niagara River beneath Niagara Falls. Ice thicknesses in excess of 40 m have been observed in this pool. A comparably scaled hanging ice dam forms each winter at Muskrat Falls on the lower Churchill River in Labrador and typically accumulates ice that exceeds 45 m in thickness, and raises river water levels by as much as 10 m.

The following criteria for the assessment of the hanging dam at the mouth of Dauphin River was based on KGS Group's experience with this ice formation process, and knowledge of the stable limits of ice deposition:

1. The rate of inflow of ice from the Dauphin River into Lake Winnipeg was estimated to reach $5 \text{ m}^3/\text{s}$ (175 cfs) when the air temperature decreases below -20°C for several days at a time. Under more extreme winter conditions concurrent with strong winds, the rate of incoming ice could be as high as $10 \text{ m}^3/\text{s}$ (350 cfs). At this rate of ice inflow, it was estimated that a deposit of ice in the shape of an inverted sector of a cone could reach major proportions within a short period of time.
2. With a rapid rate of ice delivery, it was estimated that ice deposition at the hanging ice dam would occur with velocities of about 0.8 to 1.0 m/s. At this limiting condition, the hydraulic gradient within the hanging dam was estimated to be potentially 1 m vertical in 1000 m horizontal, and possibly as much as 1 m in 700 m.
3. Based on the combination of the parameters described in points 1 and 2, it was concluded that the local rise in water level at the mouth of the Dauphin River would occur as required to allow the ice cover to accumulate and progress up the river. Separate analyses of the velocity and Froude number at the river mouth indicated that a stage at that location of about El 218.5 m for a projected river flow of $600 \text{ m}^3/\text{s}$ (21,190 cfs) would allow the ice to progress. This became the basis for the starting elevation for the simulations of ice progression along the Dauphin River. There was no attempt to mathematically represent the formation of a conical shape of ice deposition in the bay beyond the river. It was accepted that the limitations in the scientific knowledge of this highly two-dimensional process would make it difficult to credibly represent the phenomenon with a one-dimensional numerical model.

Controlling Ice Characteristics

Winter

A number of ice processes can be represented by RIVICE. Each process is controlled in the software by a selection of site-specific characteristics. Some processes that were not specifically included in the simulations of the Dauphin River using RIVICE included:

1. Border ice advancement – a worst case scenario was adopted that maintained fully open water without border ice advancement.
2. Bridging of the incoming slush ice cover at narrow channel locations – there were no means to reliably predict these closures, so the process was excluded from the simulations.
3. Stability of the ice cover to resist shoving at the leading edge of the ice cover advancement – this was deemed not to be of dominant importance in the process because of the rapid influx of ice and the rapid telescoping of the ice cover to reach a stable ice thickness within the ice cover downstream of the leading edge.

The key factors that were adopted for the Dauphin River simulations including the maximum Froude number at ice jam for ice juxtaposition, the maximum velocity for deposition under the ice cover, and the roughness coefficient of the ice cover were similar to those adopted for the VARY-ICE simulations of the Fairford River, as discussed in Section 5.2.2.

These parameters were selected to allow the RIVICE model to first represent the known open water conditions and the estimated ice conditions that had occurred in the late fall of 2010. They were also considered appropriate for the worst case conditions that may have occurred with the flows that would prevail in the winter of 2011-2012.

Figure 7 shows the computed open water profile for a river flow of 420 m³/s (14,830 cfs). This discharge was the flow at the time of the water level measurements provided by MIT (May 2011). This condition formed the basis of the channel hydraulics for the simulation of the ice processes.

Figure 8 shows the estimated peak water surface profile in the lower Dauphin River in November 2010, when the river flow was estimated at 190 m³/s (6,710 cfs) compared to the computed water surface profile using RIVICE at the same flow. The match between the

computed water levels and actual water levels appeared to be reasonably good. The model was deemed to be reasonably well calibrated for conditions similar to those that prevailed in 2010. However, it was recognized that the flows that would be occurring in early winter 2011-2012 would be significantly greater than in the previous year. The projections by RIVICE for the much higher flows expected in 2011-2012 would be approximations at best, and considerable safety factors should, therefore, be incorporated in any water level predictions used for the design of dikes.

Spring Breakup

Since there were no historical measurements of ice staging during the spring breakup, there was some degree of uncertainty whether the spring ice breakup can trigger the formation of a fragmented ice jam, and what volume of ice would be expected from ice runs upstream. Precise prediction of these factors is not possible. As a result, KGS Group selected a design criterion that was considered reasonably extreme, but not impossible to occur, based on judgment developed from experience. The following scenario was developed for the prediction of water levels in the lower river:

- Rapid release of ice cover in the upper Dauphin River and sudden increase in river flow in the Dauphin River due to the resumption of open water conditions at the outlet of Lake St. Martin. A peak flow of approximately 1,000 m³/s (35,310 cfs) was estimated from hydraulic studies of the outlet from Lake St. Martin. The peak flow was highly dependent on the level of staging on Lake St. Martin during the winter.
- Formation of an ice jam with an upstream limit approximately 4 km upstream of the confluence with Lake Winnipeg.
- Spring ice jam formation assumed to have the same ice characteristics as those for the winter ice cover formation, as described above.

Air Temperatures

Detailed air temperatures were not necessary for the purposes of simulating the ice development on the Dauphin River. Based on information from previous years, it was known that the volume of frazil ice generated on the river surface was large and that ice development occurred within weeks from the onset of winter. Detailed consideration of the winter severity (i.e. air temperatures) was not needed for the simulations.

For the upper river, the uncertainty in border ice coverage and the surface area of open water that would be exposed was so large it was considered futile to do a detailed accounting of ice volumes that could be generated. As a result, it was considered impractical in the short time available to undertake a detailed analysis of atmospheric temperatures. It was therefore assumed that the ice cover would be capable of being formed during the winter, regardless of the variation in temperatures that may occur. This decision was supported by observations from the previous winter of 2010-2011, and to be conservative in this important aspect of the studies.

6.4.3 Findings

Lower Dauphin River

A total of seven scenarios were modeled for the Lower Dauphin River and are summarized in Table 4.

TABLE 4
SUMMARY OF LOWER DAUPHIN RIVER RIVICE MODEL SCENARIOS

Scenario	Description	Inflow from Upper Dauphin River		Inflow from Buffalo Creek		Total Flow	
		m ³ /s	cfs	m ³ /s	cfs	m ³ /s	cfs
1	Early Freeze Up (2011)	420	14,720	80	2,900	500	17,620
2	Best Estimate Freeze Up (2011)	335	11,790	65	2,370	400	14,160
3	Late Freeze Up (2011)	304	10,750	61	2,150	365	12,900
4	Spring Break up at Q = 700 m ³ /s	700	24,720	0	0	700	24,720
5	Spring Break up at Q = 1000 m ³ /s	1000	35,310	0	0	1000	35,310
6	Spring Break up at Q = 444 m ³ /s	297	10,490	147	5,190	444	15,680
7	Early Freeze Up (2012)	269	9,500	0	0	269	9,500

In 2011, the water level as the ice cover developed was projected to increase by up to 4 m depending on the scenario and location along the river. The projected water surface profiles for the different ice formation simulations (Scenarios 1 to 3) are provided in Figures 9 to 11.

The simulation of a potential ice jam during a rapid severe spring melt season showed that water levels could exceed those estimated for the formation phase. Figures 12 to 14 show the results of the analyses for spring ice jams (Scenarios 4 to 6).

As discussed in Section 4.2.2, results from the simulations described above were used for selecting the crest elevations of the dikes. In addition, the dikes were designed to have 0.6 m of freeboard above the water surface profile for Scenario 1 plus a 0.7 m allowance to consider the potential effects of an ice jam during a rapid severe spring melt (the spring ice jam scenarios were not complete during the dike design phase).

During the construction of the dikes, it was decided to top up the dikes locally to provide a minimum freeboard of 0.6 m for Spring Scenario 4 at all locations. A table is included in Appendix J, which shows the tendered dike elevation, required “top up” during construction and as-built elevations. The estimated water surface profile with ice along the dikes, as well as the freeboard for each dike condition, is included in the table. The as-built elevation of the dikes is included on Figures 9 to 14.

As discussed in Section 4.2.1, Scenario 7 was modeled to simulate the ice formation period in 2012. The projected water surface profile for this scenario is shown in Figure 15. Inundation maps for the Dauphin River communities were generated based on the results of Scenario 7, assuming that the dikes were completely removed. A copy of the maps is provided in Appendix K, Annex K1. The results from Scenario 7 showed that there would be no flooding of buildings within the communities.

Upper Dauphin River

The upper Dauphin River is particularly difficult to represent with a numerical model for the following reasons:

- The ability to predict border ice advancement and the reduction of the open water area capable of generating frazil ice is crude at best. Consequently, it was assumed that the open water area would be at a maximum and the ice generated would be sufficient to cause the formation of significant ice dams. The estimated maximum profile that was computed for Scenario 1 outlined in Section 6.4.3 (Early Freeze up (2011)) is shown in Figure 16.

- Storage routing could not be analyzed with the model. The model computes water levels during the ice staging process that would equate to significant rises in the level on Lake St. Martin. The flood routing effect would cause lower flows to occur than were used in the ice calculations. Routing effects were modeled separately as described in Section 4.1.
- It also ignores the effects of erosion of the ice cover as the winter progresses, especially under conditions with frequent warm spells.

KGS Group, therefore, applied judgment to the results of the theoretical simulations, based on the observations from previous years and past experience with other rivers of similar characteristics, to reduce the maximum staging to consider the ameliorating effect of border ice advancement and the gradual erosion of ice dams that would occur during the winter. The peak winter rating curve that would be expected at the outlet of Lake St. Martin is shown on Figure 17, and is compared to the rating curves provided by MWS provided in Figure 6. This rating curve was used in the routing models to determine winter water level forecasts discussed in Section 4.0.

At the request of MIT, KGS Group also plotted the water surface profile for Scenario 7 outlined in Section 6.4.3 and projected the pre-2011 and post-2011 upgraded PR 513 profile to the river stationing to identify the location of potential flooding. This is shown on Figure 18. The open water levels surveyed in July 2011 are also shown on the figure.

The results showed that PR 513 was raised above the peak summer open water levels in 2011 to provide construction access to the downstream communities. However, winter ice staging could still cause localized flooding of PR 513, depending on weather conditions and the magnitude of Dauphin River flows. It should be noted, however, that there may be some discrepancy in the estimated water levels due to the projection of the highway profile to the river stationing.

6.5 OBSERVATIONS IN 2011–2012

6.5.1 Lower Dauphin River

The winter of 2011-2012 was exceptionally warm. Figure 4 shows the degree-days of freezing at Fisher Branch, located approximately 90 km south-east of the Lake St. Martin outlet, compared to other recorded years of data. The total degree days of freezing for the 2011-2012

winter were the lowest of the previous thirty years on record. The ice development during the winter was significantly affected by this, not only on the timing of the occurrence of the ice cover, but also the maximum staging during the formation process.

As discussed in Section 6.3.3, KGS Group surveyed water levels along the Lower Dauphin River during the winter of 2011-2012; and the data is provided in Appendix I, Annex I2. Figure 19 shows the surveyed water level for all nine monitoring stations. In general, the mild temperature conditions allowed the ice cover to form and stabilize at lower water levels than predicted under normal conditions. Nevertheless, water level staging of 3 to 4 m was measured at some locations. At Stations 8 and 9, it appears that the peak water level was not measured and that staging likely occurred before the monitoring began at the two stations. Also since the frequency of the measurements were not continuous, it is possible that the peak water was not measured at the other monitoring locations. The peak water level may have occurred either between two measurements or possibly later in the winter. The monitoring program ended on January 6, 2012. At that time, the ice front was located just upstream of Buffalo Creek; therefore, it was possible that additional staging at monitoring Stations 3 and 5 could still occur.

Figure 20 shows the peak water level surveyed by KGS Group and the computed maximum profile in the lower Dauphin River for Scenario 2. This scenario was selected for the comparison as the simulated discharge of 14,160 cfs was the closest to the 15,500 cfs that occurred during the survey period.

In spite of the extremely mild conditions that occurred in the winter, the observed peak levels compared closely to the predicted levels for the ice formation event. At Stations 8 and 9, the maximum surveyed water level is shown to be lower than the simulated results. However, as discussed above, it is possible that the peak water level may not have been captured at this location. It was, therefore, assumed that the actual peak water level that occurred at Stations 8 and 9 was equal to the water level obtained from the results of Scenario 2, due to the similarity in peak surveyed water levels and modeled results at adjacent monitoring stations. A best estimate of the maximum water surface profile that occurred in 2011 during the ice formation stage, based on the surveyed water levels and model results from Scenario 2, is shown on Figure 20.

Nevertheless, even with the warm winter, the recorded water levels were sufficiently close to the calculated worst case scenario that the construction of the dikes was shown to be clearly well justified. Inundation maps for the Dauphin River communities, for the condition without the dikes were generated from the best estimate of the maximum water surface profile described above. This is shown in Appendix K, Annex K2. On the maps, a 0.6 m high buffer was included above the water surface profile to account for the potential of ice being pushed up the shoreline. The results showed that had the dikes not been built, flooding would have occurred in the communities, and many other properties would have been at risk due to ice shoving on the shoreline.

Two time lapse cameras were installed on the Dauphin River: one in the Dauphin River community, and the other near the Buffalo Creek outlet, to monitor the formation and breakup of the ice cover during the 2011-2012 winter. Photos were taken every 30 minutes between November 16, 2011 and March 28, 2012, with the exception of a period when the batteries could not be recharged due to access difficulties. The photos are provided in Appendix H, Annex H1. Air photos and Satellite Imagery were also collected periodically during the winter. The air photos are provided in Appendix H, Annex H1. The satellite imagery is provided in Appendix H, Annex H2.

6.5.2 Upper Dauphin River

The ice model of the upper Dauphin River considered that a hanging ice dam would form at the foot of Frenchman's Rapids. That process would have required significant local staging before the conditions for ice front progression upstream from Frenchman's Rapids to Lake St. Martin would occur. During the formation of the hanging ice dam, the reach of river from the rapids to Lake St. Martin was assumed to remain open, resulting in the continual production of frazil ice for the formation of the ice dam downstream of the rapids. This assumption was selected to remain conservative in the analysis, since historic ice conditions within this reach were unknown, and to ensure that the results of the model would not underestimate the potential staging in water levels from Frenchman's Rapids to Lake St. Martin.

Due to the extremely mild winter, the advancement of the ice cover from Lake Winnipeg did not arrive at Frenchman's Rapids until mid-January, at least one month later than normal and two

months later than under severe winter conditions. The rate of frazil ice that was produced in the reach from Lake St. Martin to Frenchman's Rapids was generally low. Border ice through this reach, however, did occur, albeit at a generally slow rate. By mid-January, the width of border ice had extended sufficiently to allow bridging of the ice surface at a sharp bend in the river just upstream from the rapids. This allowed a thin ice cover to advance to Lake St. Martin and stop the supply of frazil ice to the hanging ice dam at Frenchman's Rapids. As a result, the ice front never staged through the rapids with essentially open water levels at the head of the rapids.

The actual ice conditions in the upper Dauphin River and its effects on Lake St. Martin water levels turned out to be less severe than had been expected, with a maximum staging of 0.2 m occurring. In summary, the moderate ice effects occurred for the following reasons:

1. The warmth of the winter and the effects it had on the severity of the ice dams that formed from frazil ice production. The weather was so consistently warm the ice dams that formed did not have the impeding effect of flow anticipated from experience elsewhere. However, it is expected that, had the winter been colder than normal, much more severe effects could have been expected.
2. The method by which the ice formed in the upper Dauphin River occurred differently than originally anticipated. As described above, the worst case scenario in which the channel upstream from Frenchman's Rapids remained fully open water without border ice advancement or bridging at narrow or constricted channel locations did not occur. Consequently, it was assumed that maximum open water conditions would exist to produce frazil ice and that the ice front would progress along the entire river, including through Frenchman's Rapids. Instead, during the winter of 2011-2012, portions of the upper Dauphin River formed an ice cover from border ice, and bridging of the ice occurred upstream of Frenchman's Rapids. Due to this condition, the production of frazil ice was less than anticipated; and the ice front did not progress through the rapids.
3. The capacity of the LSMEOC was increased between January 24 and February 1, 2012, by improvements at the channel inlet at Lake St. Martin, as documented in the report provided in Appendix B titled, "*Flow Metering and Water Level Measurement of the Lake St. Martin Emergency Channel System*". On February 1, the improvements were completed which provided additional outflow capacity at Reach 1, and water levels on Lake St. Martin resumed a receding trend.

Figure 21 shows the estimated winter stage-discharge relationship on the Dauphin River at the outlet of Lake St. Martin based on observed conditions in the winter of 2011-2012, the original winter relationship provided by MWS, and the estimated peak winter relationship based on model results.

Using the estimated ice conditions occurring in 2011-2012 as described above, the staging that would have occurred on Lake St. Martin during the winter without the LSMEOC in operation was calculated using the routing model described in Section 4.1 and the computed Lake Manitoba outflow between July 1, 2011 and July 1, 2012. This is shown on Figure 22. As shown on the figure, significant staging would have occurred on Lake St. Martin without Reach 1. These conditions would have been worse if the winter conditions had been normal or more severe than normal.

Based on the 2011-2012 winter experience, it was concluded that a fully advanced ice dam at Frenchman's Rapids that was assumed in the RIVICE ice model was not likely to occur and; therefore, a partial staging at Frenchman's Rapids and a thin cover upstream from the rapids would be the likely scenario. For the purpose of forecasting water levels and discharges during the winter of 2012-2013, the estimated winter rating curve adopted in the routing model was based on 2011-2012 experience.

7.0 REACH 1

7.1 PREDICTED ICE REGIME

Reach 1 was designed with velocities greater than 1.1 m/s and with a Froude number greater than 0.08. As a result, staging of the water level on Big Buffalo Lake would be required before an ice cover could advance upstream in Reach 1. The ice staging on Big Buffalo Lake and the ice cover in Reach 1 was determined using the numerical model VARY-ICE discussed in Section 5.2.1 due to its ability to model hydrodynamic conditions and account for the upstream progression of an ice cover or jam.

7.2 NUMERICAL ICE MODELING

The assumptions used in the numerical model VARY-ICE were similar to those adopted for the Fairford River, as discussed in Section 5.2.2. Other assumptions, which formed the basis of the numerical analyses to predict the ice cover in Reach 1 included:

- The water temperature on Lake St. Martin was assumed to be 0° Celsius on November 1.
- Frazil ice generation was assumed to occur immediately at the entrance to the Reach 1 channel.
- Based on past experience, the ice front was assumed to be at the upstream end of Big Buffalo Lake by early November, 2011.
- The upper Dauphin River would remain ice free at the Lake St. Martin outlet until after the ice cover formed in Reach 1.

Because the VARY-ICE model could not account for the storage effect on Lake St Martin, an upstream boundary condition was based on a predetermined water level on Lake St Martin. The Lake St. Martin water level was first determined by routing outflows from the Fairford River (Lake Manitoba) through Lake St Martin using the open water rating curve in Reach 1 and Dauphin River. The 30-day forecast of Lake St. Martin water levels was then used in VARY-ICE to determine the time varying discharge and the formation of the ice cover for the 30-day forecast period. The 30-day period was used since it was assumed that the ice cover would advance through the channel reach, given the fact that only minor staging of Big Buffalo Lake would be required to satisfy the Froude number criteria for upstream ice advancement.

The final ice cover determined in “VARY-ICE” was then used to define the ice cover thickness for the ice dam at Big Buffalo Lake and in the channel to be used in a HEC-RAS model. The HEC-RAS model with the defined ice cover was then run to estimate an ice cover stage-discharge relationship for Reach 1. This is shown on Figure 23. This relationship was then used for subsequent flood routings for the prediction of ice staging on Lake St. Martin throughout the 2011-2012 winter period. A copy of the HEC-RAS model is included in Appendix L.

7.3 OBSERVATIONS IN 2011–2012

The ice conditions in Buffalo Creek and in Reach 1 were monitored during the 2011-2012 winter. Water levels and discharge measurements taken in Reach 1 are documented in the report provided in Appendix B titled, *“Flow Metering and Water Level Measurement of the Lake St. Martin Emergency Channel System”* by KGS Group.

Additional excavation work at the inlet of Reach 1 occurring between January 24 and February 1, 2012 to complete the plug and “finger” removal towards the barge access channel made it difficult to determine the total effects of the ice on the capacity of the channel. However, as noted previously, the 2011-2012 winter was the warmest on record as measured by the total degree-days of freezing in Fisher Branch. The result was that Reach 1 remained free of an ice cover. Minor border ice developed along the length of the channel. Some frazil ice was produced in the channel, which caused only minor staging downstream of Reach 1 within the area surrounding Big Buffalo Lake; but the staging did not progress to Lake St. Martin.

It is likely that in a winter in which the air temperatures are at least normal, the ice cover would have progressed to Lake St. Martin, as predicted by the ice model. However, the winter rating curve for Reach 1 shown on Figure 23 was generated based on a model calibrated for the capacity of Reach 1 prior to the additional excavation work at the inlet. Further analysis of potential ice conditions in Reach 1 would, therefore, be required should it be operated again in the winter.

8.0 BUFFALO CREEK

8.1 PREDICTED ICE REGIME

Buffalo Creek is a small but steeply sloping channel, which under natural conditions, carries very little flow, especially in winter. The diversion of the flow through the LSMEOC at the outlet of Lake St. Martin resulted in winter flows in Buffalo Creek being several orders of magnitude greater than what would normally occur. Therefore, previous information on ice conditions in the channel was not relevant; and the ice modeling computations could not be calibrated to observed conditions. Input parameters for modeling were based on experience with other rivers. Because the model could not be verified with historical measurements, it was considered reasonable to consider the worst case scenario possible. KGS Group's previous experience on small streams and rivers was applied in the development of the model.

8.2 DATA SOURCES

A combination of LiDAR data and survey data was used to define the channel for the Buffalo Creek models. The survey data was provided by AECOM and extended from the Buffalo Creek inlet (Station 13+600) to approximately 2.5 km downstream (Station 16+100). Cross sections generated from LiDAR data was used downstream of the AECOM survey (Station 16+100) and extended to the Buffalo Creek outlet into the Dauphin River (Station 27+500). Plan drawings showing the extent of the survey are provided in Appendix C, Annex C4.

For modeling purposes, a different stationing system was adopted than the one presented in the appendix. Station 12+500 was set to 0+000 in the model. At the Buffalo Creek outlet into the Dauphin River, Station 27+500 was set to station 15+000 in the model.

8.3 NUMERICAL MODELING

8.3.1 Models Used

The RIVICE software was considered applicable and was used to estimate the worst case scenario of ice effects in this creek. It was assumed that there would be essentially unlimited

volumes of frazil ice generated upstream, and the RIVICE model was used to estimate the hydraulic effects of that ice accumulation. Results obtained from RIVICE were then also used to provide input parameters for a HEC-RAS model of the creek.

The same RIVICE model parameters as described in Section 6.4.2 for the Dauphin River were adopted for Buffalo Creek. The starting/downstream water level at the Dauphin River was assumed to be El 225.0 m (738.2 ft). However, a significant variation to this assumption was determined to have no impact on the ultimate profile computed.

The RIVICE model was originally applied for a discharge of 80 m³/s (2,825 cfs), based on the August 30, 2011 forecast, assuming an early ice formation in Reach 1. Subsequent channel improvements to the Reach 1 channel and further analysis of ice conditions in the outlet channel showed that a discharge of 140 m³/s (4,950 cfs) was possible. This scenario was, therefore, also considered in the analysis of ice effects in Buffalo Creek.

The 140 m³/s (4,950 cfs) scenario was modeled using the US Army Corps of Engineer HEC-RAS software. The ice cover that was included in the model, including the ice cover thickness and Manning's n-value for the ice cover, were taken from the RIVICE model results for the 80 m³/s (2,825 cfs) RIVICE scenario.

8.3.2 Findings

Figure 24 shows the computed maximum water surface profile with ice estimated for a continuous discharge of 80 m³/s (2,825 cfs). Figure 25 shows the computed maximum water surface profile with ice estimated for a continuous discharge of 140 m³/s (4,950 cfs).

An inundation map was prepared for the 140 m³/s (4,950 cfs) scenario and is included in Appendix K, Annex K3. The inundation map showed that there was a significant risk of flooding along many of the proposed Reach 3 alignments. An alternate Reach 3 alignment was, therefore, selected to minimize the risk of flooding by selecting an inlet location further upstream on Buffalo Creek, and by relocating the channel alignment around the area most at risk of flooding. The different Reach 3 alignments investigated are discussed in detail in the *“Reach 3 Design and Construction Report”* by KGS Group.

8.4 OBSERVATIONS IN 2011–2012

The water surface of Buffalo Creek remained essentially free of ice except for minor border ice cover that formed along the entire length of the channel. The extremely mild winter conditions were thought to have reduced the volume of frazil ice produced in the open water. Fluctuations in the water level in the creek during the winter resulted in portions of the border ice cover breaking free, causing an ice bridge to occur in Buffalo Creek approximately 5 km downstream from the Reach 3 entrance location. The ice cover advanced from the ice bridge location, but only for a short distance, and resulted in localized inundation along the creek. Photos of the conditions in Buffalo Creek during the winter of 2011-2012 are included in Appendix H, Annex H1.

Ice formation on Buffalo Creek did not occur as expected. The volumes of frazil ice formed seemed to be influenced by the relatively small exposed area of open water per unit length of the channel. It may also have been influenced by heat sources in the boggy area between Buffalo Creek and the downstream end of the excavated LSMEOC.

Detailed measurements of water levels were not made in Buffalo Creek, but it is expected that the winter water surface profile was not significantly higher than under open water conditions. It is also not clear whether the ice would form as modeled, even if winter temperatures were normal or severe. Further advancement of the technology of predicting ice behavior on such small narrow streams is needed.

9.0 PROJECT COMPLETION

The analysis and monitoring of discharges and ice processes was discontinued in December 2012, shortly after the LSMEOC was closed as required under the federal terms and conditions for emergency operations, at which point this report was prepared to document the efforts for future reference. Additional analysis and monitoring may be required in future if the LSMEOC is made permanent and/or a Lake Manitoba Outlet Channel is to be constructed.

10.0 STATEMENT OF LIMITATIONS AND CONDITIONS

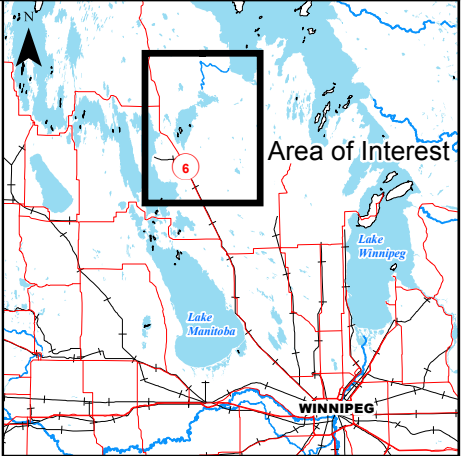
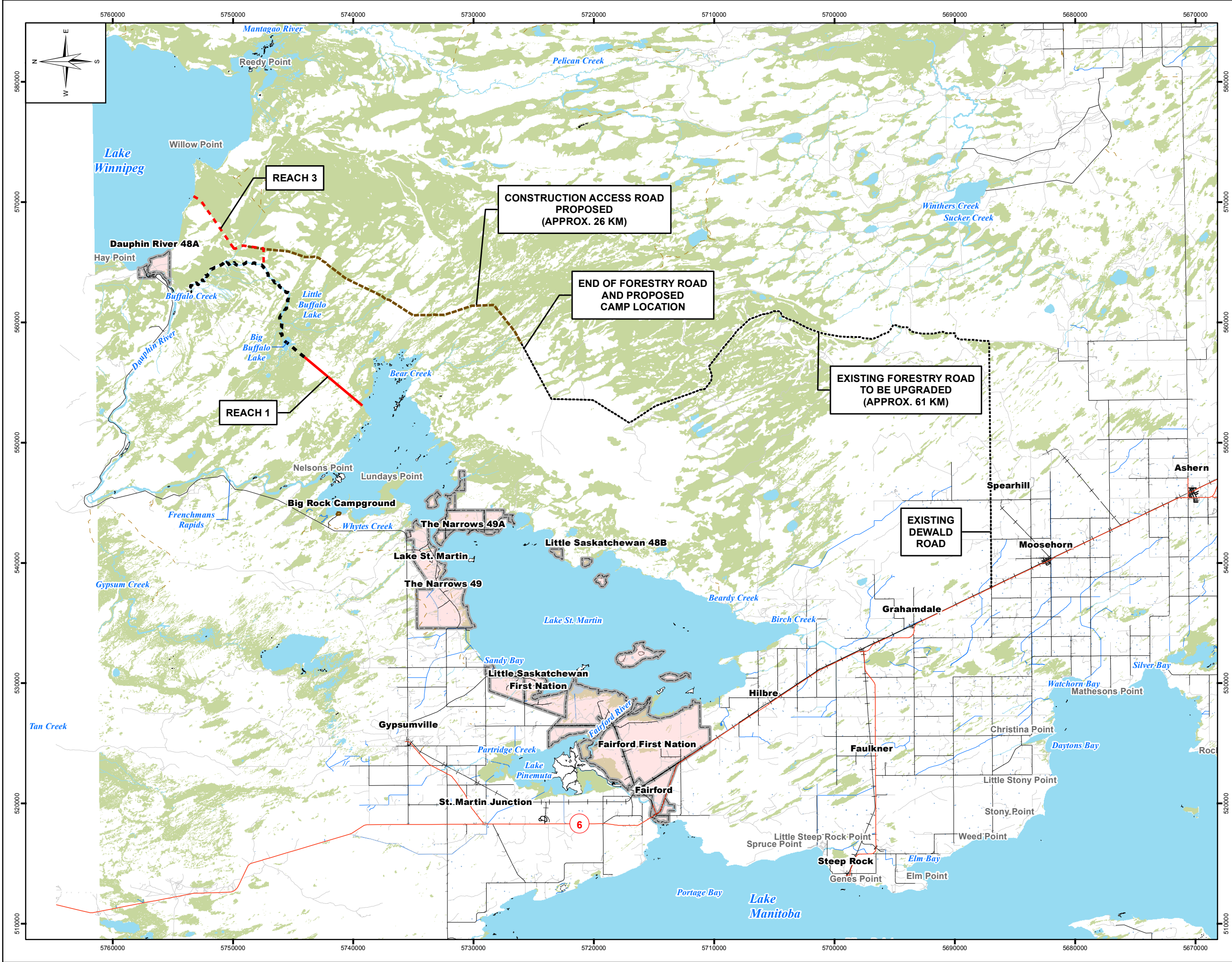
10.1 THIRD PARTY USE OF REPORT

This report has been prepared for Manitoba Infrastructure and Transportation to whom this report has been addressed and any use a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. KGS Group accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions undertaken based on this report.

FIGURES

Portions of data presented are owned by the Province of Manitoba and are produced under the licence agreement with the Province of Manitoba 2013 Queen's Printer.

FileName: P:\Projects\2011\11-0300-18\DWG\GIS\MXD\REV\ICE_PROCESSES_REPORT\11-0300-18-F01_REV0.mxd
11"x17" PLOT SCALE 1:1



LEGEND:

- Proposed Construction Access Road
- Forestry Road
- Reach 3 Emergency Channel (Proposed)
- Buffalo Creek Channel
- Reach 1 Emergency Channel
- Road Paved 2 or more lanes
- Paved Street or Road
- Gravel Road
- Unclassified Road
- Accessway or Backlane
- Trail
- Railway
- Ditch
- River/Stream, Indefinite
- River/Stream
- Dugout, Pond
- Lake
- Marsh
- First Nation
- Campsite



SCALE: 1:300,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

0	14/03/05	ISSUED WITH FINAL REPORT	PAL
NO.	YY/MM/DD	DESCRIPTION	BY

REVISIONS / ISSUE

EMERGENCY REDUCTION OF LMB & LSM
WATER LEVELS - ANALYSIS & MONITORING
OF DISCHARGES & ICE PROCESSES

GENERAL SITE PLAN

MARCH 2014

FIGURE 1

REV: 0

FIGURE 2
Fairford River Stage Discharge Relationships

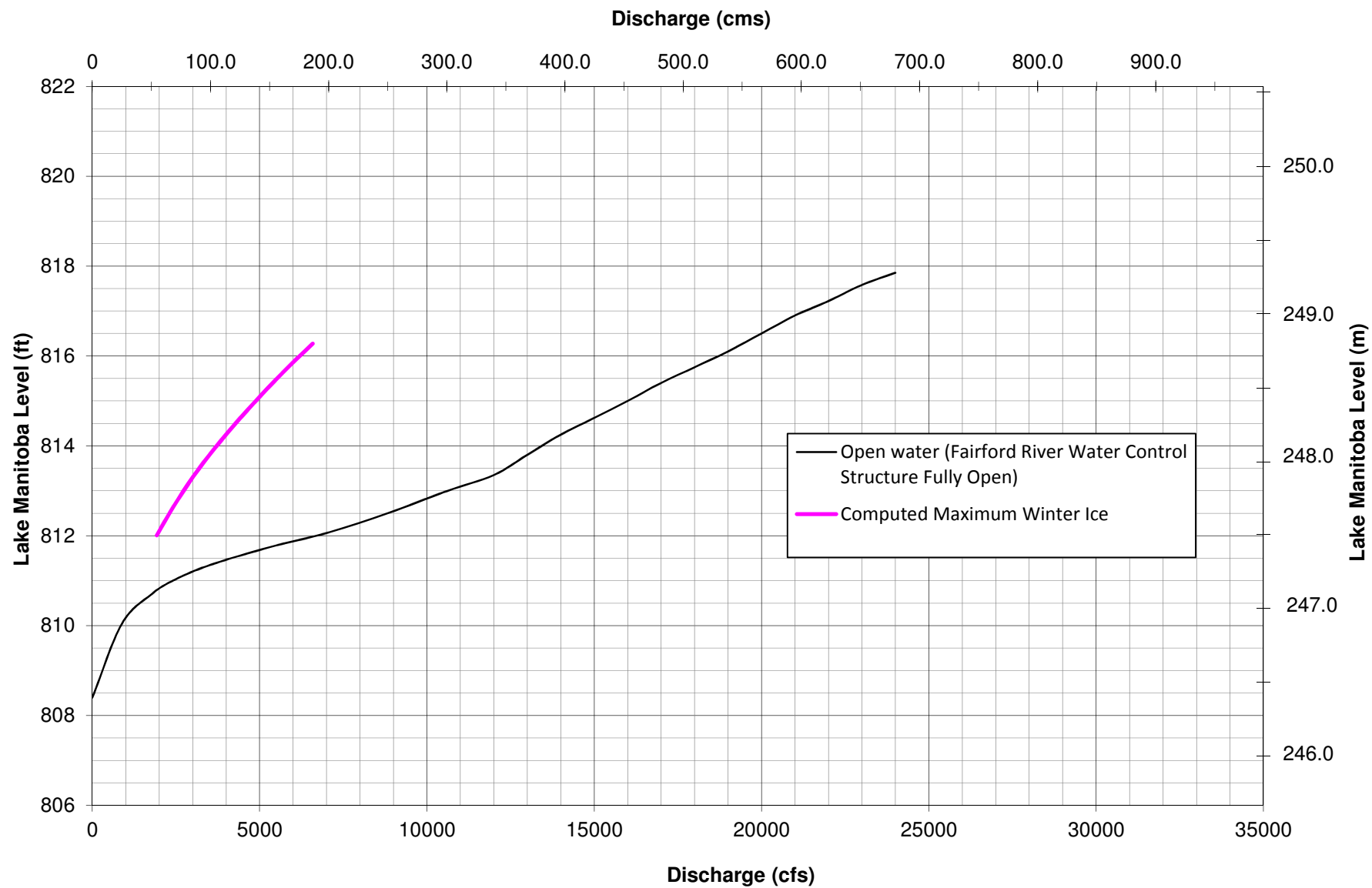


FIGURE 3
Computed Water Surface Profile on Upper Fairford River Under Maximum Winter Ice
End of January 2012

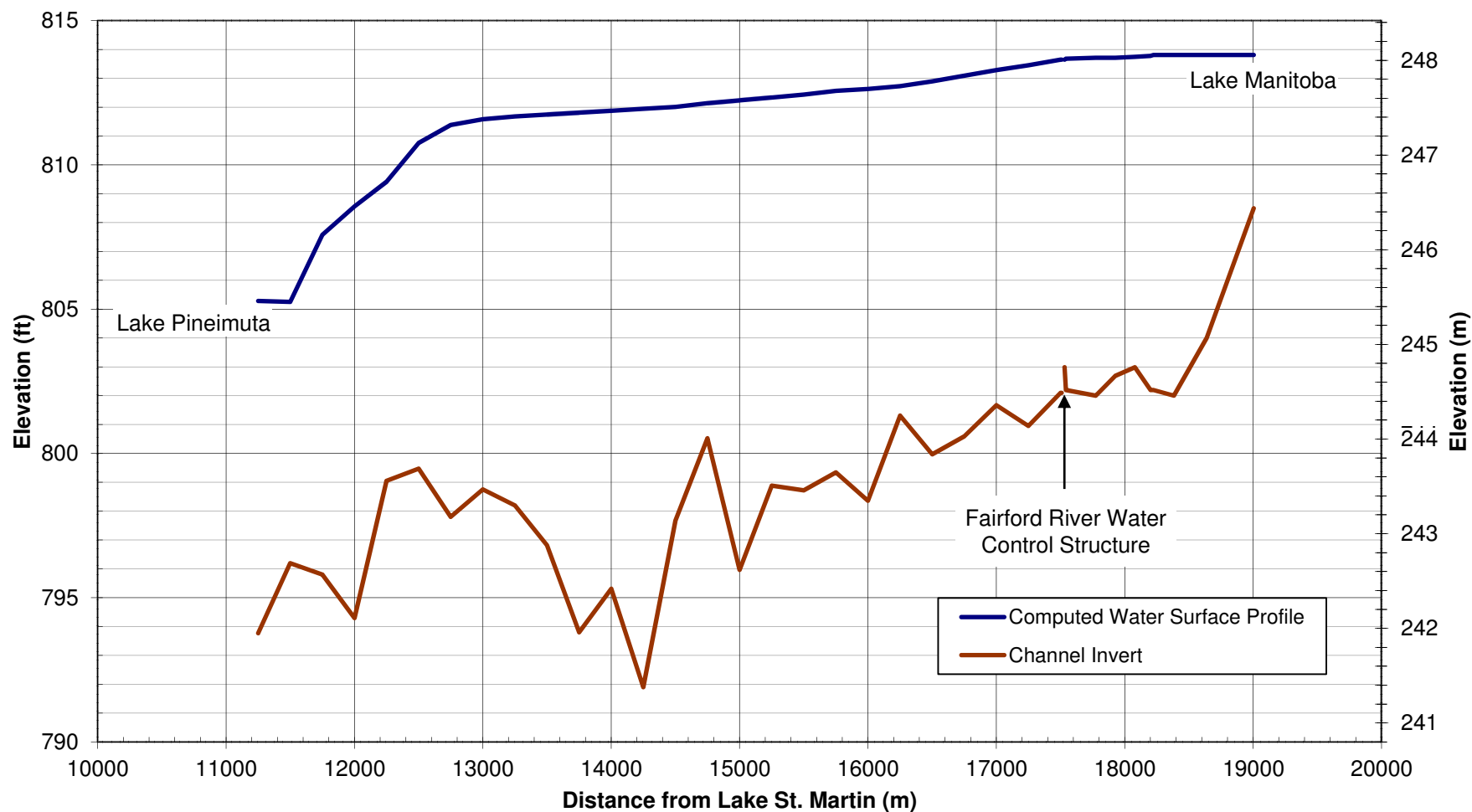


FIGURE 4
2011-2012 Accumulated Degree Days of Freezing in Fisher Branch

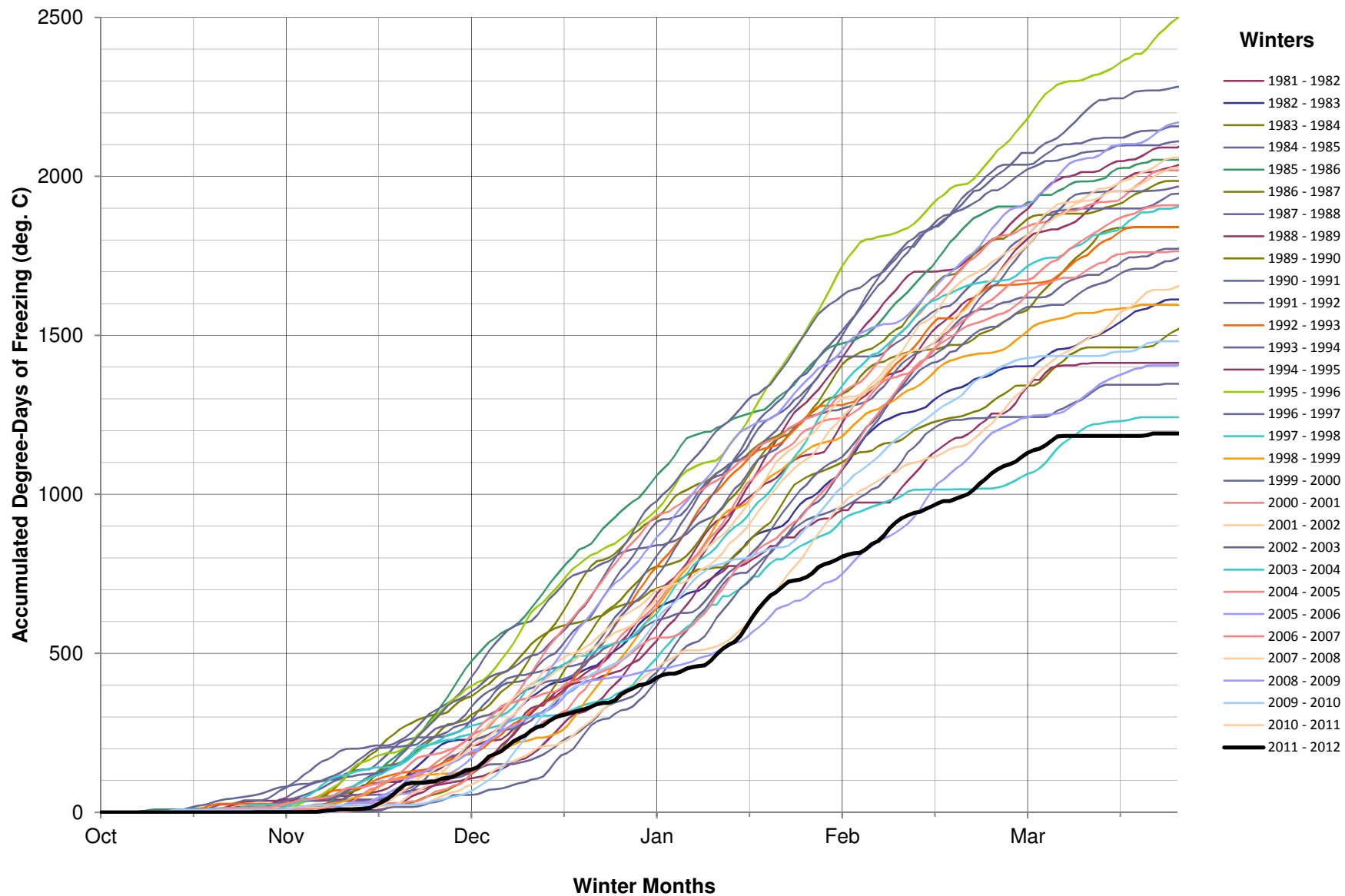


FIGURE 5
Dauphin River Open Water Surface Profile
June 29 - July 1, 2011 Survey - 565 cms (19,950 cfs)

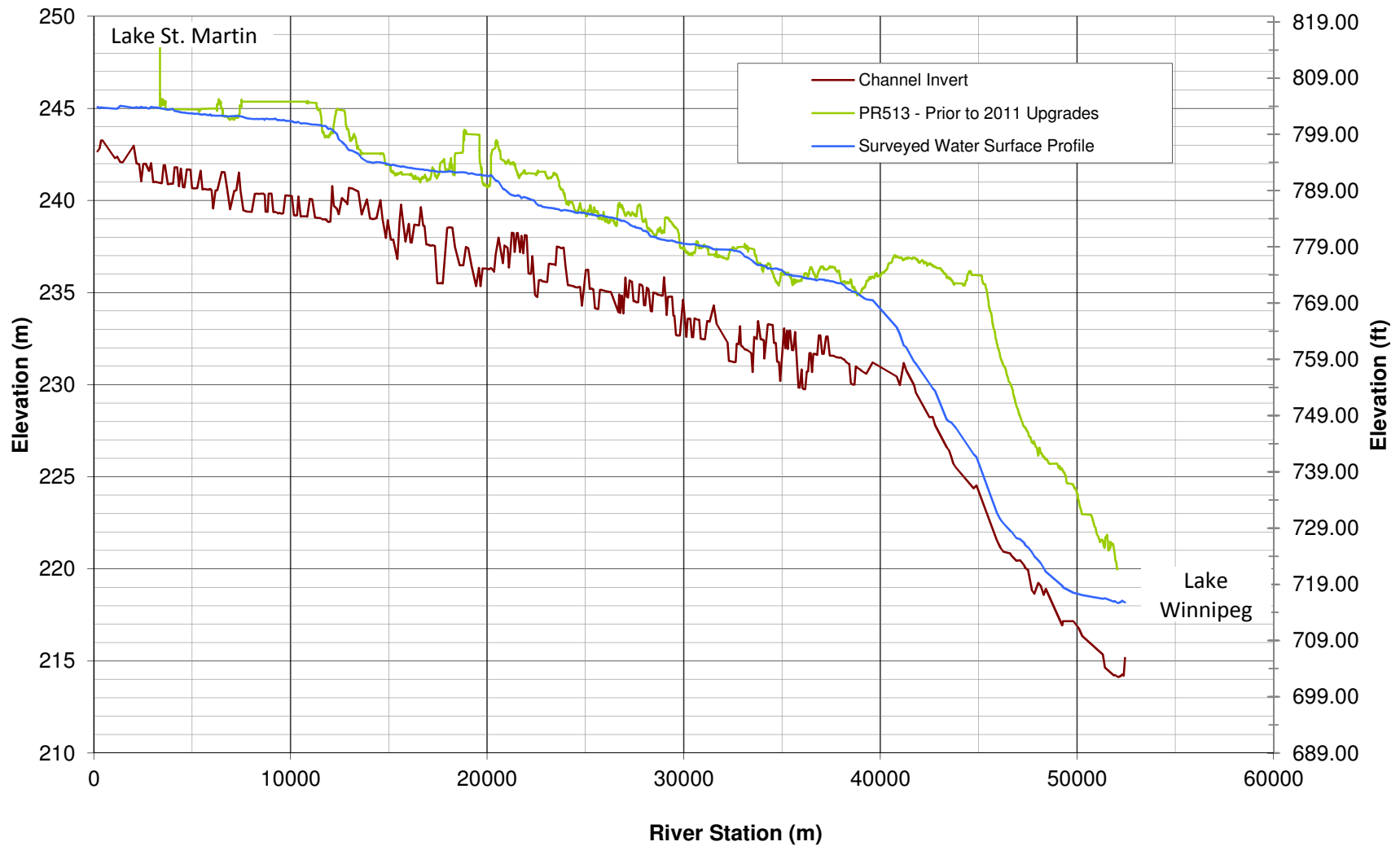


FIGURE 6
Lake St. Martin Outlet at Dauphin River Stage Discharge Relationship

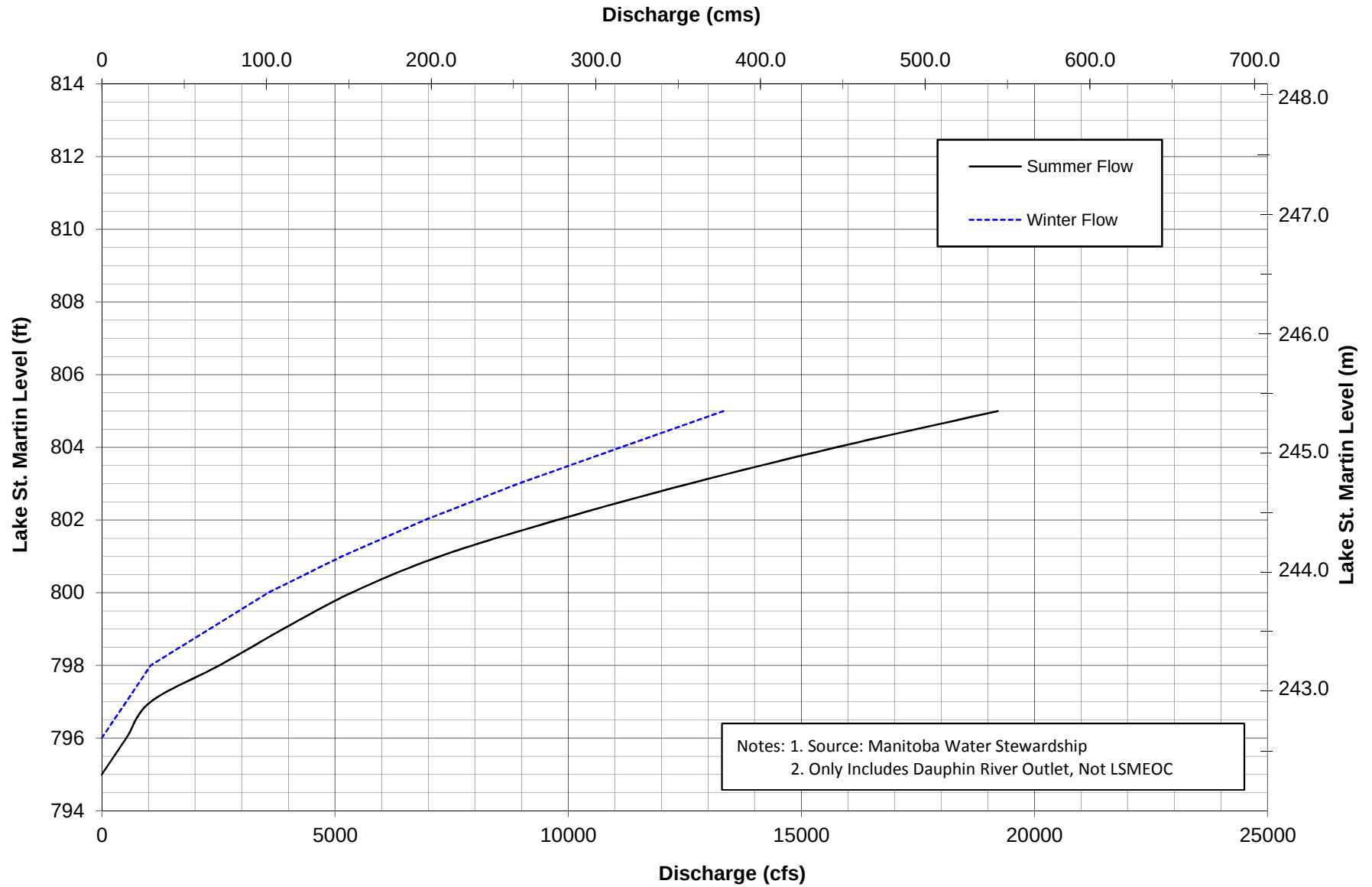


FIGURE 7
Dauphin River Open Water Model Calibration
May 19, 2011 – 420 cms (14,830 cfs)

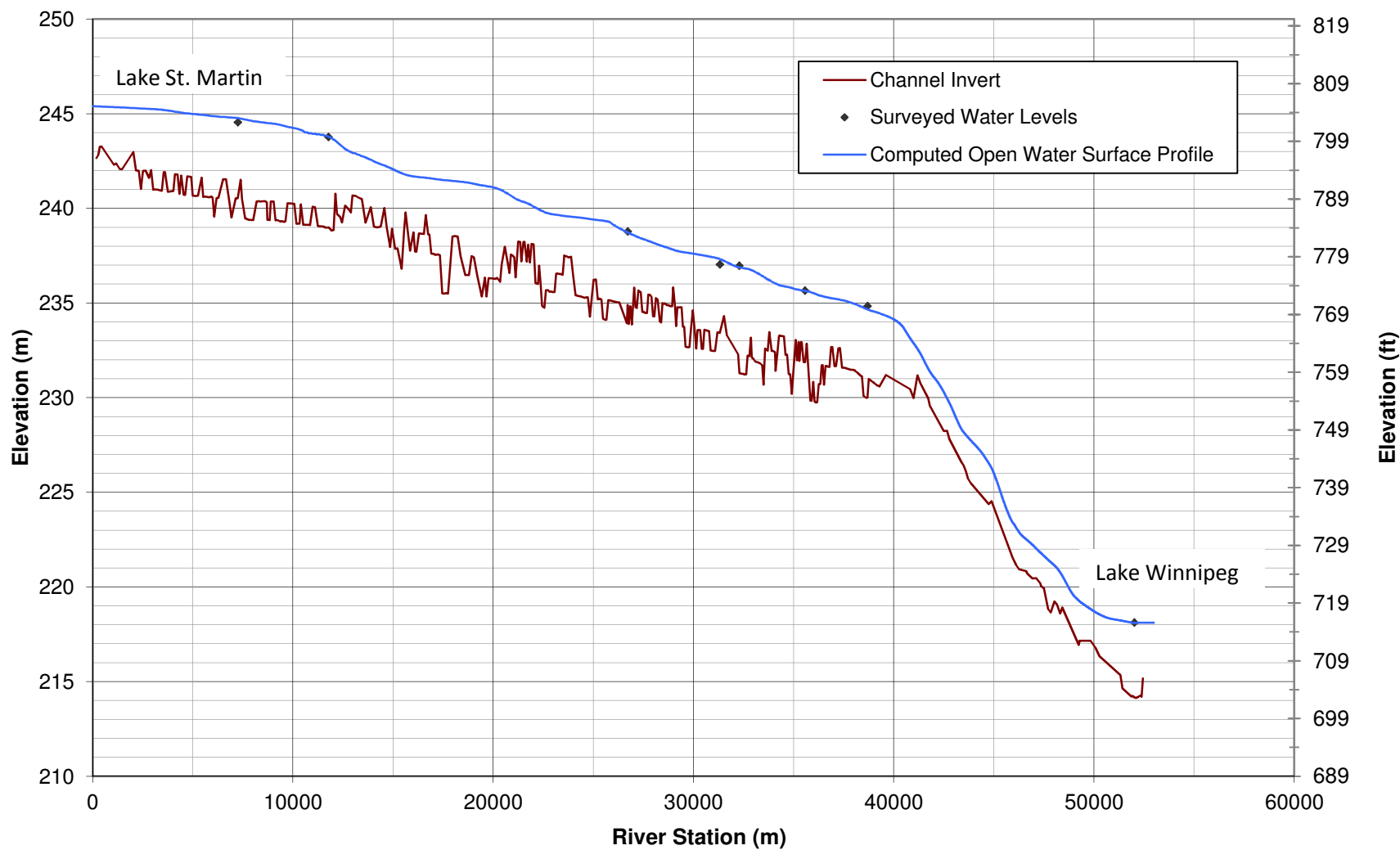


FIGURE 8
Dauphin River Ice Cover Model Calibration
Nov 2010 – 190 cms (6,710 cfs)

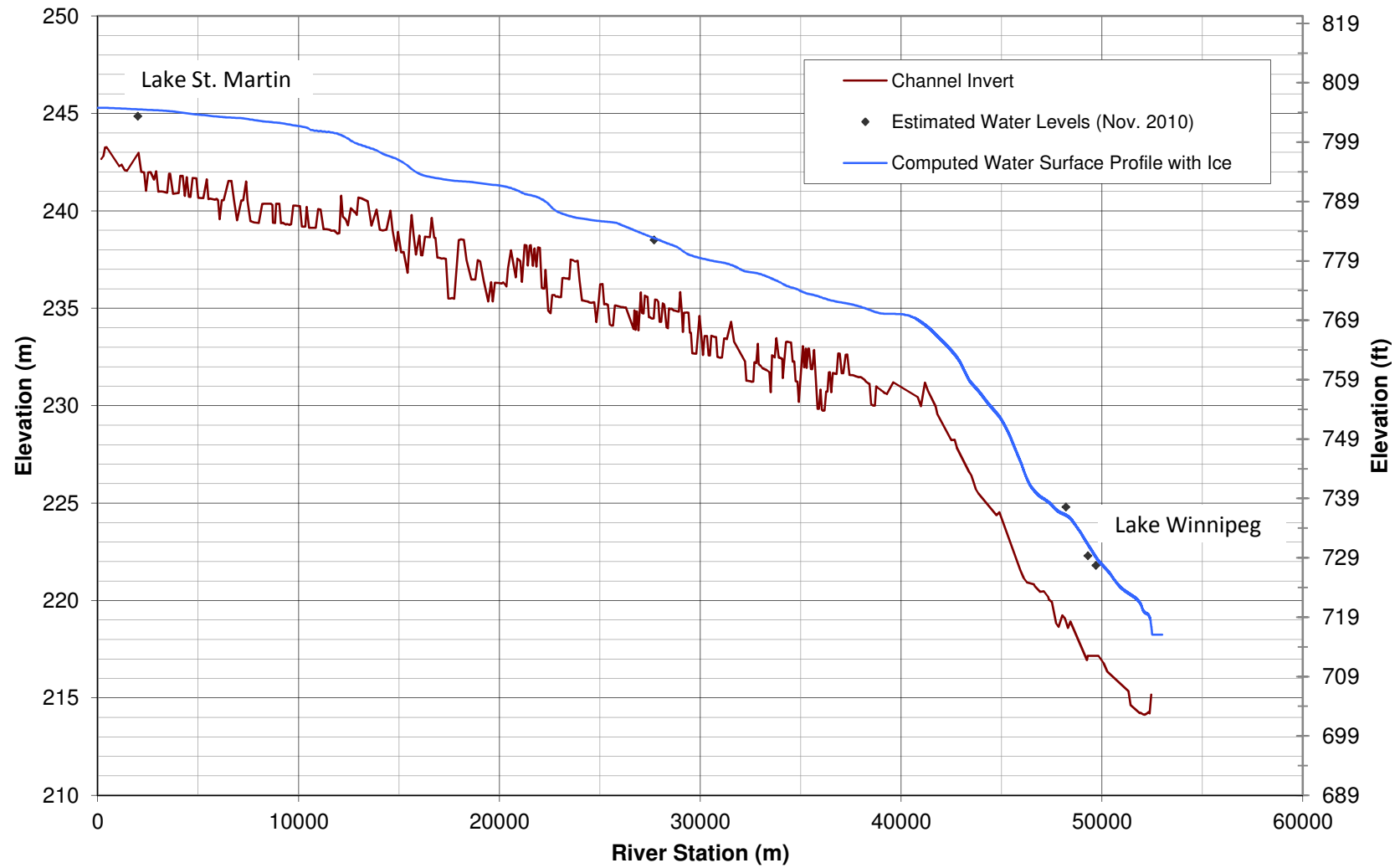


FIGURE 9
Estimated Maximum Water Surface Profile for Lower Dauphin River
Scenario 1: Early Freeze-up (2011) - 500 cms (17,620 cfs)

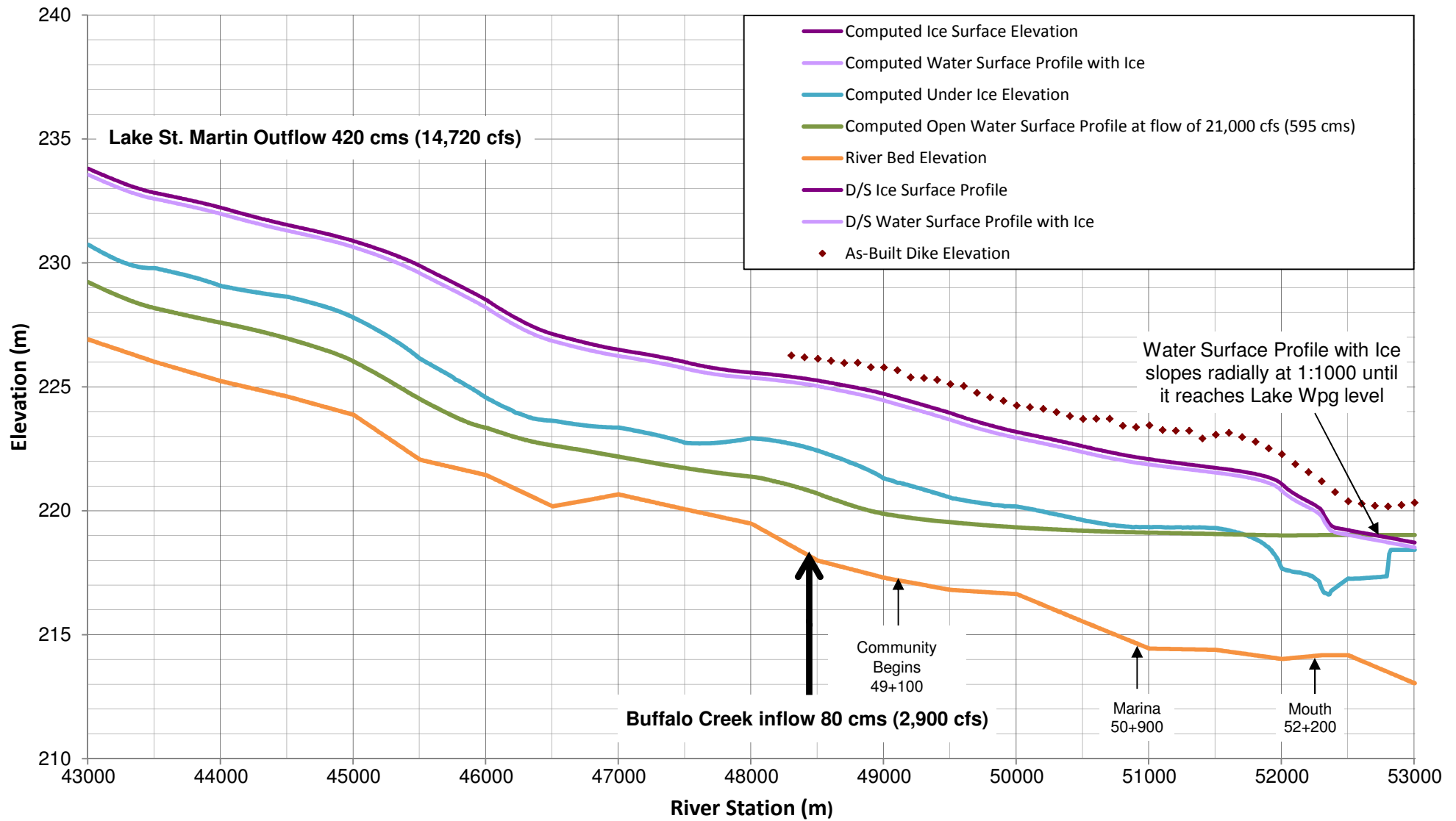


FIGURE 10
Estimated Maximum Water Surface Profile for Lower Dauphin River
Scenario 2: Best Estimate Freeze-up (2011) - 400 cms (14,160 cfs)

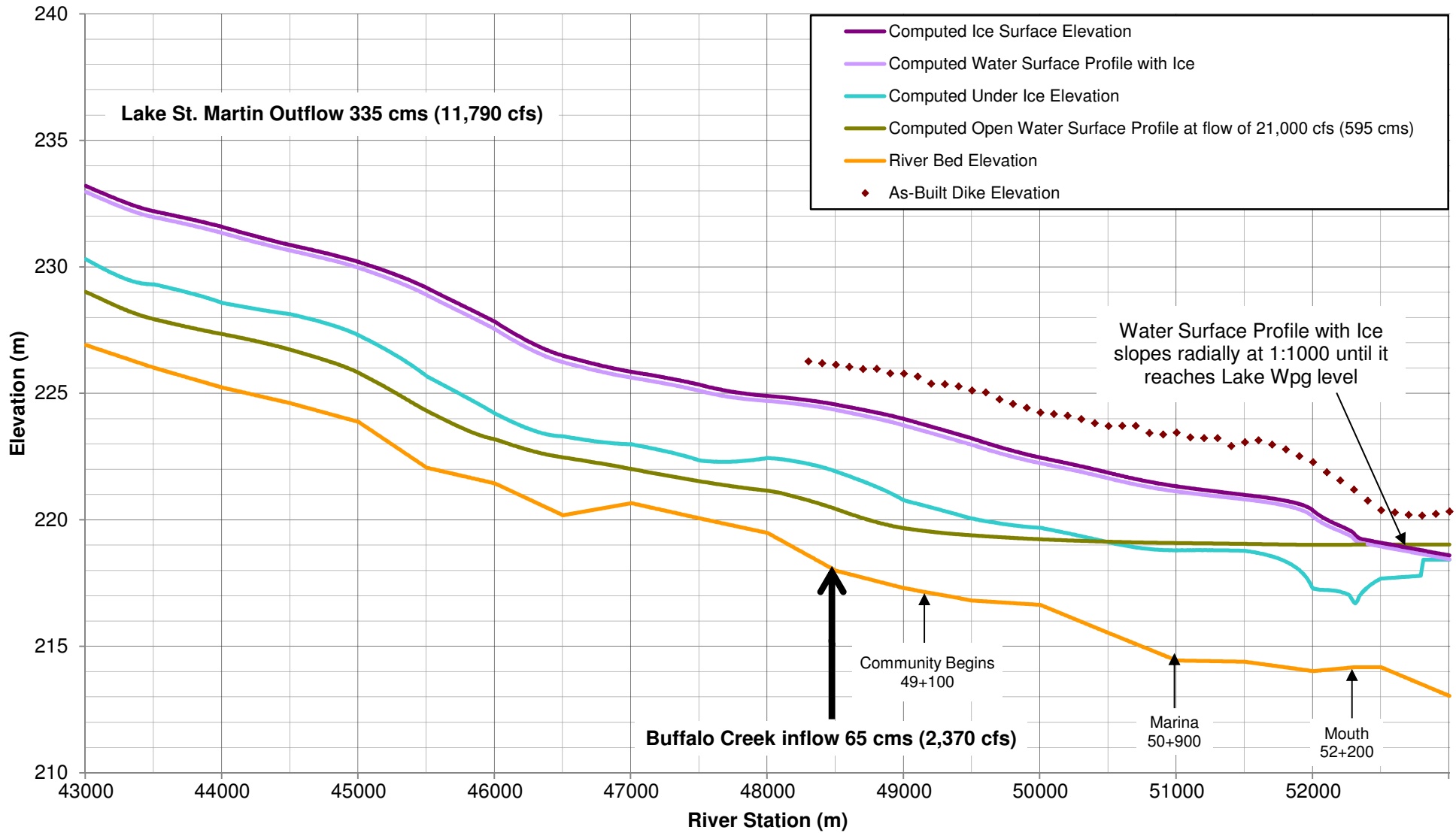


FIGURE 11
Estimated Maximum Water Surface Profile for Lower Dauphin River
Scenario 3: Late Freeze-up (2011) - 365 cms (12,900 cfs)

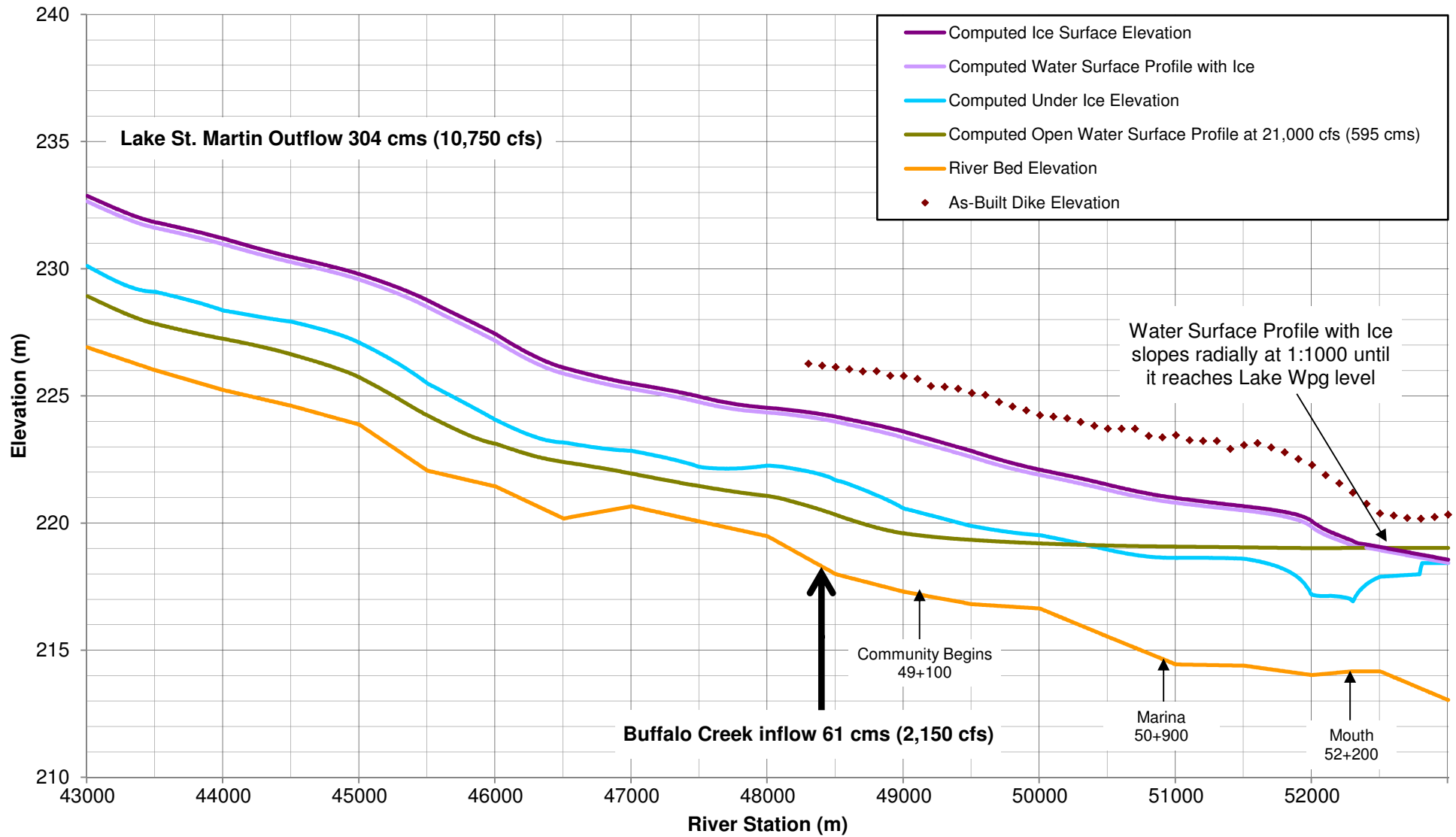


FIGURE 12
Estimated Maximum Water Surface Profile for Lower Dauphin River
Scenario 4: Spring Breakup - 700 cms (24,720 cfs)

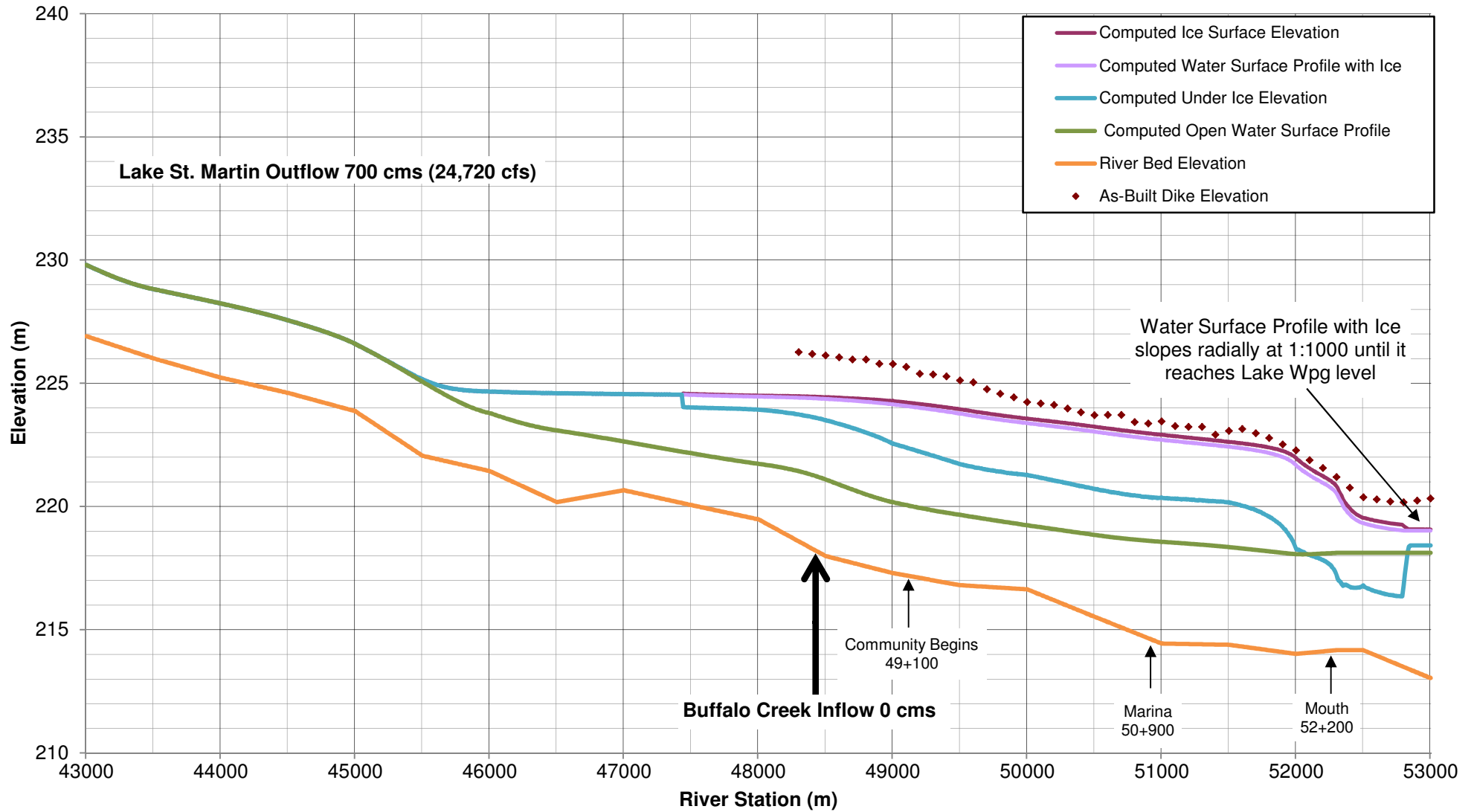


FIGURE 13
Estimated Maximum Water Surface Profile for Lower Dauphin River
Scenario 5: Spring Breakup - 1,000 cms (35,310 cfs)

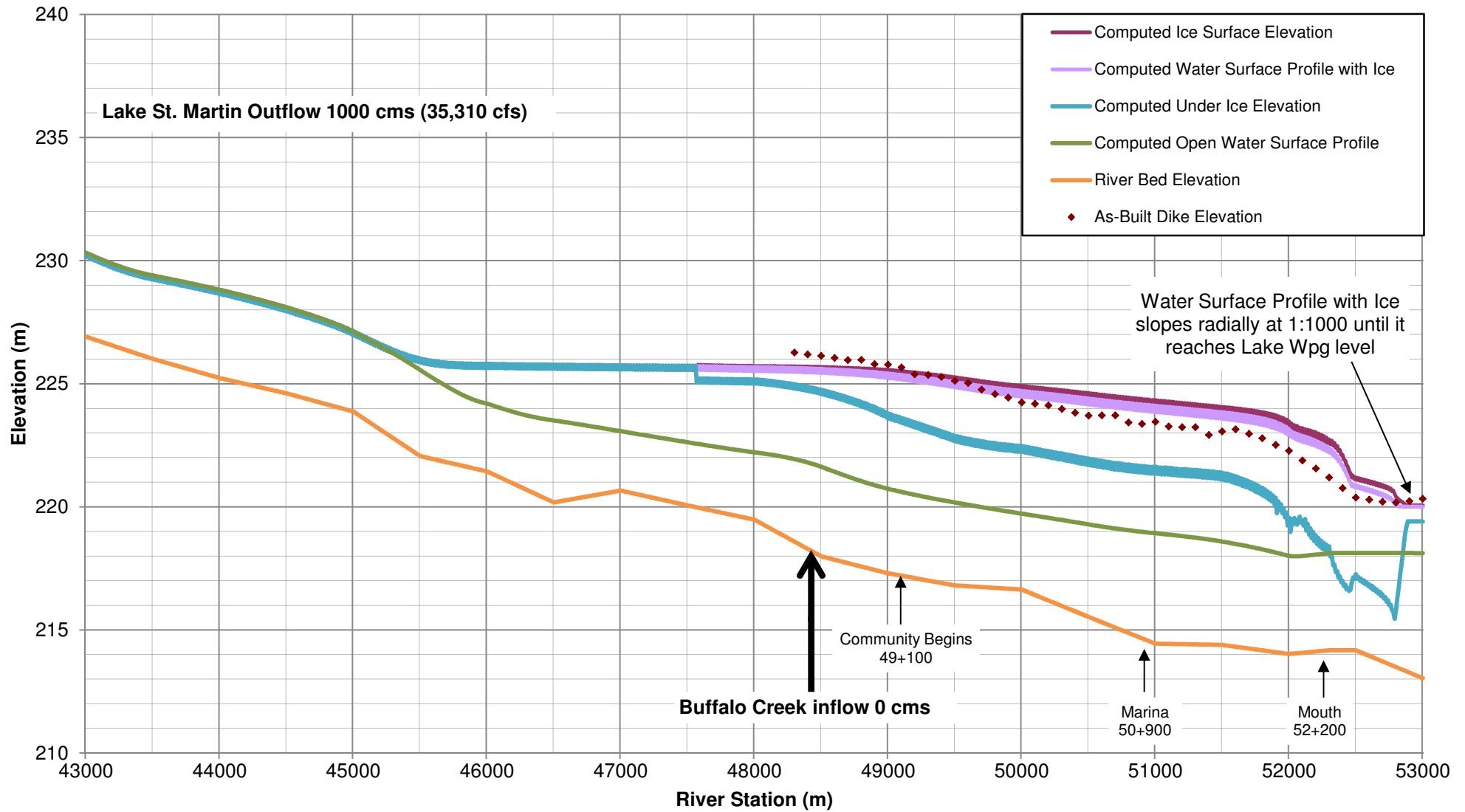


FIGURE 14
Estimated Maximum Water Surface Profile for Lower Dauphin River
Scenario 6: Spring Breakup - 444 cms (15,680 cfs)

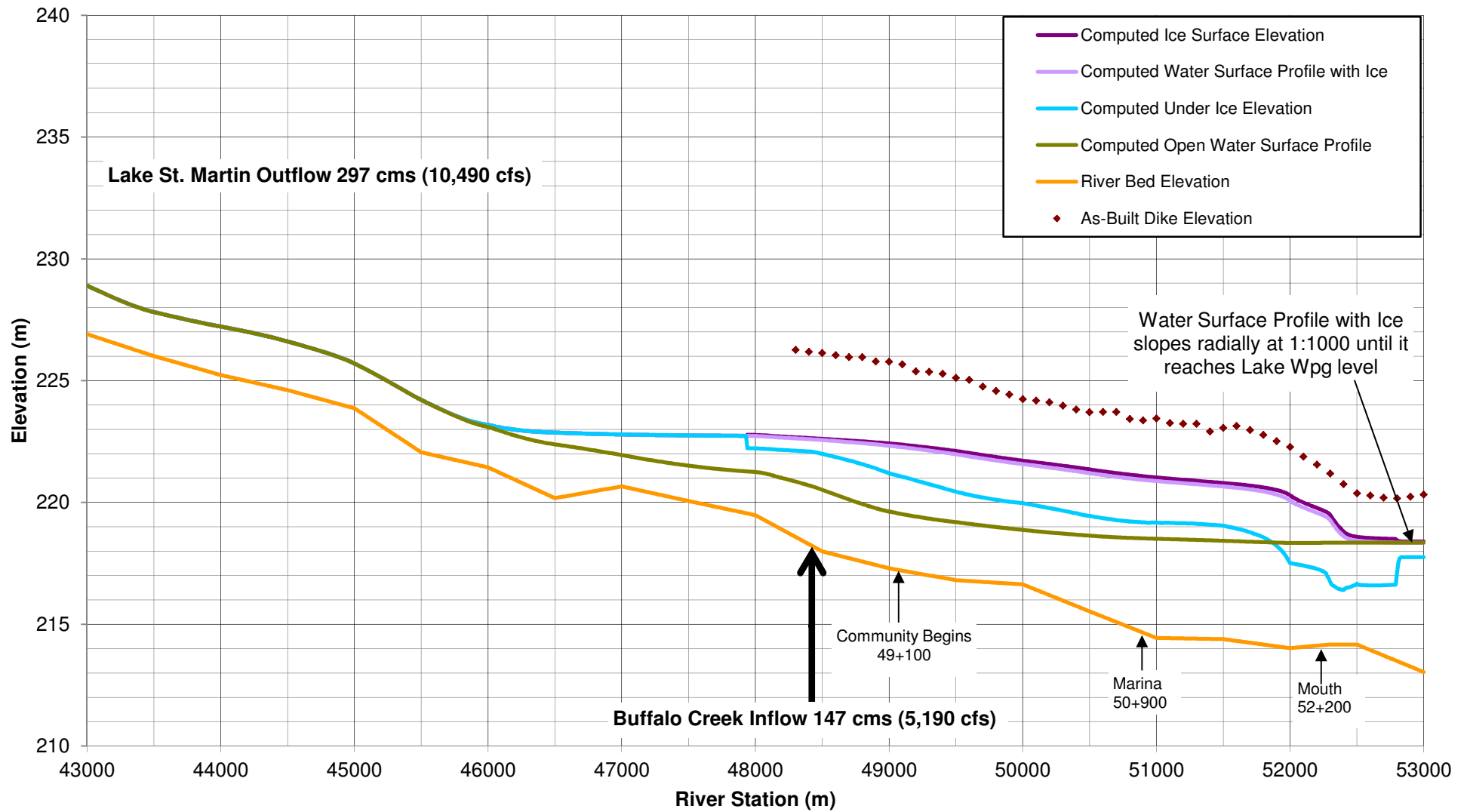


FIGURE 15
Estimated Maximum Water Surface Profile for Lower Dauphin River
Scenario 7: Early Fall Freeze-up (2012) - 269 cms (9,500 cfs)

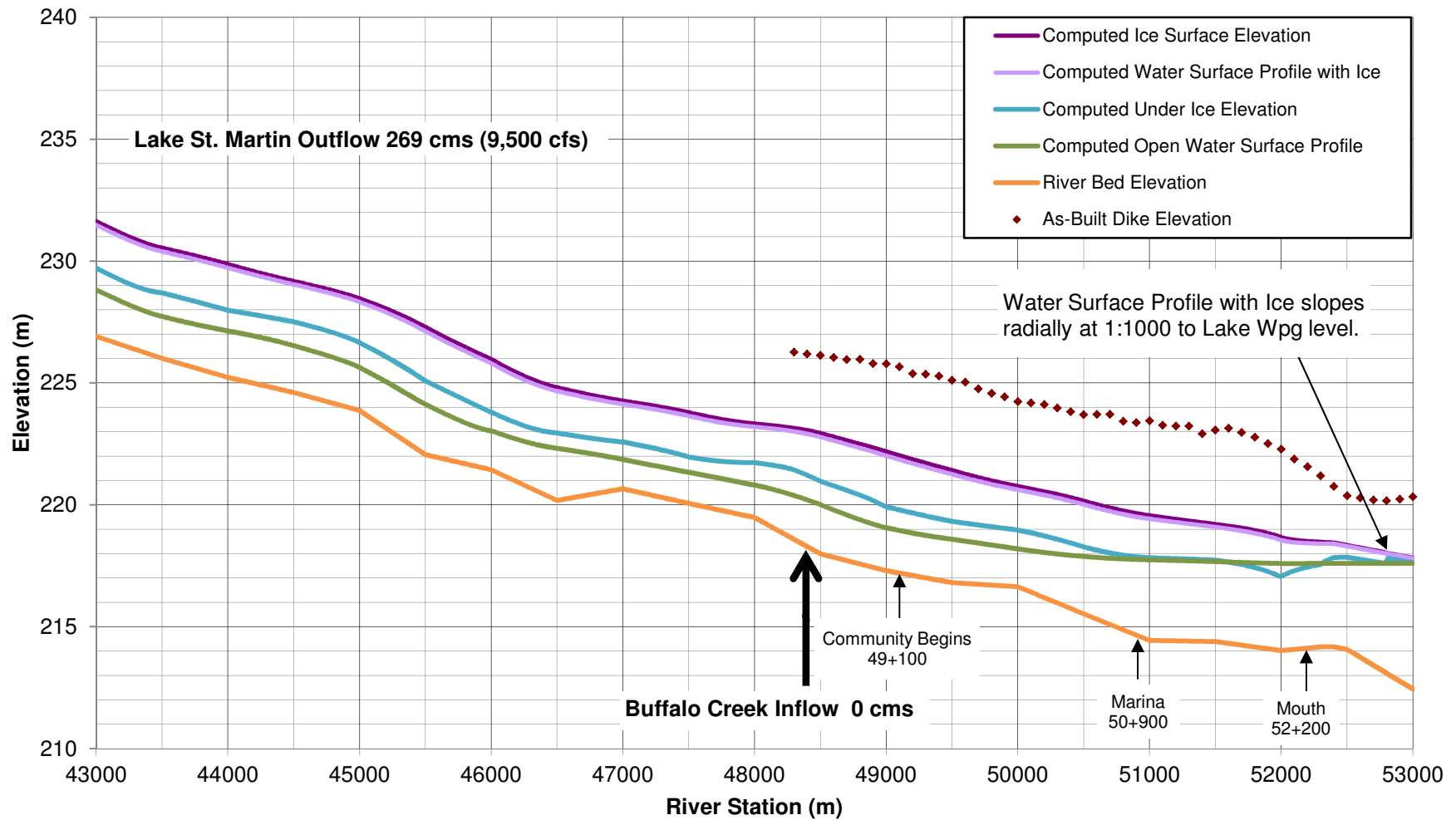


FIGURE 16
Estimated Maximum Water Surface Profile for Dauphin River
Scenario 1: - Early Freeze-up (2011) - 500 cms (17,660 cfs)

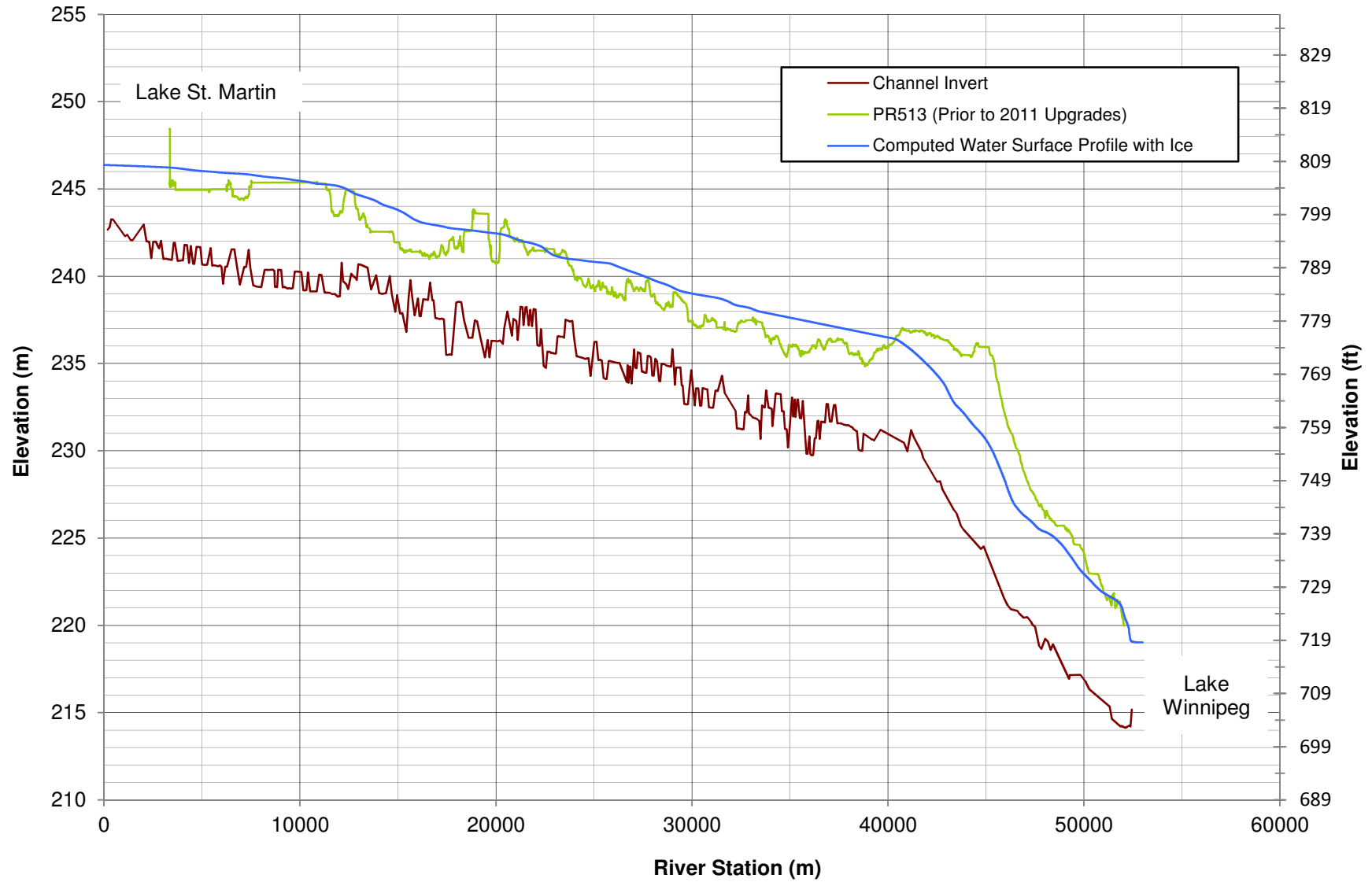


FIGURE 17
Estimated Peak Winter Stage Discharge Relationship on Dauphin River at Lake St. Martin Outlet

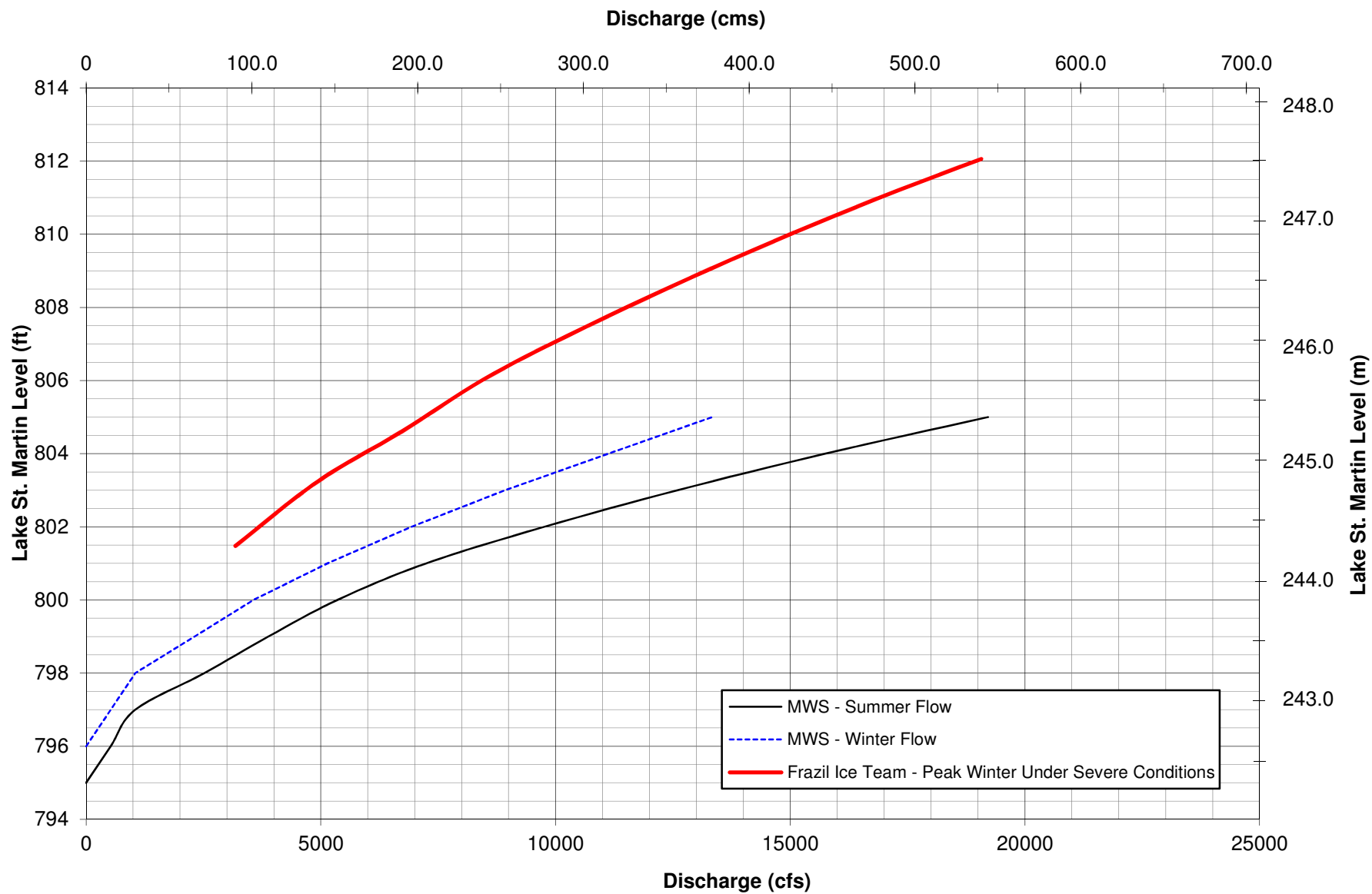


FIGURE 18
Estimated Maximum Water Surface Profile for Dauphin River
Scenario 7: Early Freeze Up (2012) - 269 cms (9,500 cfs)

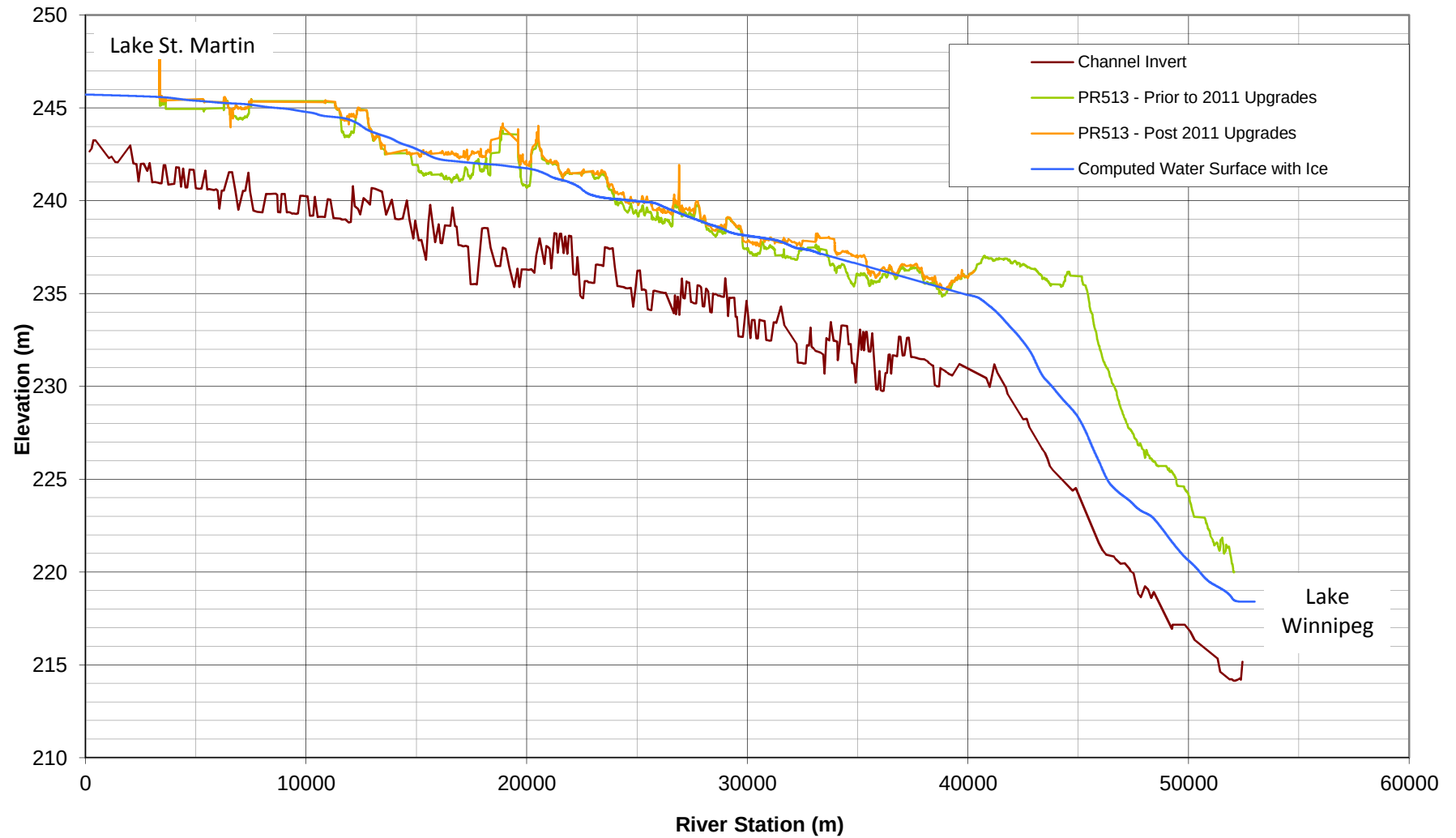


FIGURE 19
Surveyed Water Levels in Lower Dauphin River during Winter of 2011-2012

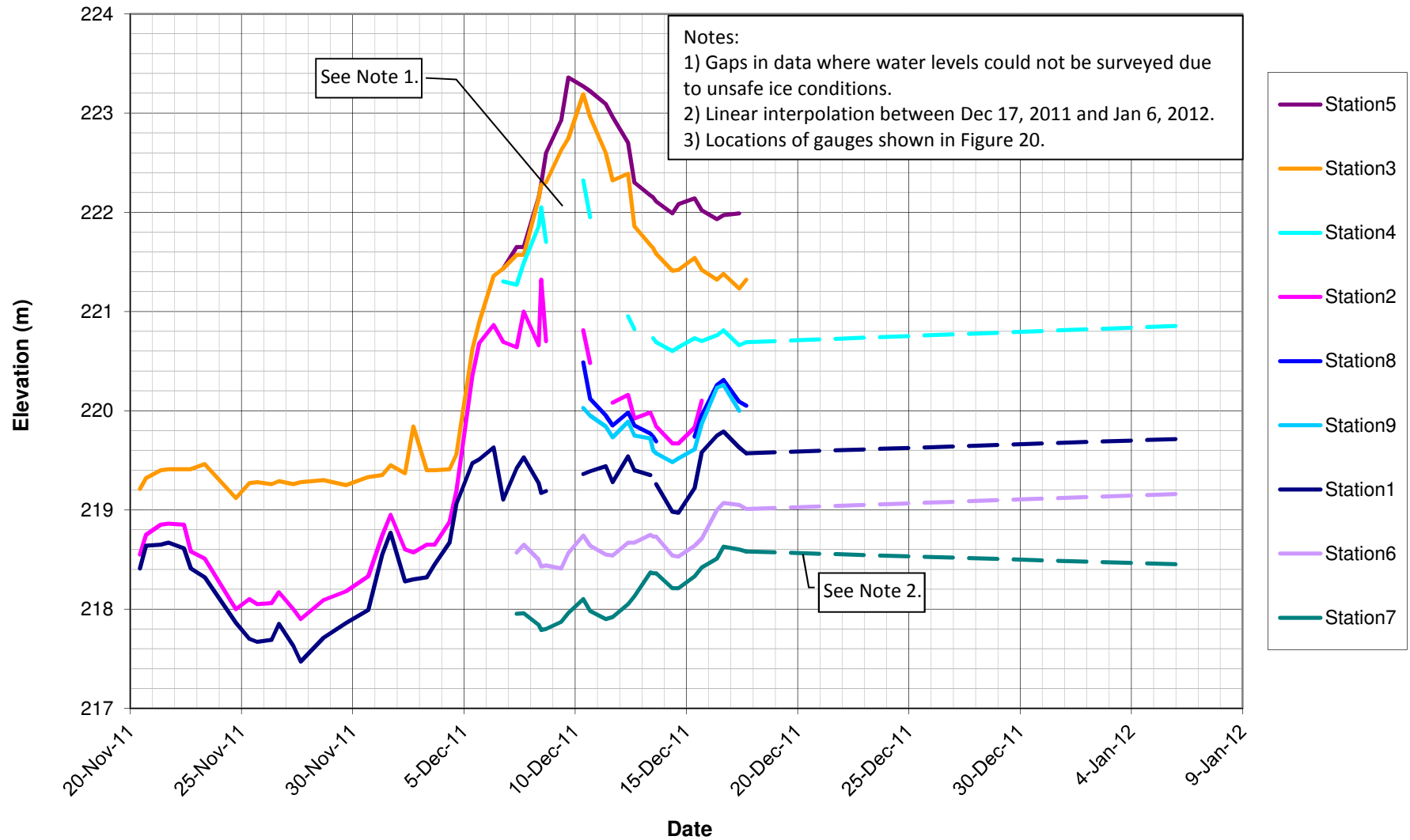


FIGURE 20
Maximum Water Surface Profile for Lower Dauphin River
November and December 2011

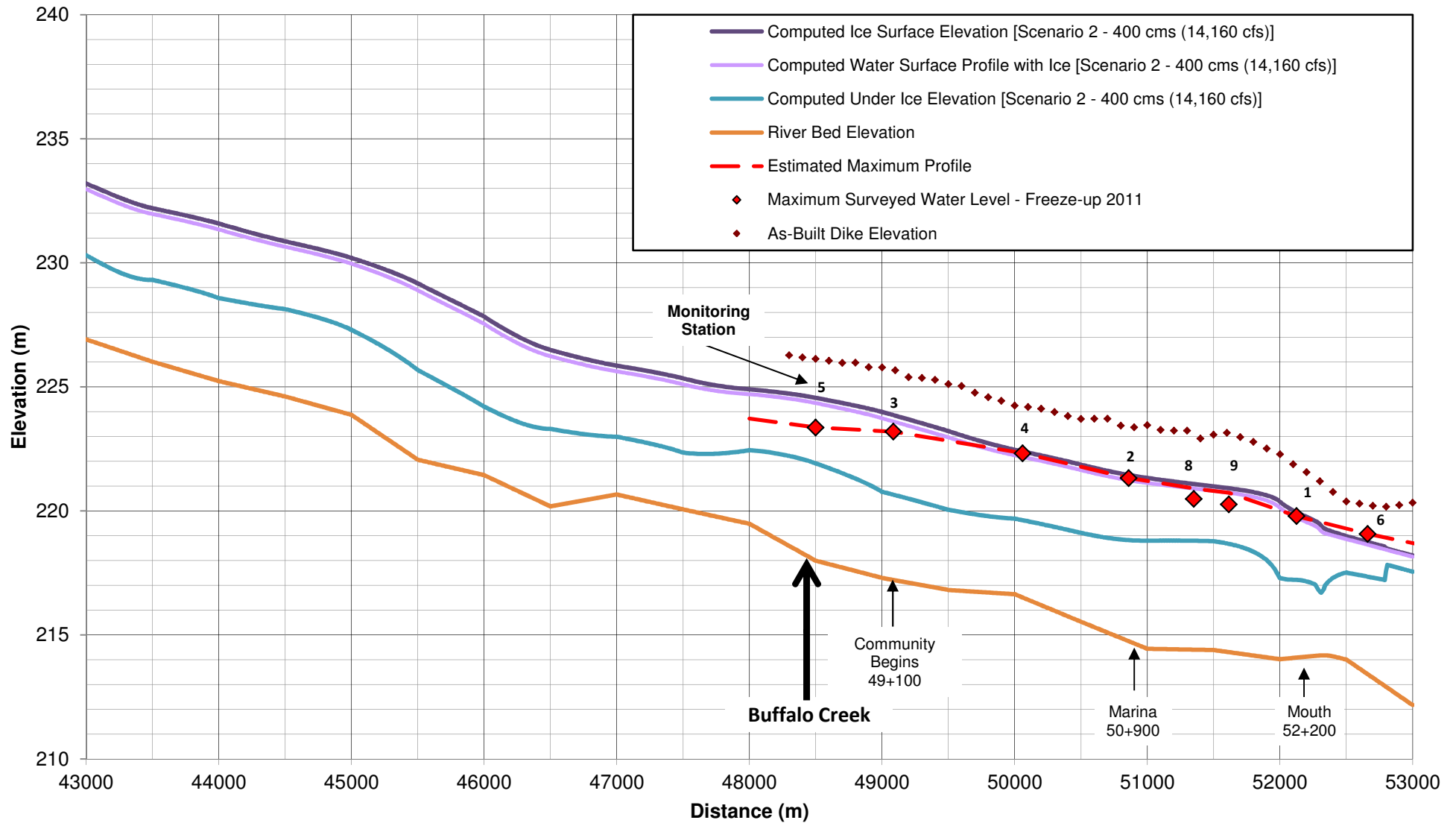


FIGURE 21
Estimated Stage Discharge Relationship on Dauphin River during Winter of 2011-2012

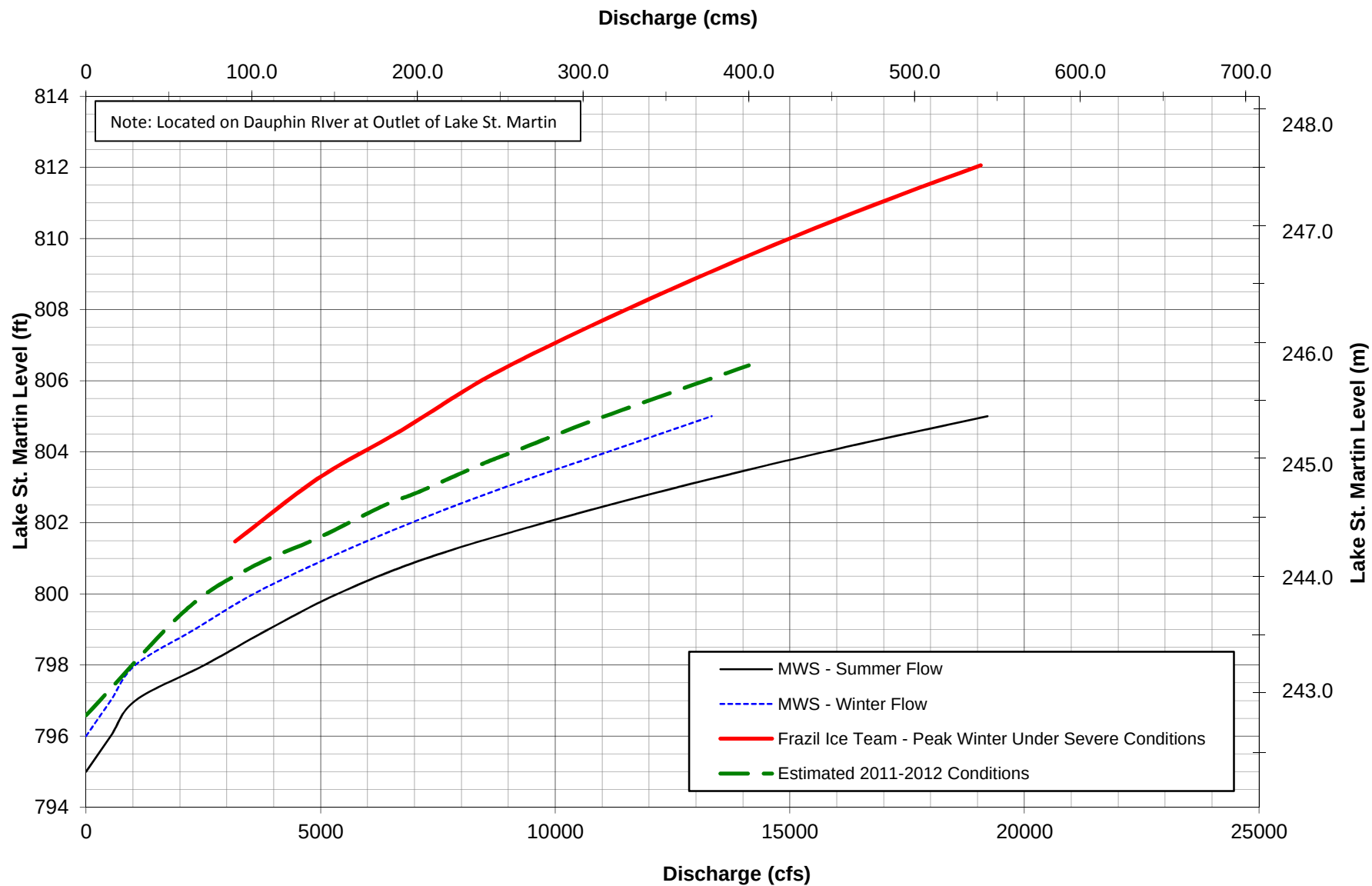


FIGURE 22
Computed Lake St. Martin Level
With and Without Operation of the Lake St. Martin Emergency Outlet Channel

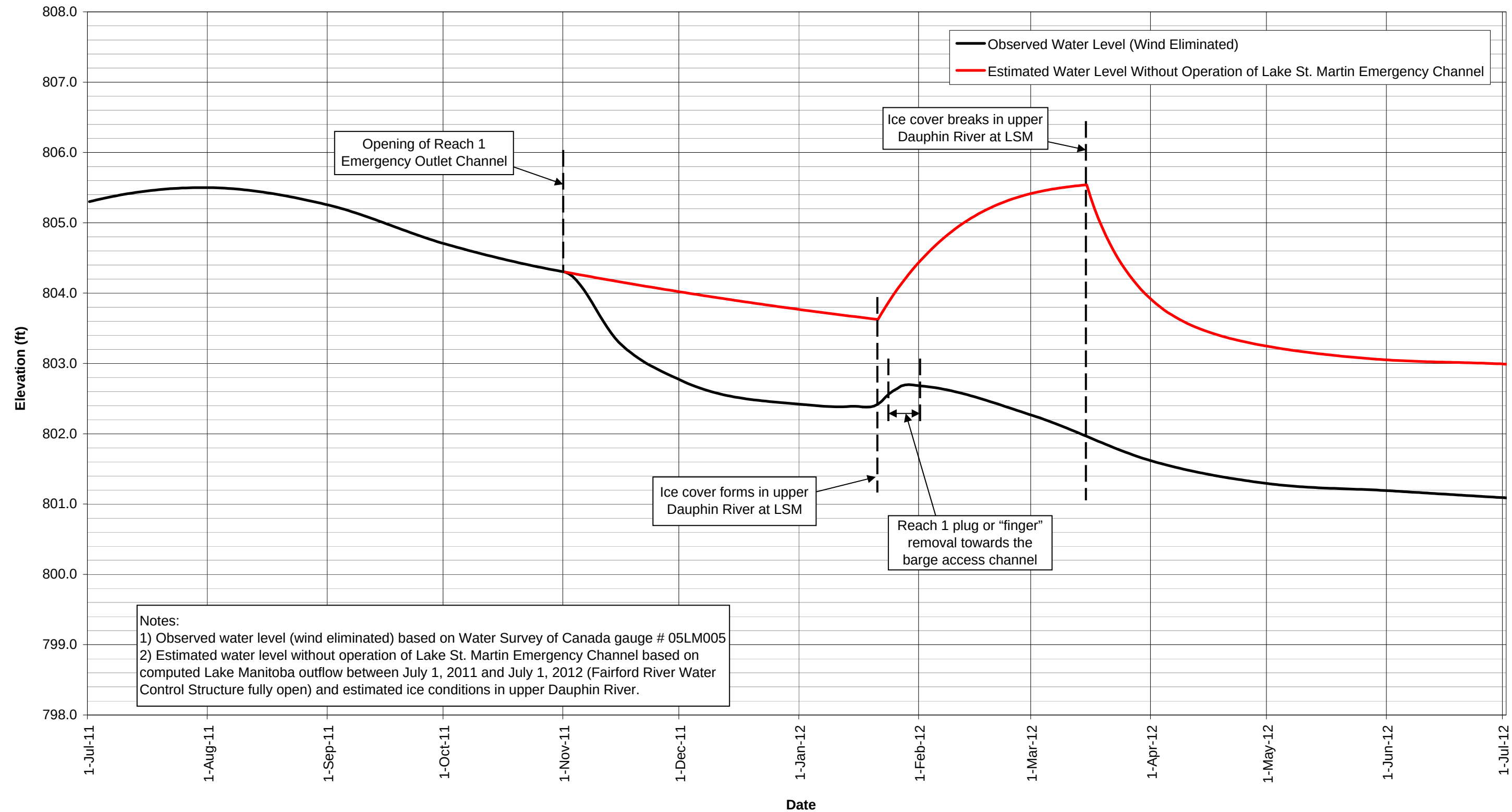


Figure 23
Reach 1 Stage Discharge Relationships

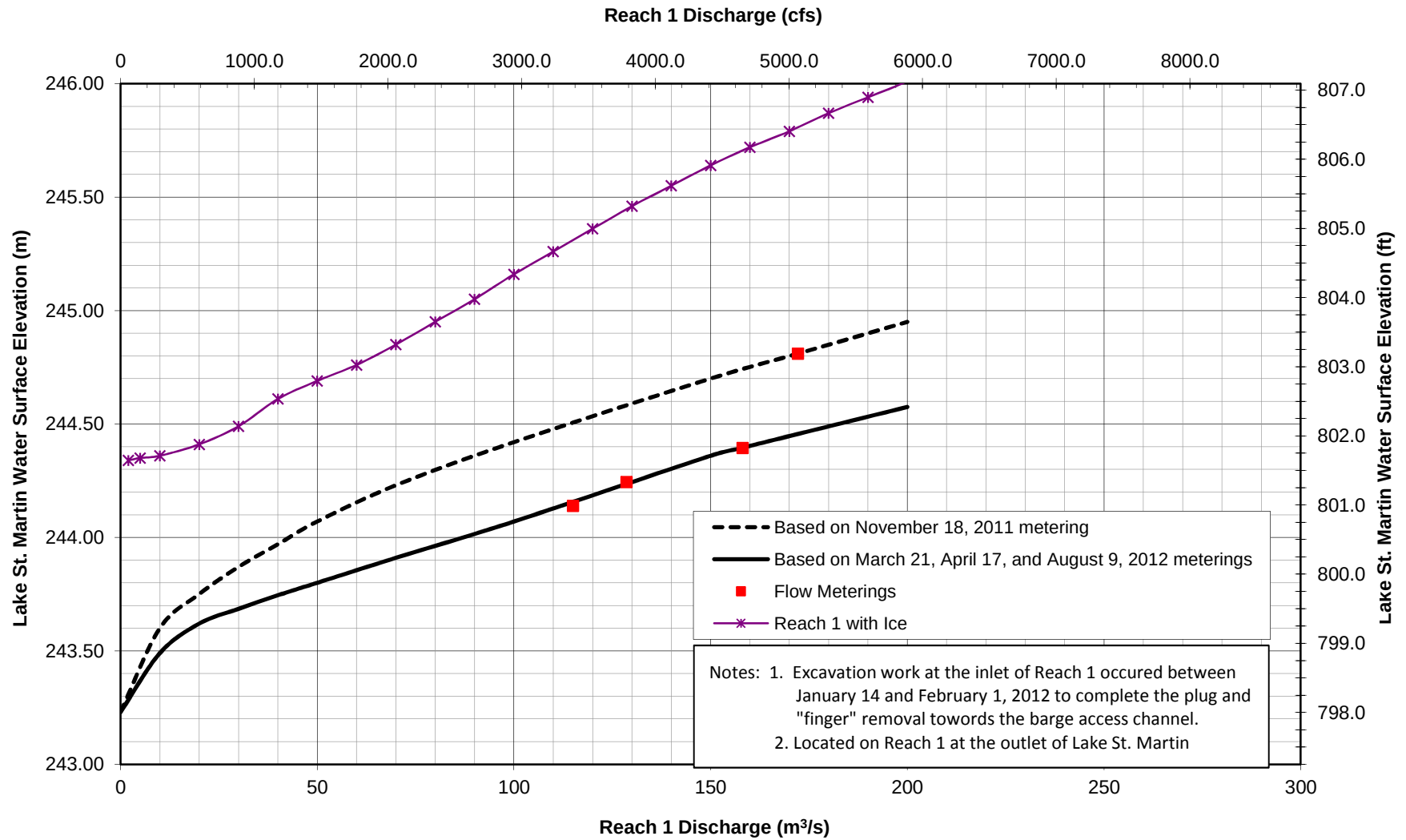


FIGURE 24
Estimated Maximum Water Surface Profile with Ice for Buffalo Creek
80 cms (2,825 cfs)

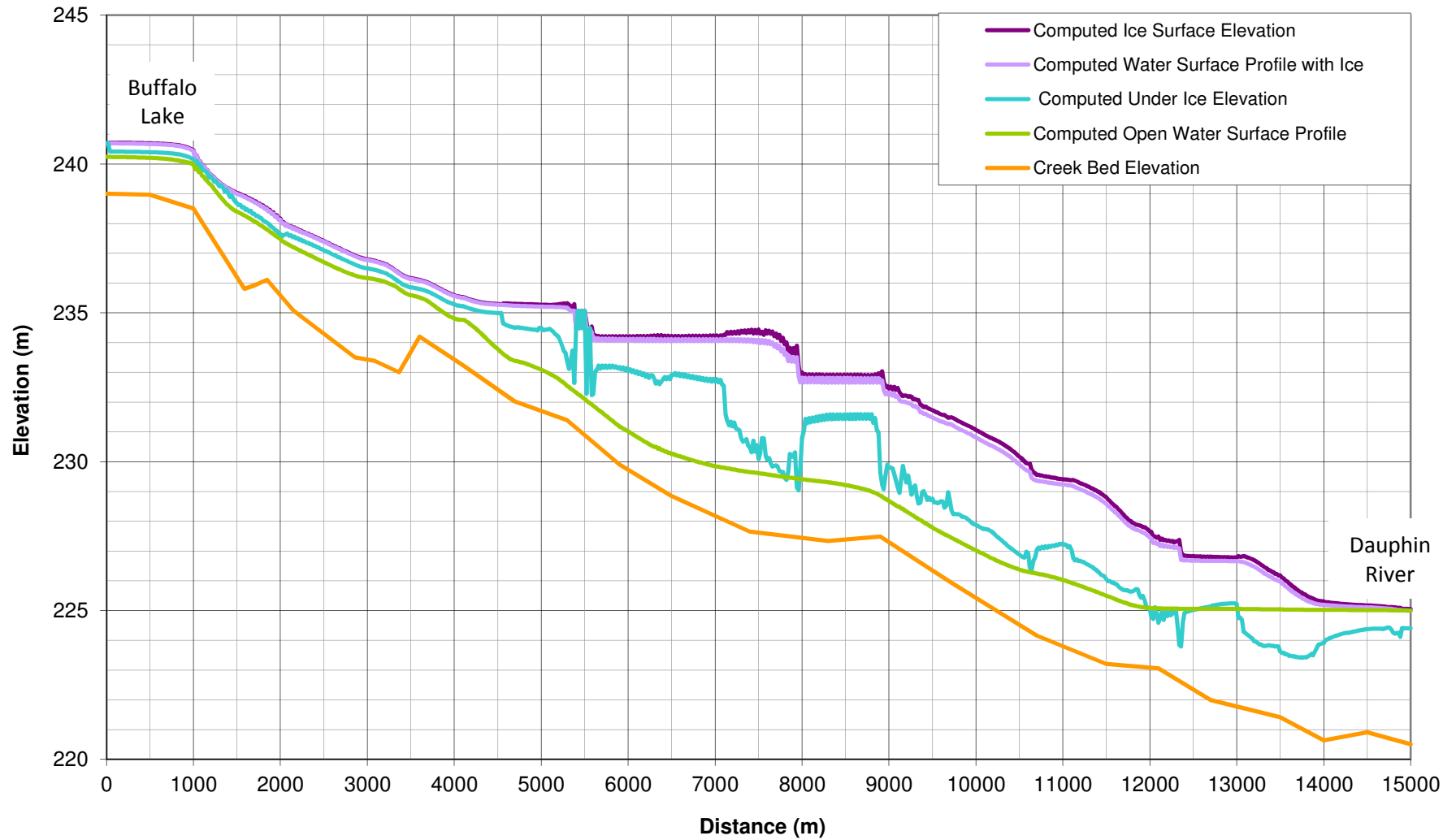
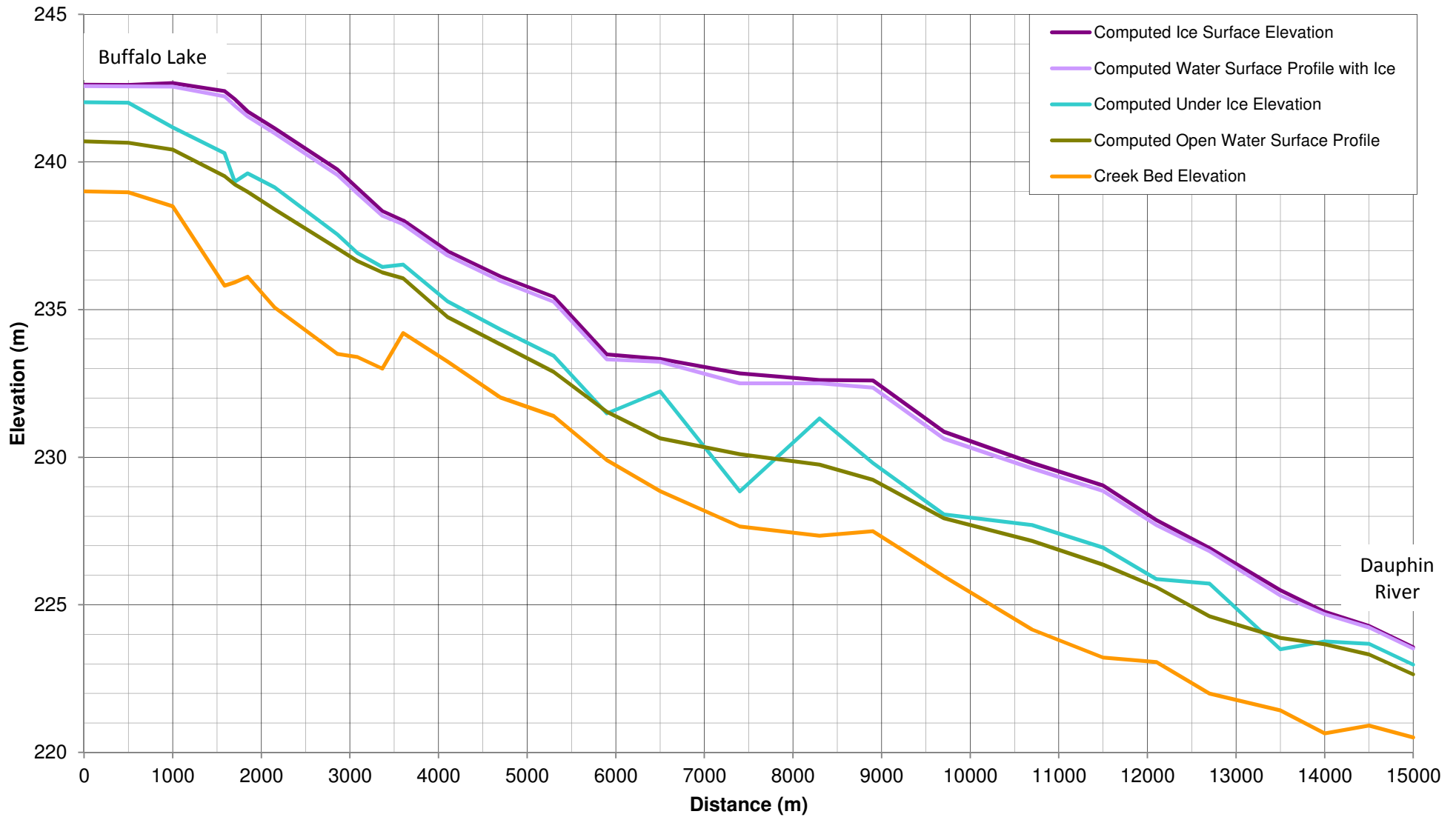


FIGURE 25
Estimated Maximum Water Surface Profile with Ice in Buffalo Creek
140 cms (4,900 cfs)



APPENDICES

APPENDIX A

LAKE MANITOBA AND LAKE ST. MARTIN FORECAST FIGURES AND DATA

Comprised of 2 Separate Appendices:

Annex 1: Lake Manitoba Inflow Forecast

Annex 2: Lake Manitoba and Lake St. Martin Forecast Figures and Emails

APPENDIX A – ANNEX 1
LAKE MANITOBA INFLOW FORECAST

Lake Manitoba Inflow Forecast

June 27, 2011

Lake Manitoba June 27, 2011 Inflow Forecast	
Date	Total Inflow (cfs)
27-Jun-11	43300
28-Jun-11	42747
29-Jun-11	42229
30-Jun-11	41740
1-Jul-11	41377
2-Jul-11	41118
3-Jul-11	40924
4-Jul-11	40735
5-Jul-11	40909
6-Jul-11	41599
7-Jul-11	42681
8-Jul-11	44641
9-Jul-11	45980
10-Jul-11	46471
11-Jul-11	46011
12-Jul-11	44971
13-Jul-11	43752
14-Jul-11	41631
15-Jul-11	39385
16-Jul-11	36888
17-Jul-11	34225
18-Jul-11	31703
19-Jul-11	29632
20-Jul-11	27813
21-Jul-11	26313
22-Jul-11	25194
23-Jul-11	23760
24-Jul-11	22801
25-Jul-11	22054
26-Jul-11	21433
27-Jul-11	20644
28-Jul-11	19641
29-Jul-11	18897
30-Jul-11	18165
31-Jul-11	17547
1-Aug-11	16985
2-Aug-11	16330
3-Aug-11	15674
4-Aug-11	15234
5-Aug-11	14921
6-Aug-11	14373
7-Aug-11	13934
8-Aug-11	12807
9-Aug-11	12051
10-Aug-11	11399
11-Aug-11	10744
12-Aug-11	10263
13-Aug-11	9863
14-Aug-11	10423
15-Aug-11	9926
16-Aug-11	9738
17-Aug-11	9868
18-Aug-11	10126
19-Aug-11	10224
20-Aug-11	10199
21-Aug-11	9575
22-Aug-11	7514
23-Aug-11	6568
24-Aug-11	6453
25-Aug-11	6501
26-Aug-11	6765
27-Aug-11	6767
28-Aug-11	6754
29-Aug-11	6797
30-Aug-11	6809
31-Aug-11	6571
1-Sep-11	6341
2-Sep-11	6090

Date	Total Inflow
3-Sep-11	6012
4-Sep-11	6091
5-Sep-11	6148
6-Sep-11	6369
7-Sep-11	6628
8-Sep-11	6783
9-Sep-11	7121
10-Sep-11	7281
11-Sep-11	7675
12-Sep-11	7770
13-Sep-11	7708
14-Sep-11	7670
15-Sep-11	7443
16-Sep-11	6928
17-Sep-11	6445
18-Sep-11	6021
19-Sep-11	5738
20-Sep-11	5669
21-Sep-11	5659
22-Sep-11	5675
23-Sep-11	5802
24-Sep-11	6014
25-Sep-11	6227
26-Sep-11	6239
27-Sep-11	6226
28-Sep-11	6129
29-Sep-11	5672
30-Sep-11	5338
1-Oct-11	4837
2-Oct-11	4424
3-Oct-11	4153
4-Oct-11	4176
5-Oct-11	3980
6-Oct-11	3850
7-Oct-11	3881
8-Oct-11	3679
9-Oct-11	3606
10-Oct-11	3682
11-Oct-11	4034
12-Oct-11	4188
13-Oct-11	4194
14-Oct-11	4017
15-Oct-11	4146
16-Oct-11	4107
17-Oct-11	4422
18-Oct-11	4942
19-Oct-11	5080
20-Oct-11	5087
21-Oct-11	4970
22-Oct-11	5147
23-Oct-11	5299
24-Oct-11	5126
25-Oct-11	5105
26-Oct-11	5090
27-Oct-11	4794
28-Oct-11	4598
29-Oct-11	4659
30-Oct-11	4282
31-Oct-11	4398
1-Nov-11	4497
2-Nov-11	4221
3-Nov-11	4617
4-Nov-11	5253
5-Nov-11	5747
6-Nov-11	6351
7-Nov-11	6932
8-Nov-11	7267
9-Nov-11	7879
10-Nov-11	8117
11-Nov-11	8206
12-Nov-11	8026
13-Nov-11	7990
14-Nov-11	8193

Date	Total Inflow
15-Nov-11	8202
16-Nov-11	8192
17-Nov-11	8664
18-Nov-11	9006
19-Nov-11	9504
20-Nov-11	10276
21-Nov-11	10554
22-Nov-11	10656
23-Nov-11	10741
24-Nov-11	10173
25-Nov-11	9887
26-Nov-11	9603
27-Nov-11	9464
28-Nov-11	9221
29-Nov-11	8826
30-Nov-11	8681
1-Dec-11	8716
2-Dec-11	8688
3-Dec-11	8732
4-Dec-11	8667
5-Dec-11	8555
6-Dec-11	8502
7-Dec-11	8498
8-Dec-11	8486
9-Dec-11	8687
10-Dec-11	8760
11-Dec-11	8782
12-Dec-11	8776
13-Dec-11	8704
14-Dec-11	8639
15-Dec-11	8434
16-Dec-11	8363
17-Dec-11	8357
18-Dec-11	8336
19-Dec-11	8242
20-Dec-11	8106
21-Dec-11	7988
22-Dec-11	7917
23-Dec-11	7869
24-Dec-11	7822
25-Dec-11	7763
26-Dec-11	7696
27-Dec-11	7603
28-Dec-11	7522
29-Dec-11	7470
30-Dec-11	7412
31-Dec-11	7344
1-Jan-12	4514
2-Jan-12	4505
3-Jan-12	4498
4-Jan-12	4491
5-Jan-12	4486
6-Jan-12	4481
7-Jan-12	4476
8-Jan-12	4472
9-Jan-12	4467
10-Jan-12	4460
11-Jan-12	4454
12-Jan-12	4447
13-Jan-12	4441
14-Jan-12	4437
15-Jan-12	4434
16-Jan-12	4432
17-Jan-12	4430
18-Jan-12	4427
19-Jan-12	4422
20-Jan-12	4417
21-Jan-12	4413
22-Jan-12	4410
23-Jan-12	4409
24-Jan-12	4409
25-Jan-12	4409
26-Jan-12	4409

Date	Total Inflow
27-Jan-12	4401
28-Jan-12	4394
29-Jan-12	4385
30-Jan-12	4374
31-Jan-12	4363
1-Feb-12	4351
2-Feb-12	4338
3-Feb-12	4323
4-Feb-12	4310
5-Feb-12	4297
6-Feb-12	4286
7-Feb-12	4278
8-Feb-12	4272
9-Feb-12	4269
10-Feb-12	4267
11-Feb-12	4266
12-Feb-12	4267
13-Feb-12	4268
14-Feb-12	4268
15-Feb-12	4268
16-Feb-12	4269
17-Feb-12	4271
18-Feb-12	4275
19-Feb-12	4282
20-Feb-12	4291
21-Feb-12	4302
22-Feb-12	4316
23-Feb-12	4335
24-Feb-12	4355
25-Feb-12	4379
26-Feb-12	4406
27-Feb-12	4436
28-Feb-12	4472
29-Feb-12	4513
1-Mar-12	4561
2-Mar-12	4613
3-Mar-12	4670
4-Mar-12	4731
5-Mar-12	4795
6-Mar-12	4864
7-Mar-12	4938
8-Mar-12	5019
9-Mar-12	5105
10-Mar-12	5192
11-Mar-12	5276
12-Mar-12	5356
13-Mar-12	5434
14-Mar-12	5509
15-Mar-12	5589
16-Mar-12	5674
17-Mar-12	5766
18-Mar-12	5864
19-Mar-12	5969
20-Mar-12	6075
21-Mar-12	6187
22-Mar-12	6310
23-Mar-12	6454
24-Mar-12	6601
25-Mar-12	6789
26-Mar-12	6976
27-Mar-12	7163
28-Mar-12	7353
29-Mar-12	7555
30-Mar-12	7795
31-Mar-12	8073
1-Apr-12	8382
2-Apr-12	8698
3-Apr-12	9125
4-Apr-12	9646
5-Apr-12	10158
6-Apr-12	10736
7-Apr-12	11519
8-Apr-12	12596

Date	Total Inflow
9-Apr-12	13770
10-Apr-12	14868
11-Apr-12	15878
12-Apr-12	16836
13-Apr-12	17719
14-Apr-12	18475
15-Apr-12	19339
16-Apr-12	20167
17-Apr-12	20726
18-Apr-12	20883
19-Apr-12	20857
20-Apr-12	20813
21-Apr-12	20798
22-Apr-12	20772
23-Apr-12	20662
24-Apr-12	20526
25-Apr-12	20248
26-Apr-12	19910
27-Apr-12	19597
28-Apr-12	19333
29-Apr-12	19081
30-Apr-12	18837
1-May-12	18567
2-May-12	18313
3-May-12	18087
4-May-12	17840
5-May-12	17603
6-May-12	17355
7-May-12	17122
8-May-12	16911
9-May-12	16734
10-May-12	16564
11-May-12	16422
12-May-12	16275
13-May-12	16151
14-May-12	16066
15-May-12	16010
16-May-12	15958
17-May-12	15878
18-May-12	15788
19-May-12	15637
20-May-12	15464
21-May-12	15270
22-May-12	15064
23-May-12	14811
24-May-12	14516
25-May-12	14172
26-May-12	13801
27-May-12	13413
28-May-12	12982
29-May-12	12577
30-May-12	12181
31-May-12	11796
1-Jun-12	11418
2-Jun-12	11078
3-Jun-12	10752
4-Jun-12	10457
5-Jun-12	10192
6-Jun-12	9971
7-Jun-12	9792
8-Jun-12	9639
9-Jun-12	9515
10-Jun-12	9395
11-Jun-12	9263
12-Jun-12	9113
13-Jun-12	8955
14-Jun-12	8790
15-Jun-12	8624
16-Jun-12	8458
17-Jun-12	8292
18-Jun-12	8104
19-Jun-12	7911
20-Jun-12	7717

Date	Total Inflow
21-Jun-12	7528
22-Jun-12	7337
23-Jun-12	7151
24-Jun-12	6956
25-Jun-12	6755
26-Jun-12	6542
27-Jun-12	6334
28-Jun-12	6141
29-Jun-12	5968
30-Jun-12	5810
1-Jul-12	5656
2-Jul-12	5500
3-Jul-12	5334
4-Jul-12	5159
5-Jul-12	4979
6-Jul-12	4797
7-Jul-12	4622
8-Jul-12	4460
9-Jul-12	4301
10-Jul-12	4139
11-Jul-12	3985
12-Jul-12	3837
13-Jul-12	3694
14-Jul-12	3558
15-Jul-12	3439
16-Jul-12	3327
17-Jul-12	3214
18-Jul-12	3097
19-Jul-12	2985
20-Jul-12	2875
21-Jul-12	2772
22-Jul-12	2671
23-Jul-12	2573
24-Jul-12	2488
25-Jul-12	2420
26-Jul-12	2355
27-Jul-12	2295
28-Jul-12	2244
29-Jul-12	2195
30-Jul-12	2142
31-Jul-12	2097
1-Aug-12	2064
2-Aug-12	2044
3-Aug-12	2022
4-Aug-12	2001
5-Aug-12	1985
6-Aug-12	1968
7-Aug-12	1948
8-Aug-12	1921
9-Aug-12	1891
10-Aug-12	1852
11-Aug-12	1803
12-Aug-12	1757
13-Aug-12	1723
14-Aug-12	1702
15-Aug-12	1690
16-Aug-12	1682
17-Aug-12	1665
18-Aug-12	1635
19-Aug-12	1596
20-Aug-12	1552
21-Aug-12	1515
22-Aug-12	1480
23-Aug-12	1454
24-Aug-12	1428
25-Aug-12	1400
26-Aug-12	1370
27-Aug-12	1342
28-Aug-12	1330
29-Aug-12	1330
30-Aug-12	1341
31-Aug-12	1349
1-Sep-12	1352

Date	Total Inflow
2-Sep-12	1343
3-Sep-12	1323
4-Sep-12	1307
5-Sep-12	1299
6-Sep-12	1300
7-Sep-12	1302
8-Sep-12	1303
9-Sep-12	1301
10-Sep-12	1304
11-Sep-12	1327
12-Sep-12	1346
13-Sep-12	1357
14-Sep-12	1354
15-Sep-12	1330
16-Sep-12	1278
17-Sep-12	1220
18-Sep-12	1168
19-Sep-12	1127
20-Sep-12	1092
21-Sep-12	1053
22-Sep-12	1028
23-Sep-12	1009
24-Sep-12	989
25-Sep-12	974
26-Sep-12	982
27-Sep-12	1004
28-Sep-12	1039
29-Sep-12	1090
30-Sep-12	1158
1-Oct-12	1230
2-Oct-12	1298
3-Oct-12	1359
4-Oct-12	1417
5-Oct-12	1477
6-Oct-12	1539
7-Oct-12	1607
8-Oct-12	1683
9-Oct-12	1765
10-Oct-12	1846
11-Oct-12	1931
12-Oct-12	2017
13-Oct-12	2105
14-Oct-12	2194
15-Oct-12	2282
16-Oct-12	2364
17-Oct-12	2429
18-Oct-12	2485
19-Oct-12	2533
20-Oct-12	2585
21-Oct-12	2646
22-Oct-12	2721
23-Oct-12	2798
24-Oct-12	2869
25-Oct-12	2933
26-Oct-12	2989
27-Oct-12	3042
28-Oct-12	3097
29-Oct-12	3154
30-Oct-12	3204
31-Oct-12	3243
1-Nov-12	3290
2-Nov-12	3343
3-Nov-12	3412
4-Nov-12	3503
5-Nov-12	3619
6-Nov-12	3736
7-Nov-12	3855
8-Nov-12	3963
9-Nov-12	4062
10-Nov-12	4158
11-Nov-12	4242
12-Nov-12	4318
13-Nov-12	4395

Date	Total Inflow
14-Nov-12	4467
15-Nov-12	4522
16-Nov-12	4566
17-Nov-12	4595
18-Nov-12	4607
19-Nov-12	4608
20-Nov-12	4603
21-Nov-12	4598
22-Nov-12	4591
23-Nov-12	4590
24-Nov-12	4584
25-Nov-12	4575
26-Nov-12	4568
27-Nov-12	4562
28-Nov-12	4552
29-Nov-12	4542
30-Nov-12	4531
1-Dec-12	4517
2-Dec-12	4505
3-Dec-12	4496
4-Dec-12	4490
5-Dec-12	4488
6-Dec-12	4490
7-Dec-12	4499
8-Dec-12	4509
9-Dec-12	4516
10-Dec-12	4519
11-Dec-12	4516
12-Dec-12	4513
13-Dec-12	4512
14-Dec-12	4512
15-Dec-12	4515
16-Dec-12	4521
17-Dec-12	4526
18-Dec-12	4532
19-Dec-12	4543
20-Dec-12	4554
21-Dec-12	4555
22-Dec-12	4551
23-Dec-12	4536
24-Dec-12	4504
25-Dec-12	4459
26-Dec-12	4413
27-Dec-12	4358
28-Dec-12	4305
29-Dec-12	4255
30-Dec-12	4205
31-Dec-12	4200

Lake Manitoba Inflow Forecast

July 8, 2011

Lake Manitoba July 8, 2011 Inflow Forecast	
Date	Total Inflow (cfs)
8-Jul-11	36714
9-Jul-11	36246
10-Jul-11	35303
11-Jul-11	34375
12-Jul-11	33668
13-Jul-11	32409
14-Jul-11	30610
15-Jul-11	28855
16-Jul-11	26922
17-Jul-11	24832
18-Jul-11	22796
19-Jul-11	21021
20-Jul-11	19268
21-Jul-11	17632
22-Jul-11	16292
23-Jul-11	14683
24-Jul-11	13653
25-Jul-11	12937
26-Jul-11	12415
27-Jul-11	11764
28-Jul-11	10927
29-Jul-11	10367
30-Jul-11	9827
31-Jul-11	9405
1-Aug-11	9028
2-Aug-11	8513
3-Aug-11	7996
4-Aug-11	7700
5-Aug-11	7531
6-Aug-11	7121
7-Aug-11	6812
8-Aug-11	6074
9-Aug-11	5582
10-Aug-11	5166
11-Aug-11	4708
12-Aug-11	4380
13-Aug-11	4097
14-Aug-11	3924
15-Aug-11	3753
16-Aug-11	3869
17-Aug-11	4285
18-Aug-11	4813
19-Aug-11	5169
20-Aug-11	5394
21-Aug-11	5682
22-Aug-11	5786
23-Aug-11	6119
24-Aug-11	6453
25-Aug-11	6501
26-Aug-11	6765
27-Aug-11	6767
28-Aug-11	6754
29-Aug-11	6797
30-Aug-11	6809
31-Aug-11	6571
1-Sep-11	6341
2-Sep-11	6090
3-Sep-11	6012
4-Sep-11	6091
5-Sep-11	6148
6-Sep-11	6369
7-Sep-11	6628
8-Sep-11	6783
9-Sep-11	7121
10-Sep-11	7281
11-Sep-11	7675
12-Sep-11	7770
13-Sep-11	7708

Date	Total Inflow
14-Sep-11	7670
15-Sep-11	7443
16-Sep-11	6928
17-Sep-11	6445
18-Sep-11	6021
19-Sep-11	5738
20-Sep-11	5669
21-Sep-11	5659
22-Sep-11	5675
23-Sep-11	5802
24-Sep-11	6014
25-Sep-11	6227
26-Sep-11	6239
27-Sep-11	6226
28-Sep-11	6129
29-Sep-11	5672
30-Sep-11	5338
1-Oct-11	4837
2-Oct-11	4424
3-Oct-11	4153
4-Oct-11	4176
5-Oct-11	3980
6-Oct-11	3850
7-Oct-11	3881
8-Oct-11	3679
9-Oct-11	3606
10-Oct-11	3682
11-Oct-11	4034
12-Oct-11	4188
13-Oct-11	4194
14-Oct-11	4017
15-Oct-11	4146
16-Oct-11	4107
17-Oct-11	4422
18-Oct-11	4942
19-Oct-11	5080
20-Oct-11	5087
21-Oct-11	4970
22-Oct-11	5147
23-Oct-11	5299
24-Oct-11	5126
25-Oct-11	5105
26-Oct-11	5090
27-Oct-11	4794
28-Oct-11	4598
29-Oct-11	4659
30-Oct-11	4282
31-Oct-11	4398
1-Nov-11	4497
2-Nov-11	4221
3-Nov-11	4617
4-Nov-11	4500
5-Nov-11	4958
6-Nov-11	5526
7-Nov-11	6070
8-Nov-11	6369
9-Nov-11	6945
10-Nov-11	7146
11-Nov-11	7199
12-Nov-11	6982
13-Nov-11	6910
14-Nov-11	7077
15-Nov-11	7049
16-Nov-11	7003
17-Nov-11	7439
18-Nov-11	7745
19-Nov-11	8207
20-Nov-11	8942
21-Nov-11	9184
22-Nov-11	9249
23-Nov-11	9298
24-Nov-11	8694
25-Nov-11	8371

Date	Total Inflow
26-Nov-11	8051
27-Nov-11	7876
28-Nov-11	7597
29-Nov-11	7165
30-Nov-11	6984
1-Dec-11	6982
2-Dec-11	6918
3-Dec-11	6925
4-Dec-11	6824
5-Dec-11	6675
6-Dec-11	6586
7-Dec-11	6546
8-Dec-11	6498
9-Dec-11	6663
10-Dec-11	6700
11-Dec-11	6685
12-Dec-11	6642
13-Dec-11	6534
14-Dec-11	6433
15-Dec-11	6191
16-Dec-11	6085
17-Dec-11	6042
18-Dec-11	5984
19-Dec-11	5854
20-Dec-11	5682
21-Dec-11	5528
22-Dec-11	5421
23-Dec-11	5336
24-Dec-11	5252
25-Dec-11	5158
26-Dec-11	5054
27-Dec-11	4925
28-Dec-11	4807
29-Dec-11	4719
30-Dec-11	4625
31-Dec-11	4520
1-Jan-12	4514
2-Jan-12	4505
3-Jan-12	4498
4-Jan-12	4491
5-Jan-12	4486
6-Jan-12	4481
7-Jan-12	4476
8-Jan-12	4472
9-Jan-12	4467
10-Jan-12	4460
11-Jan-12	4454
12-Jan-12	4447
13-Jan-12	4441
14-Jan-12	4437
15-Jan-12	4434
16-Jan-12	4432
17-Jan-12	4430
18-Jan-12	4427
19-Jan-12	4422
20-Jan-12	4417
21-Jan-12	4413
22-Jan-12	4410
23-Jan-12	4409
24-Jan-12	4409
25-Jan-12	4409
26-Jan-12	4409
27-Jan-12	4401
28-Jan-12	4394
29-Jan-12	4385
30-Jan-12	4374
31-Jan-12	4363
1-Feb-12	4351
2-Feb-12	4338
3-Feb-12	4323
4-Feb-12	4310
5-Feb-12	4297
6-Feb-12	4286

Date	Total Inflow
7-Feb-12	4278
8-Feb-12	4272
9-Feb-12	4269
10-Feb-12	4267
11-Feb-12	4266
12-Feb-12	4267
13-Feb-12	4268
14-Feb-12	4268
15-Feb-12	4268
16-Feb-12	4269
17-Feb-12	4271
18-Feb-12	4275
19-Feb-12	4282
20-Feb-12	4291
21-Feb-12	4302
22-Feb-12	4316
23-Feb-12	4335
24-Feb-12	4355
25-Feb-12	4379
26-Feb-12	4406
27-Feb-12	4436
28-Feb-12	4472
29-Feb-12	4513
1-Mar-12	4561
2-Mar-12	4613
3-Mar-12	4670
4-Mar-12	4731
5-Mar-12	4795
6-Mar-12	4864
7-Mar-12	4938
8-Mar-12	5019
9-Mar-12	5105
10-Mar-12	5192
11-Mar-12	5276
12-Mar-12	5356
13-Mar-12	5434
14-Mar-12	5509
15-Mar-12	5589
16-Mar-12	5674
17-Mar-12	5766
18-Mar-12	5864
19-Mar-12	5969
20-Mar-12	6075
21-Mar-12	6187
22-Mar-12	6310
23-Mar-12	6454
24-Mar-12	6601
25-Mar-12	6789
26-Mar-12	6976
27-Mar-12	7163
28-Mar-12	7353
29-Mar-12	7555
30-Mar-12	7795
31-Mar-12	8073
1-Apr-12	8382
2-Apr-12	8698
3-Apr-12	9125
4-Apr-12	9646
5-Apr-12	10158
6-Apr-12	10736
7-Apr-12	11519
8-Apr-12	12596
9-Apr-12	13770
10-Apr-12	14868
11-Apr-12	15878
12-Apr-12	16836
13-Apr-12	17719
14-Apr-12	18475
15-Apr-12	19339
16-Apr-12	20167
17-Apr-12	20726
18-Apr-12	20883
19-Apr-12	20857

Date	Total Inflow
20-Apr-12	20813
21-Apr-12	20798
22-Apr-12	20772
23-Apr-12	20662
24-Apr-12	20526
25-Apr-12	20248
26-Apr-12	19910
27-Apr-12	19597
28-Apr-12	19333
29-Apr-12	19081
30-Apr-12	18837
1-May-12	18567
2-May-12	18313
3-May-12	18087
4-May-12	17840
5-May-12	17603
6-May-12	17355
7-May-12	17122
8-May-12	16911
9-May-12	16734
10-May-12	16564
11-May-12	16422
12-May-12	16275
13-May-12	16151
14-May-12	16066
15-May-12	16010
16-May-12	15958
17-May-12	15878
18-May-12	15788
19-May-12	15637
20-May-12	15464
21-May-12	15270
22-May-12	15064
23-May-12	14811
24-May-12	14516
25-May-12	14172
26-May-12	13801
27-May-12	13413
28-May-12	12982
29-May-12	12577
30-May-12	12181
31-May-12	11796
1-Jun-12	11418
2-Jun-12	11078
3-Jun-12	10752
4-Jun-12	10457
5-Jun-12	10192
6-Jun-12	9971
7-Jun-12	9792
8-Jun-12	9639
9-Jun-12	9515
10-Jun-12	9395
11-Jun-12	9263
12-Jun-12	9113
13-Jun-12	8955
14-Jun-12	8790
15-Jun-12	8624
16-Jun-12	8458
17-Jun-12	8292
18-Jun-12	8104
19-Jun-12	7911
20-Jun-12	7717
21-Jun-12	7528
22-Jun-12	7337
23-Jun-12	7151
24-Jun-12	6956
25-Jun-12	6755
26-Jun-12	6542
27-Jun-12	6334
28-Jun-12	6141
29-Jun-12	5968
30-Jun-12	5810
1-Jul-12	5656

Date	Total Inflow
2-Jul-12	5500
3-Jul-12	5334
4-Jul-12	5159
5-Jul-12	4979
6-Jul-12	4797
7-Jul-12	4622
8-Jul-12	4460
9-Jul-12	4301
10-Jul-12	4139
11-Jul-12	3985
12-Jul-12	3837
13-Jul-12	3694
14-Jul-12	3558
15-Jul-12	3439
16-Jul-12	3327
17-Jul-12	3214
18-Jul-12	3097
19-Jul-12	2985
20-Jul-12	2875
21-Jul-12	2772
22-Jul-12	2671
23-Jul-12	2573
24-Jul-12	2488
25-Jul-12	2420
26-Jul-12	2355
27-Jul-12	2295
28-Jul-12	2244
29-Jul-12	2195
30-Jul-12	2142
31-Jul-12	2097
1-Aug-12	2064
2-Aug-12	2044
3-Aug-12	2022
4-Aug-12	2001
5-Aug-12	1985
6-Aug-12	1968
7-Aug-12	1948
8-Aug-12	1921
9-Aug-12	1891
10-Aug-12	1852
11-Aug-12	1803
12-Aug-12	1757
13-Aug-12	1723
14-Aug-12	1702
15-Aug-12	1690
16-Aug-12	1682
17-Aug-12	1665
18-Aug-12	1635
19-Aug-12	1596
20-Aug-12	1552
21-Aug-12	1515
22-Aug-12	1480
23-Aug-12	1454
24-Aug-12	1428
25-Aug-12	1400
26-Aug-12	1370
27-Aug-12	1342
28-Aug-12	1330
29-Aug-12	1330
30-Aug-12	1341
31-Aug-12	1349
1-Sep-12	1352
2-Sep-12	1343
3-Sep-12	1323
4-Sep-12	1307
5-Sep-12	1299
6-Sep-12	1300
7-Sep-12	1302
8-Sep-12	1303
9-Sep-12	1301
10-Sep-12	1304
11-Sep-12	1327
12-Sep-12	1346

Date	Total Inflow
13-Sep-12	1357
14-Sep-12	1354
15-Sep-12	1330
16-Sep-12	1278
17-Sep-12	1220
18-Sep-12	1168
19-Sep-12	1127
20-Sep-12	1092
21-Sep-12	1053
22-Sep-12	1028
23-Sep-12	1009
24-Sep-12	989
25-Sep-12	974
26-Sep-12	982
27-Sep-12	1004
28-Sep-12	1039
29-Sep-12	1090
30-Sep-12	1158
1-Oct-12	1230
2-Oct-12	1298
3-Oct-12	1359
4-Oct-12	1417
5-Oct-12	1477
6-Oct-12	1539
7-Oct-12	1607
8-Oct-12	1683
9-Oct-12	1765
10-Oct-12	1846
11-Oct-12	1931
12-Oct-12	2017
13-Oct-12	2105
14-Oct-12	2194
15-Oct-12	2282
16-Oct-12	2364
17-Oct-12	2429
18-Oct-12	2485
19-Oct-12	2533
20-Oct-12	2585
21-Oct-12	2646
22-Oct-12	2721
23-Oct-12	2798
24-Oct-12	2869
25-Oct-12	2933
26-Oct-12	2989
27-Oct-12	3042
28-Oct-12	3097
29-Oct-12	3154
30-Oct-12	3204
31-Oct-12	3243
1-Nov-12	3290
2-Nov-12	3343
3-Nov-12	3412
4-Nov-12	3503
5-Nov-12	3619
6-Nov-12	3736
7-Nov-12	3855
8-Nov-12	3963
9-Nov-12	4062
10-Nov-12	4158
11-Nov-12	4242
12-Nov-12	4318
13-Nov-12	4395
14-Nov-12	4467
15-Nov-12	4522
16-Nov-12	4566
17-Nov-12	4595
18-Nov-12	4607
19-Nov-12	4608
20-Nov-12	4603
21-Nov-12	4598
22-Nov-12	4591
23-Nov-12	4590
24-Nov-12	4584

Date	Total Inflow
25-Nov-12	4575
26-Nov-12	4568
27-Nov-12	4562
28-Nov-12	4552
29-Nov-12	4542
30-Nov-12	4531
1-Dec-12	4517
2-Dec-12	4505
3-Dec-12	4496
4-Dec-12	4490
5-Dec-12	4488
6-Dec-12	4490
7-Dec-12	4499
8-Dec-12	4509
9-Dec-12	4516
10-Dec-12	4519
11-Dec-12	4516
12-Dec-12	4513
13-Dec-12	4512
14-Dec-12	4512
15-Dec-12	4515
16-Dec-12	4521
17-Dec-12	4526
18-Dec-12	4532
19-Dec-12	4543
20-Dec-12	4554
21-Dec-12	4555
22-Dec-12	4551
23-Dec-12	4536
24-Dec-12	4504
25-Dec-12	4459
26-Dec-12	4413
27-Dec-12	4358
28-Dec-12	4305
29-Dec-12	4255
30-Dec-12	4205
31-Dec-12	4200

Lake Manitoba Inflow Forecast

July22, 2011

Lake Manitoba
July 22, 2011
Inflow Forecast

Date	Total Inflow (cfs)
22-Jul-11	15978
23-Jul-11	14953
24-Jul-11	14202
25-Jul-11	13667
26-Jul-11	13263
27-Jul-11	12931
28-Jul-11	12639
29-Jul-11	12381
30-Jul-11	12149
31-Jul-11	11954
1-Aug-11	11790
2-Aug-11	11628
3-Aug-11	11477
4-Aug-11	11315
5-Aug-11	11138
6-Aug-11	10938
7-Aug-11	10747
8-Aug-11	10459
9-Aug-11	10167
10-Aug-11	9885
11-Aug-11	9586
12-Aug-11	9287
13-Aug-11	8990
14-Aug-11	8869
15-Aug-11	8833
16-Aug-11	8800
17-Aug-11	8775
18-Aug-11	8757
19-Aug-11	8748
20-Aug-11	8744
21-Aug-11	8736
22-Aug-11	8721
23-Aug-11	8697
24-Aug-11	8664
25-Aug-11	8623
26-Aug-11	8582
27-Aug-11	8540
28-Aug-11	8499
29-Aug-11	8457
30-Aug-11	8417
31-Aug-11	8380
1-Sep-11	8347
2-Sep-11	8318
3-Sep-11	8292
4-Sep-11	8269
5-Sep-11	8247
6-Sep-11	8225
7-Sep-11	8201
8-Sep-11	8174
9-Sep-11	8146
10-Sep-11	8118
11-Sep-11	8088
12-Sep-11	8055
13-Sep-11	8018
14-Sep-11	7975
15-Sep-11	7926
16-Sep-11	7873
17-Sep-11	7818
18-Sep-11	7761
19-Sep-11	7702
20-Sep-11	7641
21-Sep-11	7578
22-Sep-11	7515
23-Sep-11	7453
24-Sep-11	7394
25-Sep-11	7339
26-Sep-11	7288
27-Sep-11	7241

Date	Total Inflow
28-Sep-11	7197
29-Sep-11	7157
30-Sep-11	7118
1-Oct-11	7080
2-Oct-11	7040
3-Oct-11	6998
4-Oct-11	6952
5-Oct-11	6903
6-Oct-11	6851
7-Oct-11	6796
8-Oct-11	6737
9-Oct-11	6675
10-Oct-11	6614
11-Oct-11	6556
12-Oct-11	6502
13-Oct-11	6456
14-Oct-11	6418
15-Oct-11	6390
16-Oct-11	6371
17-Oct-11	6359
18-Oct-11	6351
19-Oct-11	6344
20-Oct-11	6336
21-Oct-11	6326
22-Oct-11	6314
23-Oct-11	6302
24-Oct-11	6295
25-Oct-11	6294
26-Oct-11	6305
27-Oct-11	6329
28-Oct-11	6365
29-Oct-11	6411
30-Oct-11	6463
31-Oct-11	6516
1-Nov-11	6566
2-Nov-11	6612
3-Nov-11	6654
4-Nov-11	6692
5-Nov-11	6725
6-Nov-11	6755
7-Nov-11	6780
8-Nov-11	6803
9-Nov-11	6825
10-Nov-11	6845
11-Nov-11	6865
12-Nov-11	6881
13-Nov-11	6892
14-Nov-11	6901
15-Nov-11	6909
16-Nov-11	6915
17-Nov-11	6920
18-Nov-11	6926
19-Nov-11	6932
20-Nov-11	6935
21-Nov-11	6937
22-Nov-11	6939
23-Nov-11	6939
24-Nov-11	6940
25-Nov-11	6940
26-Nov-11	6939
27-Nov-11	6939
28-Nov-11	6938
29-Nov-11	6934
30-Nov-11	6926
1-Dec-11	6916
2-Dec-11	6899
3-Dec-11	6877
4-Dec-11	6847
5-Dec-11	6809
6-Dec-11	6861
7-Dec-11	6820
8-Dec-11	6814
9-Dec-11	6808

Date	Total Inflow
10-Dec-11	6802
11-Dec-11	6797
12-Dec-11	6791
13-Dec-11	6780
14-Dec-11	6765
15-Dec-11	6739
16-Dec-11	6702
17-Dec-11	6654
18-Dec-11	6595
19-Dec-11	6530
20-Dec-11	6466
21-Dec-11	6403
22-Dec-11	6346
23-Dec-11	6294
24-Dec-11	6249
25-Dec-11	6210
26-Dec-11	6176
27-Dec-11	6145
28-Dec-11	6117
29-Dec-11	6089
30-Dec-11	6062
31-Dec-11	6036
1-Jan-12	4514
2-Jan-12	4505
3-Jan-12	4498
4-Jan-12	4491
5-Jan-12	4486
6-Jan-12	4481
7-Jan-12	4476
8-Jan-12	4472
9-Jan-12	4467
10-Jan-12	4460
11-Jan-12	4454
12-Jan-12	4447
13-Jan-12	4441
14-Jan-12	4437
15-Jan-12	4434
16-Jan-12	4432
17-Jan-12	4430
18-Jan-12	4427
19-Jan-12	4422
20-Jan-12	4417
21-Jan-12	4413
22-Jan-12	4410
23-Jan-12	4409
24-Jan-12	4409
25-Jan-12	4409
26-Jan-12	4409
27-Jan-12	4401
28-Jan-12	4394
29-Jan-12	4385
30-Jan-12	4374
31-Jan-12	4363
1-Feb-12	4351
2-Feb-12	4338
3-Feb-12	4323
4-Feb-12	4310
5-Feb-12	4297
6-Feb-12	4286
7-Feb-12	4278
8-Feb-12	4272
9-Feb-12	4269
10-Feb-12	4267
11-Feb-12	4266
12-Feb-12	4267
13-Feb-12	4268
14-Feb-12	4268
15-Feb-12	4268
16-Feb-12	4269
17-Feb-12	4271
18-Feb-12	4275
19-Feb-12	4282
20-Feb-12	4291

Date	Total Inflow
21-Feb-12	4302
22-Feb-12	4316
23-Feb-12	4335
24-Feb-12	4355
25-Feb-12	4379
26-Feb-12	4406
27-Feb-12	4436
28-Feb-12	4472
29-Feb-12	4513
1-Mar-12	4561
2-Mar-12	4613
3-Mar-12	4670
4-Mar-12	4731
5-Mar-12	4795
6-Mar-12	4864
7-Mar-12	4938
8-Mar-12	5019
9-Mar-12	5105
10-Mar-12	5192
11-Mar-12	5276
12-Mar-12	5356
13-Mar-12	5434
14-Mar-12	5509
15-Mar-12	5589
16-Mar-12	5674
17-Mar-12	5766
18-Mar-12	5864
19-Mar-12	5969
20-Mar-12	6075
21-Mar-12	6187
22-Mar-12	6310
23-Mar-12	6454
24-Mar-12	6601
25-Mar-12	6789
26-Mar-12	6976
27-Mar-12	7163
28-Mar-12	7353
29-Mar-12	7555
30-Mar-12	7795
31-Mar-12	8073
1-Apr-12	8382
2-Apr-12	8698
3-Apr-12	9125
4-Apr-12	9646
5-Apr-12	10158
6-Apr-12	10736
7-Apr-12	11519
8-Apr-12	12596
9-Apr-12	13770
10-Apr-12	14868
11-Apr-12	15878
12-Apr-12	16836
13-Apr-12	17719
14-Apr-12	18475
15-Apr-12	19339
16-Apr-12	20167
17-Apr-12	20726
18-Apr-12	20883
19-Apr-12	20857
20-Apr-12	20813
21-Apr-12	20798
22-Apr-12	20772
23-Apr-12	20662
24-Apr-12	20526
25-Apr-12	20248
26-Apr-12	19910
27-Apr-12	19597
28-Apr-12	19333
29-Apr-12	19081
30-Apr-12	18837
1-May-12	18567
2-May-12	18313
3-May-12	18087

Date	Total Inflow
4-May-12	17840
5-May-12	17603
6-May-12	17355
7-May-12	17122
8-May-12	16911
9-May-12	16734
10-May-12	16564
11-May-12	16422
12-May-12	16275
13-May-12	16151
14-May-12	16066
15-May-12	16010
16-May-12	15958
17-May-12	15878
18-May-12	15788
19-May-12	15637
20-May-12	15464
21-May-12	15270
22-May-12	15064
23-May-12	14811
24-May-12	14516
25-May-12	14172
26-May-12	13801
27-May-12	13413
28-May-12	12982
29-May-12	12577
30-May-12	12181
31-May-12	11796
1-Jun-12	11418
2-Jun-12	11078
3-Jun-12	10752
4-Jun-12	10457
5-Jun-12	10192
6-Jun-12	9971
7-Jun-12	9792
8-Jun-12	9639
9-Jun-12	9515
10-Jun-12	9395
11-Jun-12	9263
12-Jun-12	9113
13-Jun-12	8955
14-Jun-12	8790
15-Jun-12	8624
16-Jun-12	8458
17-Jun-12	8292
18-Jun-12	8104
19-Jun-12	7911
20-Jun-12	7717
21-Jun-12	7528
22-Jun-12	7337
23-Jun-12	7151
24-Jun-12	6956
25-Jun-12	6755
26-Jun-12	6542
27-Jun-12	6334
28-Jun-12	6141
29-Jun-12	5968
30-Jun-12	5810
1-Jul-12	5656
2-Jul-12	5500
3-Jul-12	5334
4-Jul-12	5159
5-Jul-12	4979
6-Jul-12	4797
7-Jul-12	4622
8-Jul-12	4460
9-Jul-12	4301
10-Jul-12	4139
11-Jul-12	3985
12-Jul-12	3837
13-Jul-12	3694
14-Jul-12	3558
15-Jul-12	3439

Date	Total Inflow
16-Jul-12	3327
17-Jul-12	3214
18-Jul-12	3097
19-Jul-12	2985
20-Jul-12	2875
21-Jul-12	2772
22-Jul-12	2671
23-Jul-12	2573
24-Jul-12	2488
25-Jul-12	2420
26-Jul-12	2355
27-Jul-12	2295
28-Jul-12	2244
29-Jul-12	2195
30-Jul-12	2142
31-Jul-12	2097
1-Aug-12	2064
2-Aug-12	2044
3-Aug-12	2022
4-Aug-12	2001
5-Aug-12	1985
6-Aug-12	1968
7-Aug-12	1948
8-Aug-12	1921
9-Aug-12	1891
10-Aug-12	1852
11-Aug-12	1803
12-Aug-12	1757
13-Aug-12	1723
14-Aug-12	1702
15-Aug-12	1690
16-Aug-12	1682
17-Aug-12	1665
18-Aug-12	1635
19-Aug-12	1596
20-Aug-12	1552
21-Aug-12	1515
22-Aug-12	1480
23-Aug-12	1454
24-Aug-12	1428
25-Aug-12	1400
26-Aug-12	1370
27-Aug-12	1342
28-Aug-12	1330
29-Aug-12	1330
30-Aug-12	1341
31-Aug-12	1349
1-Sep-12	1352
2-Sep-12	1343
3-Sep-12	1323
4-Sep-12	1307
5-Sep-12	1299
6-Sep-12	1300
7-Sep-12	1302
8-Sep-12	1303
9-Sep-12	1301
10-Sep-12	1304
11-Sep-12	1327
12-Sep-12	1346
13-Sep-12	1357
14-Sep-12	1354
15-Sep-12	1330
16-Sep-12	1278
17-Sep-12	1220
18-Sep-12	1168
19-Sep-12	1127
20-Sep-12	1092
21-Sep-12	1053
22-Sep-12	1028
23-Sep-12	1009
24-Sep-12	989
25-Sep-12	974
26-Sep-12	982

Date	Total Inflow
27-Sep-12	1004
28-Sep-12	1039
29-Sep-12	1090
30-Sep-12	1158
1-Oct-12	1230
2-Oct-12	1298
3-Oct-12	1359
4-Oct-12	1417
5-Oct-12	1477
6-Oct-12	1539
7-Oct-12	1607
8-Oct-12	1683
9-Oct-12	1765
10-Oct-12	1846
11-Oct-12	1931
12-Oct-12	2017
13-Oct-12	2105
14-Oct-12	2194
15-Oct-12	2282
16-Oct-12	2364
17-Oct-12	2429
18-Oct-12	2485
19-Oct-12	2533
20-Oct-12	2585
21-Oct-12	2646
22-Oct-12	2721
23-Oct-12	2798
24-Oct-12	2869
25-Oct-12	2933
26-Oct-12	2989
27-Oct-12	3042
28-Oct-12	3097
29-Oct-12	3154
30-Oct-12	3204
31-Oct-12	3243
1-Nov-12	3290
2-Nov-12	3343
3-Nov-12	3412
4-Nov-12	3503
5-Nov-12	3619
6-Nov-12	3736
7-Nov-12	3855
8-Nov-12	3963
9-Nov-12	4062
10-Nov-12	4158
11-Nov-12	4242
12-Nov-12	4318
13-Nov-12	4395
14-Nov-12	4467
15-Nov-12	4522
16-Nov-12	4566
17-Nov-12	4595
18-Nov-12	4607
19-Nov-12	4608
20-Nov-12	4603
21-Nov-12	4598
22-Nov-12	4591
23-Nov-12	4590
24-Nov-12	4584
25-Nov-12	4575
26-Nov-12	4568
27-Nov-12	4562
28-Nov-12	4552
29-Nov-12	4542
30-Nov-12	4531
1-Dec-12	4517
2-Dec-12	4505
3-Dec-12	4496
4-Dec-12	4490
5-Dec-12	4488
6-Dec-12	4490
7-Dec-12	4499
8-Dec-12	4509

Date	Total Inflow
9-Dec-12	4516
10-Dec-12	4519
11-Dec-12	4516
12-Dec-12	4513
13-Dec-12	4512
14-Dec-12	4512
15-Dec-12	4515
16-Dec-12	4521
17-Dec-12	4526
18-Dec-12	4532
19-Dec-12	4543
20-Dec-12	4554
21-Dec-12	4555
22-Dec-12	4551
23-Dec-12	4536
24-Dec-12	4504
25-Dec-12	4459
26-Dec-12	4413
27-Dec-12	4358
28-Dec-12	4305
29-Dec-12	4255
30-Dec-12	4205
31-Dec-12	4200

Lake Manitoba Inflow Forecast

November 12, 2011

Lake Manitoba
Nov. 12, 2011
Inflow Forecast

Date	Total Inflow (cfs)
12-Nov-11	6693
13-Nov-11	6125
14-Nov-11	5482
15-Nov-11	5648
16-Nov-11	5111
17-Nov-11	4904
18-Nov-11	5353
19-Nov-11	5012
20-Nov-11	5329
21-Nov-11	5933
22-Nov-11	5669
23-Nov-11	5955
24-Nov-11	6215
25-Nov-11	6126
26-Nov-11	6454
27-Nov-11	6489
28-Nov-11	7056
29-Nov-11	8306
30-Nov-11	9321
1-Dec-11	10306
2-Dec-11	10977
3-Dec-11	10947
4-Dec-11	10331
5-Dec-11	9387
6-Dec-11	8248
7-Dec-11	7940
8-Dec-11	7861
9-Dec-11	8193
10-Dec-11	8865
11-Dec-11	8915
12-Dec-11	8586
13-Dec-11	8466
14-Dec-11	7773
15-Dec-11	7325
16-Dec-11	7360
17-Dec-11	7478
18-Dec-11	7362
19-Dec-11	7216
20-Dec-11	7310
21-Dec-11	7422
22-Dec-11	7395
23-Dec-11	7410
24-Dec-11	7264
25-Dec-11	7092
26-Dec-11	6977
27-Dec-11	6945
28-Dec-11	6910
29-Dec-11	6946
30-Dec-11	6861
31-Dec-11	6826
1-Jan-12	9749
2-Jan-12	9723
3-Jan-12	9813
4-Jan-12	9629
5-Jan-12	9535
6-Jan-12	9460
7-Jan-12	9401
8-Jan-12	9307
9-Jan-12	9246
10-Jan-12	9190
11-Jan-12	9285
12-Jan-12	9094
13-Jan-12	9182
14-Jan-12	9157
15-Jan-12	9171
16-Jan-12	9081
17-Jan-12	9184
18-Jan-12	9053

Date	Total Inflow
19-Jan-12	9027
20-Jan-12	8871
21-Jan-12	8680
22-Jan-12	8611
23-Jan-12	8699
24-Jan-12	8545
25-Jan-12	8523
26-Jan-12	8605
27-Jan-12	8636
28-Jan-12	8423
29-Jan-12	8273
30-Jan-12	8289
31-Jan-12	8265
1-Feb-12	8294
2-Feb-12	8342
3-Feb-12	8397
4-Feb-12	8440
5-Feb-12	8496
6-Feb-12	8489
7-Feb-12	8469
8-Feb-12	8403
9-Feb-12	8336
10-Feb-12	8257
11-Feb-12	8169
12-Feb-12	8123
13-Feb-12	8099
14-Feb-12	8117
15-Feb-12	8133
16-Feb-12	8101
17-Feb-12	8059
18-Feb-12	8033
19-Feb-12	7912
20-Feb-12	8065
21-Feb-12	8060
22-Feb-12	8035
23-Feb-12	8023
24-Feb-12	7849
25-Feb-12	8013
26-Feb-12	8020
27-Feb-12	8028
28-Feb-12	8159
29-Feb-12	8187
1-Mar-12	8152
2-Mar-12	8278
3-Mar-12	8289
4-Mar-12	8453
5-Mar-12	8441
6-Mar-12	8584
7-Mar-12	8549
8-Mar-12	8515
9-Mar-12	8453
10-Mar-12	8406
11-Mar-12	8578
12-Mar-12	8503
13-Mar-12	8505
14-Mar-12	8516
15-Mar-12	8528
16-Mar-12	8605
17-Mar-12	8699
18-Mar-12	8831
19-Mar-12	9077
20-Mar-12	9367
21-Mar-12	9564
22-Mar-12	9679
23-Mar-12	9808
24-Mar-12	9940
25-Mar-12	10098
26-Mar-12	10301
27-Mar-12	10550
28-Mar-12	10762
29-Mar-12	10838
30-Mar-12	10871
31-Mar-12	10991

Date	Total Inflow
1-Apr-12	11101
2-Apr-12	11251
3-Apr-12	11238
4-Apr-12	11108
5-Apr-12	11217
6-Apr-12	11380
7-Apr-12	11467
8-Apr-12	11592
9-Apr-12	11658
10-Apr-12	11608
11-Apr-12	11566
12-Apr-12	11105
13-Apr-12	11186
14-Apr-12	11077
15-Apr-12	10901
16-Apr-12	10827
17-Apr-12	10756
18-Apr-12	10511
19-Apr-12	10374
20-Apr-12	10390
21-Apr-12	9868
22-Apr-12	9808
23-Apr-12	9485
24-Apr-12	9437
25-Apr-12	9323
26-Apr-12	9398
27-Apr-12	9667
28-Apr-12	9742
29-Apr-12	9606
30-Apr-12	9638
1-May-12	9835
2-May-12	9809
3-May-12	10089
4-May-12	10683
5-May-12	10679
6-May-12	10508
7-May-12	10105
8-May-12	10095
9-May-12	9910
10-May-12	9185
11-May-12	9141
12-May-12	8599
13-May-12	7320
14-May-12	7201
15-May-12	8804
16-May-12	7970
17-May-12	8001
18-May-12	9068
19-May-12	9100
20-May-12	9290
21-May-12	9352
22-May-12	9687
23-May-12	10891
24-May-12	11358
25-May-12	10935
26-May-12	10634
27-May-12	11339
28-May-12	10478
29-May-12	10203
30-May-12	10458
31-May-12	10164
1-Jun-12	9830
2-Jun-12	9774
3-Jun-12	8981
4-Jun-12	8478
5-Jun-12	8647
6-Jun-12	9415
7-Jun-12	6968
8-Jun-12	7790
9-Jun-12	7097
10-Jun-12	8758
11-Jun-12	8592
12-Jun-12	8286

Date	Total Inflow
13-Jun-12	7856
14-Jun-12	8095
15-Jun-12	8060
16-Jun-12	8183
17-Jun-12	8939
18-Jun-12	9640
19-Jun-12	11304
20-Jun-12	9866
21-Jun-12	7254
22-Jun-12	7413
23-Jun-12	6669
24-Jun-12	6226
25-Jun-12	6785
26-Jun-12	9011
27-Jun-12	8317
28-Jun-12	8436
29-Jun-12	8602
30-Jun-12	8749
1-Jul-12	7927
2-Jul-12	6362
3-Jul-12	9152
4-Jul-12	7631
5-Jul-12	6277
6-Jul-12	6207
7-Jul-12	6337
8-Jul-12	5895
9-Jul-12	6159
10-Jul-12	5437
11-Jul-12	4176
12-Jul-12	3305
13-Jul-12	4861
14-Jul-12	4518
15-Jul-12	2694
16-Jul-12	4096
17-Jul-12	4990
18-Jul-12	6399
19-Jul-12	5887
20-Jul-12	5061
21-Jul-12	4721
22-Jul-12	5273
23-Jul-12	5661
24-Jul-12	6368
25-Jul-12	8055
26-Jul-12	8969
27-Jul-12	8056
28-Jul-12	7171
29-Jul-12	7509
30-Jul-12	7071
31-Jul-12	6792
1-Aug-12	7341
2-Aug-12	7954
3-Aug-12	7185
4-Aug-12	7305
5-Aug-12	5655
6-Aug-12	5234
7-Aug-12	5332
8-Aug-12	5713
9-Aug-12	7394
10-Aug-12	7117
11-Aug-12	7608
12-Aug-12	7440
13-Aug-12	6862
14-Aug-12	6851
15-Aug-12	7575
16-Aug-12	6446
17-Aug-12	5137
18-Aug-12	5520
19-Aug-12	6815
20-Aug-12	5501
21-Aug-12	5589
22-Aug-12	6319
23-Aug-12	5561
24-Aug-12	5740

Date	Total Inflow
25-Aug-12	5449
26-Aug-12	6344
27-Aug-12	6470
28-Aug-12	6460
29-Aug-12	6373
30-Aug-12	5493
31-Aug-12	6413
1-Sep-12	8181
2-Sep-12	5623
3-Sep-12	4346
4-Sep-12	5461
5-Sep-12	5292
6-Sep-12	2638
7-Sep-12	1591
8-Sep-12	1824
9-Sep-12	2725
10-Sep-12	4596
11-Sep-12	4393
12-Sep-12	3480
13-Sep-12	3127
14-Sep-12	5768
15-Sep-12	2870
16-Sep-12	1459
17-Sep-12	1638
18-Sep-12	1476
19-Sep-12	1496
20-Sep-12	1152
21-Sep-12	1215
22-Sep-12	2551
23-Sep-12	1563
24-Sep-12	2326
25-Sep-12	3652
26-Sep-12	4104
27-Sep-12	4299
28-Sep-12	4534
29-Sep-12	3209
30-Sep-12	4089
1-Oct-12	4018
2-Oct-12	3278
3-Oct-12	3767
4-Oct-12	2352
5-Oct-12	1780
6-Oct-12	1923
7-Oct-12	1912
8-Oct-12	2475
9-Oct-12	3966
10-Oct-12	3113
11-Oct-12	1465
12-Oct-12	1345
13-Oct-12	1018
14-Oct-12	792
15-Oct-12	2643
16-Oct-12	2388
17-Oct-12	2569
18-Oct-12	2028
19-Oct-12	2764
20-Oct-12	2686
21-Oct-12	3705
22-Oct-12	4168
23-Oct-12	4467
24-Oct-12	5149
25-Oct-12	6081
26-Oct-12	5470
27-Oct-12	5923
28-Oct-12	3594
29-Oct-12	4196
30-Oct-12	4222
31-Oct-12	4458
1-Nov-12	5532
2-Nov-12	5200
3-Nov-12	5702
4-Nov-12	5778
5-Nov-12	6208

Date	Total Inflow
6-Nov-12	5653
7-Nov-12	5351
8-Nov-12	6050
9-Nov-12	4729
10-Nov-12	4155
11-Nov-12	4069
12-Nov-12	3934
13-Nov-12	3787
14-Nov-12	3532
15-Nov-12	3234
16-Nov-12	2945
17-Nov-12	2626
18-Nov-12	2591
19-Nov-12	2494
20-Nov-12	2769
21-Nov-12	3425
22-Nov-12	3384
23-Nov-12	3592
24-Nov-12	3963
25-Nov-12	4110
26-Nov-12	4613
27-Nov-12	4699
28-Nov-12	4887
29-Nov-12	5248
30-Nov-12	5862
1-Dec-12	6222
2-Dec-12	6742
3-Dec-12	6496
4-Dec-12	5988
5-Dec-12	5023
6-Dec-12	4424
7-Dec-12	4302
8-Dec-12	4221
9-Dec-12	4424
10-Dec-12	4535
11-Dec-12	4693
12-Dec-12	4452
13-Dec-12	4165
14-Dec-12	3958
15-Dec-12	3627
16-Dec-12	3602
17-Dec-12	3676
18-Dec-12	3709
19-Dec-12	3856
20-Dec-12	4132
21-Dec-12	4458
22-Dec-12	4635
23-Dec-12	4630
24-Dec-12	4591
25-Dec-12	4628
26-Dec-12	4778
27-Dec-12	4962
28-Dec-12	5122
29-Dec-12	5262
30-Dec-12	5310
31-Dec-12	5305

Lake Manitoba Inflow Forecast

March 11, 2012

Lake Manitoba 11, 2012		Mar. Inflow
Forecast		
Date	Total Inflow - Median (cfs)	Total Inflow - Wet (cfs)
12-Mar-12	6377	7495
13-Mar-12	6688	7217
14-Mar-12	6842	7089
15-Mar-12	6784	6833
16-Mar-12	6881	6881
17-Mar-12	6906	6905
18-Mar-12	6912	6909
19-Mar-12	7126	7121
20-Mar-12	7197	7188
21-Mar-12	7046	7034
22-Mar-12	6820	6805
23-Mar-12	6591	6571
24-Mar-12	6284	6260
25-Mar-12	6438	6408
26-Mar-12	6675	6634
27-Mar-12	6980	6928
28-Mar-12	7283	7222
29-Mar-12	7513	7546
30-Mar-12	7742	7862
31-Mar-12	8044	8031
1-Apr-12	11868	11831
2-Apr-12	11921	11784
3-Apr-12	12046	11901
4-Apr-12	12151	11998
5-Apr-12	12108	11946
6-Apr-12	12288	12115
7-Apr-12	12431	12245
8-Apr-12	12802	12604
9-Apr-12	13014	12810
10-Apr-12	13218	13009
11-Apr-12	13671	13459
12-Apr-12	14112	13896
13-Apr-12	14027	13809
14-Apr-12	13814	13595
15-Apr-12	13443	13221
16-Apr-12	13048	12822
17-Apr-12	12782	12552
18-Apr-12	12679	12446
19-Apr-12	12820	13343
20-Apr-12	13035	14284
21-Apr-12	13032	14995
22-Apr-12	13201	15881
23-Apr-12	13143	16791
24-Apr-12	12799	18288
25-Apr-12	12622	19956
26-Apr-12	12027	21295
27-Apr-12	11437	22070
28-Apr-12	11888	22132
29-Apr-12	12142	21359
30-Apr-12	11763	20185
1-May-12	12179	18932
2-May-12	11907	17847
3-May-12	11494	16939
4-May-12	11686	16444
5-May-12	12306	16353
6-May-12	10750	16317
7-May-12	9543	16205
8-May-12	8074	16383
9-May-12	6033	16373
10-May-12	4844	16511
11-May-12	6047	16534
12-May-12	6465	16162
13-May-12	5100	15508
14-May-12	4890	15531
15-May-12	5209	15701
16-May-12	5090	16198
17-May-12	7025	16623
18-May-12	9767	16945

Date	Total Inflow	
19-May-12	10050	16842
20-May-12	9249	16968
21-May-12	10117	17328
22-May-12	9801	17930
23-May-12	9536	17473
24-May-12	11229	15923
25-May-12	12403	14507
26-May-12	10570	13214
27-May-12	8663	12711
28-May-12	9213	14134
29-May-12	9597	16975
30-May-12	11497	19384
31-May-12	13725	20912
1-Jun-12	14371	21601
2-Jun-12	13121	21380
3-Jun-12	12801	20403
4-Jun-12	12102	18523
5-Jun-12	12503	16725
6-Jun-12	14420	14258
7-Jun-12	16218	13065
8-Jun-12	16262	13941
9-Jun-12	15419	15840
10-Jun-12	15535	18286
11-Jun-12	16245	20052
12-Jun-12	15211	18179
13-Jun-12	13978	14201
14-Jun-12	12055	9665
15-Jun-12	9271	4784
16-Jun-12	6684	2254
17-Jun-12	6059	3093
18-Jun-12	6017	4640
19-Jun-12	5847	6656
20-Jun-12	5341	8588
21-Jun-12	4577	10011
22-Jun-12	4404	10728
23-Jun-12	6096	10895
24-Jun-12	8788	10288
25-Jun-12	9090	8180
26-Jun-12	9712	7752
27-Jun-12	11782	8893
28-Jun-12	10879	8630
29-Jun-12	9298	9085
30-Jun-12	9875	11941
1-Jul-12	10589	13121
2-Jul-12	9287	11440
3-Jul-12	9536	11499
4-Jul-12	10678	11412
5-Jul-12	10405	10571
6-Jul-12	8941	10089
7-Jul-12	7469	10993
8-Jul-12	4801	10601
9-Jul-12	2487	9985
10-Jul-12	2847	11234
11-Jul-12	2658	11717
12-Jul-12	1465	12056
13-Jul-12	3101	13696
14-Jul-12	3104	14270
15-Jul-12	2450	12374
16-Jul-12	1377	10422
17-Jul-12	196	9669
18-Jul-12	-2543	9078
19-Jul-12	-2699	9864
20-Jul-12	-2743	10961
21-Jul-12	-2857	12272
22-Jul-12	-2189	12399
23-Jul-12	-859	14110
24-Jul-12	-622	15733
25-Jul-12	512	16472
26-Jul-12	3736	16424
27-Jul-12	7360	17064
28-Jul-12	10056	16670
29-Jul-12	13447	15971
30-Jul-12	13961	15438

Date	Total Inflow	
31-Jul-12	13816	15669
1-Aug-12	13943	14603
2-Aug-12	13849	11853
3-Aug-12	11742	9111
4-Aug-12	12736	7502
5-Aug-12	14149	5879
6-Aug-12	14983	4347
7-Aug-12	15809	1835
8-Aug-12	16783	455
9-Aug-12	14853	-1028
10-Aug-12	11800	-2424
11-Aug-12	7919	-3746
12-Aug-12	5394	-2764
13-Aug-12	4444	-1435
14-Aug-12	4938	803
15-Aug-12	5949	1483
16-Aug-12	8775	2790
17-Aug-12	10138	4873
18-Aug-12	10088	5564
19-Aug-12	8275	5121
20-Aug-12	7308	6442
21-Aug-12	6019	7653
22-Aug-12	4876	8932
23-Aug-12	3248	9373
24-Aug-12	2031	9576
25-Aug-12	-195	8316
26-Aug-12	-1641	5799
27-Aug-12	-3517	3579
28-Aug-12	-4372	2475
29-Aug-12	-2990	2011
30-Aug-12	-1577	3221
31-Aug-12	-1775	5044
1-Sep-12	-162	3380
2-Sep-12	1669	1847
3-Sep-12	2812	798
4-Sep-12	3273	-607
5-Sep-12	2054	-1216
6-Sep-12	-740	-284
7-Sep-12	-1430	437
8-Sep-12	-729	1362
9-Sep-12	-137	3420
10-Sep-12	1300	6116
11-Sep-12	3326	7519
12-Sep-12	2562	8876
13-Sep-12	147	9561
14-Sep-12	-288	8791
15-Sep-12	1047	6924
16-Sep-12	2690	7135
17-Sep-12	4837	6856
18-Sep-12	6327	5512
19-Sep-12	6853	3566
20-Sep-12	7819	1374
21-Sep-12	6916	-2062
22-Sep-12	5235	-4903
23-Sep-12	4327	-6951
24-Sep-12	4889	-7950
25-Sep-12	4942	-7737
26-Sep-12	6535	-6915
27-Sep-12	7864	-5491
28-Sep-12	8465	-4654
29-Sep-12	6996	-4107
30-Sep-12	3112	-2957
1-Oct-12	-640	-667
2-Oct-12	-2433	1481
3-Oct-12	-3267	4404
4-Oct-12	-3202	6985
5-Oct-12	-1694	9085
6-Oct-12	1871	11268
7-Oct-12	4612	11342
8-Oct-12	8581	10573
9-Oct-12	12345	9794
10-Oct-12	15683	6205
11-Oct-12	15767	2249

Date	Total Inflow	
12-Oct-12	17177	-193
13-Oct-12	17636	-1372
14-Oct-12	18392	-1130
15-Oct-12	20659	715
16-Oct-12	21884	1783
17-Oct-12	20722	3333
18-Oct-12	18205	4547
19-Oct-12	15114	4469
20-Oct-12	11986	4634
21-Oct-12	11051	3482
22-Oct-12	10769	2498
23-Oct-12	8490	2155
24-Oct-12	6643	2121
25-Oct-12	4257	4022
26-Oct-12	637	7588
27-Oct-12	-2906	10479
28-Oct-12	-4156	12039
29-Oct-12	-5444	12293
30-Oct-12	-6530	9674
31-Oct-12	-5533	7081
1-Nov-12	-3933	5030
2-Nov-12	-1018	3664
3-Nov-12	2677	4648
4-Nov-12	6254	6171
5-Nov-12	7995	8797
6-Nov-12	9276	12074
7-Nov-12	10157	14150
8-Nov-12	9756	14893
9-Nov-12	9110	15906
10-Nov-12	10302	15371
11-Nov-12	11970	13736
12-Nov-12	12761	13146
13-Nov-12	13381	13614
14-Nov-12	13966	14804
15-Nov-12	13094	15864
16-Nov-12	12054	16377
17-Nov-12	11135	16534
18-Nov-12	10421	15610
19-Nov-12	9598	13772
20-Nov-12	9136	11987
21-Nov-12	8517	10563
22-Nov-12	8116	9746
23-Nov-12	7873	9433
24-Nov-12	8175	9400
25-Nov-12	8373	9408
26-Nov-12	7814	9343
27-Nov-12	7145	8899
28-Nov-12	7127	8189
29-Nov-12	6936	7678
30-Nov-12	6925	7466
1-Dec-12	7397	7692
2-Dec-12	7716	8151
3-Dec-12	7595	8557
4-Dec-12	7253	8968
5-Dec-12	6752	9430
6-Dec-12	6310	9789
7-Dec-12	6001	9847
8-Dec-12	5766	9733
9-Dec-12	5541	9538
10-Dec-12	5469	9388
11-Dec-12	5705	9156
12-Dec-12	5864	9124
13-Dec-12	5799	9345
14-Dec-12	5552	9465
15-Dec-12	5237	9430
16-Dec-12	5056	9416
17-Dec-12	5188	9123
18-Dec-12	5314	8754
19-Dec-12	5669	8635
20-Dec-12	6092	8411
21-Dec-12	6221	8237
22-Dec-12	5985	8466
23-Dec-12	5862	8944

Date	Total Inflow	
24-Dec-12	5812	9070
25-Dec-12	5933	9159
26-Dec-12	5983	9263
27-Dec-12	6252	9131
28-Dec-12	6468	8807
29-Dec-12	6737	8569
30-Dec-12	6938	8405
31-Dec-12	6861	8016

Lake Manitoba Inflow Forecast

March 16, 2012

Lake Manitoba 16, 2012		Mar. Inflow
Forecast		
Date	Total Inflow (cfs)	Total Inflow - Wet (cfs)
16-Mar-12	4689	5765
17-Mar-12	4697	5779
18-Mar-12	4709	5797
19-Mar-12	4714	5807
20-Mar-12	4740	5842
21-Mar-12	4733	5837
22-Mar-12	4746	5857
23-Mar-12	4780	5902
24-Mar-12	4822	5957
25-Mar-12	4856	6003
26-Mar-12	4924	6089
27-Mar-12	5002	6188
28-Mar-12	5064	6267
29-Mar-12	5120	6339
30-Mar-12	5198	6439
31-Mar-12	5291	6555
1-Apr-12	9055	10348
2-Apr-12	9125	10442
3-Apr-12	9208	10551
4-Apr-12	9269	10633
5-Apr-12	9341	10729
6-Apr-12	9381	10784
7-Apr-12	9424	10845
8-Apr-12	9499	10944
9-Apr-12	9618	11097
10-Apr-12	9714	11222
11-Apr-12	9837	11380
12-Apr-12	9926	11495
13-Apr-12	9908	11481
14-Apr-12	9812	11369
15-Apr-12	9794	11354
16-Apr-12	9789	11355
17-Apr-12	9806	11382
18-Apr-12	9874	11473
19-Apr-12	10013	11649
20-Apr-12	10031	11678
21-Apr-12	10066	11727
22-Apr-12	10074	11743
23-Apr-12	10017	11680
24-Apr-12	9998	11663
25-Apr-12	9924	11579
26-Apr-12	9750	11371
27-Apr-12	9578	11168
28-Apr-12	9422	10982
29-Apr-12	9222	10744
30-Apr-12	9199	10721
1-May-12	9234	10770
2-May-12	9196	10730
3-May-12	9261	10815
4-May-12	9387	10976
5-May-12	9407	11006
6-May-12	9325	10912
7-May-12	9334	10928
8-May-12	9305	10898
9-May-12	9230	10812
10-May-12	9042	10589
11-May-12	8978	10515
12-May-12	8680	10156
13-May-12	8541	9992
14-May-12	8479	9922
15-May-12	8450	9892
16-May-12	8400	9836
17-May-12	8316	9739
18-May-12	8254	9669
19-May-12	8198	9606
20-May-12	8159	9564
21-May-12	8138	9543
22-May-12	8097	9499

Date	Total Inflow	
23-May-12	8091	9497
24-May-12	8041	9442
25-May-12	7936	9319
26-May-12	7872	9245
27-May-12	7812	9178
28-May-12	7709	9057
29-May-12	7629	8964
30-May-12	7544	8866
31-May-12	7716	8742
1-Jun-12	7660	8693
2-Jun-12	7632	8674
3-Jun-12	7609	8662
4-Jun-12	7574	8635
5-Jun-12	7480	8540
6-Jun-12	7360	8416
7-Jun-12	7293	8351
8-Jun-12	7174	8226
9-Jun-12	7085	8135
10-Jun-12	7047	8105
11-Jun-12	6990	8052
12-Jun-12	6853	7905
13-Jun-12	6745	7791
14-Jun-12	6650	7692
15-Jun-12	6584	7627
16-Jun-12	6527	7573
17-Jun-12	6481	7532
18-Jun-12	6400	7449
19-Jun-12	6297	7339
20-Jun-12	6145	7171
21-Jun-12	6001	7012
22-Jun-12	5895	6898
23-Jun-12	5840	6845
24-Jun-12	5846	6864
25-Jun-12	5885	6924
26-Jun-12	5857	6903
27-Jun-12	5720	6750
28-Jun-12	5541	6547
29-Jun-12	5371	6352
30-Jun-12	5218	6179
1-Jul-12	5114	6065
2-Jul-12	5071	6024
3-Jul-12	5063	6026
4-Jul-12	4930	5875
5-Jul-12	4737	5651
6-Jul-12	4647	5551
7-Jul-12	4582	5483
8-Jul-12	4543	5445
9-Jul-12	4543	5455
10-Jul-12	4569	5498
11-Jul-12	4562	5499
12-Jul-12	4496	5428
13-Jul-12	4431	5359
14-Jul-12	4398	5327
15-Jul-12	4375	5309
16-Jul-12	4353	5292
17-Jul-12	4316	5255
18-Jul-12	4268	5206
19-Jul-12	4167	5090
20-Jul-12	4048	4951
21-Jul-12	3955	4845
22-Jul-12	3899	4784
23-Jul-12	3817	4691
24-Jul-12	3740	4603
25-Jul-12	3657	4507
26-Jul-12	3540	4370
27-Jul-12	3413	4218
28-Jul-12	3288	4069
29-Jul-12	3207	3975
30-Jul-12	3142	3901
31-Jul-12	3070	3818
1-Aug-12	2991	3726
2-Aug-12	2951	3683
3-Aug-12	2911	3640

Date	Total Inflow	
4-Aug-12	2900	3634
5-Aug-12	2929	3679
6-Aug-12	2936	3696
7-Aug-12	2898	3655
8-Aug-12	2843	3594
9-Aug-12	2761	3497
10-Aug-12	2652	3364
11-Aug-12	2589	3292
12-Aug-12	2526	3220
13-Aug-12	2466	3150
14-Aug-12	2398	3070
15-Aug-12	2345	3009
16-Aug-12	2320	2985
17-Aug-12	2319	2990
18-Aug-12	2296	2968
19-Aug-12	2279	2953
20-Aug-12	2250	2923
21-Aug-12	2184	2845
22-Aug-12	2126	2776
23-Aug-12	2067	2706
24-Aug-12	2013	2644
25-Aug-12	1996	2629
26-Aug-12	1968	2600
27-Aug-12	1989	2633
28-Aug-12	2027	2691
29-Aug-12	2017	2685
30-Aug-12	1966	2624
31-Aug-12	1950	2611
1-Sep-12	1930	2592
2-Sep-12	1914	2436
3-Sep-12	1981	2514
4-Sep-12	2064	2611
5-Sep-12	2136	2694
6-Sep-12	2186	2753
7-Sep-12	2228	2802
8-Sep-12	2289	2873
9-Sep-12	2370	2967
10-Sep-12	2453	3062
11-Sep-12	2498	3114
12-Sep-12	2566	3193
13-Sep-12	2607	3242
14-Sep-12	2602	3237
15-Sep-12	2596	3232
16-Sep-12	2628	3269
17-Sep-12	2656	3304
18-Sep-12	2653	3302
19-Sep-12	2642	3291
20-Sep-12	2608	3254
21-Sep-12	2547	3187
22-Sep-12	2498	3133
23-Sep-12	2526	3167
24-Sep-12	2589	3241
25-Sep-12	2626	3285
26-Sep-12	2630	3292
27-Sep-12	2642	3308
28-Sep-12	2615	3279
29-Sep-12	2584	3245
30-Sep-12	2583	3247
1-Oct-12	2613	3283
2-Oct-12	2611	3282
3-Oct-12	2610	3284
4-Oct-12	2642	3322
5-Oct-12	2686	3375
6-Oct-12	2739	3438
7-Oct-12	2831	3545
8-Oct-12	2881	3605
9-Oct-12	2892	3620
10-Oct-12	2910	3643
11-Oct-12	2941	3681
12-Oct-12	2970	3716
13-Oct-12	3045	3804
14-Oct-12	3149	3926
15-Oct-12	3244	4037

Date	Total Inflow	
16-Oct-12	3345	4155
17-Oct-12	3429	4252
18-Oct-12	3485	4319
19-Oct-12	3546	4389
20-Oct-12	3615	4470
21-Oct-12	3675	4542
22-Oct-12	3731	4607
23-Oct-12	3775	4659
24-Oct-12	3783	4670
25-Oct-12	3780	4669
26-Oct-12	3795	4689
27-Oct-12	3846	4748
28-Oct-12	3908	4821
29-Oct-12	4008	4937
30-Oct-12	4114	5059
31-Oct-12	4174	5130
1-Nov-12	4220	5184
2-Nov-12	4277	5252
3-Nov-12	4324	5308
4-Nov-12	4368	5360
5-Nov-12	4408	5407
6-Nov-12	4436	5442
7-Nov-12	4467	5480
8-Nov-12	4490	5507
9-Nov-12	4521	5545
10-Nov-12	4579	5613
11-Nov-12	4632	5677
12-Nov-12	4711	5768
13-Nov-12	4796	5867
14-Nov-12	4855	5937
15-Nov-12	4916	6009
16-Nov-12	4937	6035
17-Nov-12	4933	6033
18-Nov-12	4945	6049
19-Nov-12	4965	6074
20-Nov-12	4974	6087
21-Nov-12	4889	5992
22-Nov-12	4843	5943
23-Nov-12	4872	5979
24-Nov-12	4946	6067
25-Nov-12	5071	6213
26-Nov-12	5218	6384
27-Nov-12	5372	6563
28-Nov-12	5450	6656
29-Nov-12	5505	6722
30-Nov-12	5543	6769
1-Dec-12	5592	6829
2-Dec-12	5634	6880
3-Dec-12	5680	6936
4-Dec-12	5672	6930
5-Dec-12	5638	6895
6-Dec-12	5595	6848
7-Dec-12	5573	6826
8-Dec-12	5554	6807
9-Dec-12	5535	6788
10-Dec-12	5538	6794
11-Dec-12	5549	6809
12-Dec-12	5531	6792
13-Dec-12	5560	6828
14-Dec-12	5640	6923
15-Dec-12	5700	6994
16-Dec-12	5714	7013
17-Dec-12	5769	7079
18-Dec-12	5771	7084
19-Dec-12	5731	7041
20-Dec-12	5707	7017
21-Dec-12	5695	7006
22-Dec-12	5636	6942
23-Dec-12	5578	6880
24-Dec-12	5523	6820
25-Dec-12	5466	6758
26-Dec-12	5419	6707
27-Dec-12	5397	6685

Date	Total Inflow	
28-Dec-12	5396	6688
29-Dec-12	5388	6682
30-Dec-12	5391	6689
31-Dec-12	5391	6692

Lake Manitoba Inflow Forecast

August 28, 2012

Lake Manitoba 28, 2012			Aug. Inflow
Forecast			
Date	Total Inflow - Median (cfs)	Total Inflow - Upper (cfs)	Total Inflow - Lower (cfs)
1-Sep-12	2876	2972	2845
2-Sep-12	2890	3021	2841
3-Sep-12	2904	3070	2836
4-Sep-12	2919	3119	2832
5-Sep-12	2933	3169	2827
6-Sep-12	2948	3218	2823
7-Sep-12	2962	3267	2818
8-Sep-12	2976	3316	2814
9-Sep-12	2991	3365	2809
10-Sep-12	3005	3414	2805
11-Sep-12	3020	3463	2800
12-Sep-12	3034	3513	2795
13-Sep-12	3048	3562	2791
14-Sep-12	3063	3611	2786
15-Sep-12	3077	3660	2782
16-Sep-12	3092	3709	2777
17-Sep-12	3106	3758	2773
18-Sep-12	3121	3808	2768
19-Sep-12	3135	3857	2764
20-Sep-12	3149	3906	2759
21-Sep-12	3164	3955	2755
22-Sep-12	3178	4004	2750
23-Sep-12	3193	4053	2745
24-Sep-12	3207	4102	2741
25-Sep-12	3221	4152	2736
26-Sep-12	3236	4201	2732
27-Sep-12	3250	4250	2727
28-Sep-12	3286	4339	2723
29-Sep-12	3321	4429	2718
30-Sep-12	3357	4518	2714
1-Oct-12	3393	4607	2709
2-Oct-12	3429	4696	2705
3-Oct-12	3464	4786	2700
4-Oct-12	3500	4875	2695
5-Oct-12	3536	4964	2691
6-Oct-12	3571	5054	2686
7-Oct-12	3607	5143	2682
8-Oct-12	3643	5232	2677
9-Oct-12	3679	5321	2673
10-Oct-12	3714	5411	2668
11-Oct-12	3750	5500	2664
12-Oct-12	3786	5589	2659
13-Oct-12	3821	5679	2655
14-Oct-12	3857	5768	2650
15-Oct-12	3893	5857	2645
16-Oct-12	3929	5946	2641
17-Oct-12	3964	6036	2636
18-Oct-12	4000	6125	2632
19-Oct-12	4036	6214	2627
20-Oct-12	4071	6304	2623
21-Oct-12	4107	6393	2618
22-Oct-12	4143	6482	2614
23-Oct-12	4179	6571	2609
24-Oct-12	4214	6661	2605
25-Oct-12	4250	6750	2600
26-Oct-12	4286	6821	2607
27-Oct-12	4321	6893	2613
28-Oct-12	4357	6964	2620
29-Oct-12	4393	7036	2627
30-Oct-12	4429	7107	2634
31-Oct-12	4464	7179	2640
1-Nov-12	4500	7250	2647
2-Nov-12	4536	7321	2654
3-Nov-12	4571	7393	2660
4-Nov-12	4607	7464	2667
5-Nov-12	4643	7536	2680
6-Nov-12	4679	7607	2700
7-Nov-12	4714	7679	2730

Date	Total Inflow		
8-Nov-12	4750	7750	2761
9-Nov-12	4804	7768	2831
10-Nov-12	4857	7786	2901
11-Nov-12	4911	7804	2972
12-Nov-12	4964	7821	3042
13-Nov-12	5018	7839	3112
14-Nov-12	5071	7857	3182
15-Nov-12	5125	7875	3253
16-Nov-12	5179	7893	3323
17-Nov-12	5232	7911	3393
18-Nov-12	5286	7929	3463
19-Nov-12	5339	7946	3534
20-Nov-12	5393	7964	3604
21-Nov-12	5446	7982	3674
22-Nov-12	5500	7990	3744
23-Nov-12	5554	7982	3814
24-Nov-12	5607	7964	3885
25-Nov-12	5661	7946	3955
26-Nov-12	5714	7929	4025
27-Nov-12	5768	7911	4095
28-Nov-12	5821	7893	4166
29-Nov-12	5875	7875	4236
30-Nov-12	5929	7857	4306
1-Dec-12	5982	7839	4376
2-Dec-12	6036	7821	4447
3-Dec-12	6089	7804	4517
4-Dec-12	6143	7786	4587
5-Dec-12	6196	7768	4657
6-Dec-12	6230	7750	4728
7-Dec-12	6252	7746	4798
8-Dec-12	6253	7741	4868
9-Dec-12	6255	7737	4938
10-Dec-12	6257	7733	5009
11-Dec-12	6259	7728	5079
12-Dec-12	6260	7724	5149
13-Dec-12	6262	7720	5219
14-Dec-12	6264	7715	5250
15-Dec-12	6266	7711	5270
16-Dec-12	6267	7707	5297
17-Dec-12	6269	7702	5300
18-Dec-12	6271	7698	5303
19-Dec-12	6273	7693	5307
20-Dec-12	6274	7689	5310
21-Dec-12	6276	7685	5314
22-Dec-12	6278	7680	5317
23-Dec-12	6280	7676	5320
24-Dec-12	6281	7672	5324
25-Dec-12	6283	7667	5327
26-Dec-12	6285	7663	5330
27-Dec-12	6287	7659	5334
28-Dec-12	6288	7654	5337
29-Dec-12	6290	7650	5340
30-Dec-12	6292	7646	5344
31-Dec-12	6293	7641	5347
1-Jan-13	6295	7637	5351
2-Jan-13	6297	7633	5354
3-Jan-13	6299	7628	5357
4-Jan-13	6300	7624	5361
5-Jan-13	6302	7620	5364
6-Jan-13	6304	7615	5367
7-Jan-13	6306	7611	5371
8-Jan-13	6307	7607	5374
9-Jan-13	6309	7602	5377
10-Jan-13	6311	7598	5381
11-Jan-13	6313	7593	5384
12-Jan-13	6314	7589	5388
13-Jan-13	6316	7585	5391
14-Jan-13	6318	7580	5394
15-Jan-13	6320	7576	5398
16-Jan-13	6321	7572	5401
17-Jan-13	6323	7567	5404
18-Jan-13	6325	7563	5408
19-Jan-13	6327	7559	5411

Date	Total Inflow		
20-Jan-13	6328	7554	5414
21-Jan-13	6330	7550	5418
22-Jan-13	6332	7546	5421
23-Jan-13	6333	7541	5425
24-Jan-13	6335	7537	5428
25-Jan-13	6337	7533	5431
26-Jan-13	6339	7528	5435
27-Jan-13	6340	7524	5438
28-Jan-13	6342	7520	5441
29-Jan-13	6344	7515	5445
30-Jan-13	6346	7511	5448
31-Jan-13	6347	7507	5451
1-Feb-13	6349	7502	5455
2-Feb-13	6351	7498	5458
3-Feb-13	6353	7493	5462
4-Feb-13	6354	7489	5465
5-Feb-13	6356	7485	5468
6-Feb-13	6358	7480	5472
7-Feb-13	6360	7476	5475
8-Feb-13	6361	7472	5478
9-Feb-13	6363	7467	5482
10-Feb-13	6365	7463	5485
11-Feb-13	6367	7459	5489
12-Feb-13	6368	7454	5492
13-Feb-13	6370	7450	5495
14-Feb-13	6372	7446	5499
15-Feb-13	6373	7441	5502
16-Feb-13	6375	7437	5505
17-Feb-13	6377	7433	5509
18-Feb-13	6379	7428	5512
19-Feb-13	6380	7424	5515
20-Feb-13	6382	7420	5519
21-Feb-13	6384	7415	5522
22-Feb-13	6386	7411	5526
23-Feb-13	6387	7407	5529
24-Feb-13	6389	7402	5532
25-Feb-13	6391	7398	5536
26-Feb-13	6393	7393	5539
27-Feb-13	6394	7389	5542
28-Feb-13	6396	7385	5546
1-Mar-13	6398	7380	5549
2-Mar-13	6400	7376	5552
3-Mar-13	6401	7372	5556
4-Mar-13	6403	7367	5559
5-Mar-13	6405	7363	5563
6-Mar-13	6407	7359	5566
7-Mar-13	6408	7354	5569
8-Mar-13	6410	7350	5573
9-Mar-13	6412	7346	5576
10-Mar-13	6413	7341	5579
11-Mar-13	6415	7337	5583
12-Mar-13	6417	7333	5586
13-Mar-13	6419	7328	5589
14-Mar-13	6420	7324	5593
15-Mar-13	6422	7320	5596
16-Mar-13	6424	7315	5600
17-Mar-13	6426	7311	5603
18-Mar-13	6427	7307	5606
19-Mar-13	6429	7302	5610
20-Mar-13	6431	7298	5613
21-Mar-13	6433	7293	5616
22-Mar-13	6434	7289	5620
23-Mar-13	6436	7285	5623
24-Mar-13	6438	7280	5626
25-Mar-13	6440	7276	5630
26-Mar-13	6441	7272	5633
27-Mar-13	6443	7267	5637
28-Mar-13	6445	7263	5640
29-Mar-13	6447	7259	5643
30-Mar-13	6448	7254	5647
31-Mar-13	6450	7250	5650

Lake Manitoba Inflow Forecast

October 4, 2012

Lake Manitoba 4, 2012			Oct. Inflow
Forecast			
Date	Total Inflow - Median (cfs)	Total Inflow - Upper (cfs)	Total Inflow - Lower (cfs)
4-Oct-12	1078	4075	-464
5-Oct-12	1104	4100	-452
6-Oct-12	1130	4125	-440
7-Oct-12	1156	4150	-429
8-Oct-12	1182	4175	-417
9-Oct-12	1208	4200	-405
10-Oct-12	1234	4225	-393
11-Oct-12	1260	4250	-381
12-Oct-12	1286	4275	-369
13-Oct-12	1312	4300	-357
14-Oct-12	1338	4325	-345
15-Oct-12	1364	4350	-333
16-Oct-12	1390	4375	-321
17-Oct-12	1416	4400	-310
18-Oct-12	1442	4425	-298
19-Oct-12	1468	4450	-286
20-Oct-12	1494	4475	-274
21-Oct-12	1519	4500	-262
22-Oct-12	1545	4525	-250
23-Oct-12	1571	4550	-238
24-Oct-12	1597	4575	-226
25-Oct-12	1623	4600	-214
26-Oct-12	1649	4625	-202
27-Oct-12	1675	4650	-190
28-Oct-12	1701	4675	-179
29-Oct-12	1727	4700	-167
30-Oct-12	1753	4725	-155
31-Oct-12	1779	4750	-143
1-Nov-12	1805	4775	-131
2-Nov-12	1831	4800	-119
3-Nov-12	1857	4825	-107
4-Nov-12	1883	4850	-95
5-Nov-12	1909	4875	-83
6-Nov-12	1935	4900	-71
7-Nov-12	1961	4925	-60
8-Nov-12	1987	4950	-48
9-Nov-12	2013	4975	-36
10-Nov-12	2039	5000	-24
11-Nov-12	2065	5025	-12
12-Nov-12	2091	5050	0
13-Nov-12	2117	5075	39
14-Nov-12	2143	5100	79
15-Nov-12	2169	5125	118
16-Nov-12	2195	5150	158
17-Nov-12	2221	5175	197
18-Nov-12	2247	5200	237
19-Nov-12	2273	5225	276
20-Nov-12	2299	5250	316
21-Nov-12	2325	5275	355
22-Nov-12	2351	5300	395
23-Nov-12	2377	5325	434
24-Nov-12	2403	5350	474
25-Nov-12	2429	5375	513
26-Nov-12	2455	5400	553
27-Nov-12	2481	5425	592
28-Nov-12	2506	5450	632
29-Nov-12	2532	5475	671
30-Nov-12	2558	5500	711
1-Dec-12	2584	5466	750
2-Dec-12	2610	5418	789
3-Dec-12	2636	5370	829
4-Dec-12	2662	5319	868
5-Dec-12	2688	5278	908
6-Dec-12	2714	5236	947
7-Dec-12	2740	5171	987
8-Dec-12	2766	5133	1026
9-Dec-12	2792	5081	1066
10-Dec-12	2818	5075	1105

Date	Total Inflow		
11-Dec-12	2844	5039	1145
12-Dec-12	2870	5001	1184
13-Dec-12	2896	4957	1224
14-Dec-12	2922	4915	1263
15-Dec-12	2948	4875	1303
16-Dec-12	2974	4840	1342
17-Dec-12	3000	4823	1382
18-Dec-12	2947	4810	1421
19-Dec-12	2899	4770	1461
20-Dec-12	2866	4746	1500
21-Dec-12	2843	4731	1512
22-Dec-12	2798	4694	1460
23-Dec-12	2769	4674	1424
24-Dec-12	2740	4653	1389
25-Dec-12	2704	4625	1345
26-Dec-12	2668	4597	1302
27-Dec-12	2635	4572	1262
28-Dec-12	2604	4549	1224
29-Dec-12	2571	4525	1185
30-Dec-12	2540	4502	1147
31-Dec-12	2510	4481	1111
1-Jan-13	2491	4460	1384
2-Jan-13	2477	4444	1370
3-Jan-13	2473	4438	1349
4-Jan-13	2466	4430	1319
5-Jan-13	2457	4419	1310
6-Jan-13	2451	4411	1283
7-Jan-13	2443	4401	1261
8-Jan-13	2436	4392	1238
9-Jan-13	2429	4384	1206
10-Jan-13	2421	4374	1185
11-Jan-13	2411	4362	1167
12-Jan-13	2396	4345	1172
13-Jan-13	2382	4330	1165
14-Jan-13	2379	4326	1139
15-Jan-13	2374	4318	1124
16-Jan-13	2369	4311	1107
17-Jan-13	2362	4303	1089
18-Jan-13	2359	4298	1084
19-Jan-13	2354	4291	1075
20-Jan-13	2348	4284	1056
21-Jan-13	2344	4278	1036
22-Jan-13	2265	4197	1019
23-Jan-13	2252	4182	994
24-Jan-13	2232	4161	980
25-Jan-13	2202	4130	981
26-Jan-13	2180	4107	996
27-Jan-13	2178	4103	999
28-Jan-13	2165	4089	976
29-Jan-13	2155	4078	948
30-Jan-13	2165	4087	920
31-Jan-13	2189	4110	905
1-Feb-13	2257	4054	932
2-Feb-13	2239	4035	928
3-Feb-13	2211	4006	930
4-Feb-13	2209	4002	932
5-Feb-13	2210	4003	921
6-Feb-13	2214	4005	895
7-Feb-13	2220	4010	875
8-Feb-13	2201	3990	859
9-Feb-13	2191	3979	842
10-Feb-13	2199	3985	821
11-Feb-13	2189	3975	799
12-Feb-13	2187	3972	782
13-Feb-13	2199	3982	769
14-Feb-13	2187	3969	771
15-Feb-13	2161	3943	762
16-Feb-13	2158	3938	757
17-Feb-13	2164	3943	754
18-Feb-13	2166	3944	748
19-Feb-13	2150	3927	745
20-Feb-13	2137	3912	743
21-Feb-13	2126	3901	740

Date	Total Inflow		
22-Feb-13	2110	3883	739
23-Feb-13	2113	3885	732
24-Feb-13	2096	3867	730
25-Feb-13	2114	3885	725
26-Feb-13	2105	3876	727
27-Feb-13	2091	3862	727
28-Feb-13	2095	3866	729
1-Mar-13	2371	4442	852
2-Mar-13	2382	4452	859
3-Mar-13	2385	4456	857
4-Mar-13	2389	4460	859
5-Mar-13	2402	4473	855
6-Mar-13	2408	4479	852
7-Mar-13	2420	4491	845
8-Mar-13	2427	4497	843
9-Mar-13	2418	4489	843
10-Mar-13	2405	4475	843
11-Mar-13	2428	4499	855
12-Mar-13	2435	4506	857
13-Mar-13	2427	4497	854
14-Mar-13	2423	4493	852
15-Mar-13	2451	4522	853
16-Mar-13	2448	4518	854
17-Mar-13	2449	4520	856
18-Mar-13	2425	4495	857
19-Mar-13	2456	4527	855
20-Mar-13	2546	4616	868
21-Mar-13	2647	4718	859
22-Mar-13	2802	4873	850
23-Mar-13	2865	4935	868
24-Mar-13	2902	4972	873
25-Mar-13	2959	5030	882
26-Mar-13	2981	5051	908
27-Mar-13	2997	5067	914
28-Mar-13	3037	5107	930
29-Mar-13	3044	5114	965

APPENDIX A – ANNEX 2

LAKE MANITOBA AND LAKE ST. MARTIN FORECAST FIGURES AND EMAILS

Table A2-1
Summary of Lake Manitoba and Lake St. Martin Water Level and Discharge Forecasts Issued to MIT

					Date of Forecast																											
					30-Aug-11	20-Sep-11	11-Oct-11	8-Nov-11	1-Dec-11	5-Jan-12	19-Jan-12	31-Jan-12	10-Feb-12	14-Feb-12	22-Feb-12	24-Feb-12	13-Mar-12	5-Apr-12	10-Apr-12	12-Apr-12	30-Jun-12	31-Jul-12	15-Aug-12	31-Aug-12	30-Sep-12	12-Oct-12	31-Oct-12	30-Nov-12	31-Dec-12	31-Jan-13		
	Figure Number	Type	Description	Revision Number																												
Lake Manitoba	1	.1	Water Level	Fairford Fully Open	RevA		RevB	RevC	RevD		RevE		RevF		RevG		RevH	RevI			RevJ	RevK	RevL	RevM	RevN	RevO	RevP	RevQ	RevR	RevS		
		.2	Discharge	Fairford Fully Open			RevB				RevE														RevF	RevG	RevH	RevI	RevJ	RevK		
Lake St. Martin	2	.1	.1	Water Level	5000 cfs channel on Nov 1 - Early Ice Formation	RevA	RevB																									
		.2	Discharge	5000 cfs channel on Nov 1 - Early Ice Formation	RevA	RevB																										
		.2	.1	Water Level	5000 cfs channel on Nov 1 - Normal Ice Formation	RevA	RevB																									
		.2	Discharge	5000 cfs channel on Nov 1 - Normal Ice Formation	RevA	RevB																										
		.3	.1	Water Level	5000 cfs channel on Nov 1 - Late Ice Formation	RevA	RevB																									
		.2	Discharge	5000 cfs channel on Nov 1 - Late Ice Formation	RevA	RevB																										
		.4	.1	Water Level	3/4 channel on Nov 1 - Early Ice Formation		RevA																									
		.2	Discharge	3/4 channel on Nov 1 - Early Ice Formation		RevA																										
		.5	.1	Water Level	3/4 channel on Nov 1 - Normal Ice Formation		RevA		RevB																							
		.2	Discharge	3/4 channel on Nov 1 - Normal Ice Formation		RevA		RevB																								
		.6	.1	Water Level	3/4 channel on Nov 1 - Late Ice Formation		RevA			RevB																						
		.2	Discharge	3/4 channel on Nov 1 - Late Ice Formation		RevA			RevB																							
		.7	.1	Water Level	1/2 channel on Nov 1 - Early Ice Formation		RevA																									
		.2	Discharge	1/2 channel on Nov 1 - Early Ice Formation		RevA																										
		.8	.1	Water Level	1/2 channel on Nov 1 - Normal Ice Formation		RevA																									
		.2	Discharge	1/2 channel on Nov 1 - Normal Ice Formation		RevA																										
		.9	.1	Water Level	1/2 channel on Nov 1 - Late Ice Formation		RevA																									
		.2	Discharge	1/2 channel on Nov 1 - Late Ice Formation		RevA																										
		.10	.1	Water Level	Full channel on Dec 1 - Early Ice Formation		RevA																									
		.2	Discharge	Full channel on Dec 1 - Early Ice Formation		RevA																										
		.11	.1	Water Level	Full channel on Dec 1 - Normal Ice Formation		RevA																									
		.2	Discharge	Full channel on Dec 1 - Normal Ice Formation		RevA																										
		.12	.1	Water Level	Full channel on Dec 1 - Late Ice Formation		RevA																									
		.2	Discharge	Full channel on Dec 1 - Late Ice Formation		RevA																										
		.13	.1	Water Level	Reach 1 channel in operation							RevA		RevB	RevC	RevD	RevE		RevF		RevG	RevH	RevI	RevJ	RevK	RevL	RevM	RevN	RevO	RevP	RevQ	RevR
		.2	Discharge	Reach 1 channel in operation								RevA		RevB	RevC	RevD	RevE		RevF		RevG	RevH	RevI	RevJ	RevK	RevL	RevM	RevN	RevO	RevP	RevQ	RevR
		.2b	Discharge	Reach 1 channel in operation (Buffalo Creek)								RevA		RevB	RevC		RevD				RevG	RevH	RevI									
		.14	.1	Water Level	Temporarily closure of channel during ice breakup							RevA																				
		.2	Discharge	Temporarily closure of channel during ice breakup								RevA																				
		.15	.1	Water Level	Raising Reach 1 Sill Elevation													RevA														
		.2	Discharge	Raising Reach 1 Sill Elevation														RevA														
		.2b	Discharge	Raising Reach 1 Sill Elevation (Buffalo Creek)														RevA														

**Lake Manitoba Forecast
Correspondence and Figures**

August 30, 2011

Garrett Wellwood

From: Patrice Leclercq [PLeclercq@kgsgroup.com]**Sent:** Thursday, February 28, 2013 3:47 PM**To:** 'Patrice Leclercq'**Subject:** Copy of Dauphin River Discharges below Buffalo Creek Confluence**From:** Brian Bodnaruk <BBodnaruk@kgsgroup.com>**To:** RCarson@kgsgroup.com <RCarson@kgsgroup.com>**Cc:** CSiepman@kgsgroup.com <CSiepman@kgsgroup.com>; Richardson, Ron (MIT); BSmith@kgsgroup.com <BSmith@kgsgroup.com>**Sent:** Tue Aug 30 16:18:19 2011**Subject:** Dauphin River Discharges below Buffalo Creek Confluence

The three ice freeze-up scenarios with ice jam formation at the DRFN shown below were routed through Lake Manitoba and Lake St Martin. The 3 scenarios included:

CONDITION	DATE	TOTAL DISCHARGE	DAUPHIN RIVER
BUFFALO CREEK			
• Early Freeze-up 2,900 CFS	Nov 10	17,620 cfs	14,720 cfs
• Normal Freeze-up cfs	Nov 25 2,370 cfs	14,160 cfs	11,790
• Late Freeze-up 2,150 cfs	Dec 10	12,900 cfs	10,750 cfs

For each scenario, freeze-up of the diversion channel was assumed to occur one week prior to the date of the ice jam formation date at the DRFN and the ice jam was assumed to reach LSM three weeks after freeze-up at the DRFN. i.e. for early freeze-up case the diversion channel was assumed to be ice covered on Nov 3 and the ice cover on the Dauphin R was assumed to reach LSM on Dec 1.

Complete charts showing daily water levels and discharges for each scenario will be sent shortly.

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Garrett Wellwood

From: Patrice Leclercq [PLeclercq@kgsgroup.com]
Sent: Thursday, February 28, 2013 3:47 PM
To: 'Patrice Leclercq'
Subject: Copy of FW: Dauphin River Discharges below Buffalo Creek Confluence
Attachments: Figure 1.1.1_RevA.pdf; Figure 2.1.1_RevA.pdf; Figure 2.1.2_RevA.pdf; Figure 2.2.1_RevA.pdf; Figure 2.2.2_RevA.pdf; Figure 2.3.1_RevA.pdf; Figure 2.3.2_RevA.pdf

From: Brian Bodnaruk [mailto:BBodnaruk@kgsgroup.com]
Sent: Tuesday, August 30, 2011 6:53 PM
To: 'Rick Carson'
Cc: 'Richardson, Ron (MIT)'; CSiepmann@kgsgroup.com; BSmith@kgsgroup.com; PLeclercq@kgsgroup.com
Subject: RE: Dauphin River Discharges below Buffalo Creek Confluence

The declining flows are related to the water level on Lake St Martin. Delaying the date of the freeze-up allows the level on LSM to fall with high outflows under open water conditions. It also is affected by the assumption of an ice cover on the Diversion channel when the ice cover forms at the DRFN.

The attached Figures show water levels and flows on Lake Manitoba and LSM as well as discharge from LSM for the "Early", "Normal" and "Late" freeze-up date scenarios

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Figure 1.1.1
Computed Lake Manitoba Level
Fairford Fully Open

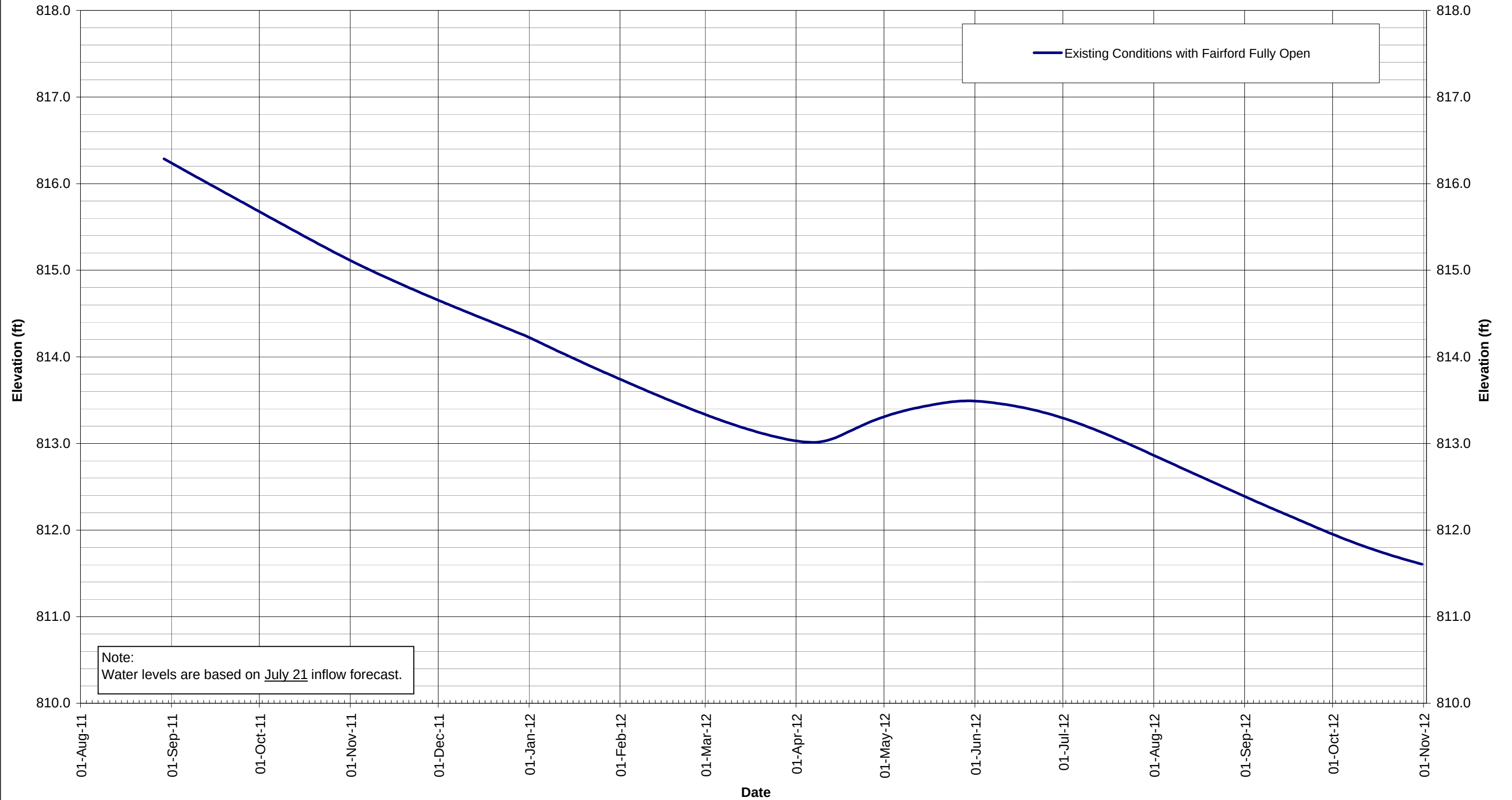


Figure 2.1.1
Computed Lake St. Martin Level
Early Ice Formation Condition

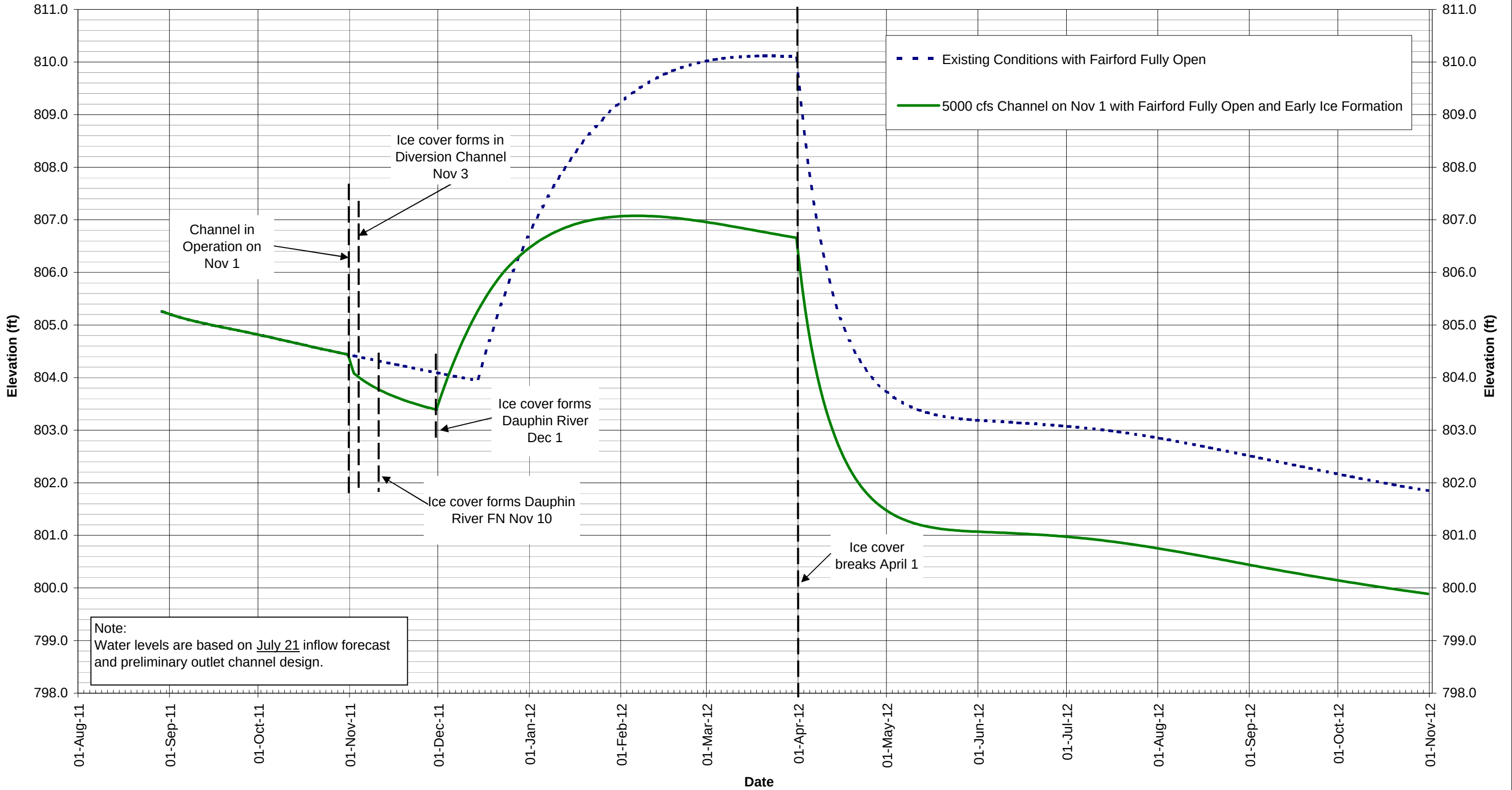


Figure 2.1.2
Computed Lake St. Martin Outflow
Early Ice Formation Condition

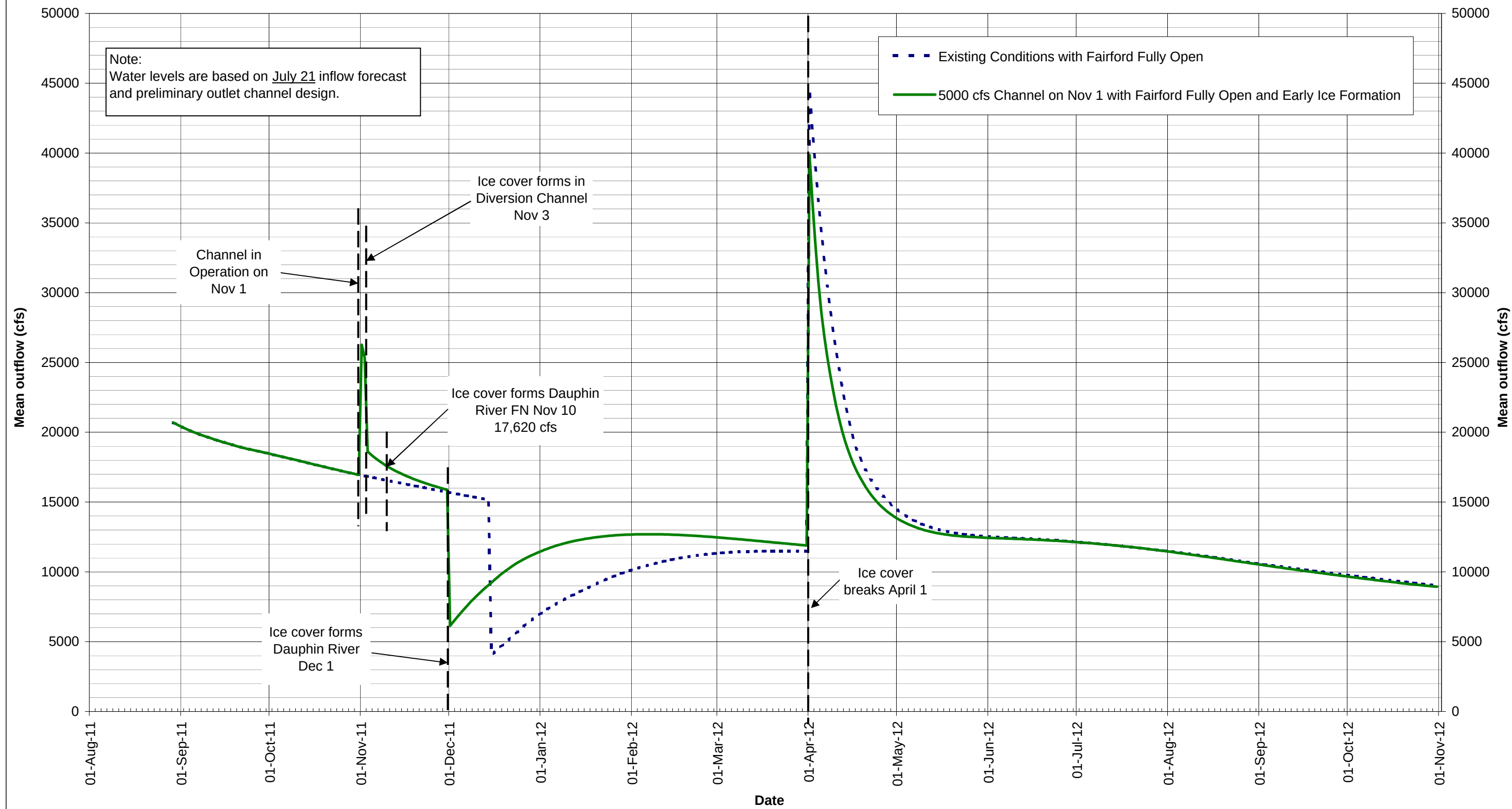


Figure 2.2.1
Computed Lake St. Martin Level
Normal Ice Formation Condition

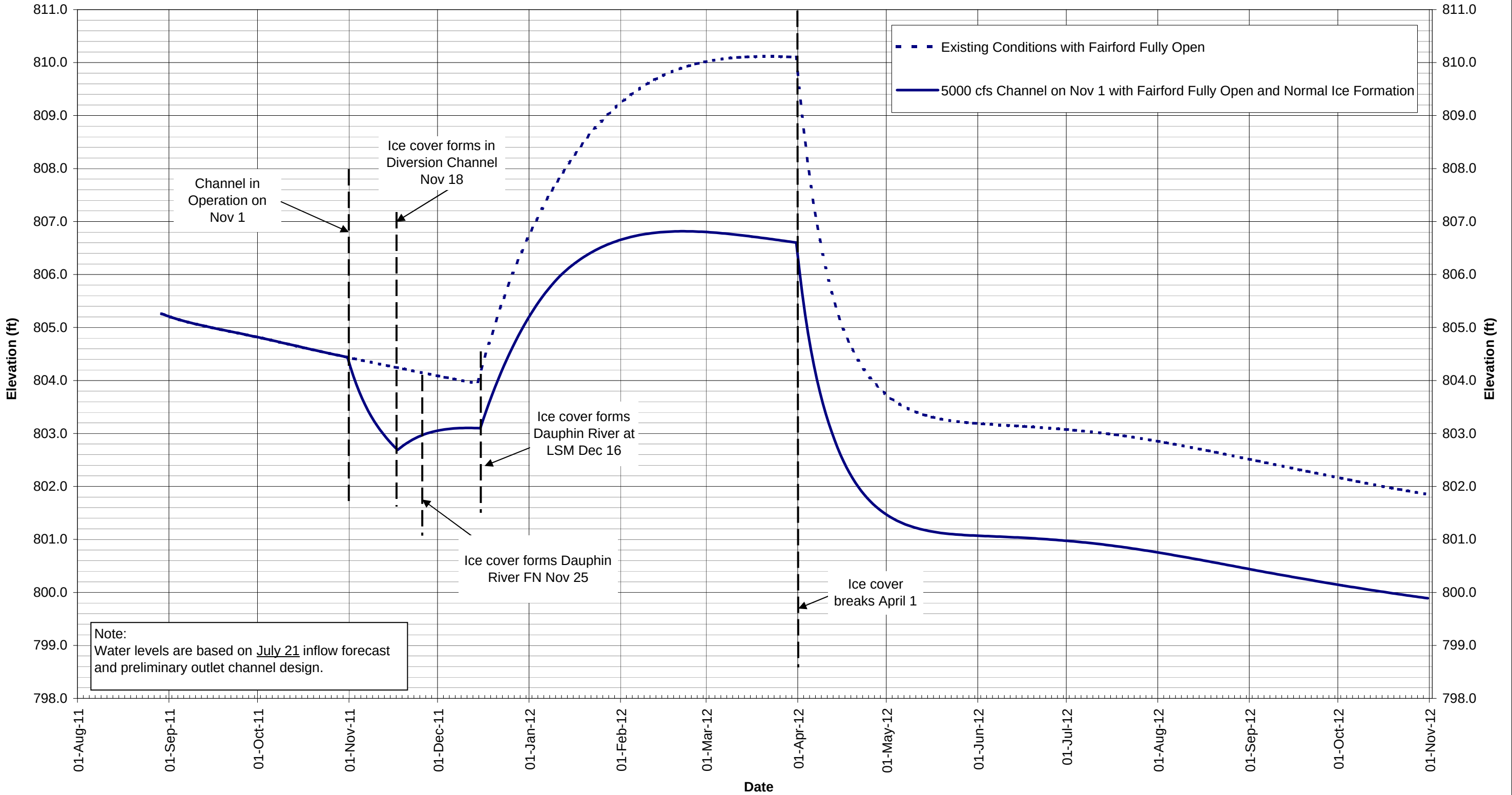


Figure 2.2.2
Computed Lake St. Martin Outflow
Normal Ice Formation Condition

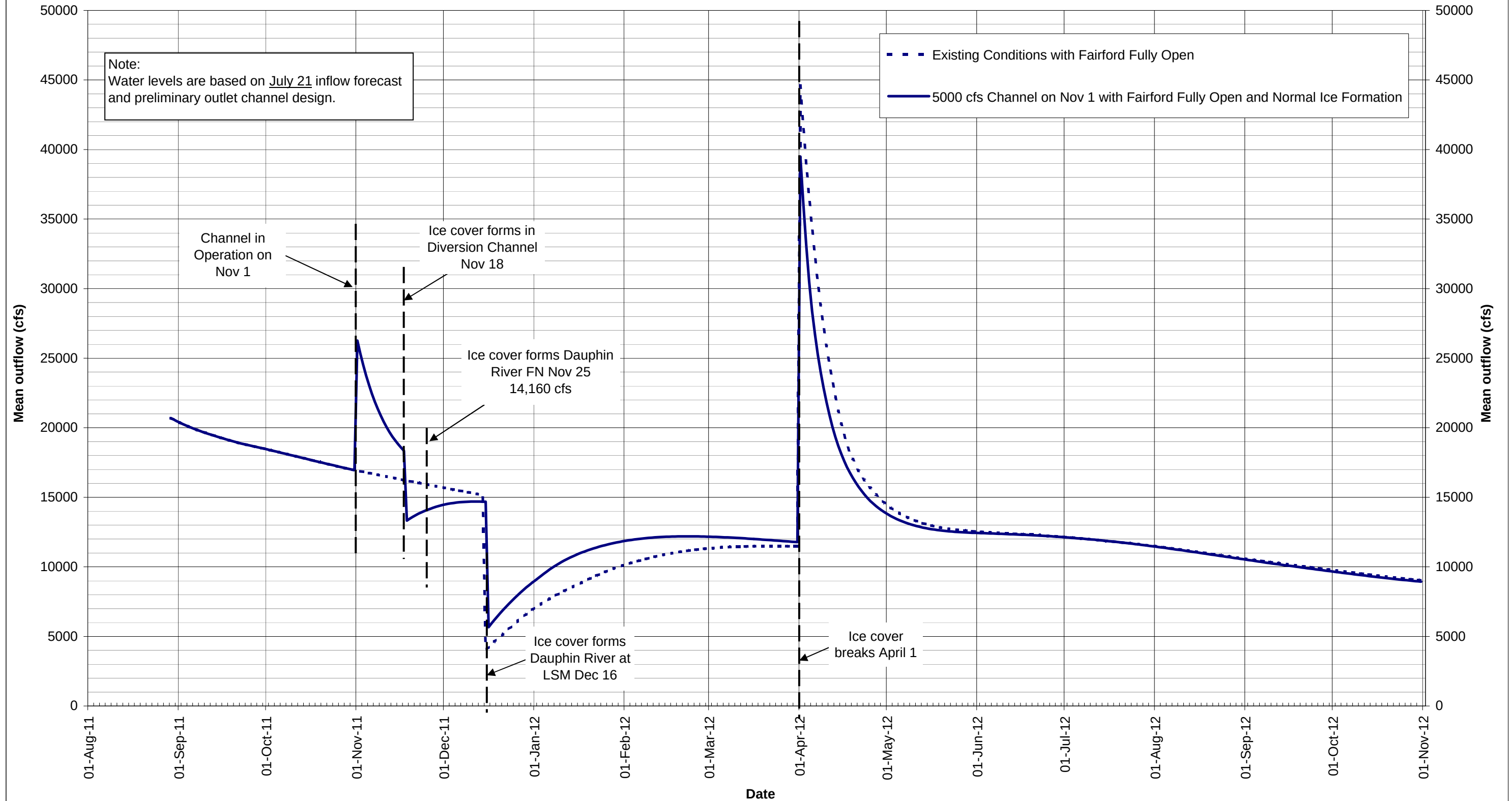


Figure 2.3.1
Computed Lake St. Martin Level
Late Ice Formation Condition

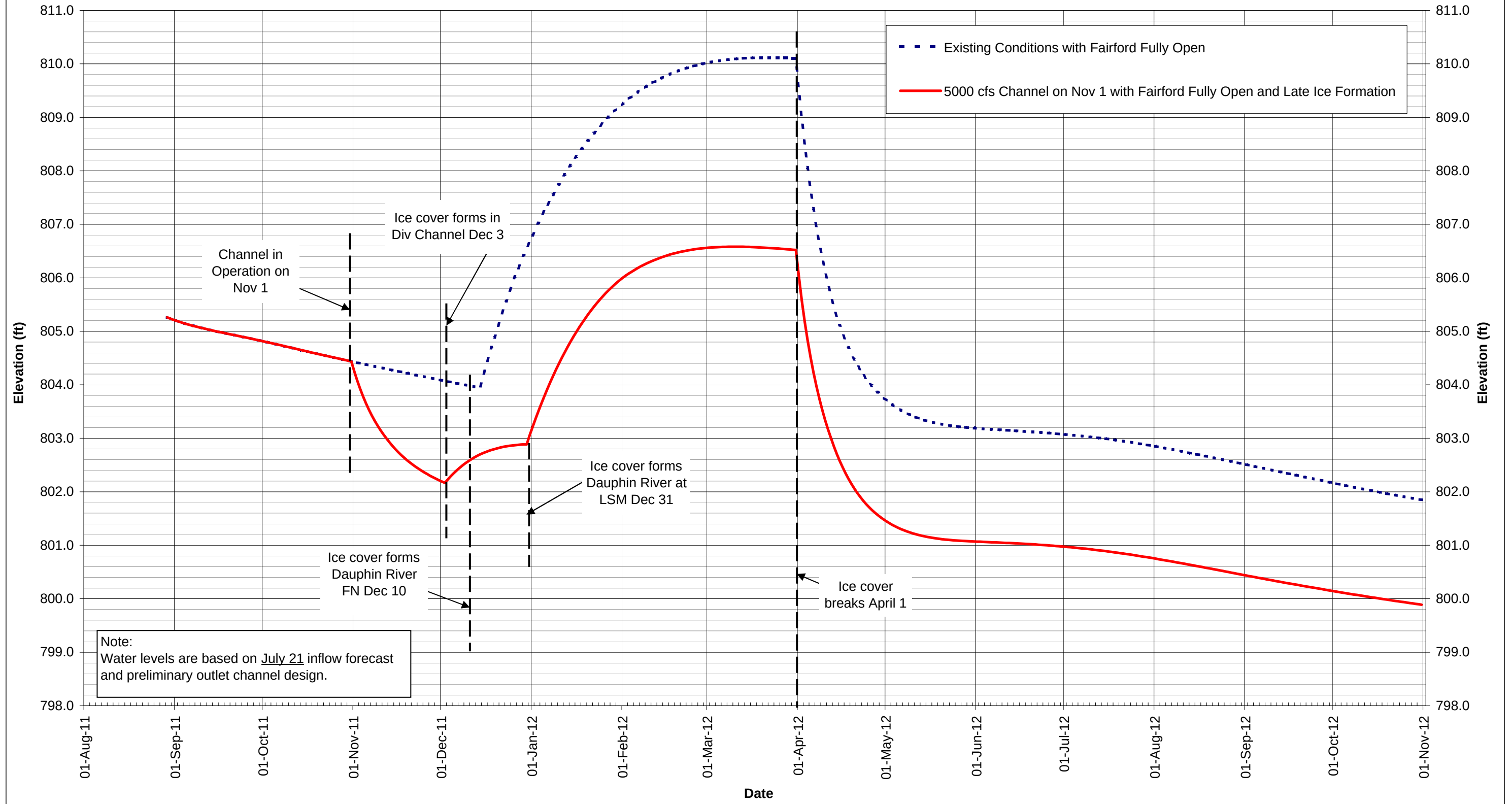
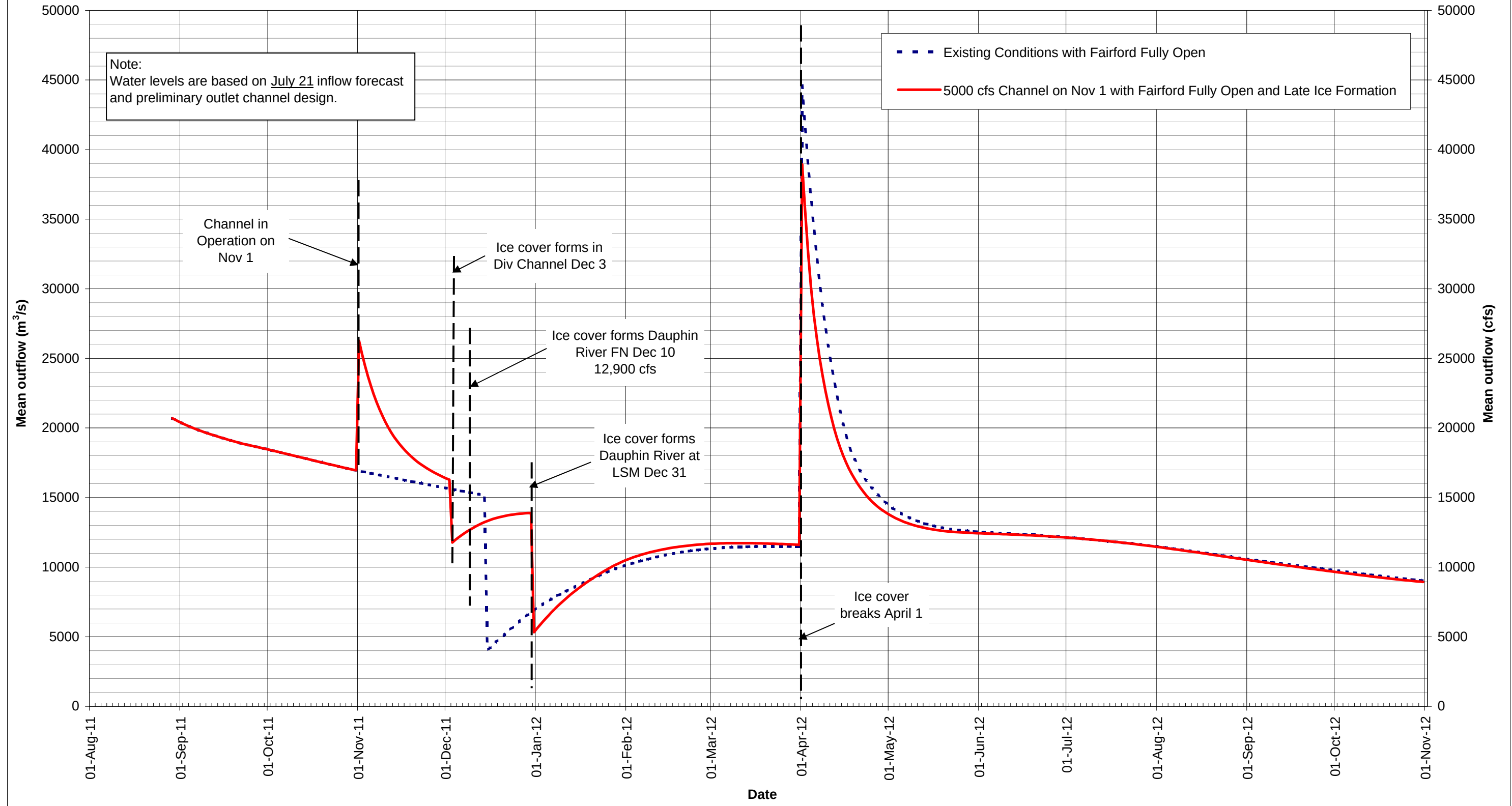


Figure 2.3.2
Computed Lake St. Martin Outflow
Late Ice Formation Condition



**Lake Manitoba Forecast
Correspondence and Figures**

September 20, 2011

Garrett Wellwood

From: Brian Bodnaruk [BBodnaruk@kgsgroup.com]
Sent: Tuesday, September 20, 2011 5:05 PM
To: 'Richardson, Ron (MIT)'; RCarson@kgsgroup.com
Cc: CSiepmann@kgsgroup.com; 'Kaatze, Ron G (MIT)'; PLeclercq@kgsgroup.com
Subject: RE: DRFN Discharges for Channel Completion Scenarios

Rick,

For the early ice formation scenario with the diversion channel in-service date on Nov 1, the date of the ice formation at the DRFN was assumed as Nov 10 and Nov 8 on Buffalo Creek. The two dates practically coincide. In the interest of conservatism, the open water flow on Buffalo Creek was assumed in defining the flow at the DRFN in the previous flow Table.

An assumption used in the simulations was that the transition from open water condition to ice covered flow conditions would occur instantaneously. If a more gradual transition were to occur, it is possible that open water conditions on Buffalo Creek would prevail when the ice jam was forming at the DRFN. Another point to consider is that an early ice date for ice formation on Lake Winnipeg is not typical.

Nevertheless, I have revised the flow Table to show flows on the dates assumed in the simulations rather than adjusting for coincident conditions if the dates of occurrence were close. The revised flows are shown in **BOLD**.

Please review and comment on the appropriate flow condition to use.

Revised Flow Table

Channel Capacity	Ice Formation Condition	Diversion Channel In-Service Date	Dauphin River Discharge (cfs)	Buffalo Creek Discharge (cfs)	DRFN Discharge (cfs)
Full Channel	Early	1-Dec	16,220	0	16,220
	Normal		15,610	0	15,610
	Late		12,090	2,430	14,520
Full Channel	Early	1-Nov	13,090	2,600	15,690
	Normal		11,500	2,320	13,820
	Late		10,450	2,090	12,540
3/4 Channel	Early	1-Nov	13,845	2,965	16,810
	Normal		12,210	2,730	14,940
	Late		11,205	2,575	13,780
1/2 Channel	Early	1-Nov	14,485	2,215	16,700
	Normal		13,095	2,065	15,160
	Late		12,170	1,960	14,130

Comments from Ron Richardson

1. The dates corresponding to the flows in the Right Hand column for the DRFN vary depending on the Early, Normal or Late date for ice formation on the DRFN. The corresponding dates are November 10, November 25 and December 10 (approximately 2 weeks between each)
2. The Lake Manitoba chart does not change from the one previous sent.
3. The assumptions used in the simulations were that the ice cover would form on the diversion channel 7 days before the ice formed at the DRFN. For the early date for ice formation on Nov 10, the ice cover was assumed to form on the diversion channel on Nov 3. This was 2 days after the channel was assumed to be commissioned. Applying these dates strictly according to the assumed rule, meant that the ice cover would fully develop on the diversion channel in 2 days after the start of flow. This is considered to be too soon. The simulations were therefore subsequently revised to

delay the ice formation on the channel to 7 days from the 2 days.

4. The revised Table shows that the flow would increase for the ½ channel capacity compared to the full channel case. This is contrary to that presented previously. The reason was that the early flow case used approximate flows corresponding to open water conditions on Buffalo Creek.

Brian Bodnaruk, P. Eng.

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From: Richardson, Ron (MIT) [mailto:Ron.Richardson@gov.mb.ca]
Sent: Tuesday, September 20, 2011 1:15 PM
To: Brian Bodnaruk; RCarson@kgsgroup.com
Cc: CSiepman@kgsgroup.com; Kaatz, Ron G (MIT); PLeclercq@kgsgroup.com
Subject: RE: DRFN Discharges for Channel Completion Scenarios

Hi Brian

Four things:

1. Could you please confirm that the right hand column in the table below "DRFN Discharge cfs" is for the "Nov 10 Ice cover forms DRFN".
2. Can you supply the Lake Manitoba Levels graph for each or does it remain the same (Lk MB outflow governed only by Fairford Dam) with the only change being the level of LSM.
3. I do not think I have the revised 5000 cfs channel (Nov 1 opening) for early, normal , late ice formations. I think I am still using the one we discussed Sept 2 where it has a vertical spike (up and down ~ 9000 cfs) based on Ice Cover forms in the Diversion Channel Nov 3.
4. The frazil impacts at DRFN would seem to be lower with the smaller (1/2) size channel with a DR flow of 19,070 cfs as opposed to the full (5000 cfs) diversion which would yield a DR flow of 21510 cfs. Viewing this it would seem that we should construct the ½ size channel and address the extra LSM level increase, but I may be missing something.

Thanks,

*Ron Richardson, P.Eng.
Director, Water Control Operations Branch
Manitoba Infrastructure and Transportation
600-215 Garry Street*

Phone: <personal information removed>

Fax: <personal information removed>

From: Brian Bodnaruk [mailto:BBodnaruk@kgsgroup.com]

3/4/2013

Sent: September-20-11 11:24 AM

To: RCarson@kgsgroup.com

Cc: CSiepmann@kgsgroup.com; Richardson, Ron (MIT); Kaatz, Ron G (MIT); PLeclercq@kgsgroup.com

Subject: DRFN Discharges for Channel Completion Scenarios

The following Table summarizes flows on the Dauphin River and Buffalo Creek for full, ½, and ¾ partial completion of the LSM to Buffalo Creek Diversion channel for early, normal and late dates for ice formation and for channel In-Service dates of Nov 1 and Dec 1. I have also attached corresponding Figures showing the LSM water levels and Dauphin River and Buffalo Creek during the ice formation period.

Channel Capacity	Ice Formation Condition	Diversion Channel In-Service Date	Dauphin River Discharge (cfs)	Buffalo Creek Discharge (cfs)	DRFN Discharge (cfs)
Full Channel	Early	1-Dec	16,220	0	16,220
	Normal		15,610	0	15,610
	Late		12,270	7,800	20,070
Full Channel	Early	1-Nov	13,280	8,230	21,510
	Normal		11,500	2,320	13,820
	Late		10,450	2,090	12,540
3/4 Channel	Early	1-Nov	14,195	5,895	20,090
	Normal		12,210	2,730	14,940
	Late		11,205	2,575	13,780
1/2 Channel	Early	1-Nov	4,270	14,800	19,070
	Normal		2,065	13,095	15,160
	Late		1,960	12,170	14,130

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Figure 2.1.1 RevB
Computed Lake St. Martin Level
Full Channel in Operation Nov 1 - Early Ice Formation Condition

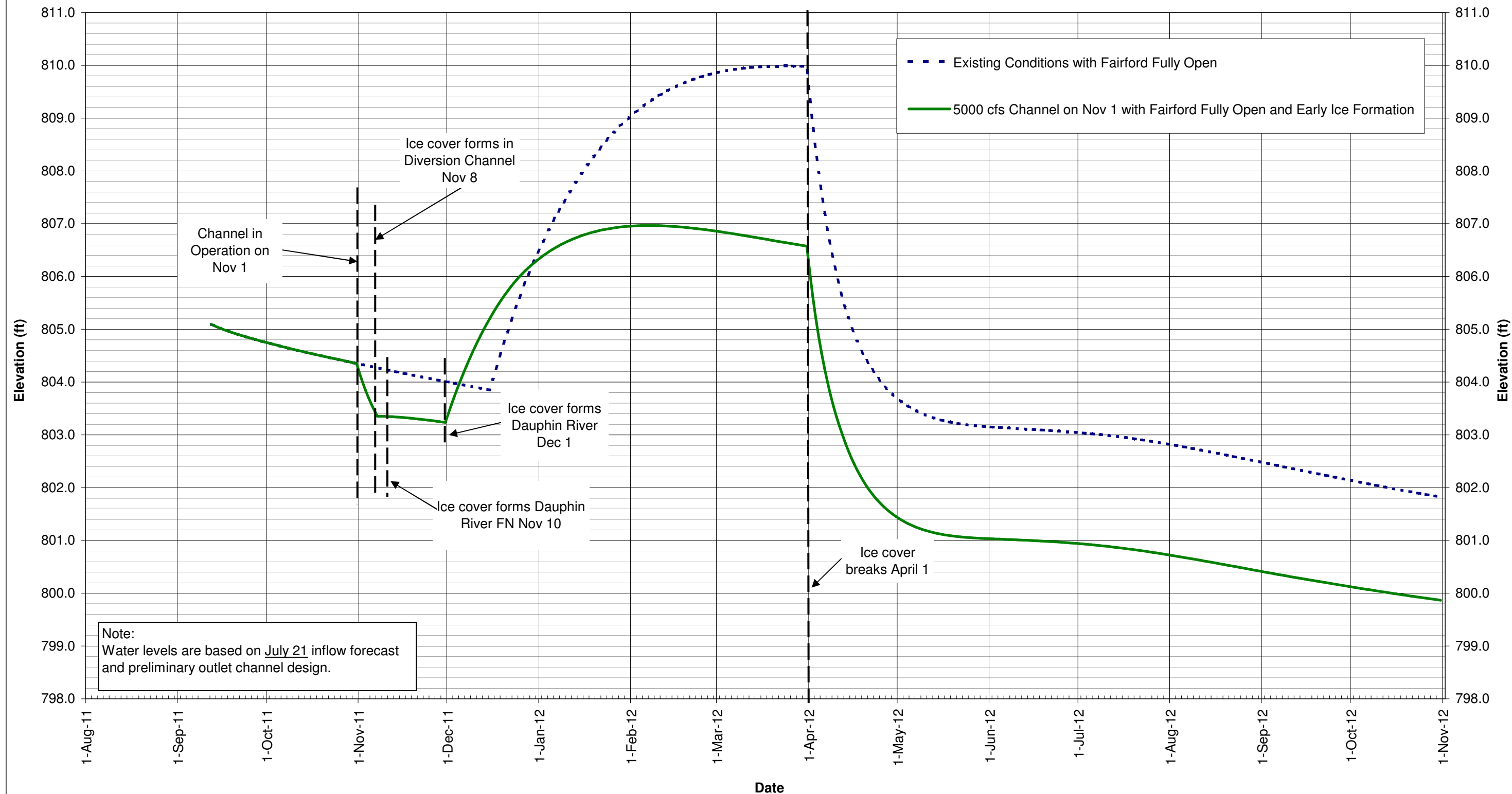


Figure 2.1.2 RevB
Computed Lake St. Martin Outflow
Full Channel in Operation Nov 1 - Early Ice Formation Condition

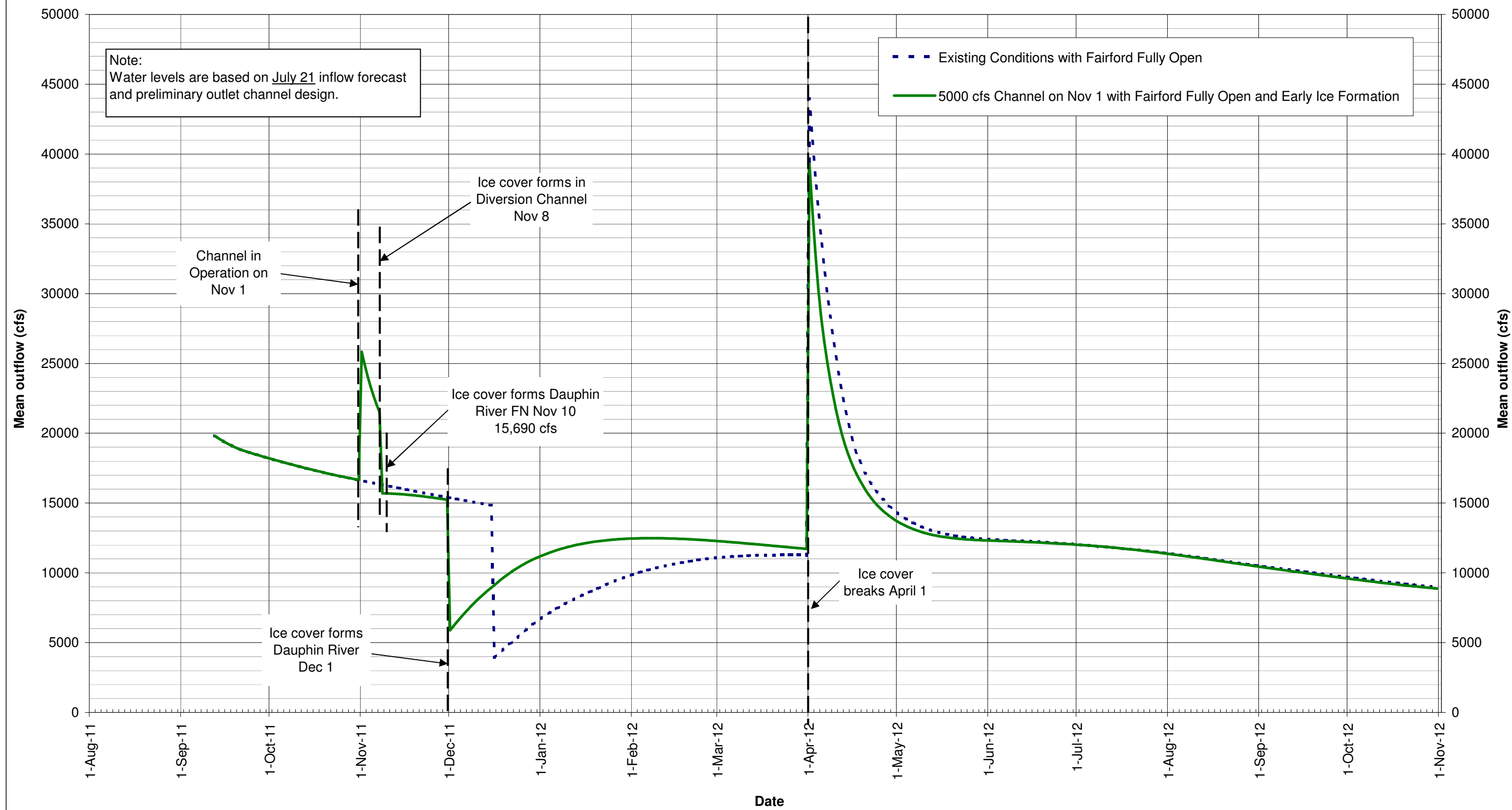


Figure 2.2.1 RevB
Computed Lake St. Martin Level
Full Channel in Operation Nov 1 - Normal Ice Formation Condition

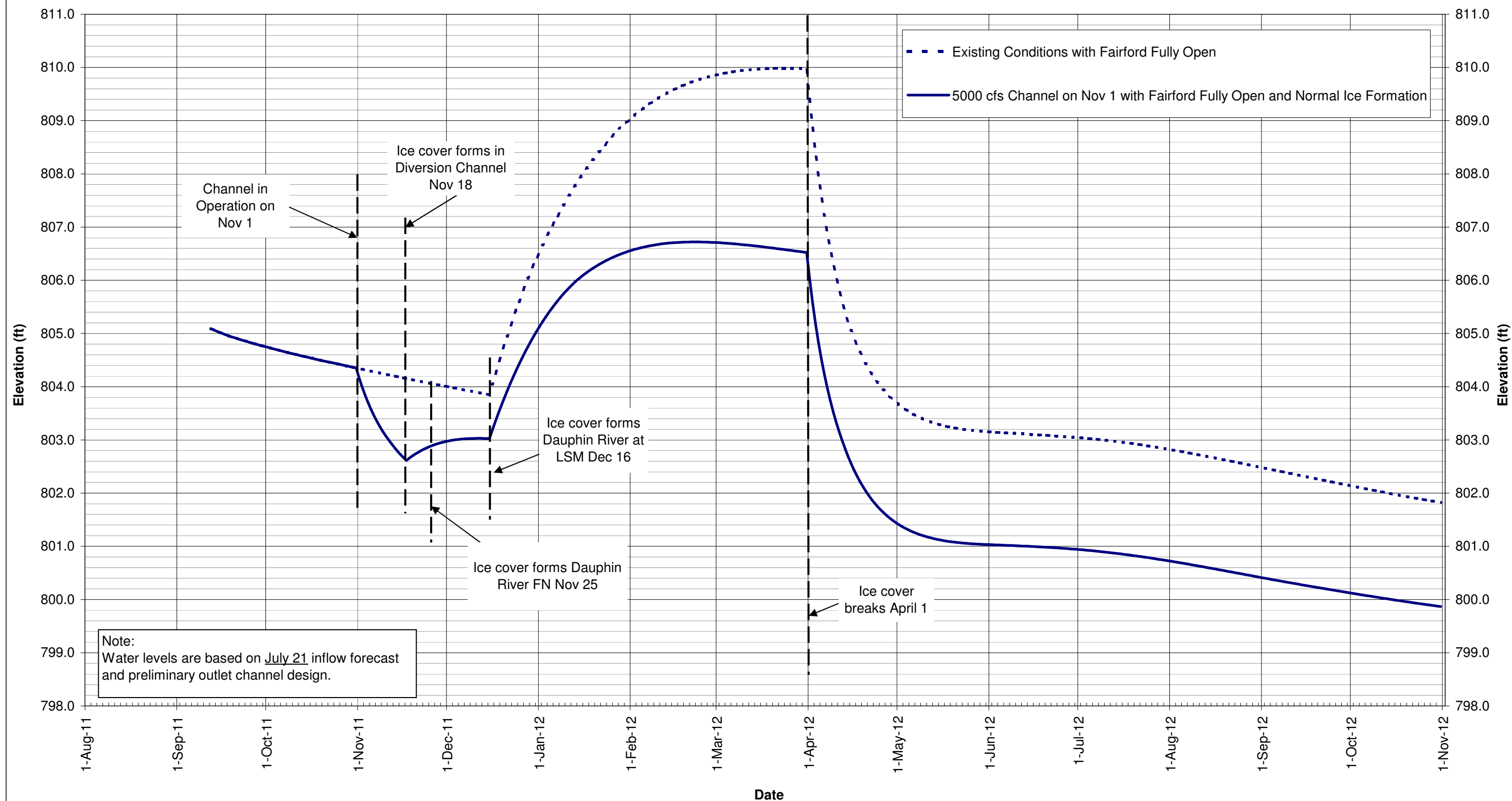


Figure 2.2.2 RevB
Computed Lake St. Martin Outflow
Full Channel in Operation Nov 1 - Normal Ice Formation Condition

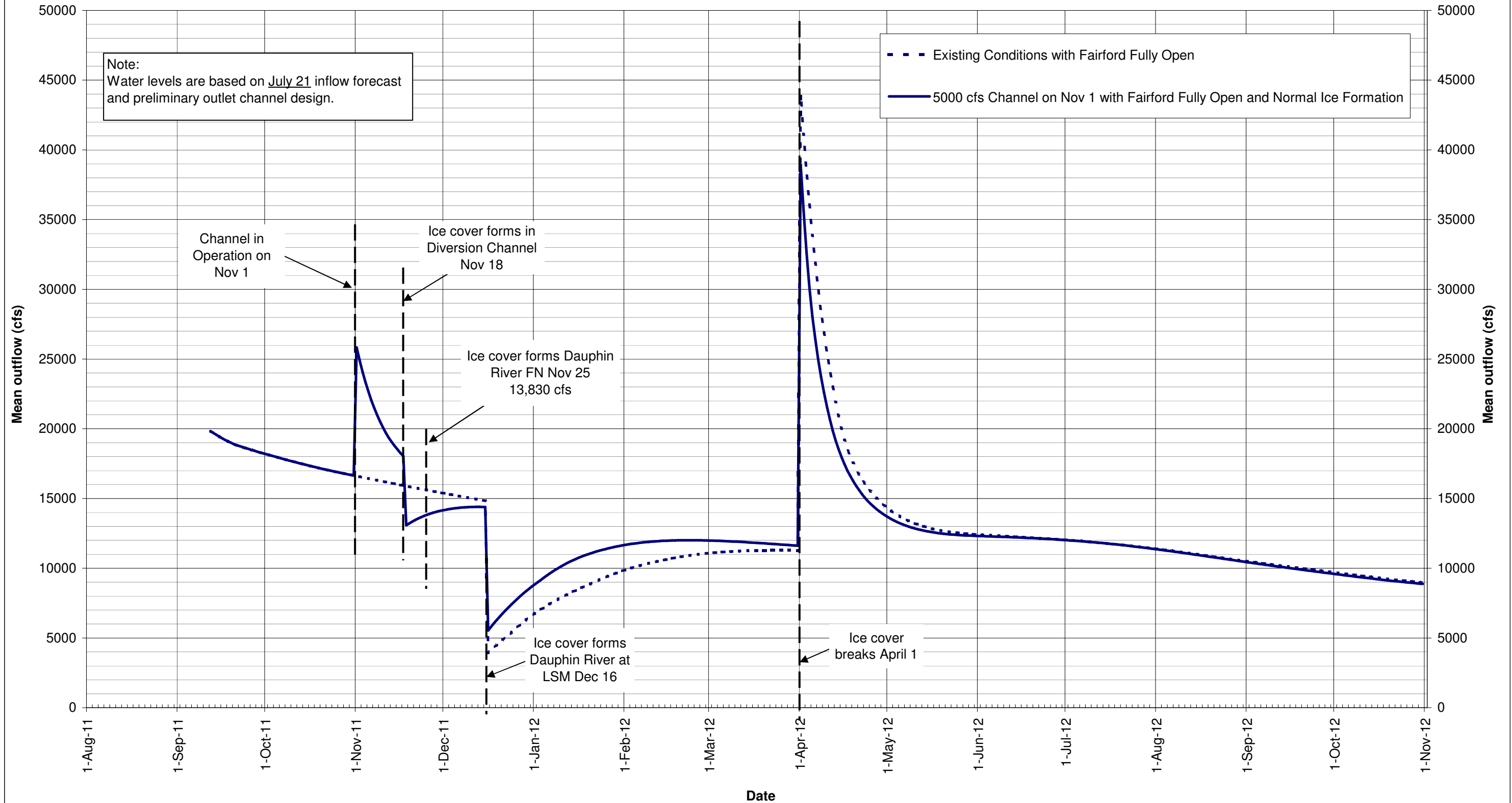


Figure 2.3.1 RevB
Computed Lake St. Martin Level
Full Channel in Operation Nov 1 - Late Ice Formation Condition

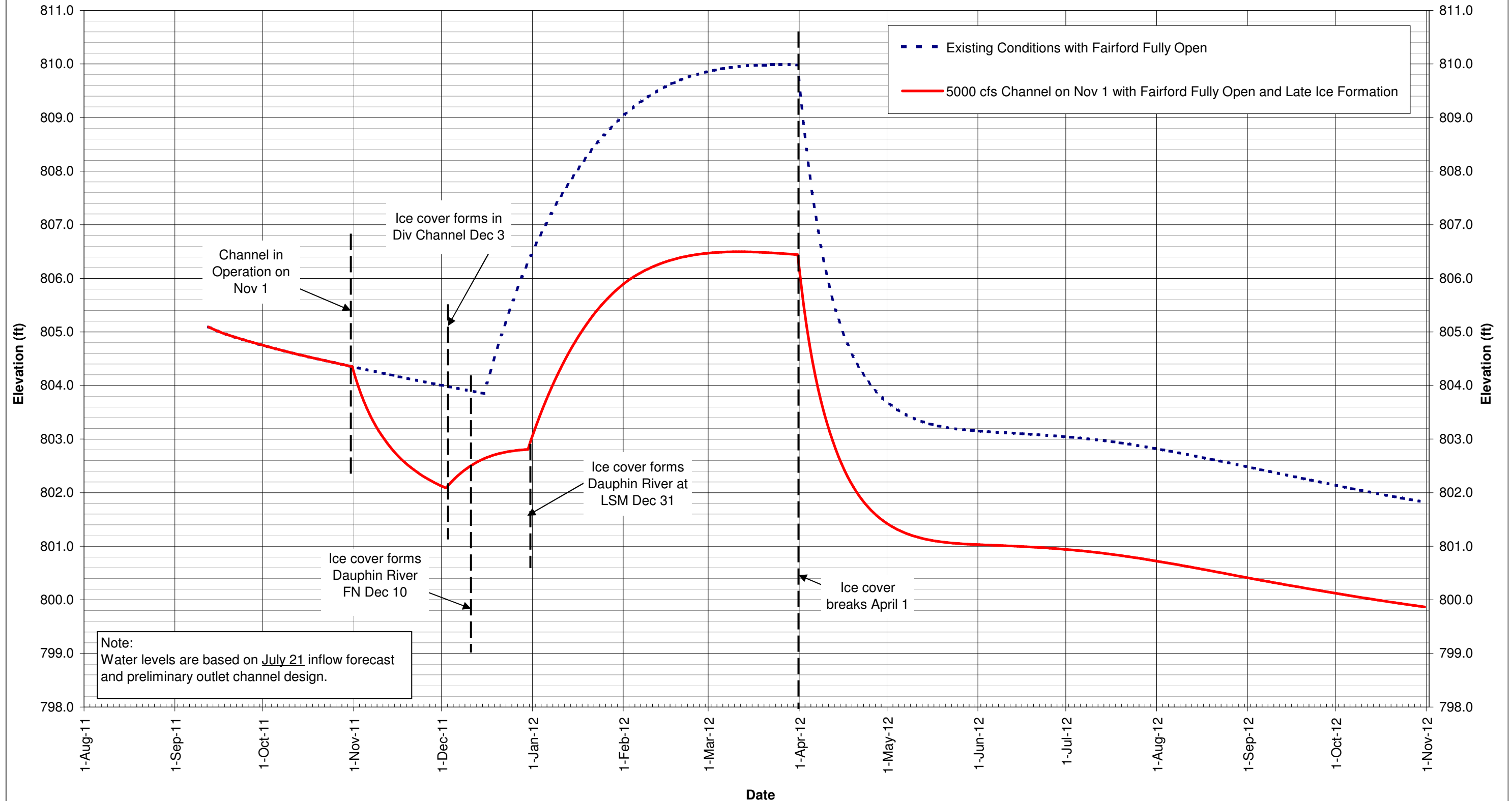


Figure 2.3.2 RevB
Computed Lake St. Martin Outflow
Full Channel in Operation Nov 1 - Late Ice Formation Condition

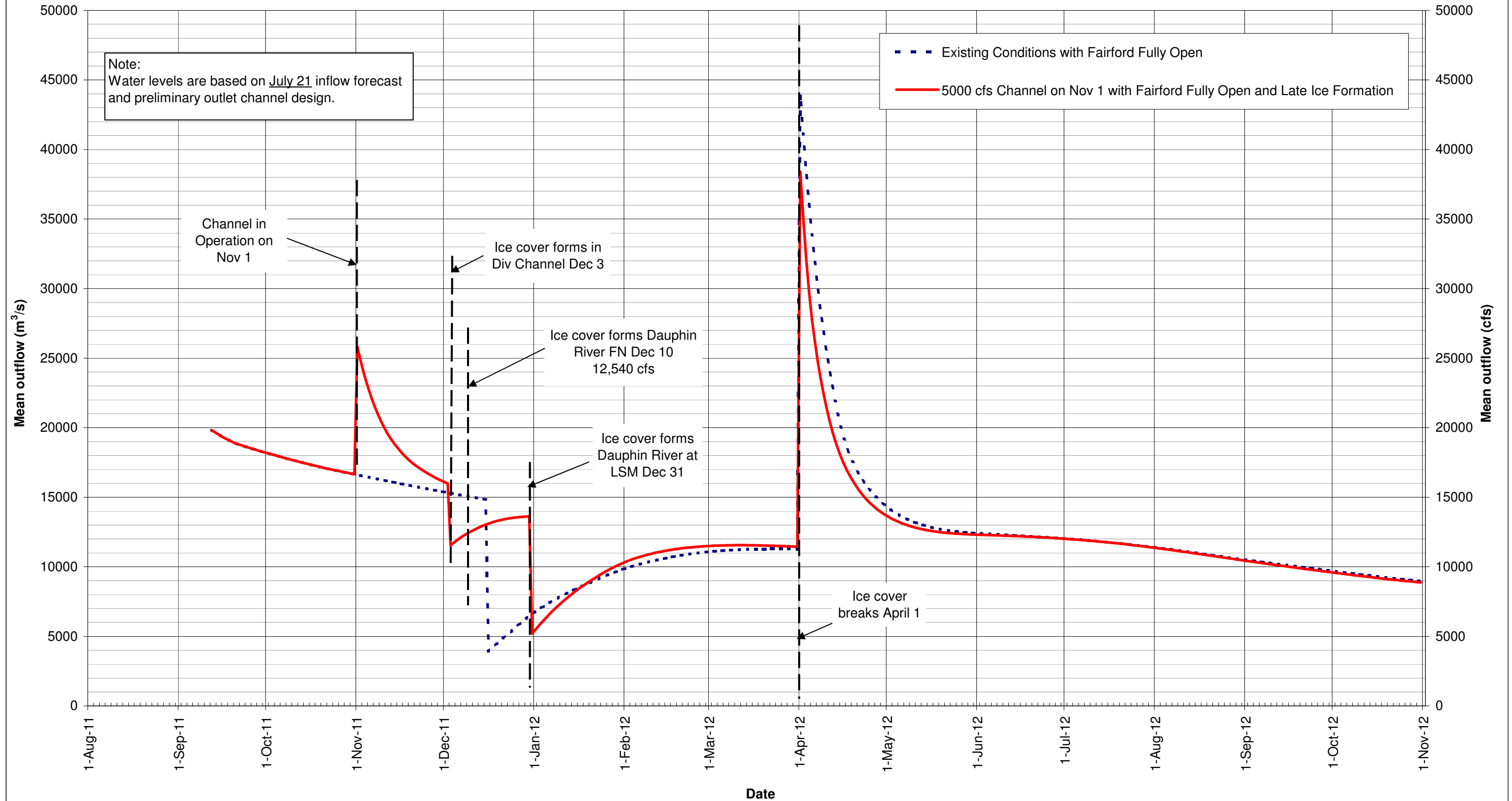


Figure 2.4.1
Computed Lake St. Martin Level
3/4 Channel in Operation Nov 1 - Early Ice Formation Condition

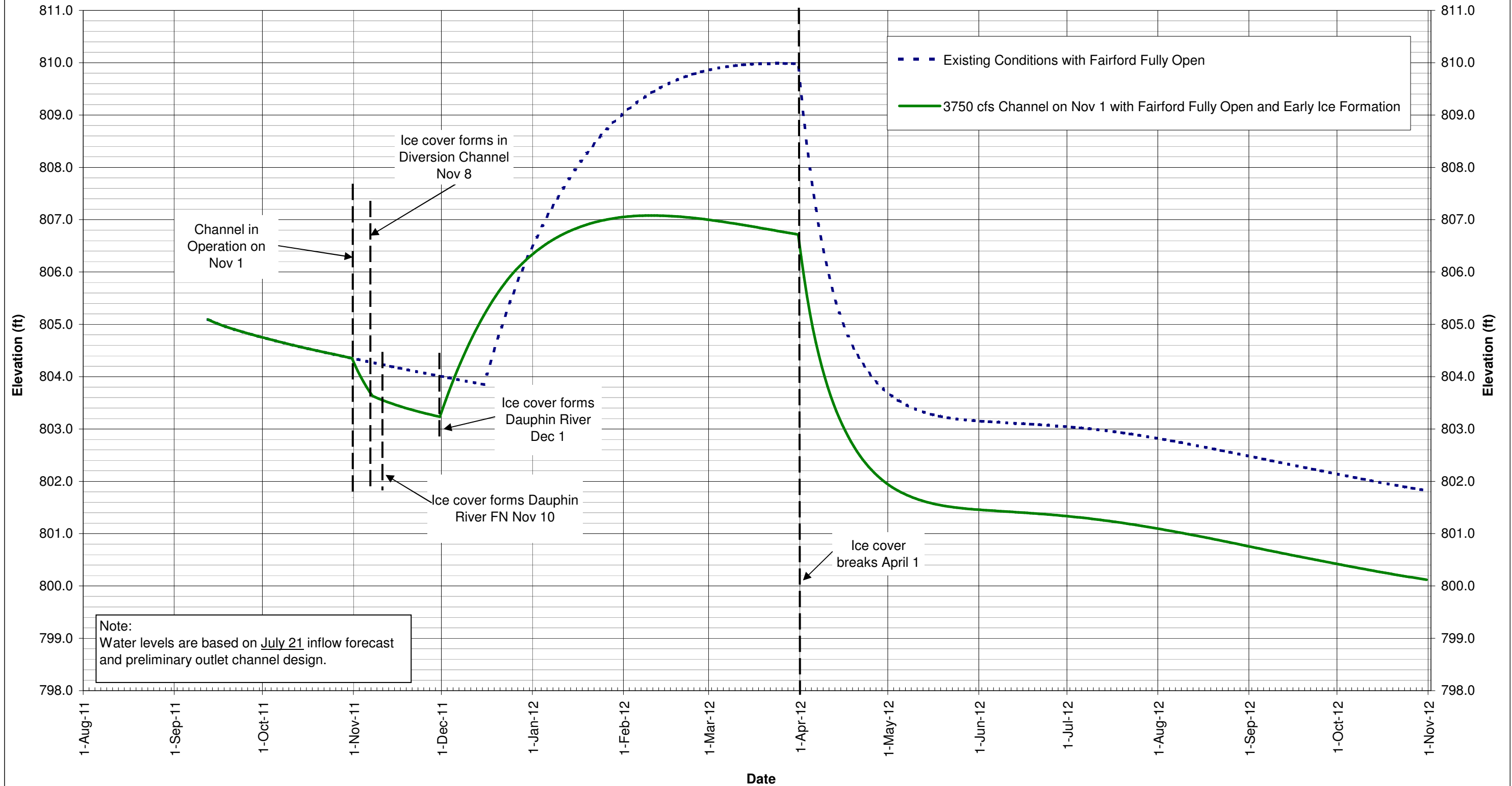


Figure 2.4.2
Computed Lake St. Martin Outflow
3/4 Channel in Operation Nov 1 - Early Ice Formation Condition

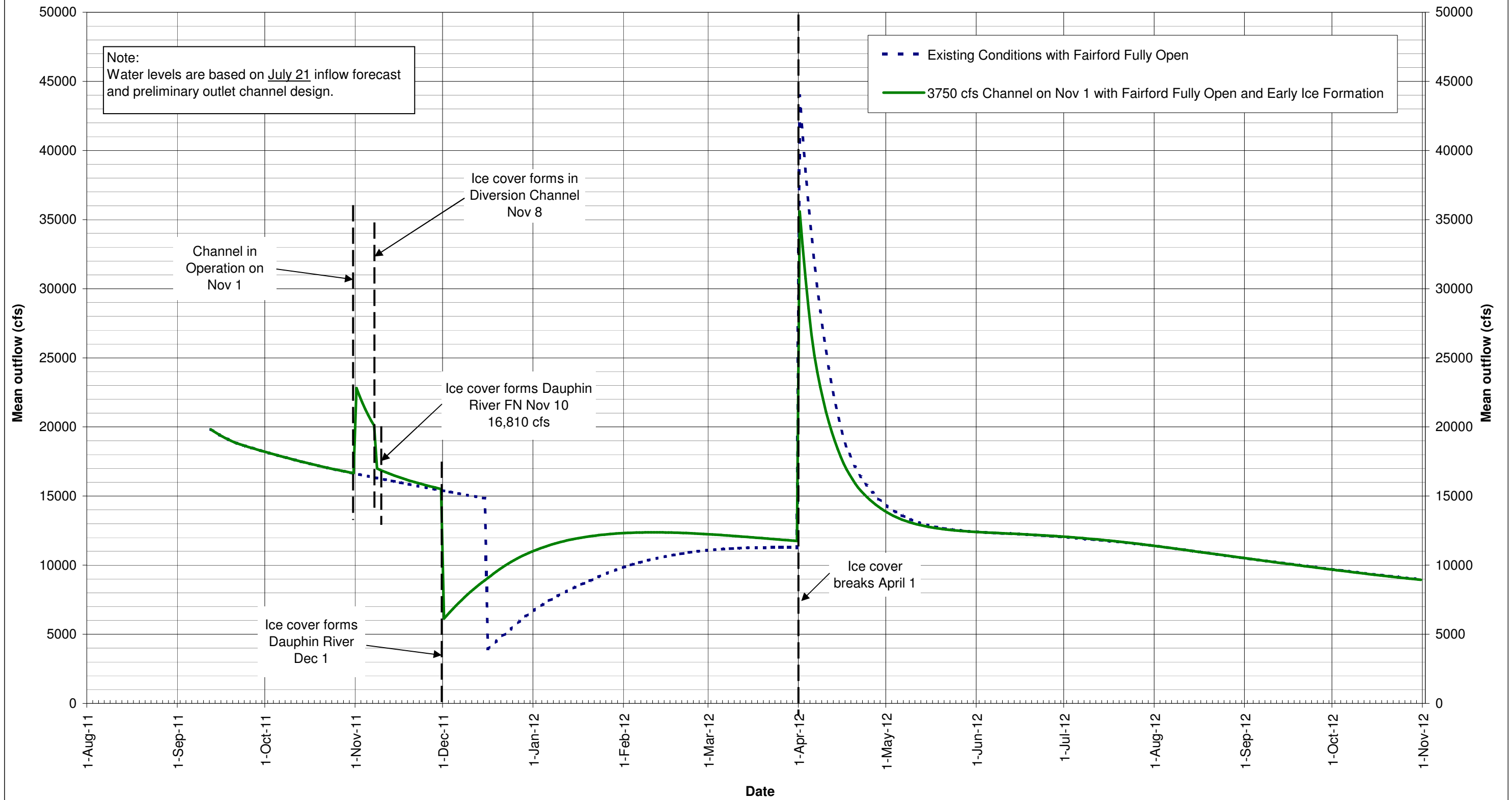


Figure 2.5.1
Computed Lake St. Martin Level
3/4 Channel in Operation Nov 1 - Normal Ice Formation Condition

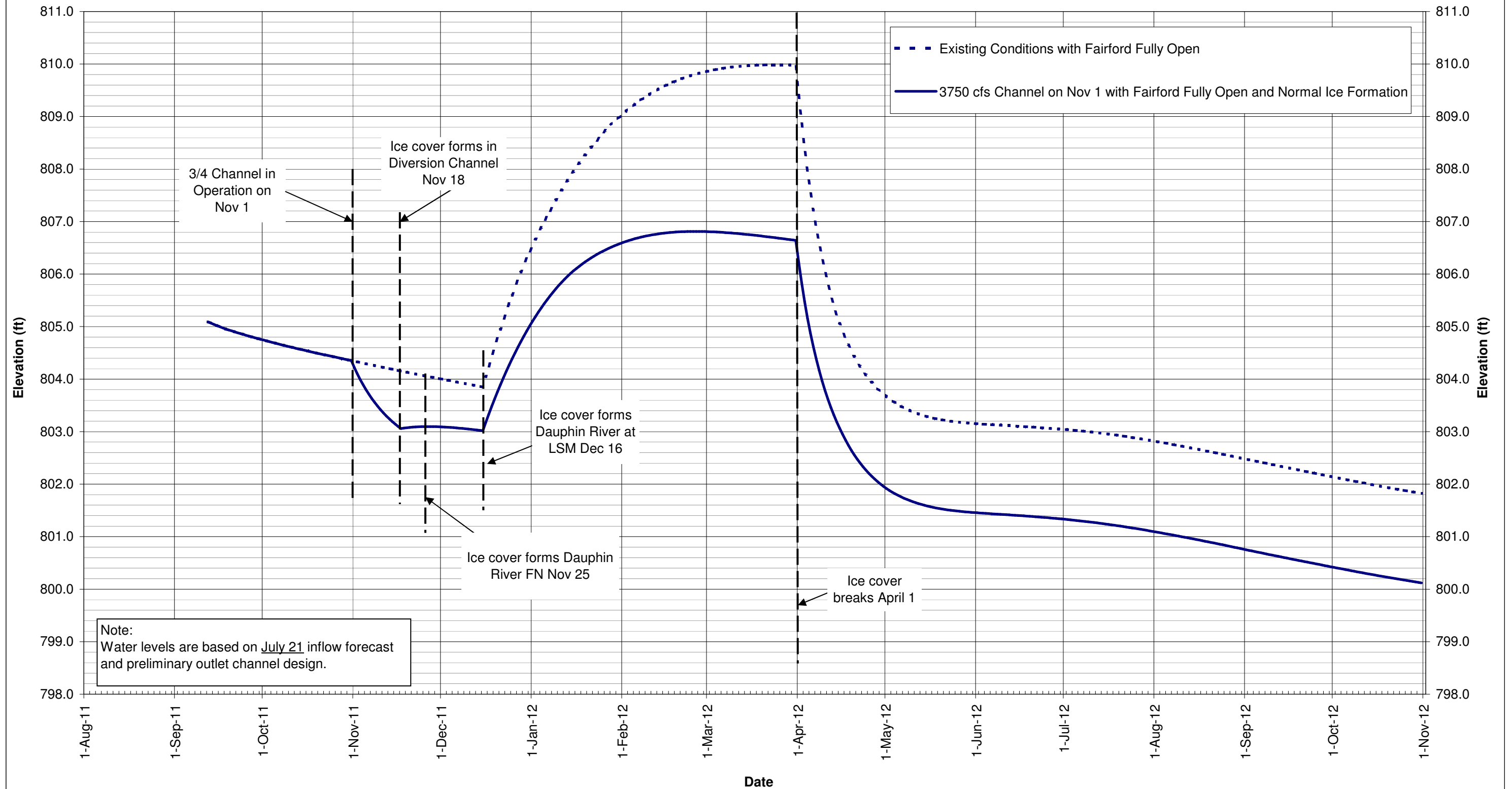


Figure 2.5.2
Computed Lake St. Martin Outflow
3/4 Channel in Operation Nov 1 - Normal Ice Formation Condition

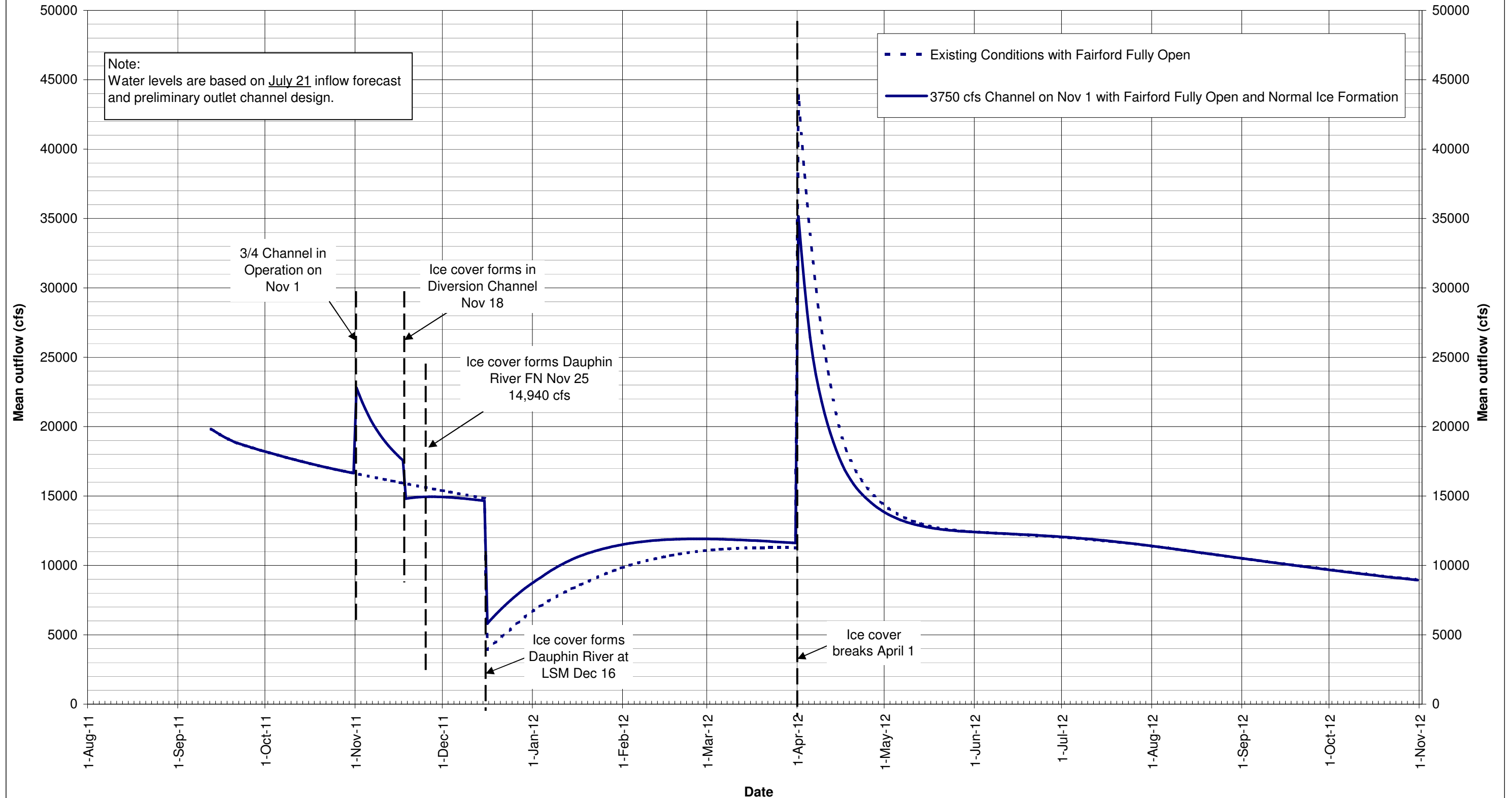


Figure 2.6.1
Computed Lake St. Martin Level
3/4 Channel in Operation Nov 1 - Late Ice Formation Condition

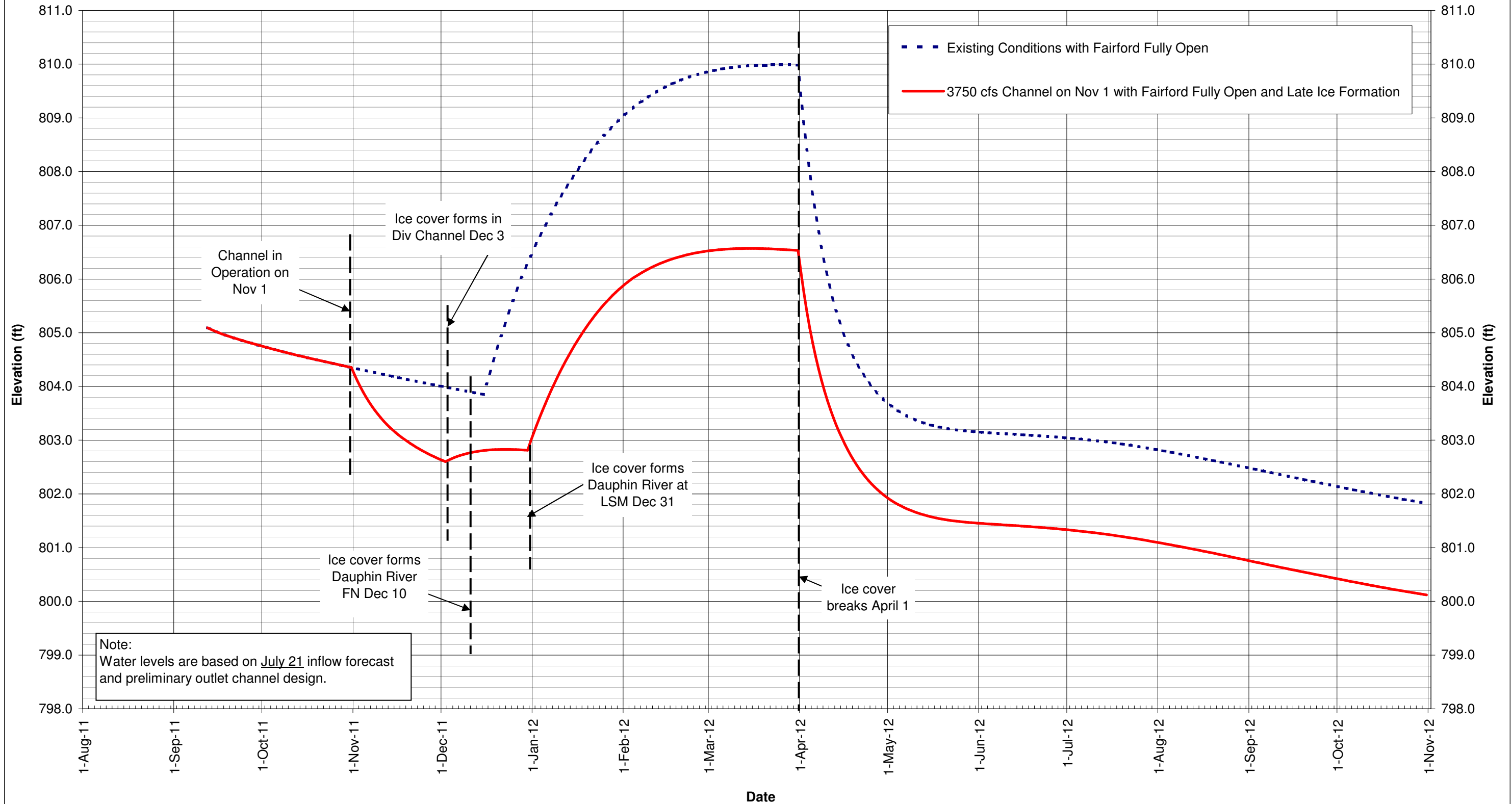


Figure 2.6.2
Computed Lake St. Martin Outflow
3/4 Channel in Operation Nov 1 - Late Ice Formation Condition

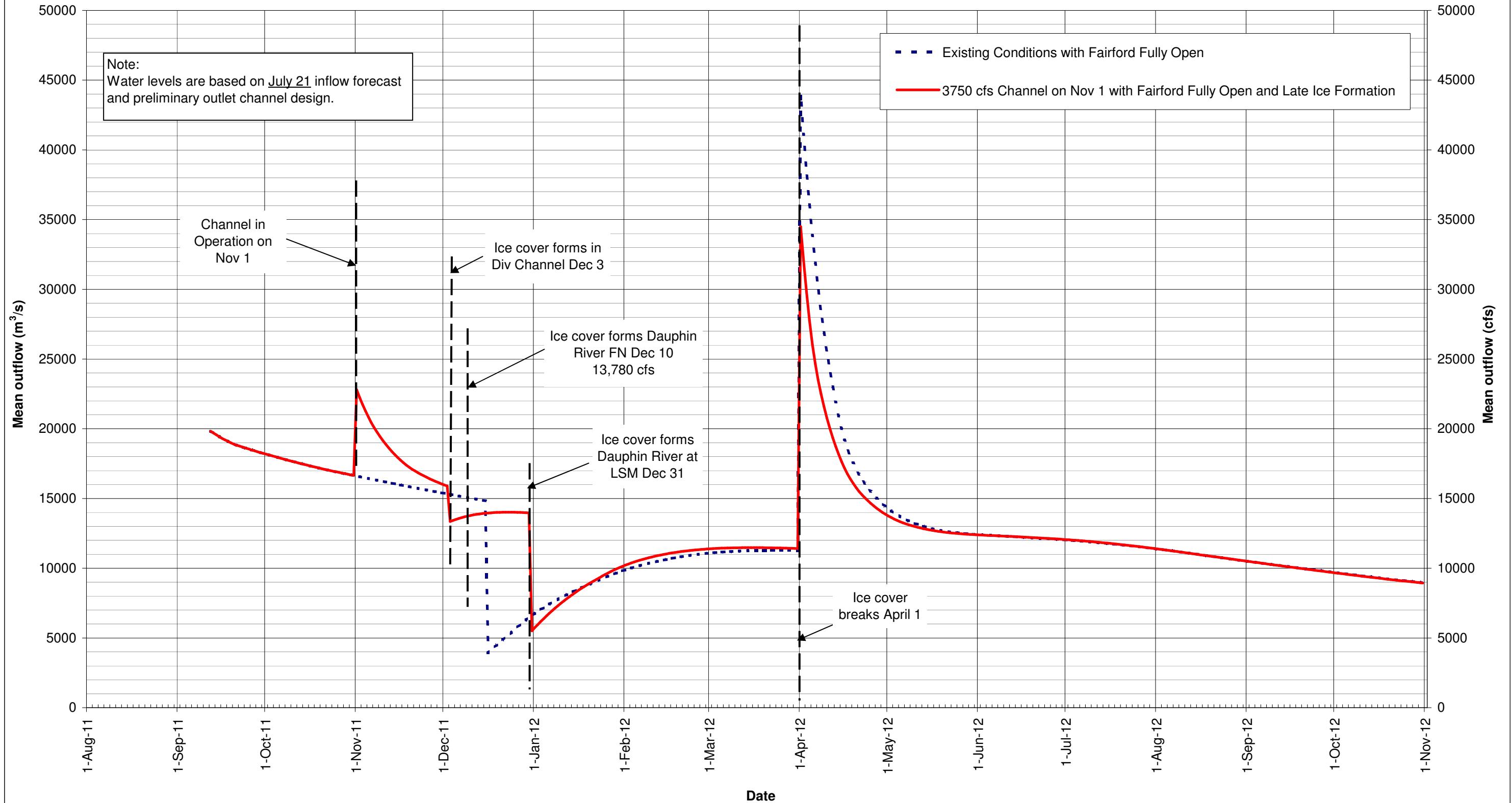


Figure 2.7.1
Computed Lake St. Martin Level
1/2 Channel in Operation Nov 1 - Early Ice Formation Condition

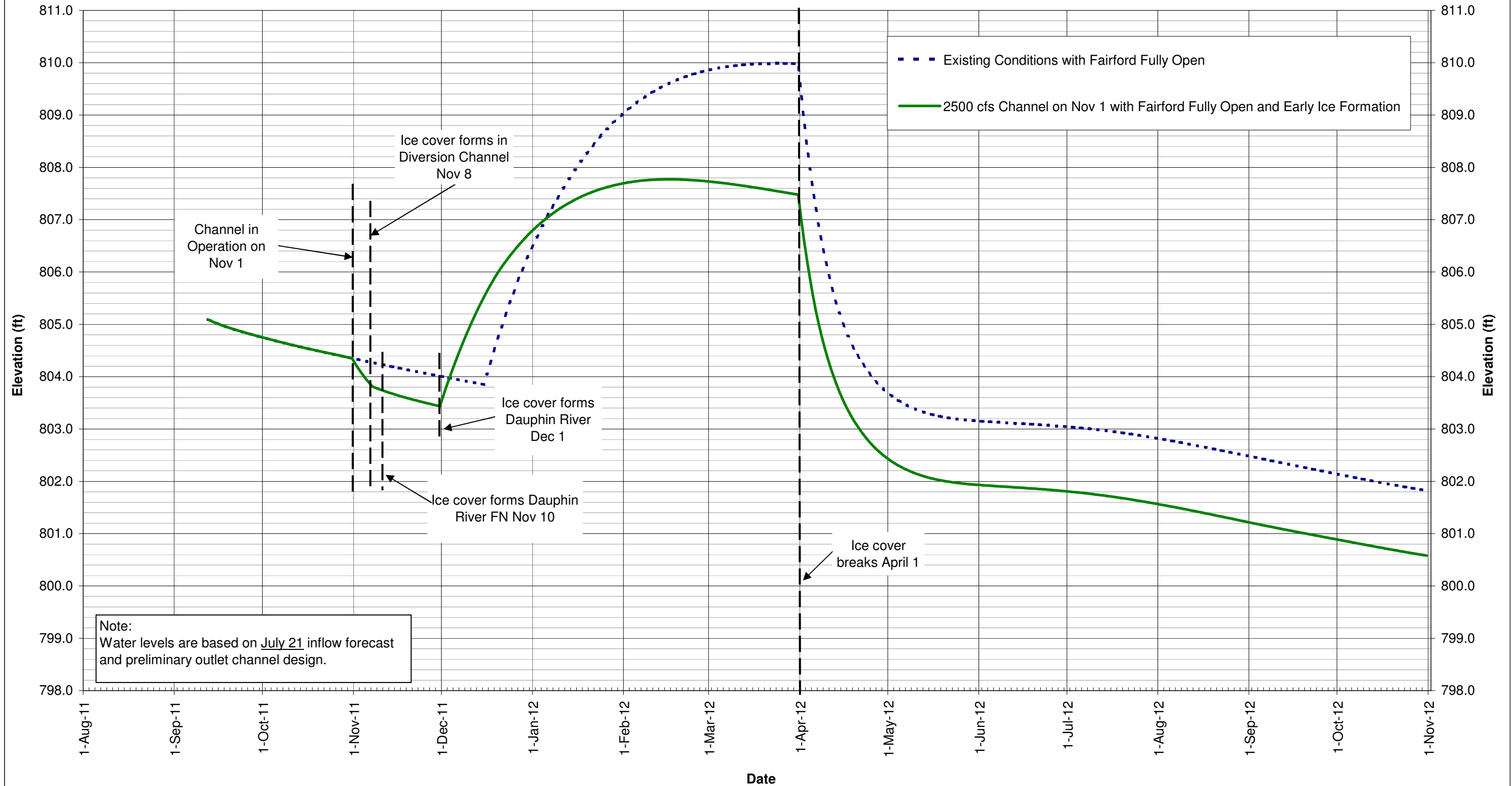


Figure 2.7.2
Computed Lake St. Martin Outflow
1/2 Channel in Operation Nov 1 - Early Ice Formation Condition

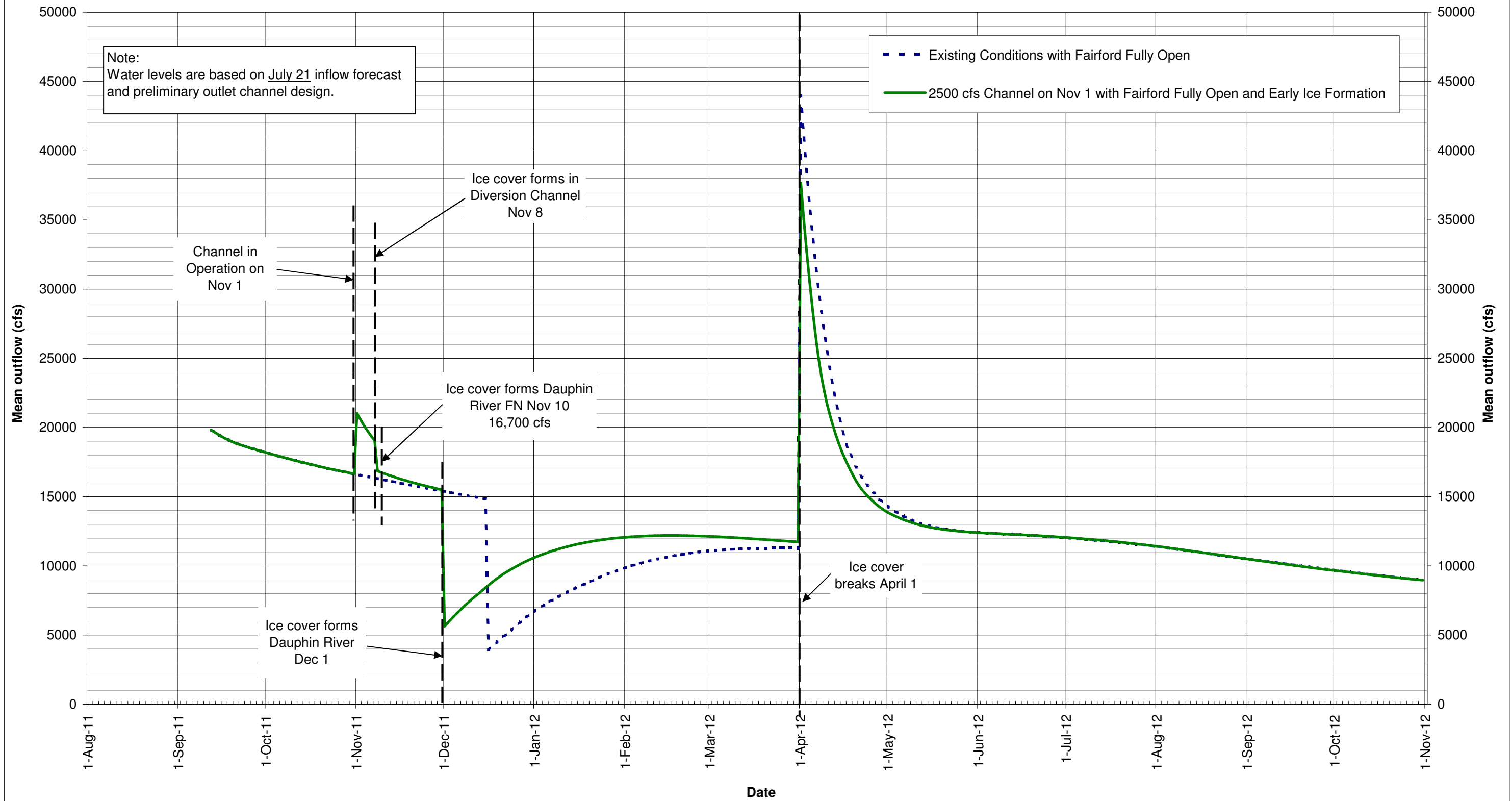


Figure 2.8.1
Computed Lake St. Martin Level
1/2 Channel in Operation Nov 1 - Normal Ice Formation Condition

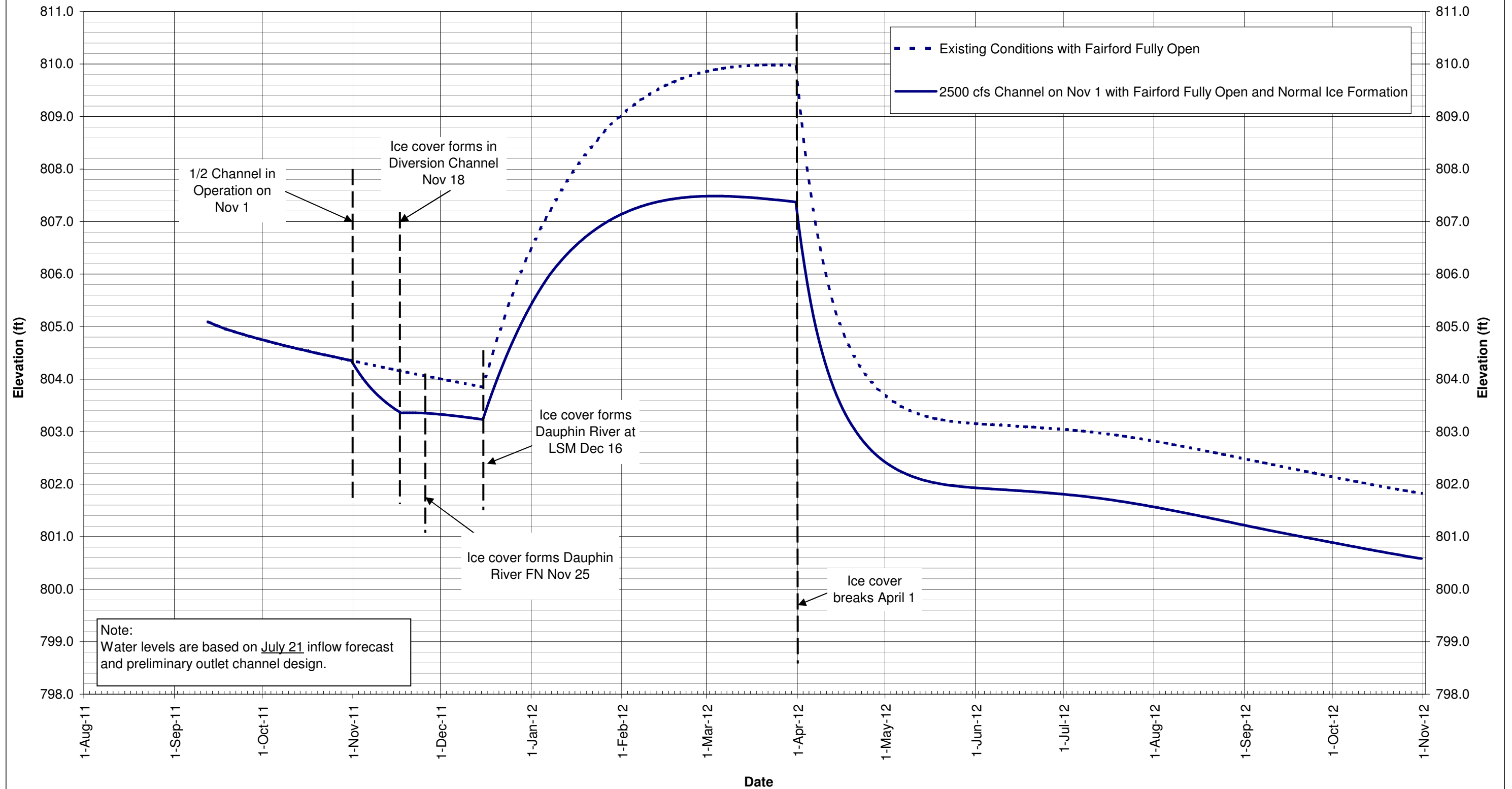


Figure 2.8.2
Computed Lake St. Martin Outflow
1/2 Channel in Operation Nov 1 - Normal Ice Formation Condition

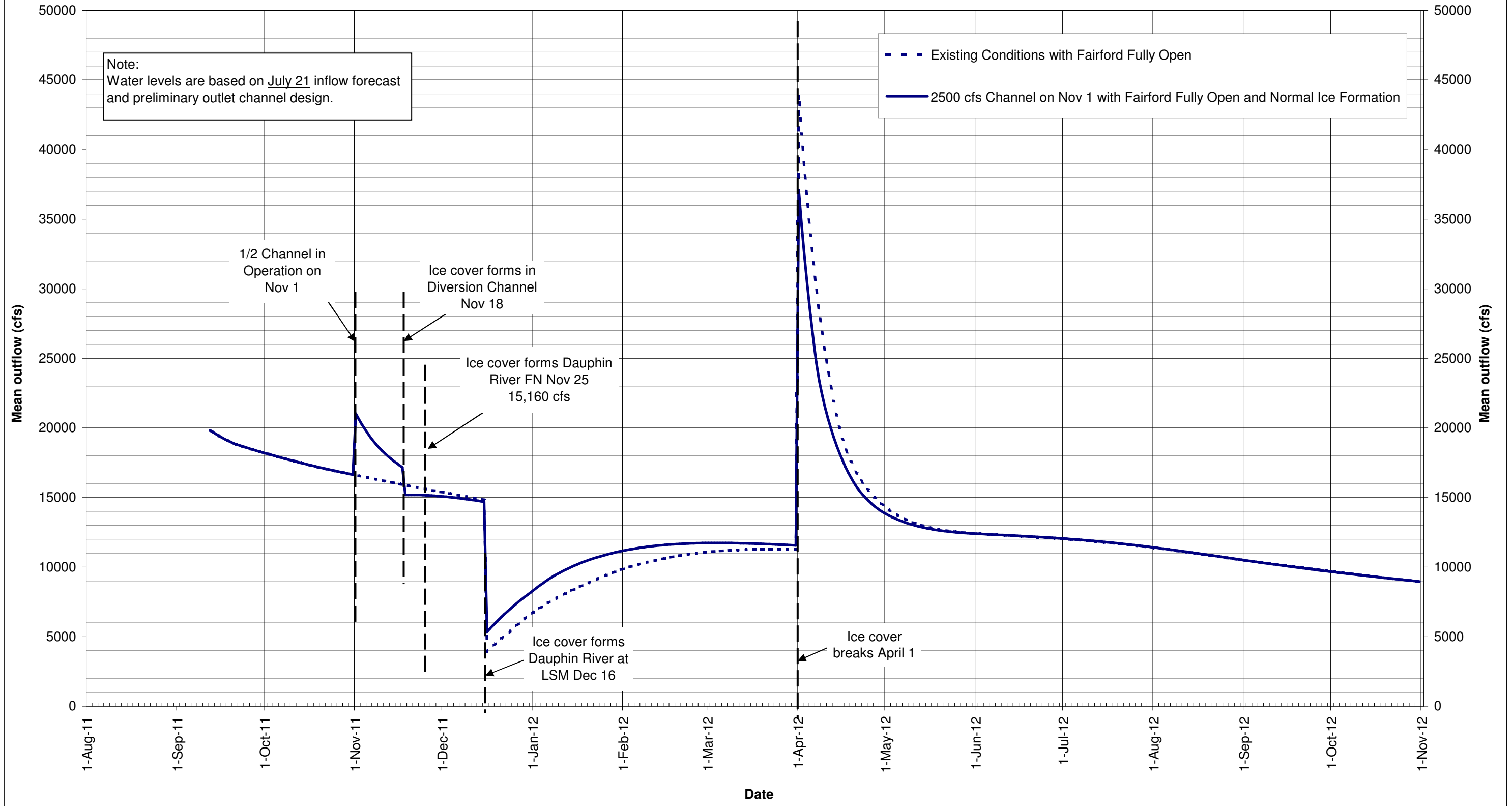


Figure 2.9.1
Computed Lake St. Martin Level
1/2 Channel in Operation Nov 1 - Late Ice Formation Condition

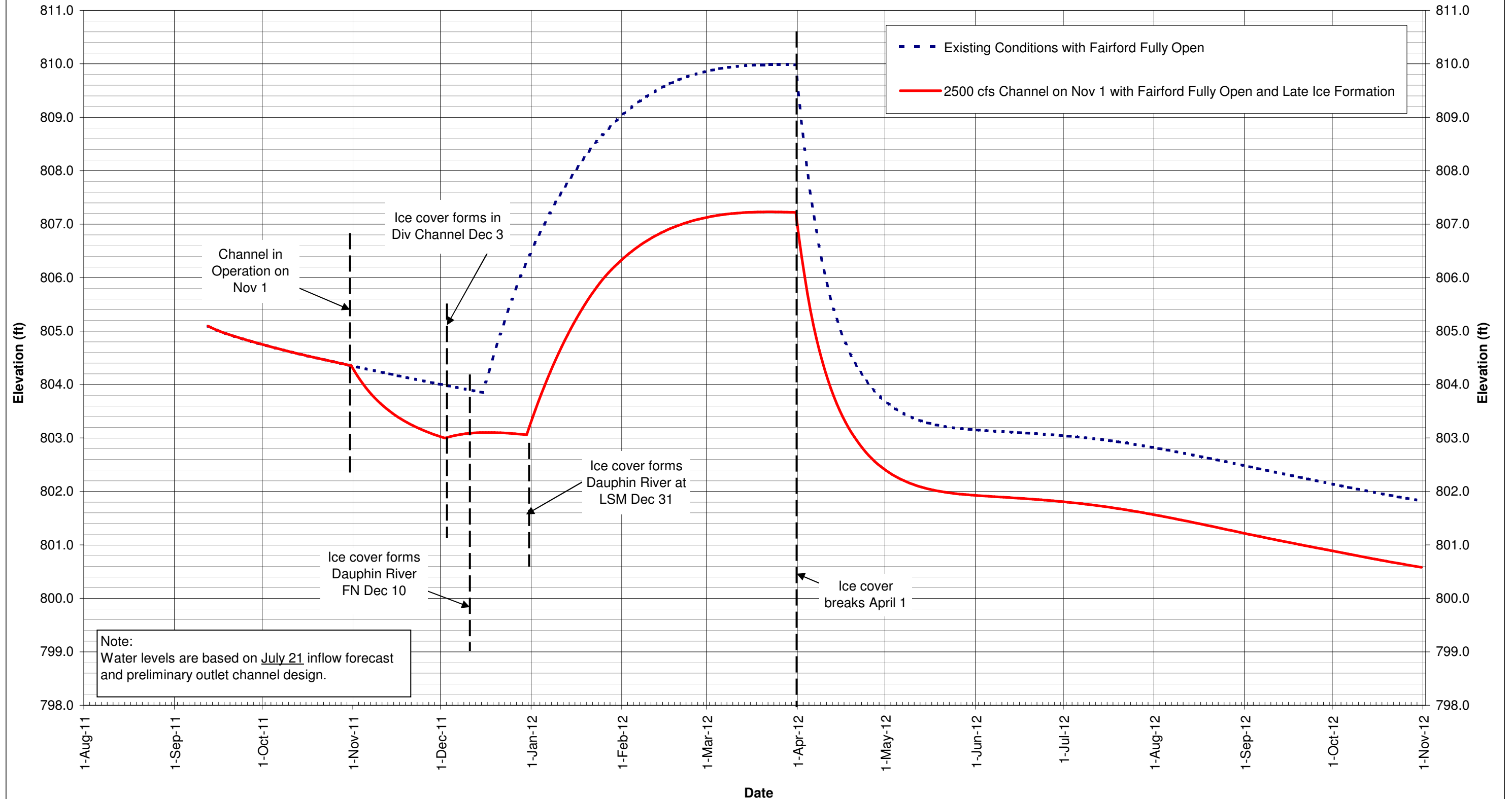


Figure 2.9.2
Computed Lake St. Martin Outflow
1/2 Channel in Operation Nov 1 - Late Ice Formation Condition

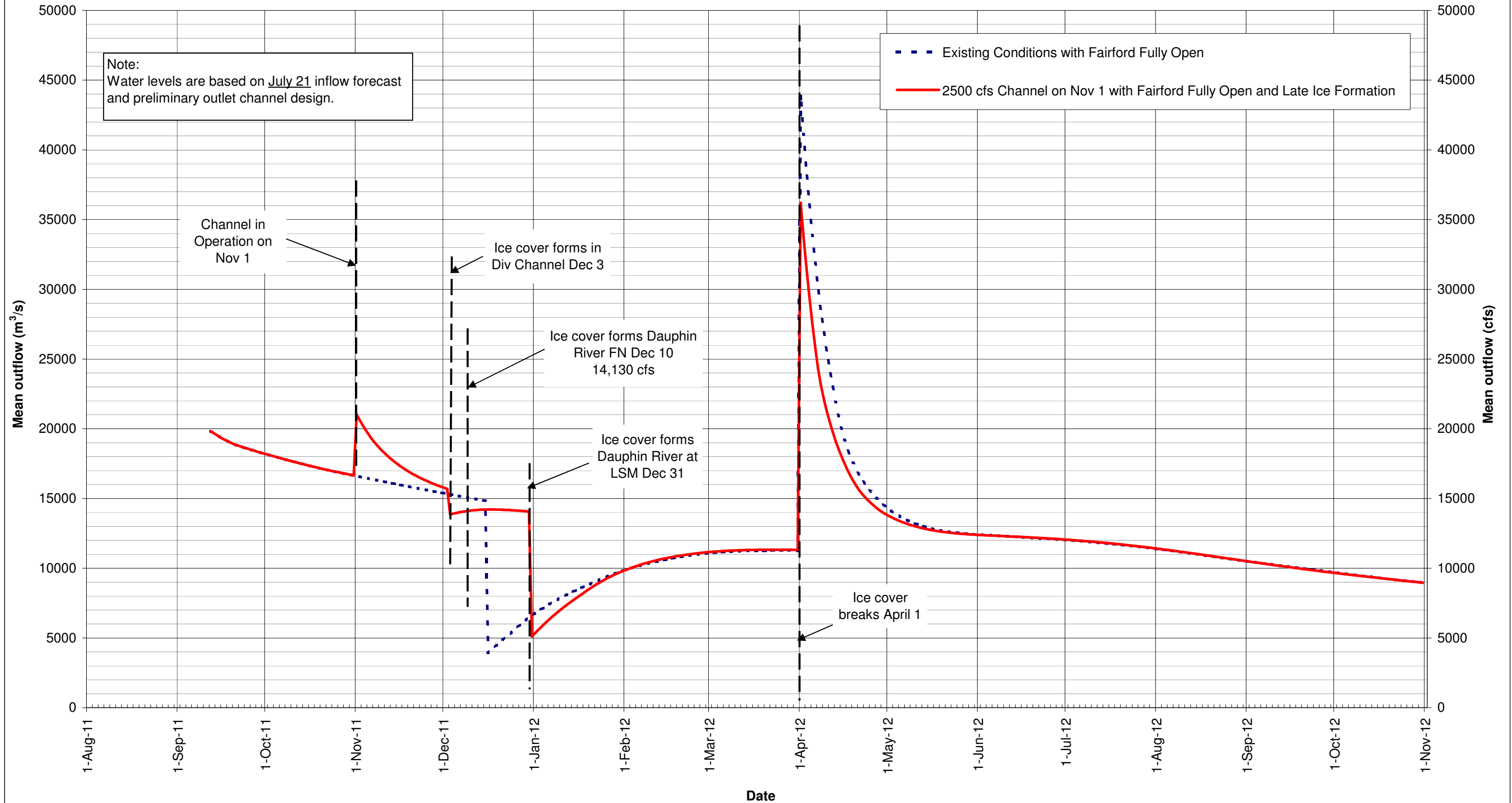


Figure 2.10.1
Computed Lake St. Martin Level
Full Channel in Operation on Dec 1 - Early Ice Formation Condition

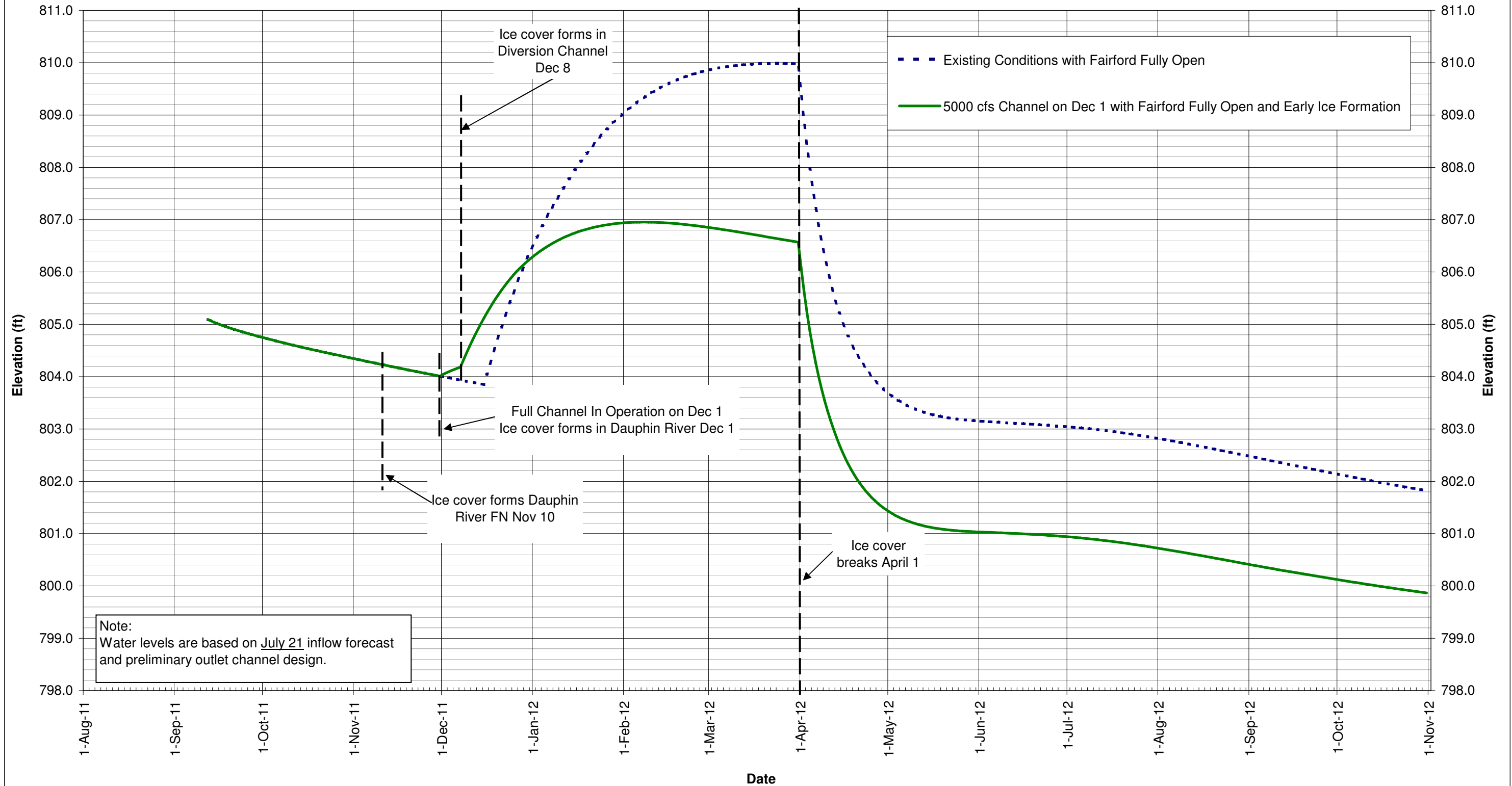


Figure 2.10.2
Computed Lake St. Martin Outflow
Full Channel in Operation on Dec 1 - Early Ice Formation Condition

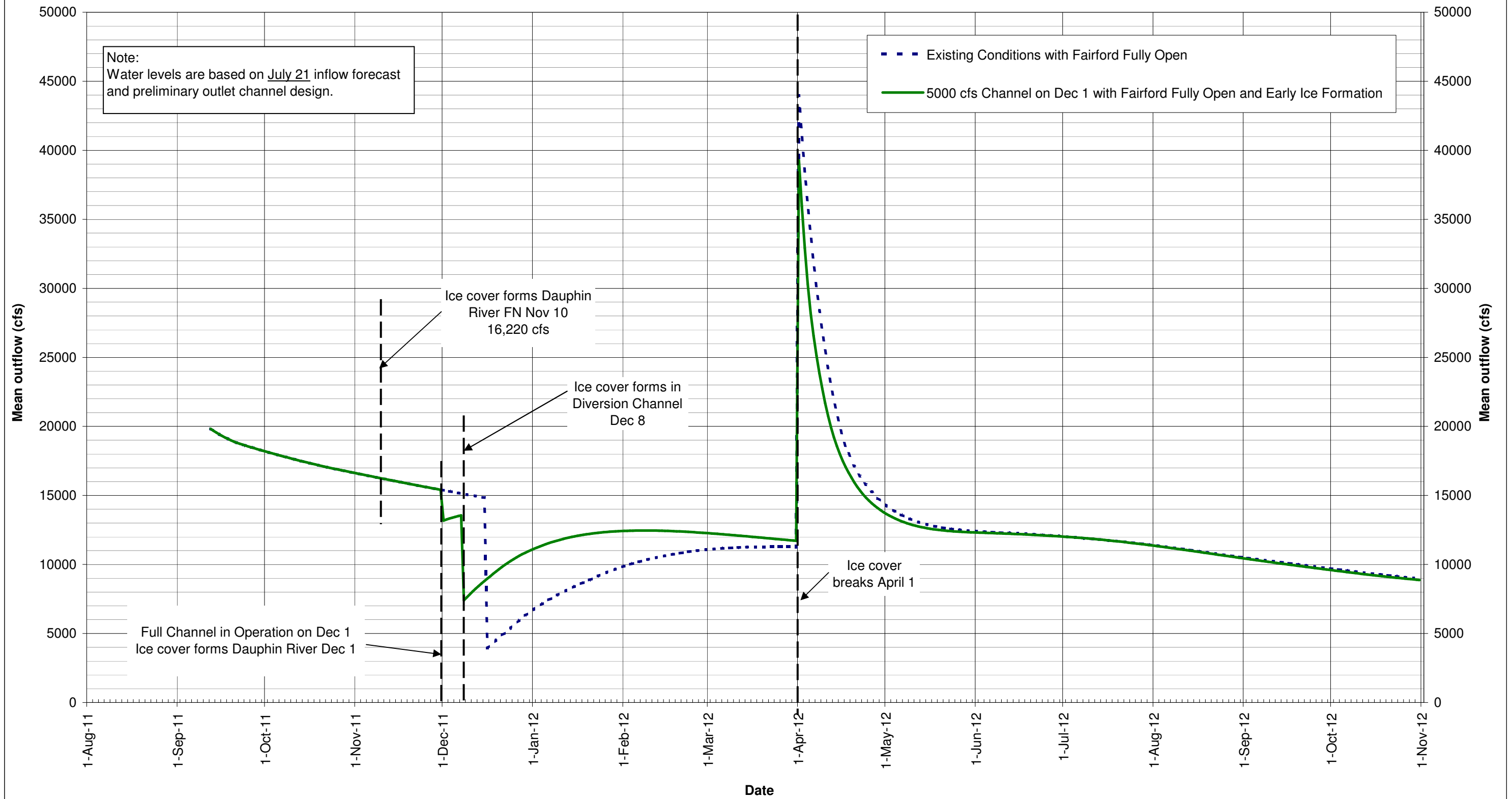


Figure 2.11.1
Computed Lake St. Martin Level
Full Channel in Operation Dec 1 - Normal Ice Formation Condition

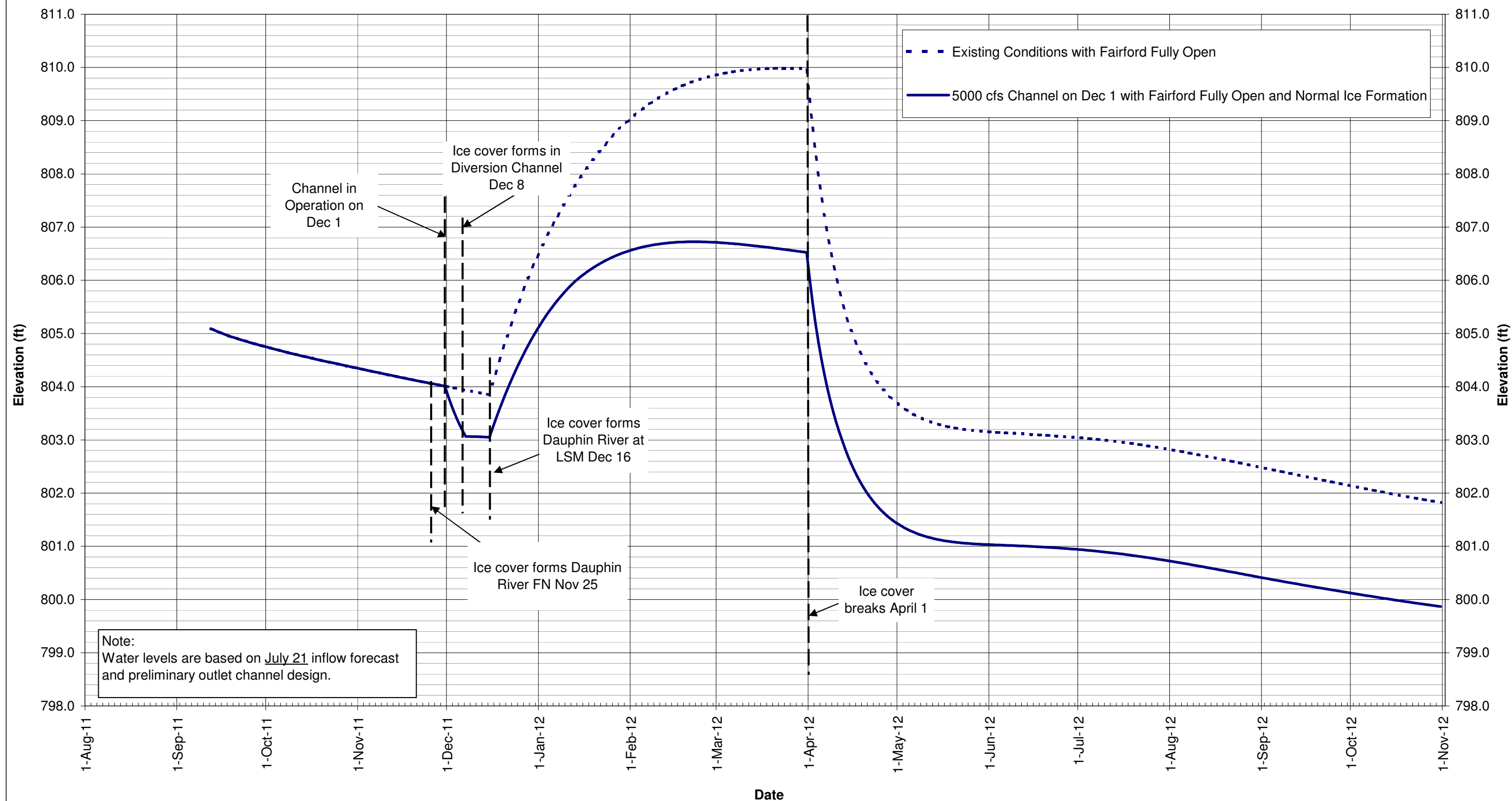


Figure 2.11.2
Computed Lake St. Martin Outflow
Full Channel in Operation Dec 1 - Normal Ice Formation Condition

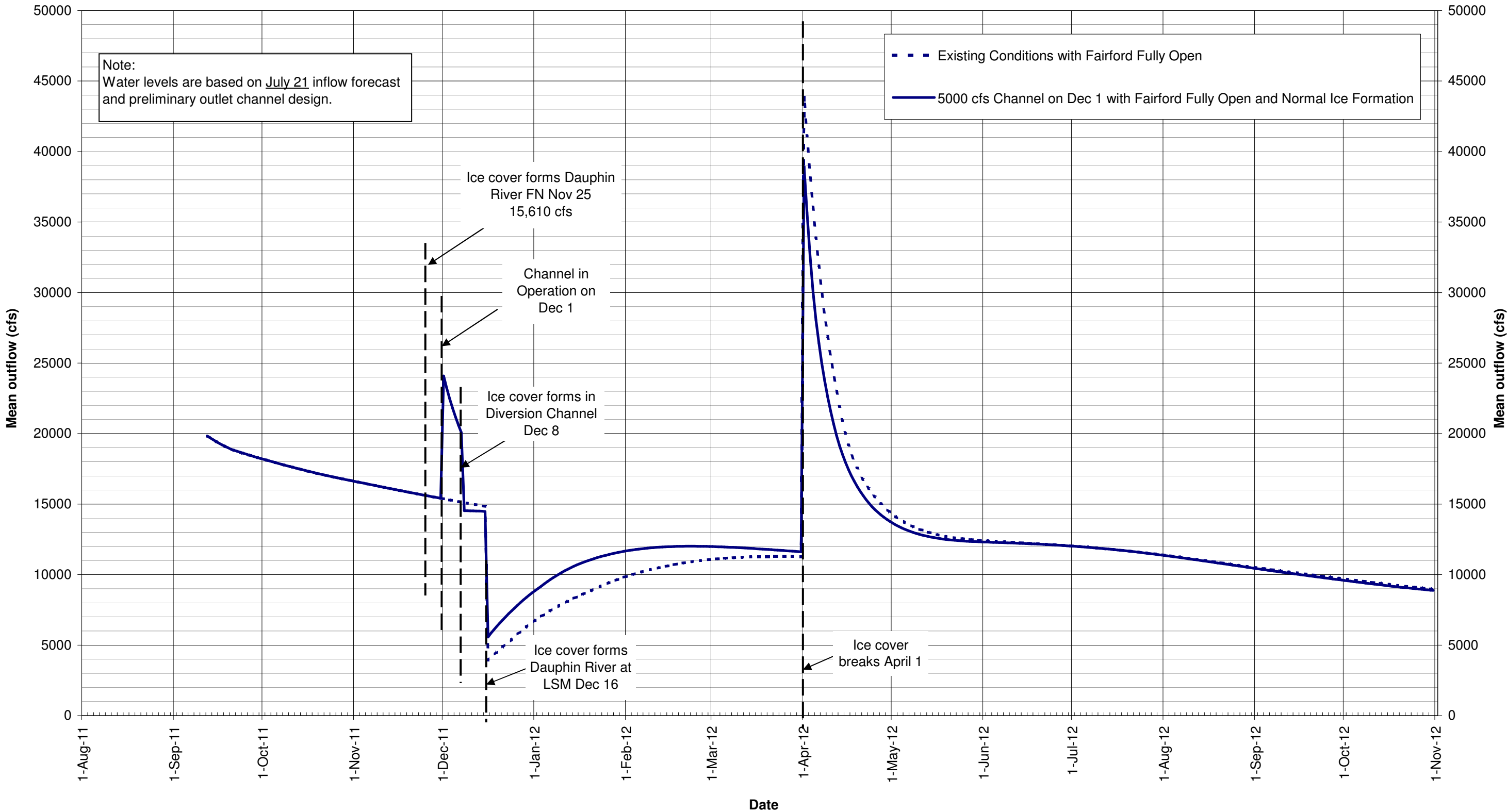


Figure 2.12.1
Computed Lake St. Martin Level
Full Channel in Operation Dec 1 - Late Ice Formation Condition

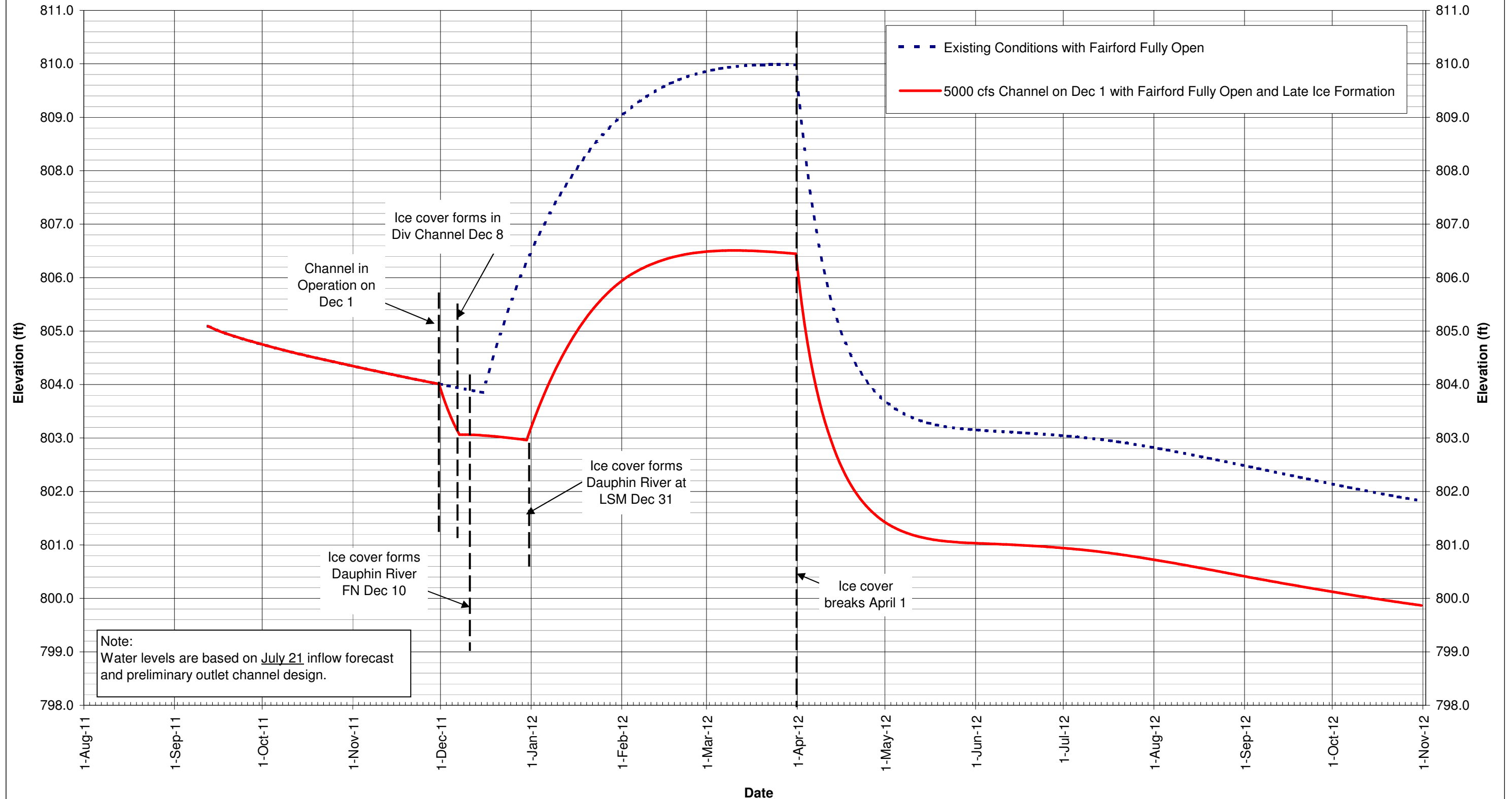
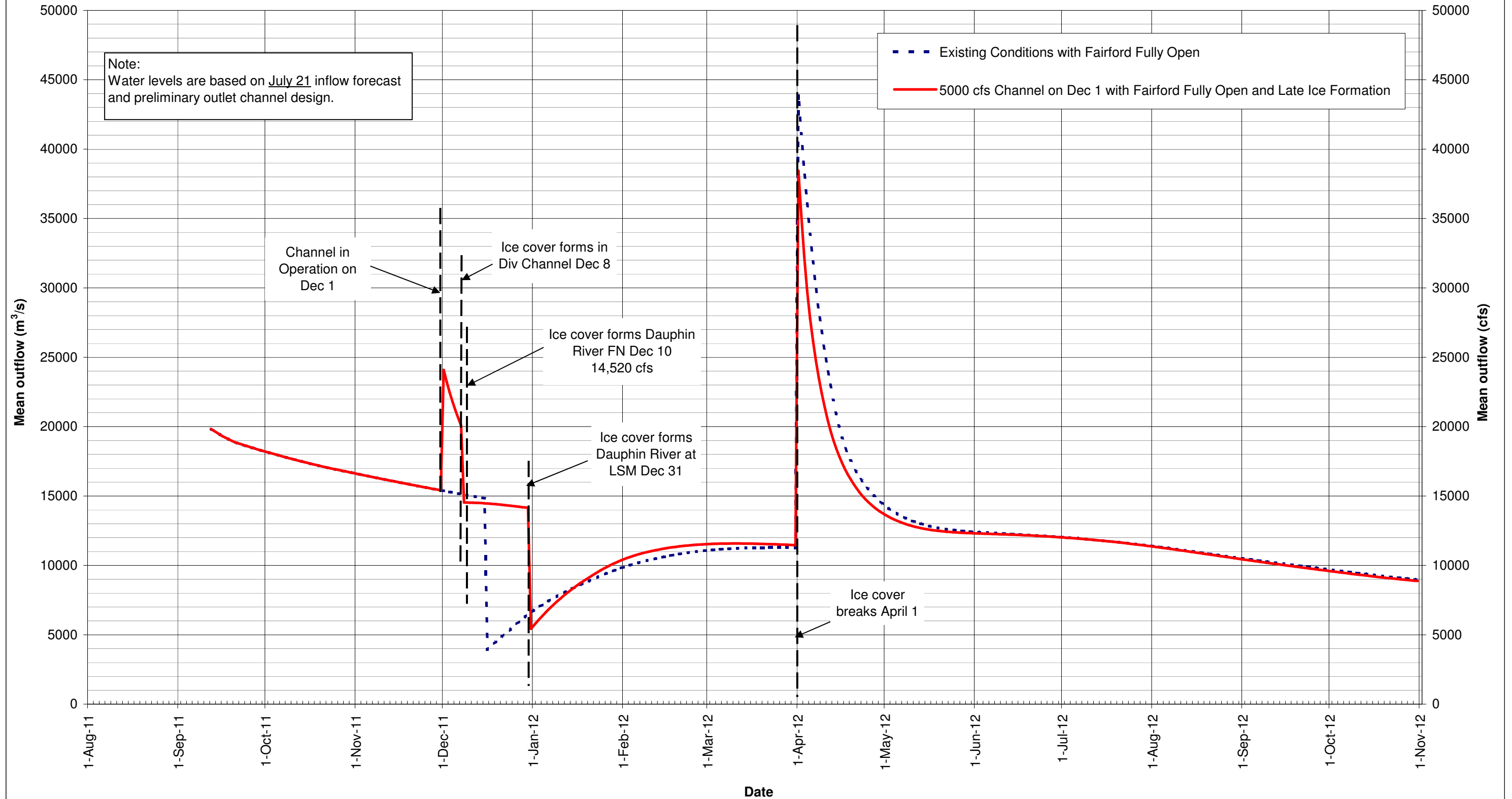


Figure 2.12.2
Computed Lake St. Martin Outflow
Full Channel in Operation Dec 1 - Late Ice Formation Condition



**Lake Manitoba Forecast
Correspondence and Figures**

October 11, 2011

Garrett Wellwood

From: Patrice Leclercq [PLeclercq@kgsgroup.com]
Sent: Friday, March 01, 2013 8:01 AM
To: 'Patrice Leclercq'
Subject: FW: URGENT - Lake Manitoba Forecast
Attachments: 0.75 Channel Nov 1 Late Q.pdf; 0.75 Channel Nov 1 Late WL.pdf; 0.75 Channel Nov 1 Normal Q.pdf; 0.75 Channel Nov 1 Normal WL.pdf; 0.75 Channel Nov 1 Early Q.pdf; 0.75 Channel Nov 1 Early WL.pdf; Figure 1.1.2_RevB.PDF; Figure 1.1.1_RevA.PDF

From: Colin Siepman [mailto:CSiepman@kgsgroup.com]
Sent: October-19-11 3:48 PM
To: Steve Topping
Cc: Rick Carson; Brian Bodnaruk; Karl-Erich Lindenschmidt; Ron Richardson
Subject: RE: URGENT - Lake Manitoba Forecast

Steve,

I believe these are the graphs that you requested for a 75% LSM Channel in service on Nov 1st. They are the same as the ones that I forwarded to you a few weeks ago.

Note that these graphs assume:

1. The Fairford River remains fully open and unrestricted by ice (this is still under review).
2. The LSM channel inlet is dredged successfully (this is currently not on schedule for Nov 1st)

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
 Senior Project Manager
 KGS Group

From: Rick Carson [mailto:rcarson@kgsgroup.com]
Sent: October 17, 2011 10:06 PM
To: Colin Siepman; bbodnaruk@kgsgroup.com
Cc: steve.topping@gov.mb.ca
Subject: Fwd: URGENT - Lake Manitoba Forecast

See request from Steve Topping below.

Begin forwarded message:

From: "Topping, Steve (MWS)" <Steve.Topping@gov.mb.ca>
Date: October 17, 2011 2:41:42 PM MST
To: "Rcarson@kgsgroup.com" <Rcarson@kgsgroup.com>
Subject: FW: URGENT - Lake Manitoba Forecast

Rick, as per Deputy Minister Norquay's request could you have Brian forward the long range projections for Lake Manitoba and Lake St Martin.

Thank you

Steven D. Topping, P. Eng.
Executive Director
Regulatory and Operational Services Division
Manitoba Water Stewardship
Phone: <personal information removed>
Fax: <personal information removed>
e-mail: steve.topping@gov.mb.ca

-----Original Message-----

From: Norquay, Don [<mailto:Don.Norquay@leg.gov.mb.ca>]
Sent: October-17-11 4:34 PM
To: Topping, Steve (MWS)
Cc: Williamson, Dwight (MWS); Beattie, Shannon (LEG); Wereta, Grace (LEG)
Subject: URGENT - Lake Manitoba Forecast
Importance: High

We need a revised long-range forecast on Thursday this week for Lake Manitoba and Lake St. Martin, assuming LSM emergency channel operation commencing November 1st at 75% of its original design capacity and Fairford dam flows at full capacity.

I assume that updating the hydrographs prepared by the consultants with our input around the time of the announcement of the emergency channel project is doable and will meet this need.

Please advise how you will be proceeding and call me to clarify direction as necessary.

Thanks.

Figure 1.1.1 RevB
Computed Lake Manitoba Level
Fairford Fully Open

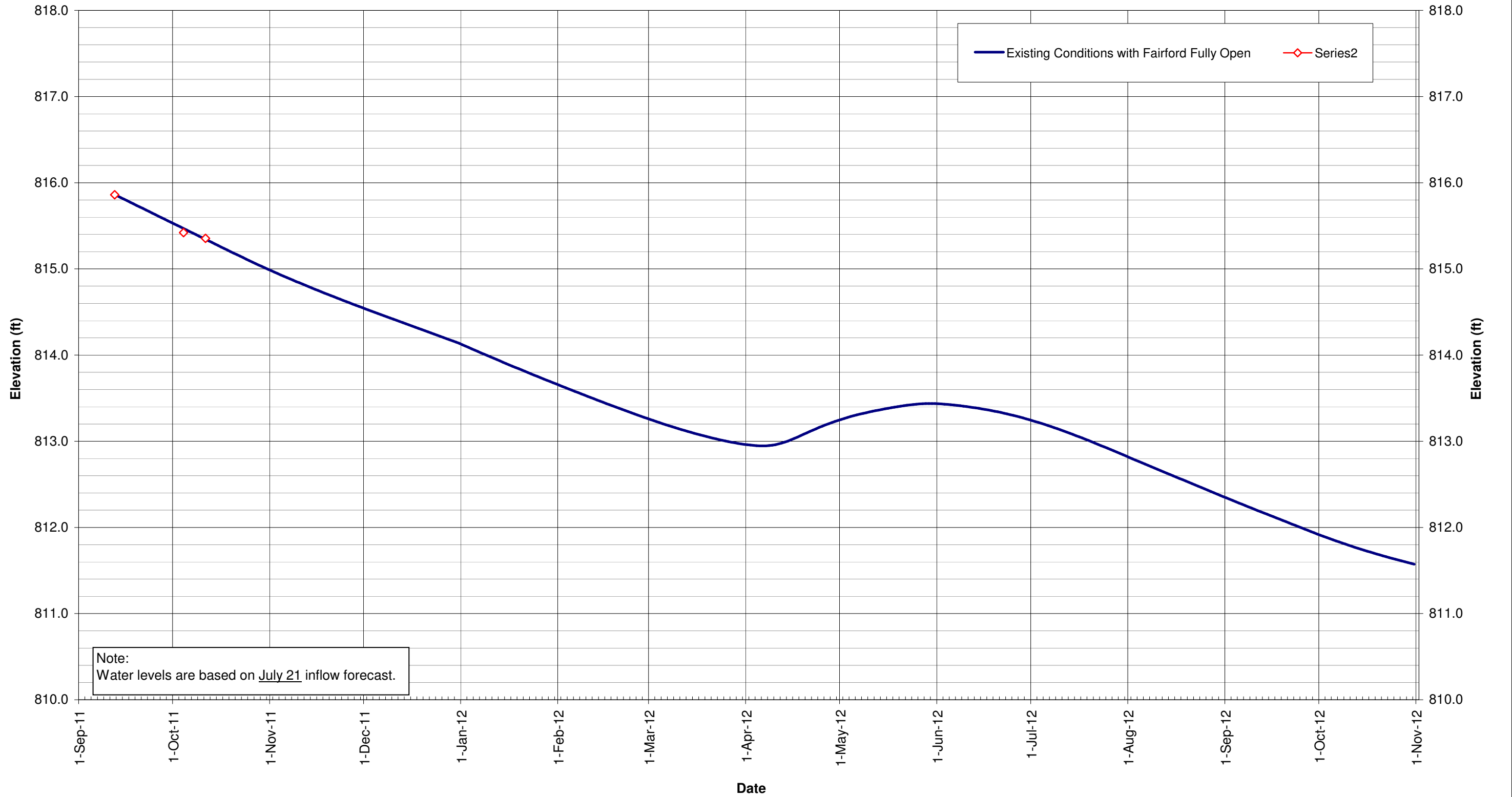
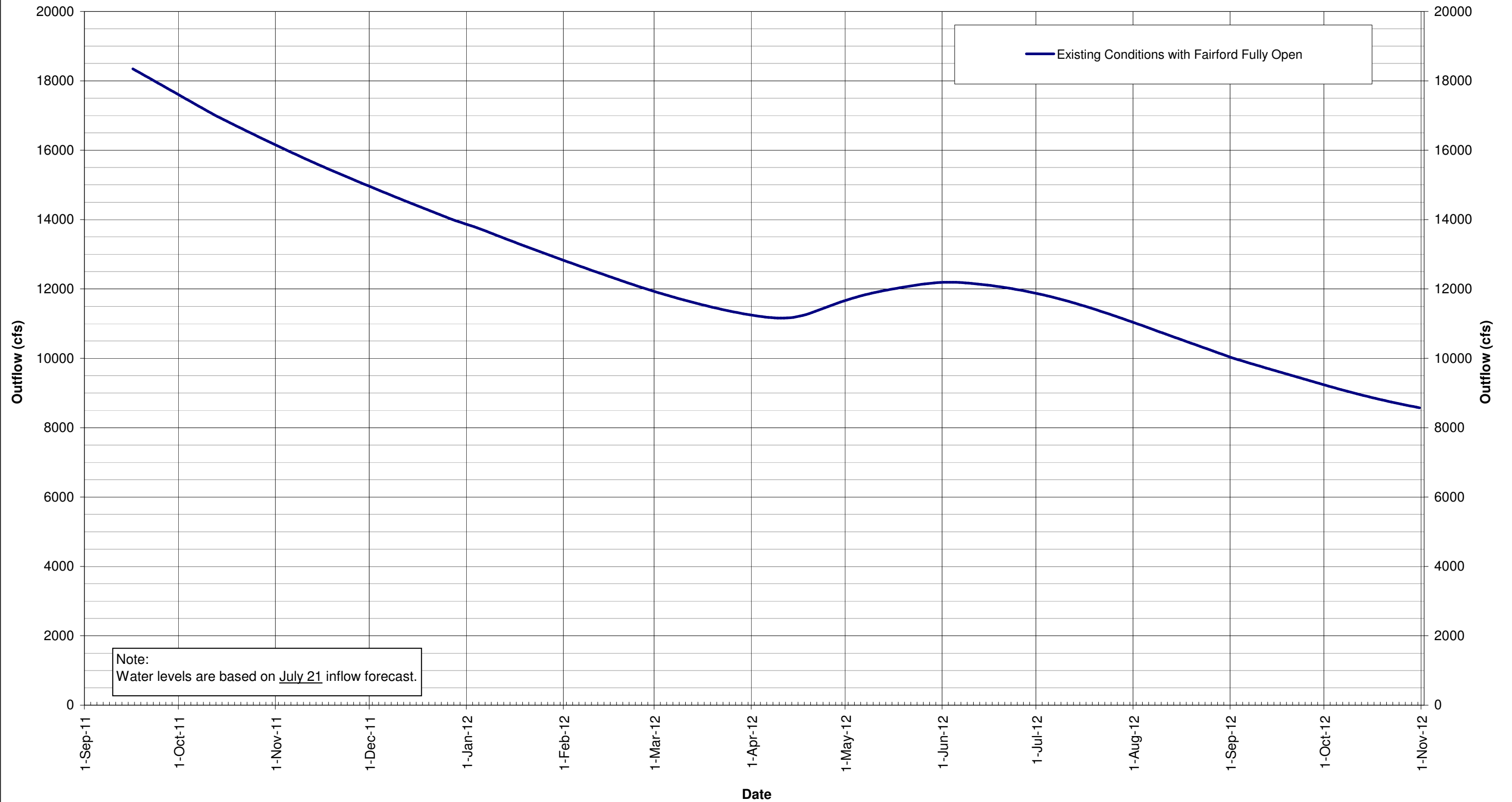


Figure 1.1.2 RevB
Computed Lake Manitoba Outflow
Fairford Fully Open



**Lake Manitoba Forecast
Correspondence and Figures**

November 8, 2011

Garrett Wellwood

From: Patrice Leclercq [PLeclercq@kgsgroup.com]
Sent: Friday, March 01, 2013 8:02 AM
To: 'Patrice Leclercq'
Subject: FW: Computed Discharges on Diversion Channel, Dauphin River and LSM Water Levels
Attachments: Lake St Martin Outflow Summary Inlet 50% Removed.xls

From: Brian Bodnaruk [mailto:BBodnaruk@kgsgroup.com]
Sent: November-08-11 12:49 PM
To: 'Colin Siepman'; Richardson, Ron (MIT)
Cc: Kaatz, Ron G (MIT)
Subject: Computed Discharges on Diversion Channel, Dauphin River and LSM Water Levels

As requested, I have attached a file listing the computed discharges on the Diversion Channel and the Dauphin River and water levels on Lake St Martin from today until March 31. For the Diversion channel, the entrance plug has been assumed to be opened 50 percent. Also, it has been assumed that the Diversion Channel would be ice covered by November 20 and that the Dauphin River outlet at Lake St Martin would be ice covered on December 15.

Brian Bodnaruk, P. Eng.

KGS Group - Consulting Engineers
Winnipeg, Manitoba
865 Waverley Street
Direct Line - <personal information removed>
Switch Board - 204.896.1209
Fax - 204.896.0754
bbodnaruk@kgsgroup.com

Figure 1.1.1 RevC
Computed Lake Manitoba Level
Fairford Fully Open

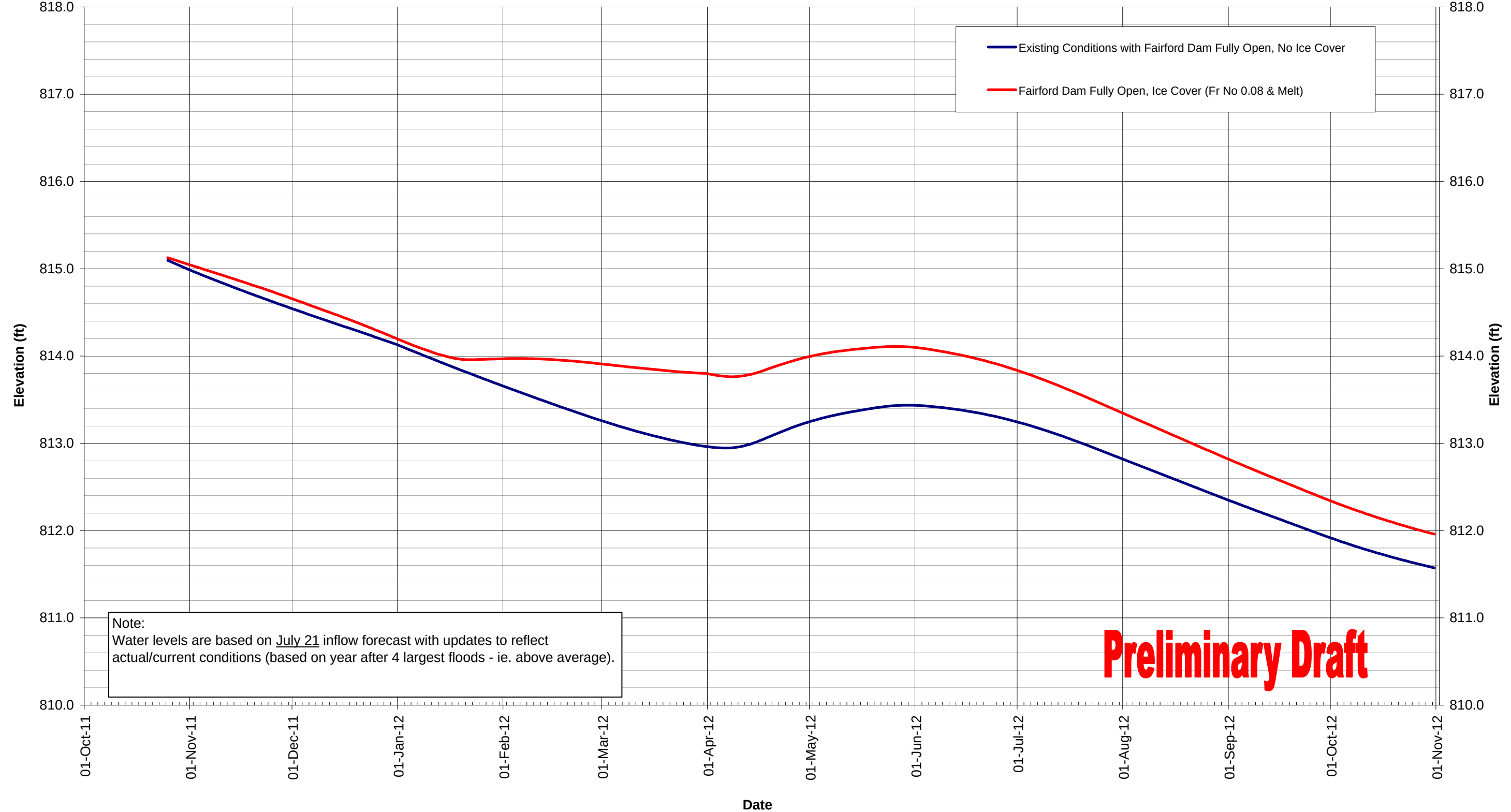


Figure 2.5.1 RevB
Computed Lake St. Martin Level
3/4 Channel in Operation Nov 1 - Normal Ice Formation Condition

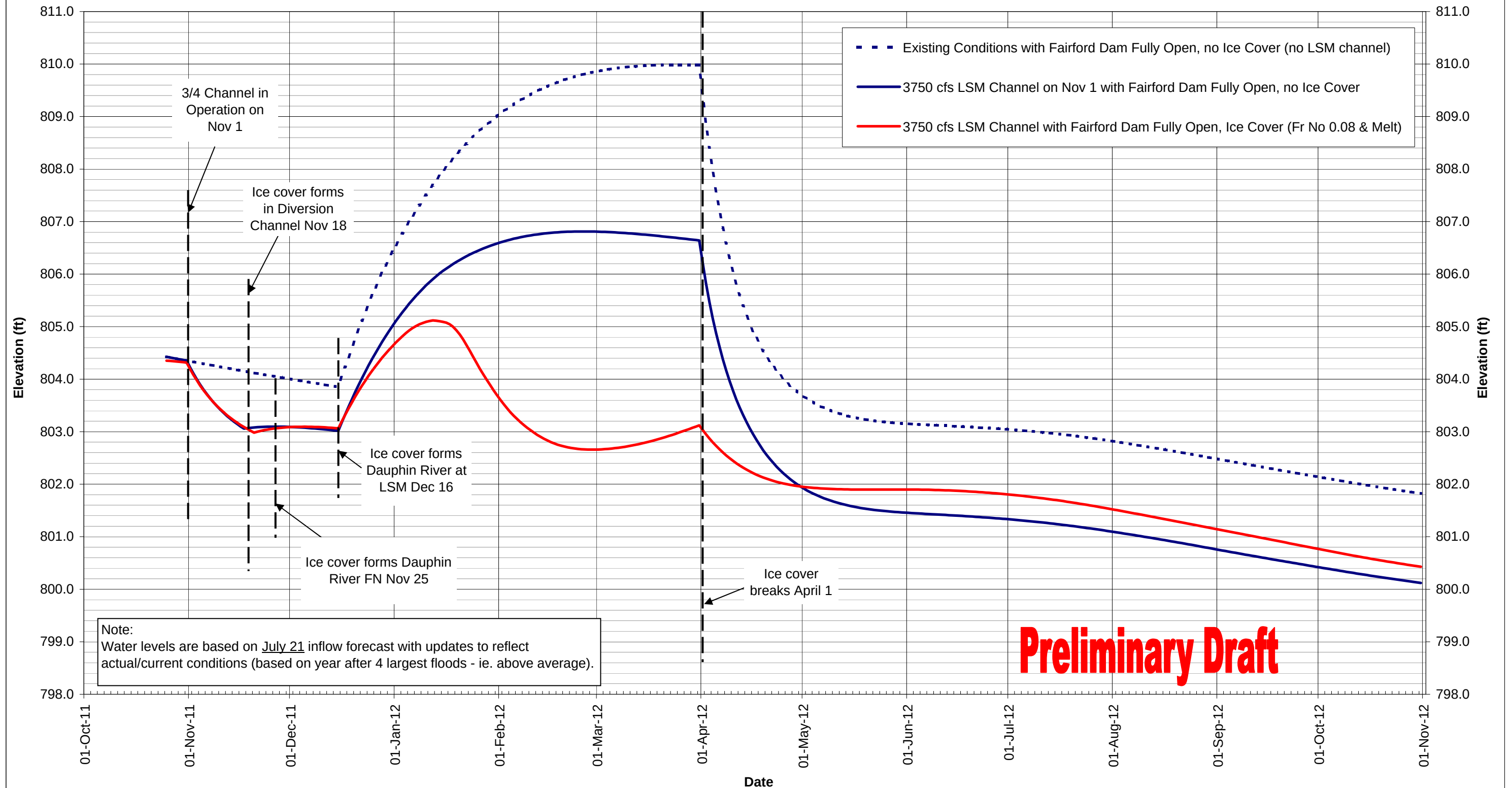
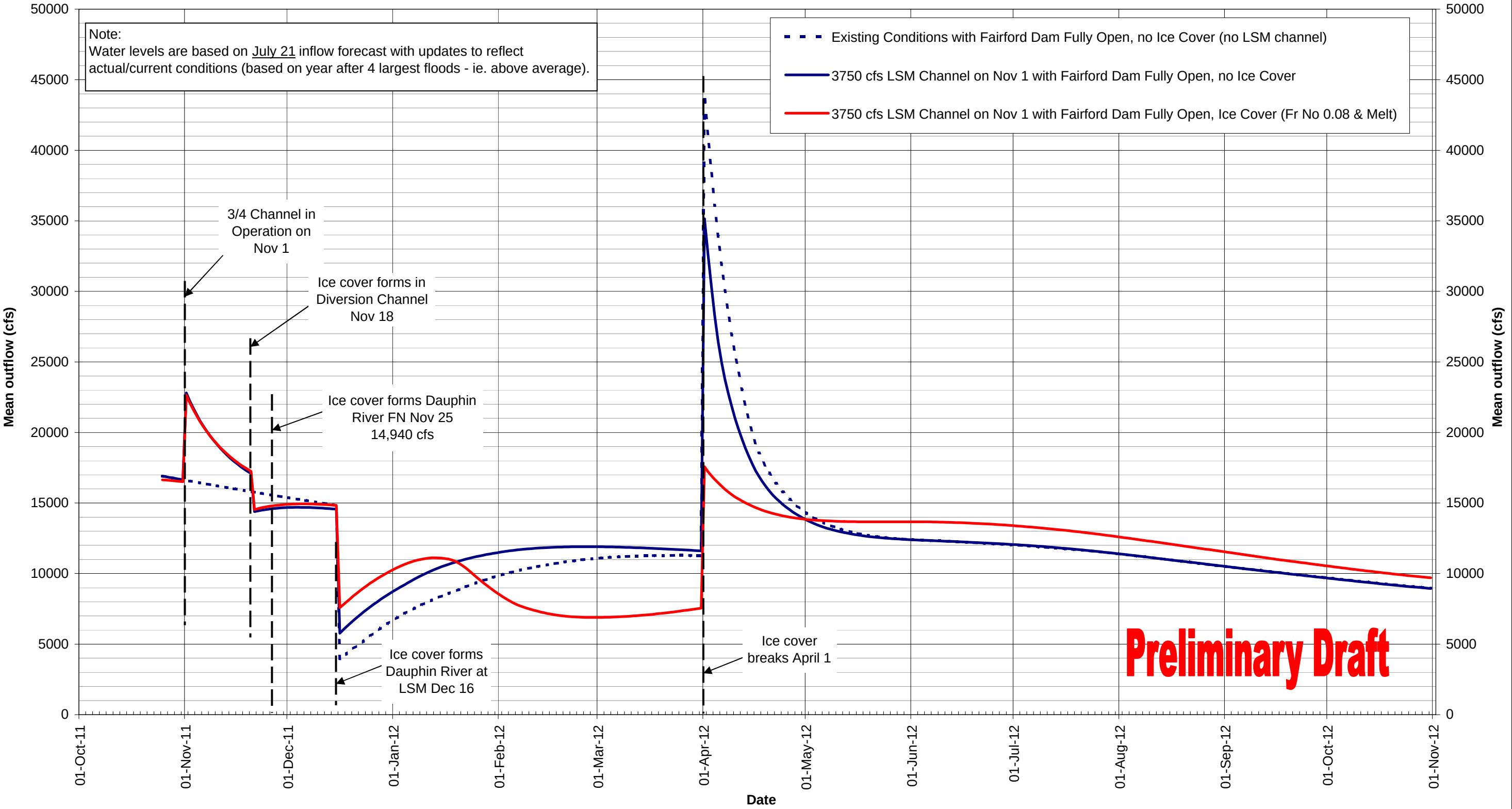


Figure 2.5.2 RevB
Computed Lake St. Martin Outflow
3/4 Channel in Operation Nov 1 - Normal Ice Formation Condition



**Lake Manitoba Forecast
Correspondence and Figures**

December 1, 2011

Garrett Wellwood

From: Patrice Leclercq [PLEclercq@kgsgroup.com]
Sent: Friday, March 01, 2013 8:02 AM
To: 'Patrice Leclercq'
Subject: FW: Performance of the LSM emergency outlet
Attachments: Lake Manitoba WL Forecast.pdf; LSM Water Level Forecast.pdf; LSM Outflow Forecast.pdf

From: Brian Bodnaruk [mailto:BBodnaruk@kgsgroup.com]
Sent: December-01-11 11:36 AM
To: 'Topping, Steve (MWS)'; Eric.Blais@aecom.com; 'McNeil, Doug (LEG)'; 'Weatherburn, Ron (MIT)'; 'McMahon, Doug (MIT)'; 'Halayko, Larry (MIT)'; 'Richardson, Ron (MIT)'; 'Kaatz, Ron G (MIT)'; mark.allard@govmb.ca; 'Smyrski, Tim (MIT)'; 'Lovie, Mark (MIT)'; Rcarson@kgsgroup.com; csiepmann@kgsgroup.com; 'Lindenschmidt, Karl-Erich (MWS)'
Cc: Jim.Friesen@aecom.com; Geoff.Hutchinson@aecom.com
Subject: RE: Performance of the LSM emergency outlet

The forecasted water level on Lake Manitoba and Lake St Martin water level and total outflow are attached based mild temperature conditions persisting for the next 10 days. The LSM charts have been revised from those submitted yesterday to correct an error in the Dauphin R outflow. The correct discharge on the Dauphin River on Nov 30 should have read 11,300 cfs not 14,100 cfs. A linear interpolation function of the Lake St Martin outflow rating curve was used rather than the correct curvilinear interpolation. The forecast for Lake Manitoba was not affected by the error.

Brian Bodnaruk, P. Eng.

KGS Group - Consulting Engineers

Winnipeg, Manitoba
865 Waverley Street
Direct Line - <personal information removed>
Switch Board - 204.896.1209
Fax - 204.896.0754
bbodnaruk@kgsgroup.com

From: Topping, Steve (MWS) [<mailto:Steve.Topping@gov.mb.ca>]
Sent: Thursday, December 01, 2011 10:06 AM
To: 'Eric.Blais@aecom.com'; 'BBodnaruk@kgsgroup.com'; McNeil, Doug (LEG); Weatherburn, Ron (MIT); McMahon, Doug (MIT); Halayko, Larry (MIT); Richardson, Ron (MIT); Kaatz, Ron G (MIT); 'mark.allard@govmb.ca'; Smyrski, Tim (MIT); Lovie, Mark (MIT); 'Rcarson@kgsgroup.com'; 'csiepmann@kgsgroup.com'; Lindenschmidt, Karl-Erich (MWS)
Cc: 'Jim.Friesen@aecom.com'; 'Geoff.Hutchinson@aecom.com'
Subject: Re: Performance of the LSM emergency outlet

Would either firm have graphs of projected levels of Lake St Martin and Lake Manitoba given the better understanding of the LSM channel and the prolonged open water season?

Sent from my BlackBerry Wireless Handheld

From: Blais, Eric <Eric.Blais@aecom.com>
To: Brian Bodnaruk <BBodnaruk@kgsgroup.com>; McNeil, Doug (LEG); Weatherburn, Ron (MIT); McMahon, Doug (MIT); Halayko, Larry (MIT); Richardson, Ron (MIT); Kaatz, Ron G (MIT); mark.allard@govmb.ca <mark.allard@govmb.ca>; Smyrski, Tim (MIT); Lovie, Mark (MIT);

RCarson@kqsgroup.com <RCarson@kqsgroup.com>; csiepman@kqsgroup.com <csiepman@kqsgroup.com>;
Topping, Steve (MWS); Lindenschmidt, Karl-Erich (MWS); CSiepman@kqsgroup.com
<CSiepman@kqsgroup.com>

Cc: Friesen, Jim <Jim.Friesen@aecom.com>; Hutchinson, Geoff <Geoff.Hutchinson@aecom.com>

Sent: Thu Dec 01 09:32:23 2011

Subject: RE: Performance of the LSM emergency outlet

Brian,

Not to quibble over the numbers but the data doesn't support the degree of precision that you have presented. The values I quoted were based on the observed trends as shown on the data below.

Dauphin river flows have been dropping steadily since the channel has been opened as have the Fairford flows (with minor wind generated fluctuations).

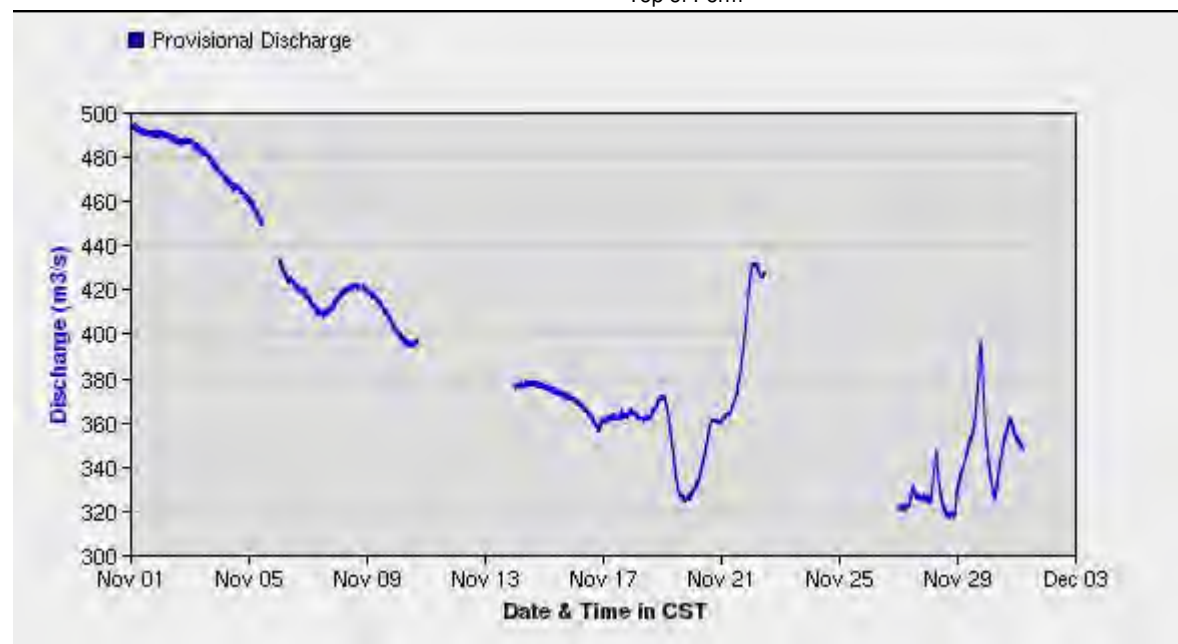
I would suggest that the recent jumps in flow rates on the Dauphin have more to do with a problem with the measuring device than any fluctuation in flow, as we commonly see these problems at this time of year.

At the end of the day the drop in Lake St. Martin is the best indication of the relative difference between inflow and outflow.

Eric

DAUPHIN RIVER NEAR DAUPHIN RIVER [MB] (05LM006)

Top of Form



FAIRFORD RIVER NEAR FAIRFORD [MB] (05LM001)

Top of Form



Bottom of Form
Bottom of Form

Eric-L. Blais B.Sc., M.A.
Manager, Water Resources

D <personal information removed>

C <personal information removed>

eric.blais@aecom.com

AECOM

99 Commerce Drive
Winnipeg, MB R3P 0Y7
T 204 477 5381
www.aecom.com

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Please consider the environment before printing this page.

From: Brian Bodnaruk [<mailto:BBodnaruk@kqsgroup.com>]

Sent: November 30, 2011 5:56 PM

To: 'McNeil, Doug'; Blais, Eric; 'Weatherburn, Ron (MIT)'; 'McMahon, Doug (MIT)'; 'Halayko, Larry (MIT)'; 'Richardson, Ron (MIT)'; 'Kaatz, Ron G (MIT)'; mark.allard@govmb.ca; 'Smyrski, Tim (MIT)'; 'Lovie, Mark (MIT)'; RCarson@kqsgroup.com; csiepmann@kqsgroup.com; 'Topping, Steve (MWS)'; 'Lindenschmidt, Karl-Erich (MWS)'; CSiepmann@kqsgroup.com

Subject: RE: Performance of the LSM emergency outlet

We have adjusted the inflow to Lake Manitoba based on observed Lake Winnipegosis outflows and Lake Manitoba water levels. The inflow to Lake Manitoba was routed through the Fairford Control Structure and LSM. The following discharges have been computed for November 30.

Inflow to Lake Manitoba	9,165 cfs
Lake Manitoba Outflow (Fairford CS)	15,447 cfs

Lake St Martin Inflow	15,447 cfs
Diversion Channel Flow	5,447 cfs
Dauphin R Discharge	14,100 cfs
Total LSM outflow	19,582 cfs

The routed flows through L Manitoba and LSM are shown on the attached Charts

The chart for LSM shows freeze-up of the Diversion Channel to occur on December 10 and freeze-up of the Dauphin River at the outlet of LSM to occur on January 7. Based on these freeze-up date assumptions, the level on LSM is calculated to fall by another 0.5 ft by December 10.

Looking at forecasted temperatures at Gypsumville for the next 2 week period, the temperatures appear to be too mild to have freeze-up to occur by Dec 10. If the date of freeze-up of the Diversion Channel occurs later than Dec 10, the water level on LSM will fall even further.

Brian Bodnaruk, P. Eng.

KGS Group - Consulting Engineers

Winnipeg, Manitoba

865 Waverley Street

Direct Line - <personal information removed>

Switch Board - 204.896.1209

Fax - 204.896.0754

bbodnaruk@kgsgroup.com

From: McNeil, Doug [<mailto:Doug.McNeil@leg.gov.mb.ca>]

Sent: Wednesday, November 30, 2011 2:59 PM

To: 'Blais, Eric'; Weatherburn, Ron (MIT); McMahon, Doug (MIT); Halayko, Larry (MIT); Richardson, Ron (MIT); Kaatz, Ron G (MIT); mark.allard@govmb.ca; Smyrski, Tim (MIT); Lovie, Mark (MIT); BBodnaruk@kgsgroup.com; RCarson@kgsgroup.com; csiepmann@kgsgroup.com; Topping, Steve (MWS); Lindenschmidt, Karl-Erich (MWS)

Subject: RE: Performance of the LSM emergency outlet

Thanks for this – it will be helpful when I meet with the Lake Manitoba groups, and I have one meeting coming up within two weeks.

Doug

Doug McNeil, M.Eng., P.Eng.

Deputy Minister, Manitoba Infrastructure and Transportation

Room 209 Legislative Building

Winnipeg MB R3C 0V8

Legislative Building Phone: 945-3768 FAX: 945-4766

From: Blais, Eric [<mailto:Eric.Blais@aecom.com>]

Sent: Wednesday, November 30, 2011 2:20 PM

To: Weatherburn, Ron (MIT); McMahon, Doug (MIT); Halayko, Larry (MIT); Richardson, Ron (MIT); Kaatz, Ron G (MIT); mark.allard@govmb.ca; Smyrski, Tim (MIT); Lovie, Mark (MIT); BBodnaruk@kgsgroup.com; RCarson@kgsgroup.com; csiepmann@kgsgroup.com; Topping, Steve (MWS); Lindenschmidt, Karl-Erich (MWS);

McNeil, Doug

Subject: Performance of the LSM emergency outlet

We have done some calculations based on data from Water Survey of Canada to gauge the performance of the emergency works up until November 28th.

As of November 1 Lake Manitoba had dropped approximately 2.2' from the peak water level. It dropped an additional 0.15' from November 1 to the 28th to a level of approximately 814.95' or a total of 2.35'.

Lake St. Martin had only dropped 1.2' from peak to November 1 and has dropped an additional 1.6' between November 1 and 28th, for a total of 2.8' and a water level of approximately 802.8'.

Based on the area of Lake St. Martin the 1.6' drop over 28 days (approximately 0.7"/day) would mean that the outflow rates have (on average) exceeded inflow rates by approximately 2300cfs over the 28 day period.

Since we are still dealing with open water conditions it was possible to use the open water rating curves to support this estimate.

Based on Monday's water levels the Fairford flow should have been approximately 15,000 cfs, Dauphin River approximately 12,000 cfs and the emergency outlet channel (based on design conditions) approximately 6,000 cfs. This would give a difference of 3,000 cfs,

Since we know that the channel is performing at slightly less than the design, these numbers would support the value computed from water levels.

Regards

Eric-L. Blais B.Sc., M.A.

Manager, Water Resources

D <personal information removed>

C <personal information removed>

eric.blais@aecom.com

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Figure 1.1.1 RevD
Computed Lake Manitoba Level
Fairford Fully Open

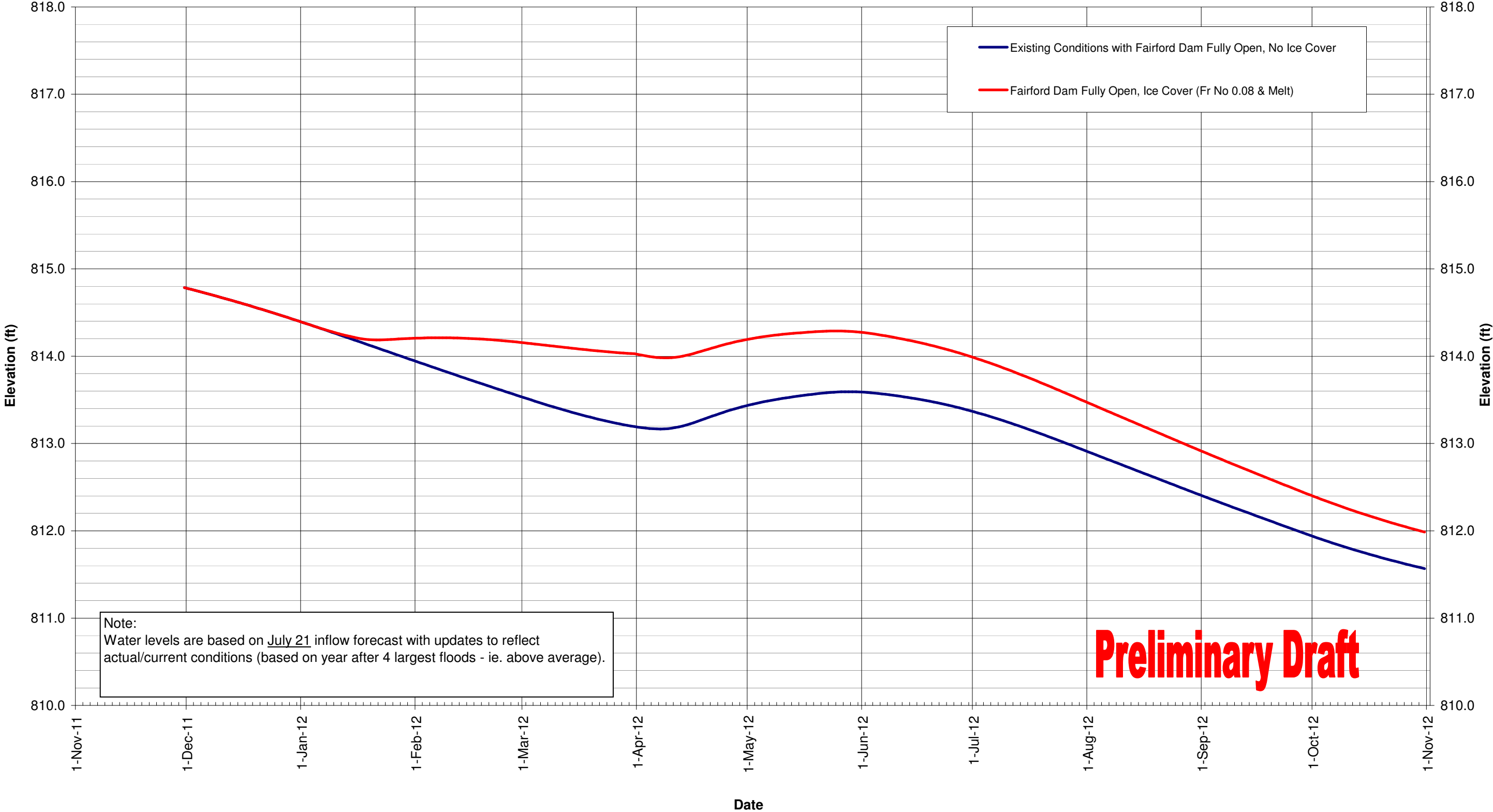


Figure 2.6.1 RevB
Computed Lake St. Martin Level
Channel in Operation - Very Late Ice Formation Condition

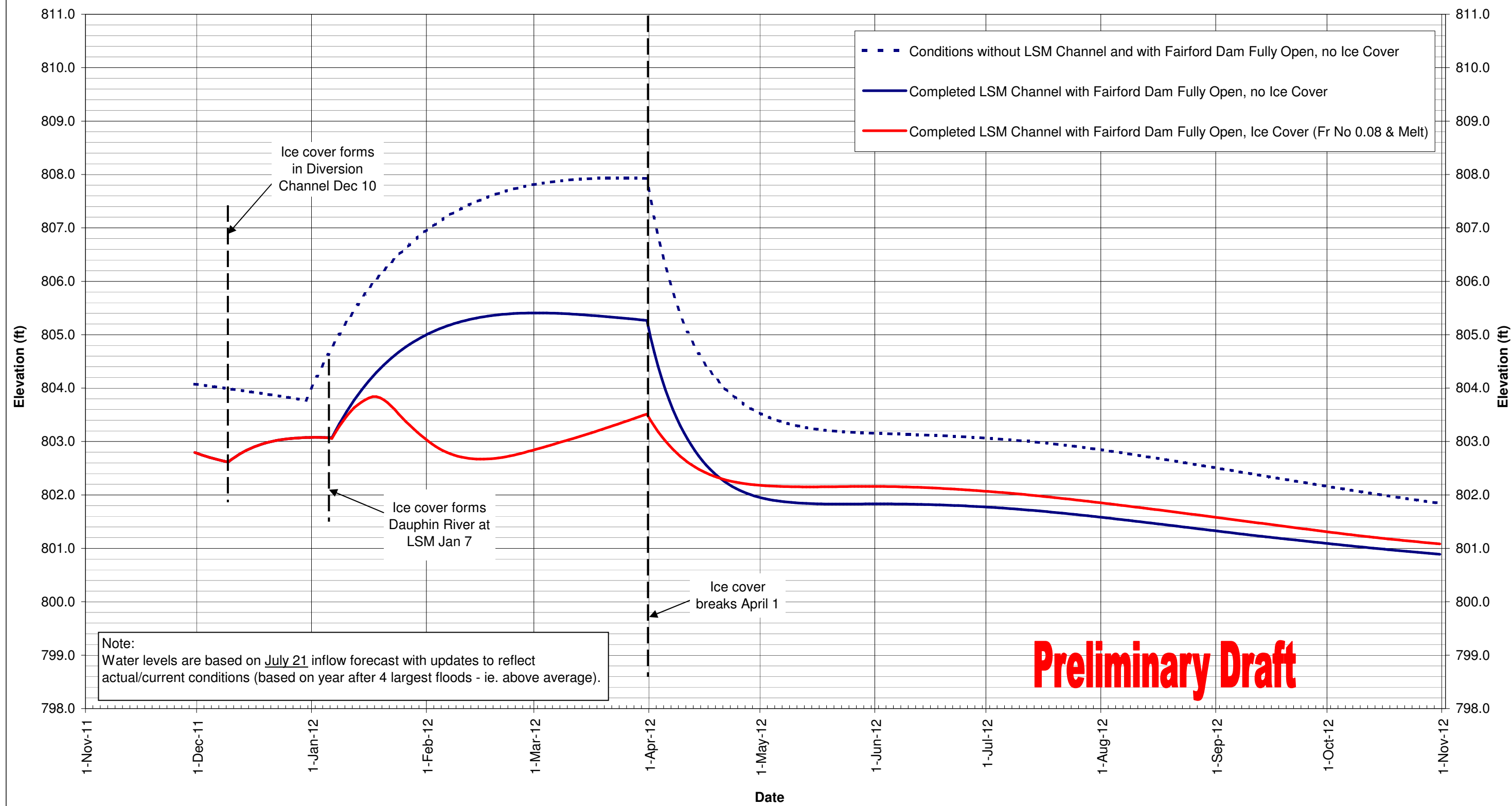
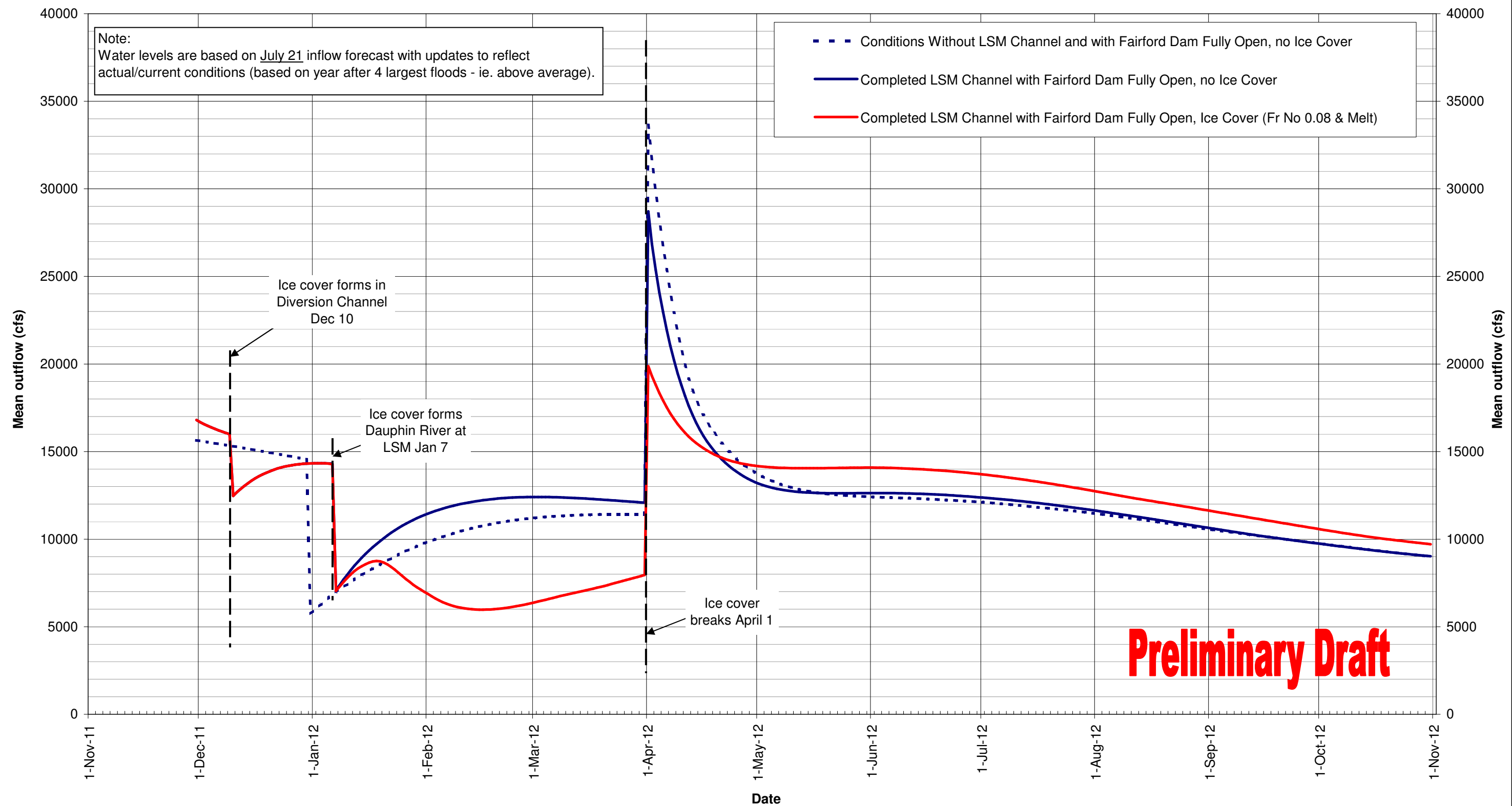


Figure 2.6.2 RevB
Computed Lake St. Martin Outflow
Channel in Operation - Very Late Ice Formation Condition



**Lake Manitoba Forecast
Correspondence and Figures**

January 5, 2012

Garrett Wellwood

From: Colin Siepman [CSiepman@kgsgroup.com]
Sent: Thursday, January 05, 2012 7:14 PM
To: Mark Allard
Cc: Bert Smith; Rob Kenyon; Tony Ng; Brian Bodnaruk; Steve Offman; Patrice Leclercq
Subject: RE: Reach 3 - Design Update Meeting - Jan 3
Follow Up Flag: Follow up
Flag Status: Red
Attachments: Figure 2.13.1.pdf; Figure 2.13.2.pdf; Figure 2.13.2b.pdf; Figure 2.14.1.pdf; Figure 2.14.2.pdf
 Mark,

As discussed at our Jan 3 meeting, projected future water levels on LSM near the end of this winter are decreasing more than originally forecast due to extended open water conditions. Therefore additional alternatives may now be possible.

The original justification for Reach 3 was to reduce river staging during the spring 2012 ice breakup and correspondingly reduce the risk of overtopping the dikes recently constructed at the Dauphin River Communities. The Dauphin River dikes were constructed to accommodate a spring breakup flow of roughly 24,000 cfs with the assumption that any flows above this value would be passed through Reach 3.

Considering that we are still experiencing mild weather and open water conditions we have updated our forecasts based on three new ice formation dates of Jan 25, Feb 1 & Feb 22 (Figures are attached).

Based on current long range weather forecasts an ice formation date of Feb 1 is probable, therefore a date of Jan 25 could be considered conservative.

Alternative 1 - Reduce Reach 3 Capacity

For the Jan 25 case the peak Reach 1 flow would be 8500 cfs and the combined Dauphin River flow would be 27,000 cfs if Reach 3 is not constructed (Fig 2.13.2 & 2.13.2b). Since the limit for the DR dikes is 24,000 cfs a minimum capacity of 3000 cfs is required for Reach 3. To be conservative we have considered an alternate Reach 3 channel that has a capacity of 4250 cfs which is 50% of the peak capacity of the tendered channel. This means that the Reach 1 peak spring flow of 8500 cfs would be shared equally between Buffalo Creek and Reach 3. After about 1 month the Reach 1 flow will subside to roughly 4000 cfs and could be handled entirely by Buffalo Creek or by Reach 3 for the remainder of the summer, whichever is considered more advantageous from an environmental perspective.

The base width of the 50% capacity channel would be reduced from 47 m to 21 m and the excavation volume would decrease from 915,000 to roughly 500,000 cu. m. (to be confirmed). A long-term analysis has not been performed but the 4250 cfs channel should be capable of handling the entire Reach 1 peak flow in the future if it were made permanent (may be necessary since DR dikes will be removed).

Alternative 2 – Temporary Closure of Reach 1 in Spring

For the Jan 25 case the peak combined Dauphin River flow would be 24,300 cfs (Fig 2.14.2). This is essentially equal to the 24,000 cfs limit for the DR dikes. For the current analysis it has been conservatively assumed that the Reach 1 channel would be closed for 0.5 months prior and 0.5 months after the spring ice breakup since the exact timing of the closure may be difficult to predict. Closing the Reach 1 channel for this 1 month period would increase the peak spring level on Lake St. Martin from 805 ft to about 806 ft but would have a negligible effect shortly thereafter.

Note that, unless a permanent road were constructed, there would be no access to bring in assistance if something went awry during installation & removal of the closure and any equipment used would be temporarily stranded until it could be removed by barge. Since a long-term analysis has not been performed it is not clear if Reach 1 could be operated in this manner in the future if made permanent (since the DR dikes will be removed).

Reach 3 - Sediment Transport Models

We completed the sediment transport model for the following Reach 3E options:

- 1) November 25 Tender without Rock Checks
- 2) November 25 Tender with Rock Checks
- 3) Drop Structure Option without Rock Checks
- 4) Drop Structure Option with extension to Willow Point

A 6 month simulation time window (April 1st to October 1st) was selected for the analysis at a constant flow of 115 m³/s (4000 cfs). The model starts at the Reach 3E inlet and ends in Lake Winnipeg. The model did not allow erosion to occur in the inundated area between the outlet of the channel and Lake Winnipeg but did allow for deposition of the sediments to occur within this area. This inundated area is still being analyzed using a 2D model.

The total cumulative volume of sediments that exit the system is provided below:

- 1) November 25 Tender without Rock Checks: 190,000 m³
- 2) November 25 Tender with Rock Checks: 190,000 m³
- 3) Drop Structure Option without Rock Checks: 95,000 m³
- 4) Drop Structure Option with extension to Willow Point: 180,000 m³

As a basis for comparison, a total cumulative volume of 190,000 m³ was obtained in our Buffalo Creek sediment model using a 5 month simulation window at 180 cfs, and 231,000 m³ at a flow of 4100 cfs.

From these results, we can make the following conclusions:

- The use of Rock Checks in the inundated area is not an effective way of reducing the total volume of sediments that exit the system.
- The Drop Structure Option significantly reduces the amount of erosion occurring in the channel.
- The extension of the channel to Willow Point increases the potential for erosion within the channel.

Results from this analysis are approximate and should be used qualitatively due to the limitations of the HEC RAS Sediment Transport program to model cohesive sediments.

Reach 3 Outlet - Impact on Fish & Fish Habitat

We are still awaiting a summary memo from North/South Consultants comparing the proposed outlet locations east & west of Willow Point.

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
Senior Project Manager
KGS Group

From: Colin Siepman [mailto:CSiepman@kgsgroup.com]

Sent: January 2, 2012 10:35 PM

To: Mark Allard ; Ron Kaatz; Michael Foth; Paul Graveline; Tony Ng; Brian Bodnaruk; Steve Offman; Patrice Leclercq; Don MacDonell; Warren Bernhardt

Cc: Bert Smith; Rob Kenyon; Eric Christiansen; Ron Richardson; Rick Postlethwaite

Subject: Reach 3 - Design Update Meeting - Jan 3

The following items have been attached for discussion at the meeting.

1. Buffalo Creek sediment transport model.
2. Updated design summary sheet including Option 3 - Willow Point Channel. Note that the quantity estimate

for Option 2 - Stepped Invert Channel was refined using Civil 3D and has decreased significantly.

3. Willow Point Channel plan and profile
4. Willow Point Channel hydraulic profile

The Willow Point Channel route follows Route 3E to Station 22+300 and then turns East to Station 26+000 and then NE to Lake Winnipeg. The majority of the route must be excavated, as opposed to overland flow, to ensure the flow is directed east of Willow Point. Seven 1-metre high drop structures are required to control erosion similar to the upstream reach.

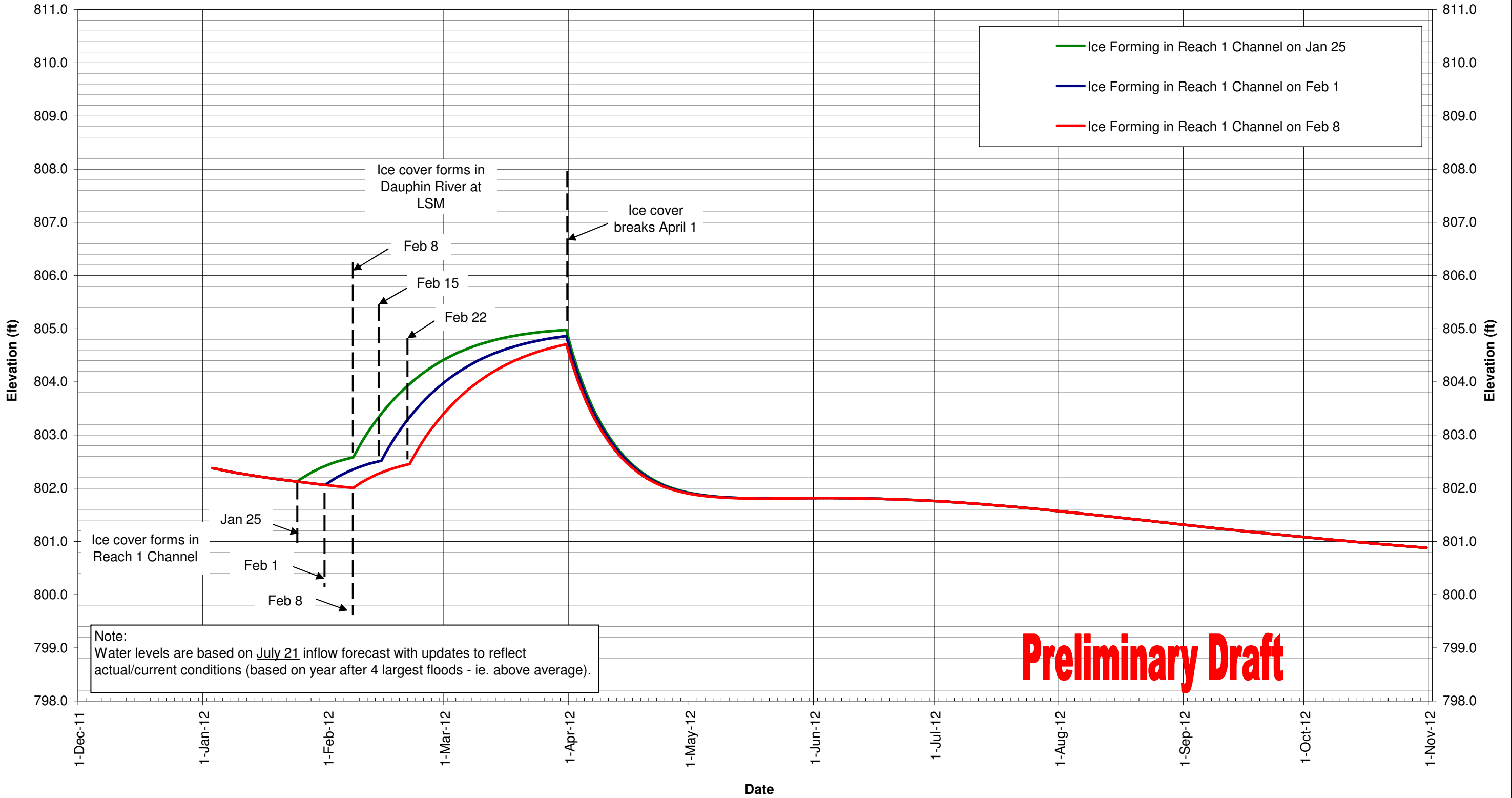
We will also have some preliminary sediment transport model results for the various Reach 3 channel configurations at the meeting.

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
Senior Project Manager
KGS Group

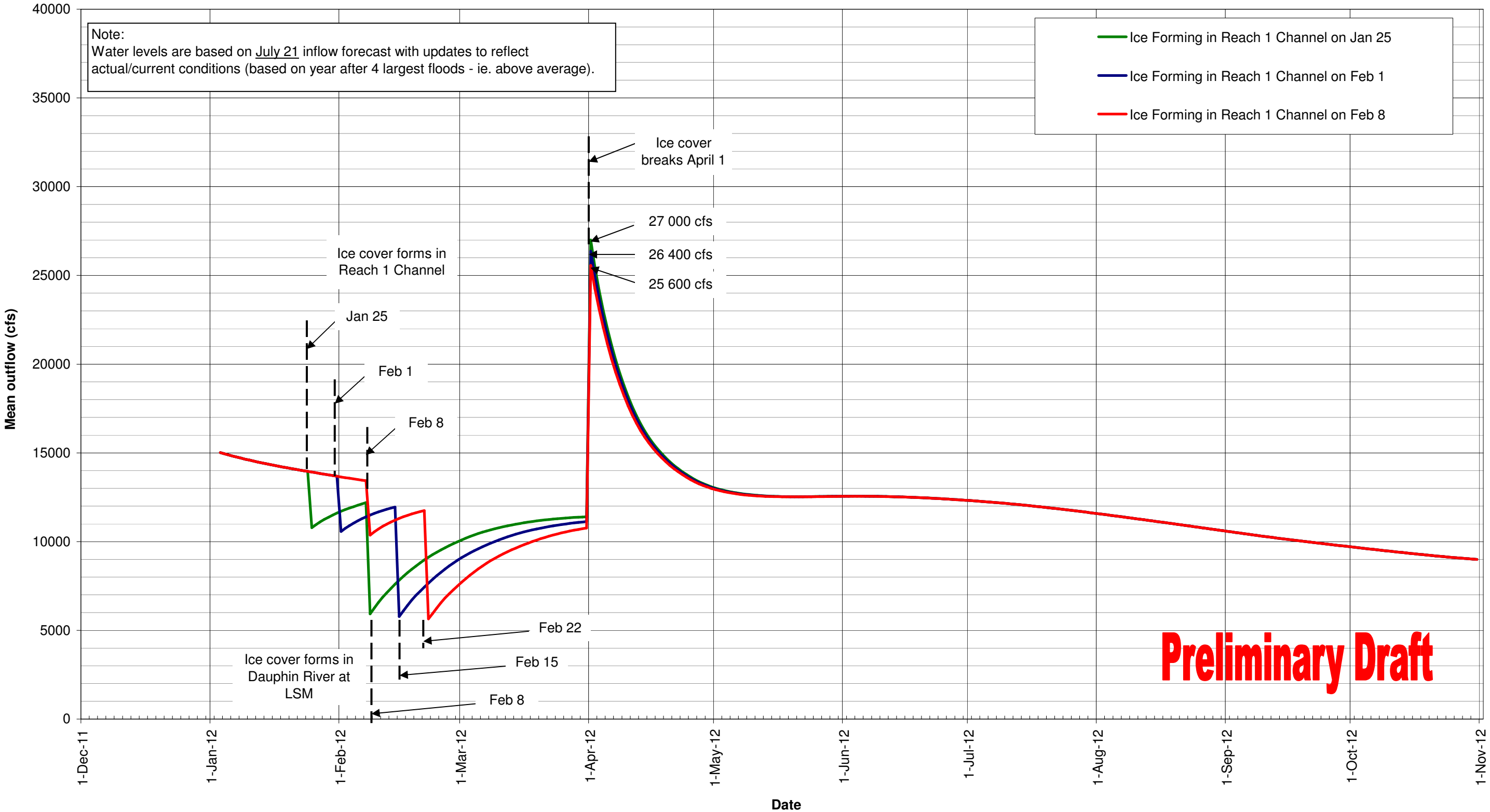
KGS Place
3rd Flr - 865 Waverley St.
Winnipeg, MB, R3T 5P4
Phone : (204) 896-1209
Fax : <personal information remove
CSiepman@ksgsgroup.com

Figure 2.13.1
Computed Lake St. Martin Level
Reach 1 Channel in Operation



Preliminary Draft

Figure 2.13.2
Computed Lake St. Martin Outflow
Reach 1 Channel in Operation



Preliminary Draft

Figure 2.13.2b
Computed Buffalo Creek Outflow
Reach 1 Channel in Operation

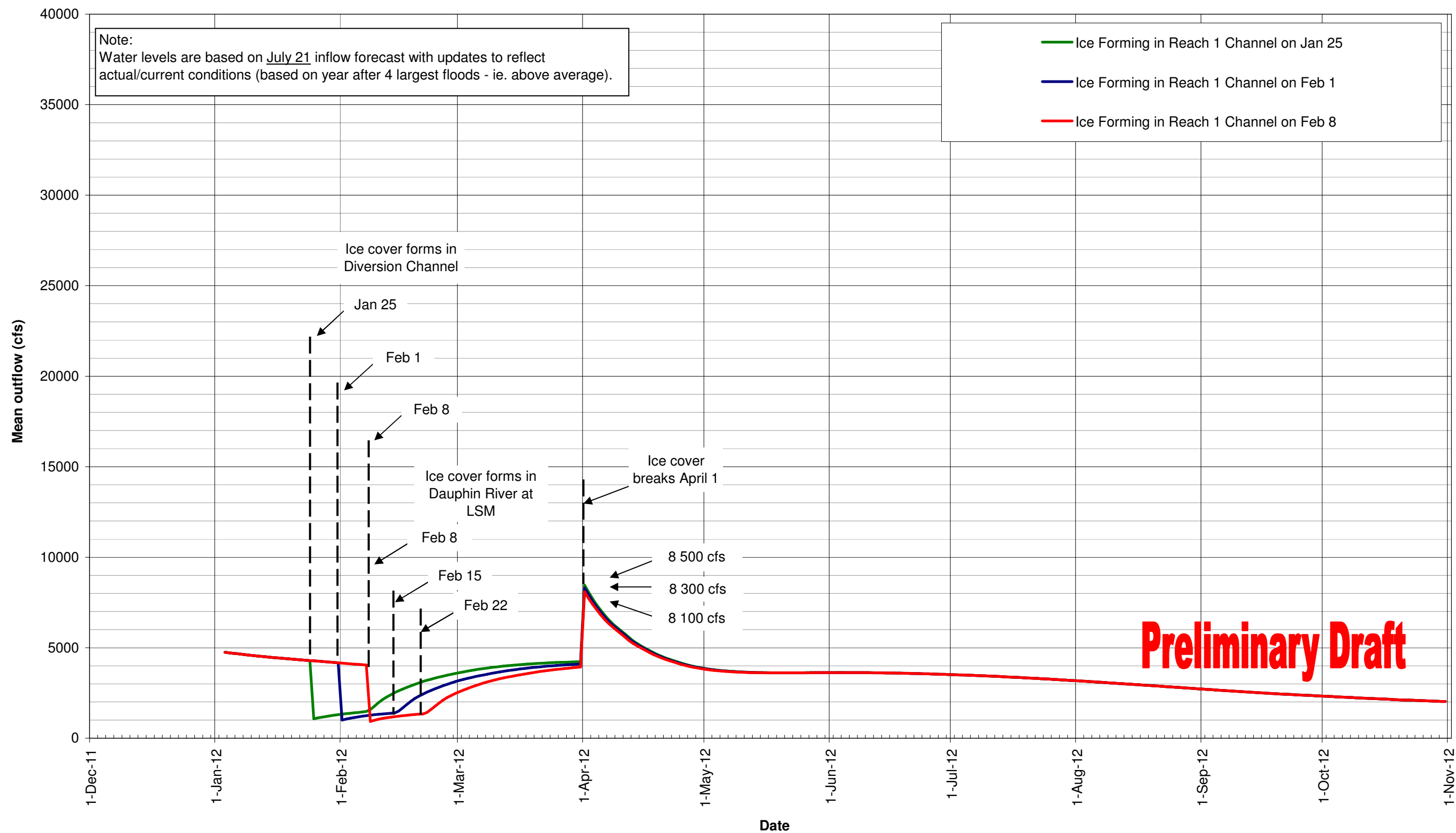


Figure 2.14.1
Computed Lake St. Martin Level
Temporary Closure of Reach 1 Channel During Ice Breakup

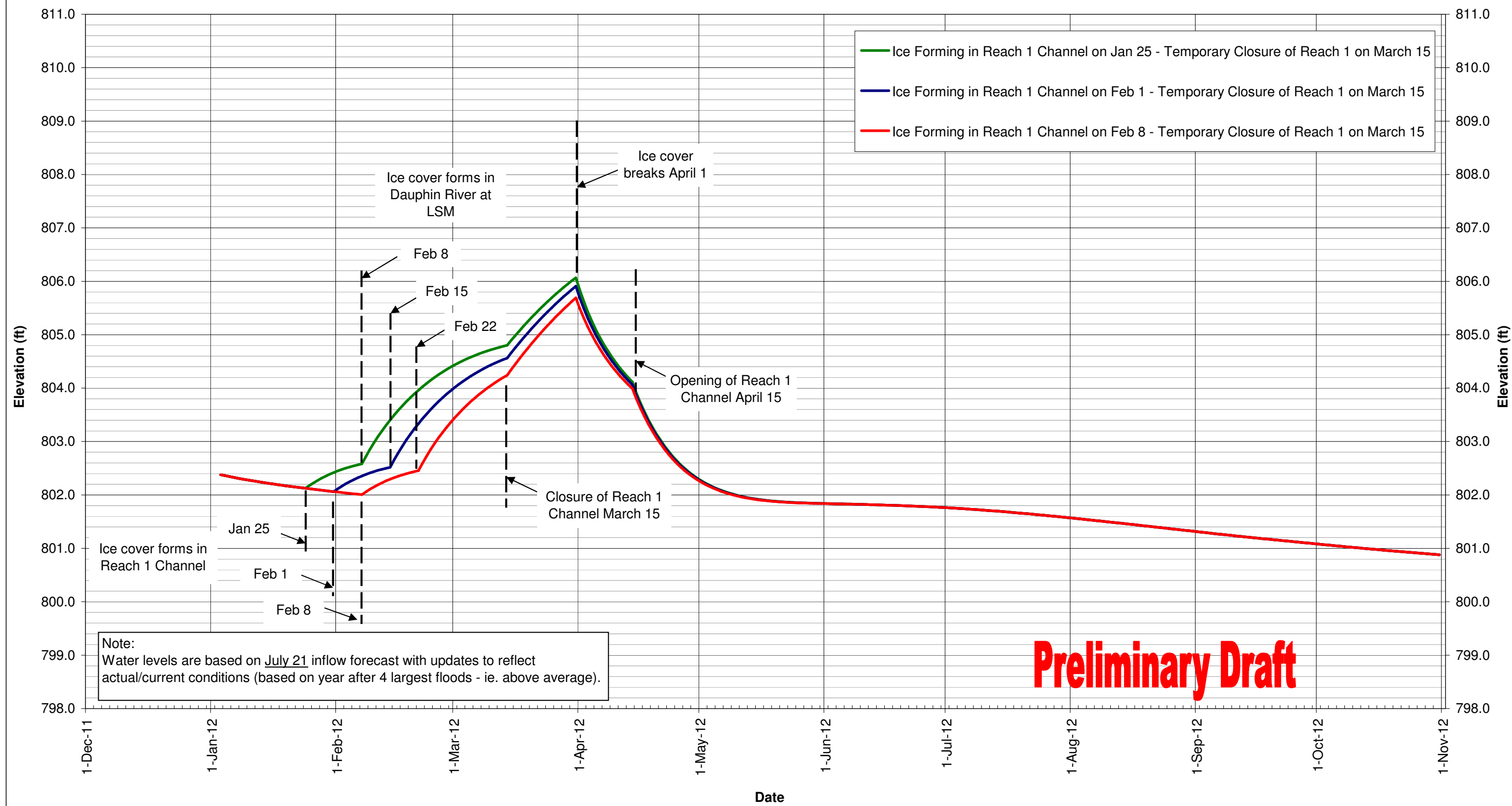
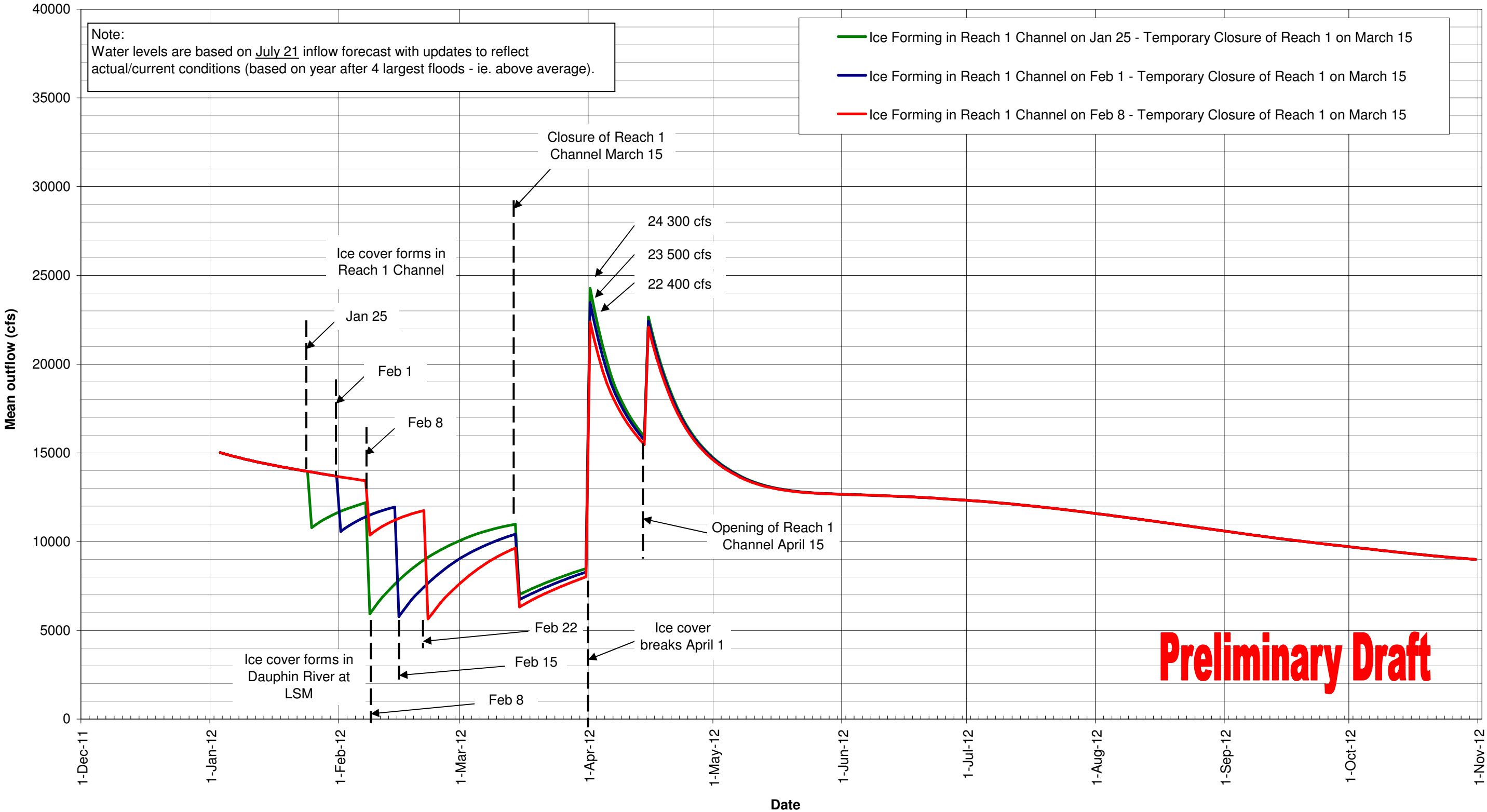


Figure 2.14.2
Computed Lake St. Martin Outflow
Temporary Closure of Reach 1 Channel During Ice Breakup



Preliminary Draft

**Lake Manitoba Forecast
Correspondence and Figures**

January 19, 2012

Garrett Wellwood

From: Brian Bodnaruk [BBodnaruk@kgsgroup.com]
Sent: Thursday, January 19, 2012 3:44 PM
To: 'Loukili, Youssef (MWS)'; 'Westmacott, Jason'
Cc: 'Mutulu, Phillip (MWS)'; 'Magura, Christopher'; 'Gawne, Kevin'; CSiepman@kgsgroup.com; PLeclercq@kgsgroup.com
Subject: RE: Lake Outflows Forecast Request
Attachments: Figure 1.1.1 RevE.pdf; Figure 1.1.2 RevE.pdf; Figure 2.13.1.pdf

The attached charts show the projected water level (Figure 1.1.1 Rev E) and outflow (Figure 1.1.2 Rev E) from Lake Manitoba and the water level on Lake St. Martin (Figure 2.13.1) for the period to the end of summer 2012. The charts are based on inflow forecasts to Lake Manitoba during this period. The inflow to Lake Manitoba is based on the inflow forecast provided by Rick Bowering in July 2011 and modified for winter flows from Lake Winnipegosis to the end of March due to ice on the Waterhen River.

The forecasted inflow to Lake Manitoba to the end of March is based on recession flows from this summer's flood. Inflows after April 1 are assumed values and are subject to change based on the potential from runoff in the spring from snowmelt and from rainfall in the spring and summer. The inflow has for this period has been estimated only from statistical means and can change depending on future snowfall and rainfall.

The outflow from Lake Manitoba (Figure 1.1.2 Rev E) is based on fully opened conditions at the Fairford Control Structure without backwater from ice jams downstream from the control structure to Lake Pinemuta.

Inflow to Lake St. Martin is equal to the computed outflow from Lake Manitoba shown on Figure 1.1.2 Rev E. The computed water level on Lake St. Martin (Figure 2.13.1 Rev E) is affected by ice conditions on the Dauphin River Channel at outlet of Lake St. Martin and on the constructed Reach 1 diversion channel from Lake St. Martin to Buffalo Creek. As shown on the Lake St Martin water level chart we have assumed three dates for the formation of the ice cover on the outlet channel. Corresponding outflows are based on rating curves developed for open water and for ice conditions on the diversion channel and the Dauphin River.

Brian Bodnaruk, P. Eng.

KGS Group - Consulting Engineers
 Winnipeg, Manitoba
 865 Waverley Street
 Direct Line - <personal information removed>
 Switch Board - 204.896.1209
 Fax - 204.896.0754
bbodnaruk@kgsgroup.com

From: Loukili, Youssef (MWS) [mailto:Youssef.Loukili@gov.mb.ca]
Sent: Tuesday, January 17, 2012 2:38 PM
To: Westmacott, Jason
Cc: Mutulu, Phillip (MWS); Brian Bodnaruk; Magura, Christopher; Gawne, Kevin
Subject: RE: Lake Outflows Forecast Request

Hi Jason,

Thank you for the reminder, and yeah we need an updated forecast of levels and flows through Lake Manitoba/Lake St Martin in connection with the emergency channel. Personally, I don't know and

wasn't involved in this subcontracted forecasting work.

Thanks,

Youssef

From: Westmacott, Jason [mailto:jwestmacott@hydro.mb.ca]
Sent: January-17-12 1:47 PM
To: Loukili, Youssef (MWS)
Cc: Mutulu, Phillip (MWS); Brian Bodnaruk; Magura, Christopher; Gawne, Kevin
Subject: RE: Lake Outflows Forecast Request

Hi Youssef,
Any luck on getting a forecast for Fairford? It would be greatly appreciated.
Thanks,
Jason

From: Loukili, Youssef (MWS) [mailto:Youssef.Loukili@gov.mb.ca]
Sent: Monday, December 19, 2011 2:28 PM
To: Brian Bodnaruk
Cc: Mutulu, Phillip (MWS); Westmacott, Jason; Magura, Christopher
Subject: Lake Outflows Forecast Request

Hi Brian,

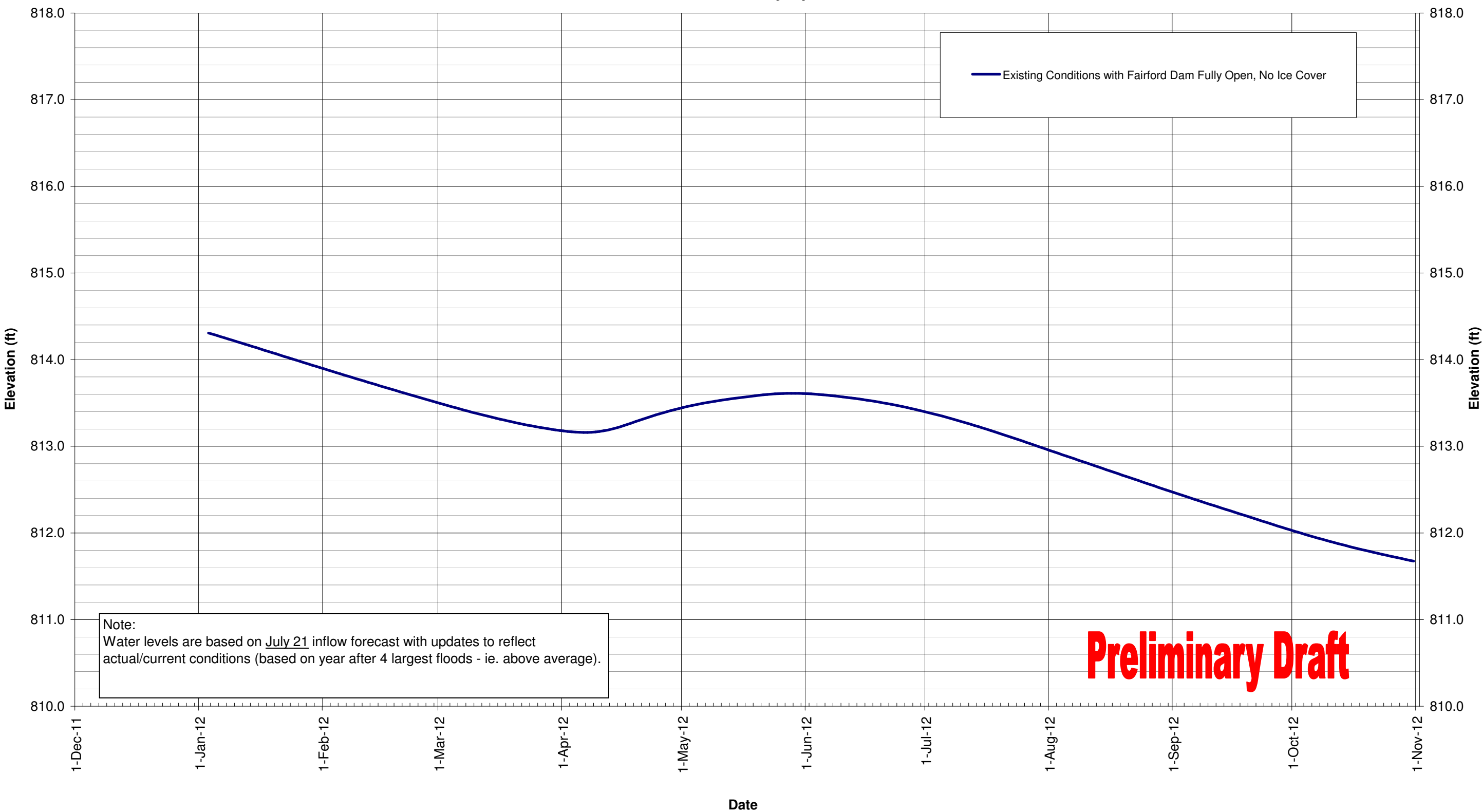
We need Lake Manitoba daily outflows forecast as well as those going from Lake St Martin to Lake Winnipeg, as soon as you can, for the next three months.

I noticed Lake St Martin levels drop curbed down since last week, and would like you confirm this stemming mainly from ice cover over the channel or not.

Thank you in advance,

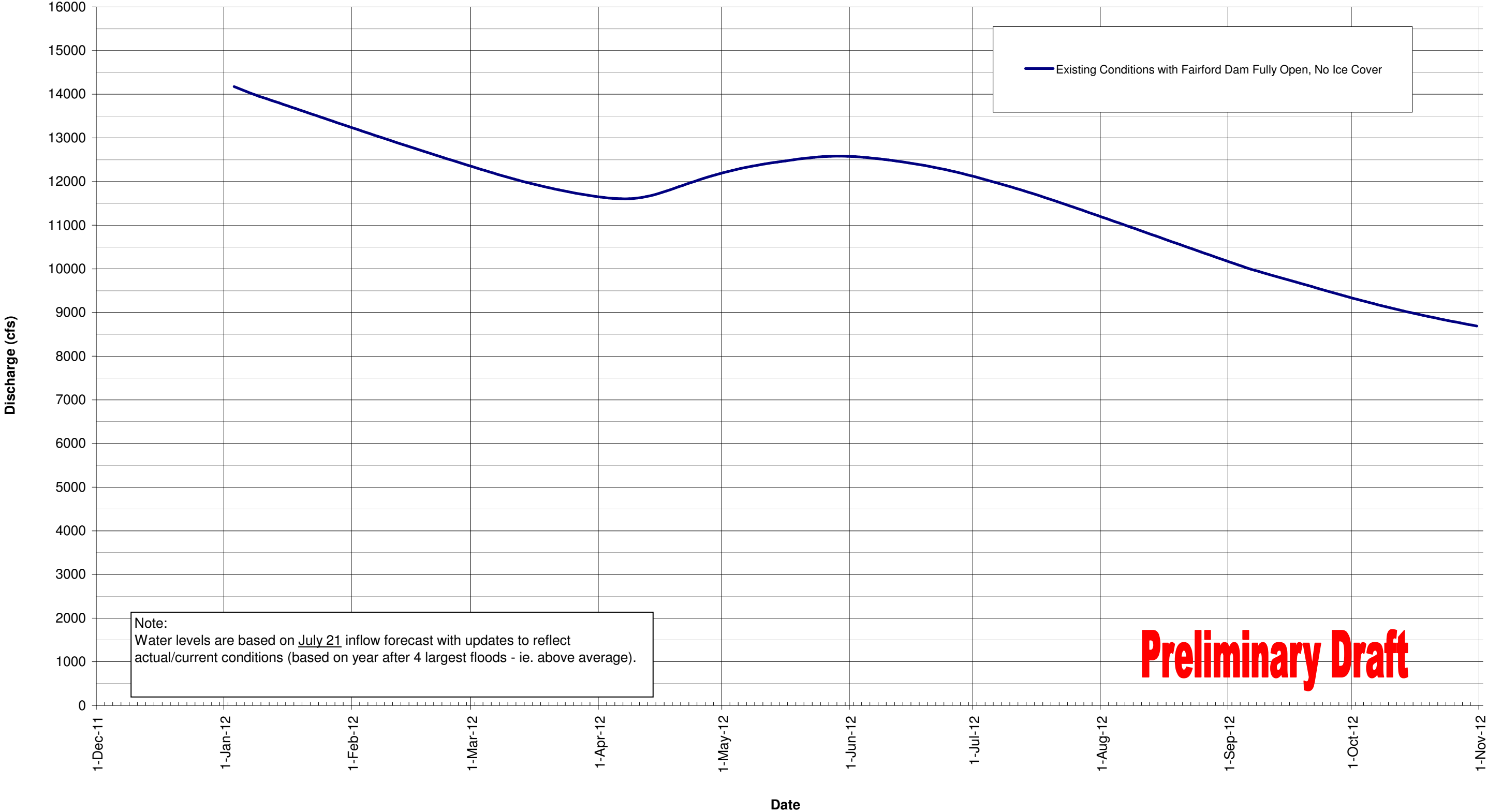
Youssef Loukili, PhD
Hydrologic Forecaster
Flood Forecasting & Coordination
Regulatory and Operational Services Division
Manitoba Water Stewardship
200 Saulteaux Crescent
Winnipeg, Manitoba R3J 3W3
Tel: <personal information removed>, Fax: 1-204-945-7419

Figure 1.1.1 RevE
Computed Lake Manitoba Level
Fairford Fully Open



Preliminary Draft

Figure 1.1.2 RevE
Computed Lake Manitoba Outflow
Fairford Fully Open



Preliminary Draft

**Lake Manitoba Forecast
Correspondence and Figures**

January 31, 2012

Garrett Wellwood

From: Colin Siepman [CSiepman@kgsgroup.com]
Sent: Tuesday, January 31, 2012 10:39 PM
To: Mark Allard ; Doug McMahon; Ron Richardson; Ron Kaatz; Eric Christiansen; Rick Postlethwaite; Paul Graveline; Michael Foth
Cc: Bert Smith; Dave MacMillan; Rick Carson; Rob Kenyon; Tony Ng; Brian Bodnaruk; Patrice Leclercq; Steve Offman
Subject: Forecast for the Operation of Reach 3 - Jan31 Update - Confidential
Attachments: Figure 2.13.2b RevB.pdf; Figure 2.13.1 RevB.pdf; Figure 2.13.2 RevB.pdf; Reach 1 Outlet - Jan 30.jpg; Buffalo Creek at Reach3 - Jan 30.jpg; Buffalo Creek Inlet - Jan 30.jpg; Buffalo Creek Outlet - Jan 30.jpg; Dauphin River Inlet - Jan 30.jpg; Reach 1 Inlet - Jan 30.jpg

Due to the rise of Lake St. Martin levels observed starting February 21, and an ice cover forming in the upper reaches of the Dauphin River, we have updated our Lake St. Martin water level and outflow forecasts (attached). Our routing model was calibrated by adjusting the Dauphin River and Reach 1 Channel outflow rating curves to represent actual conditions observed on Lake St. Martin.

Our revised forecasts consider three new ice formation dates at 2 week intervals of Feb 10, Feb 24 and Mar 9. The ice formation dates represent "worst case" conditions where an ice cover forms in the Reach 1 Channel and the ice cover in the upper Dauphin River thickens. The figures also consider a "best case" scenario where ice conditions as observed today would remain unchanged until ice breakup, where an ice cover does not form in Reach 1 Channel and the ice cover in the upper Dauphin River does not thicken.

Depending on weather conditions until ice breakup and how the Dauphin River and Reach 1 Channel respond to the possible thickening or formation of an ice cover, expected conditions at ice breakup will likely fall within the upper and lower bounds provided in our forecasts. Based on current long range weather forecasts, an ice formation date earlier than Feb 10 is unlikely; therefore this date could be considered conservative.

For the February 10 scenario, the water level in Lake St. Martin would reach 804.4 at spring ice breakup (Fig 2.13.1 RevB). Peak Reach 1 flow would be 7,600 cfs and the combined Dauphin River flow would be 24,000 cfs if Reach 3 is not operated (Fig 2.13.2 RevB & 2.13.2b RevB). As noted previously, the current Dauphin River Community dikes can accommodate a peak spring flow of 24,000 cfs.

Therefore, due to an extremely mild winter, we have reached the point where Reach 3 will not have to be operated to its full capacity of 4250 cfs and are close to the point where the Operation of Reach 3 will not be required.

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
 Senior Project Manager
 KGS Group

Figure 2.13.2 RevB
Computed Lake St. Martin Level
Reach 1 Channel in Operation

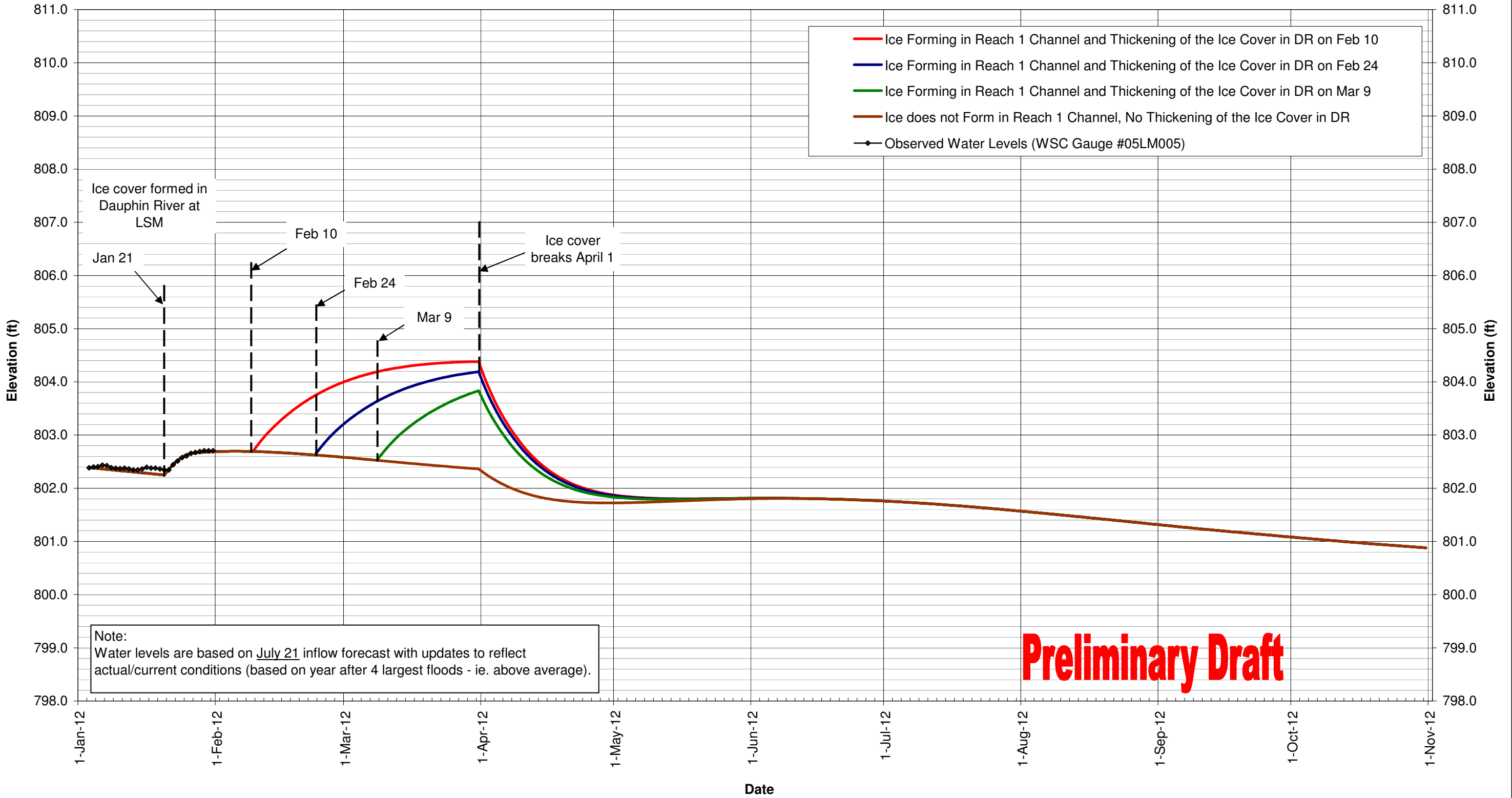


Figure 2.13.2 RevB
Computed Lake St. Martin Outflow
Reach 1 Channel in Operation

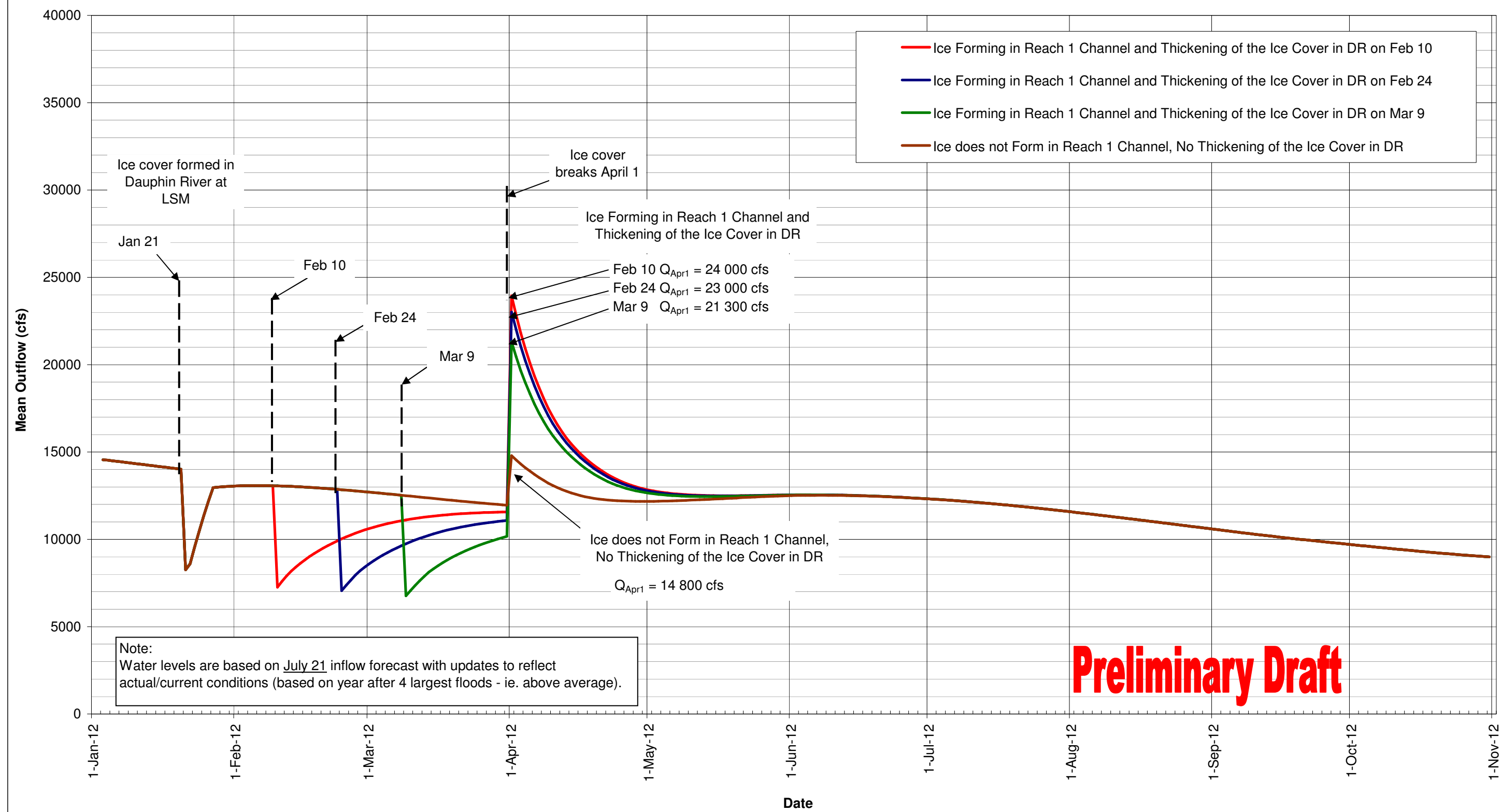
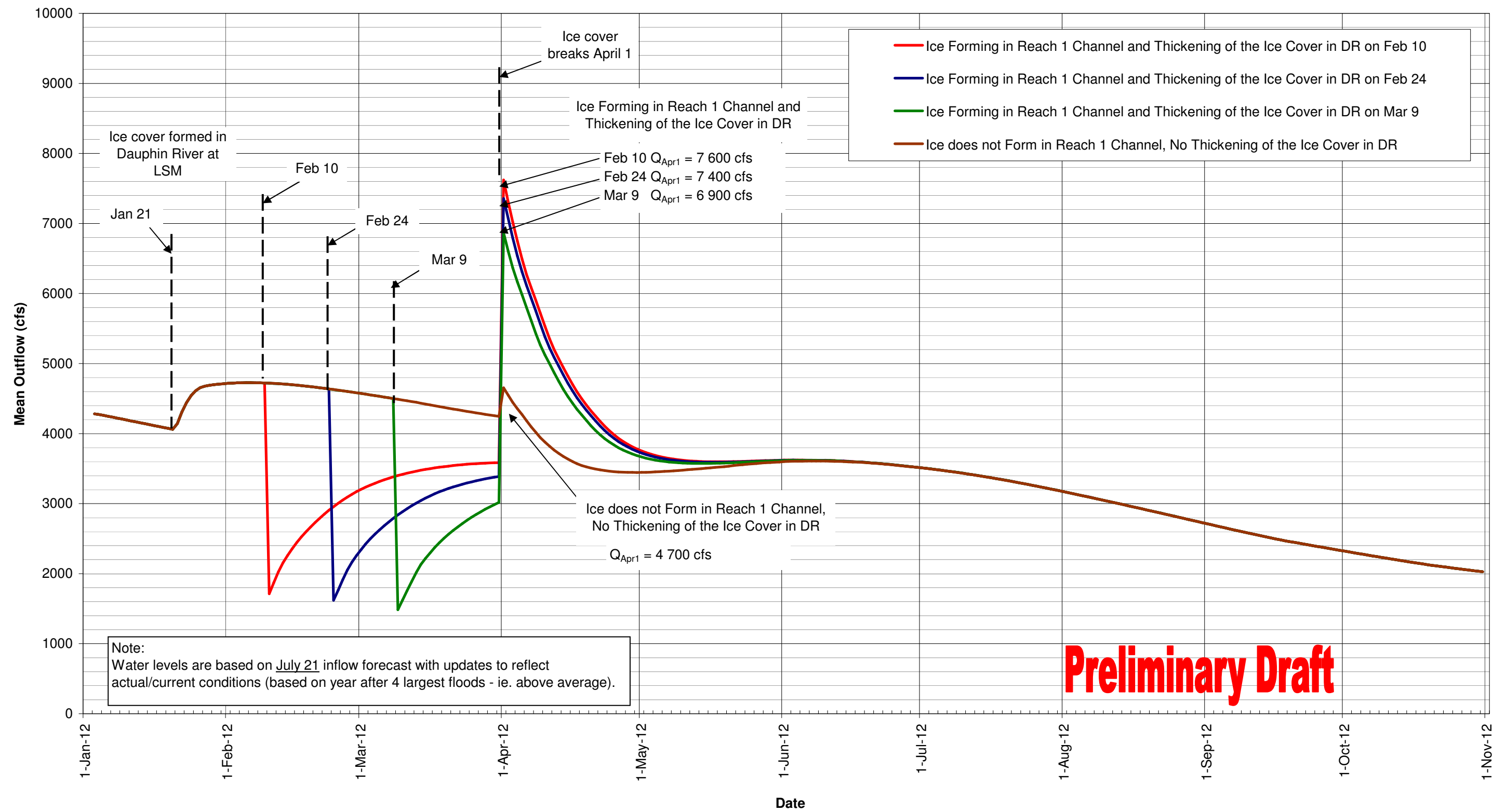


Figure 2.13.2b RevB
Computed Buffalo Creek Outflow
Reach 1 Channel in Operation



**Lake Manitoba Forecast
Correspondence and Figures**

February 10, 2012

Garrett Wellwood

From: Colin Siepman [CSiepman@kgsgroup.com]
Sent: Saturday, February 11, 2012 11:31 AM
To: Mark Allard ; Doug McMahon; Ron Richardson; Ron Kaatz; Eric Christiansen; Rick Postlethwaite; Paul Graveline; Michael Foth
Cc: Bert Smith; Dave MacMillan; Rick Carson; Rob Kenyon; Tony Ng; Brian Bodnaruk; Patrice Leclercq; Steve Offman
Subject: Forecast for the Operation of Reach 3 - Feb10 Update
Attachments: Figure 2.13.2b RevC.PDF; Figure 1.1.1 RevF.PDF; Figure 2.13.1 RevC.PDF; Figure 2.13.2 RevC.PDF

Find attached our updated Lake Manitoba and Lake St. Martin water level and outflow forecasts.

The Lake Manitoba water level forecast (Figure 1.1.1 RevF) was updated based on a revised inflow forecast to reflect current and expected conditions in Lake Winnipegosis and the Waterhen River. The water level in Lake Manitoba is expected to reach 813.4 ft by April 1st, and continue to drop thereafter.

The Lake St. Martin water level and outflow forecast was updated based on the revised Lake Manitoba outflow forecast, and calibrated by adjusting the Dauphin River and Reach 1 Channel outflow rating curves to represent actual conditions observed in the system.

Our revised forecast considers a "worst case" condition where the ice cover in the upper Dauphin River thickens beginning February 21, in conjunction with a restriction in flow in the Reach 1 Channel due to backwater effects from Buffalo Lake. The figures also consider a "best case" scenario where ice conditions as observed today would remain unchanged until ice breakup, where an ice cover does not form in Reach 1 Channel and the ice cover in the upper Dauphin River does not thicken.

Depending on weather conditions until ice breakup and how the Dauphin River and Reach 1 Channel respond to the possible thickening or formation of an ice cover, expected conditions at ice breakup will likely fall within the upper and lower bounds provided in our forecasts.

For the "worst case" scenario, the water level in Lake St. Martin would reach 803.7 ft at spring ice breakup (Fig 2.13.1 RevC). Peak Reach 1 flow would be 7,000 cfs and the combined Dauphin River flow would be 20,800 cfs if Reach 3 is not operated (Fig 2.13.2 RevC & 2.13.2b RevC). As noted previously, the current Dauphin River Community dikes can accommodate a peak spring flow of 24,000 cfs.

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
 Senior Project Manager
 KGS Group

From: Colin Siepman [mailto:CSiepman@kgsgroup.com]
Sent: January 31, 2012 10:39 PM
To: Mark Allard ; Doug McMahon; Ron Richardson; Ron Kaatz; Eric Christiansen; Rick Postlethwaite; Paul Graveline; Michael Foth
Cc: Bert Smith; Dave MacMillan; Rick Carson; Rob Kenyon; Tony Ng; Brian Bodnaruk; Patrice Leclercq; Steve Offman
Subject: Forecast for the Operation of Reach 3 - Jan31 Update - Confidential

Due to the rise of Lake St. Martin levels observed starting January 21, and an ice cover forming in the upper reaches of the Dauphin River, we have updated our Lake St. Martin water level and outflow forecasts (attached). Our routing model was calibrated by adjusting the Dauphin River and Reach 1 Channel outflow rating curves to represent actual conditions observed on Lake St. Martin.

Our revised forecasts consider three new ice formation dates at 2 week intervals of Feb 10, Feb 24 and

Mar 9. The ice formation dates represent “worst case” conditions where an ice cover forms in the Reach 1 Channel and the ice cover in the upper Dauphin River thickens. The figures also consider a “best case” scenario where ice conditions as observed today would remain unchanged until ice breakup, where an ice cover does not form in Reach 1 Channel and the ice cover in the upper Dauphin River does not thicken.

Depending on weather conditions until ice breakup and how the Dauphin River and Reach 1 Channel respond to the possible thickening or formation of an ice cover, expected conditions at ice breakup will likely fall within the upper and lower bounds provided in our forecasts. Based on current long range weather forecasts, an ice formation date earlier than Feb 10 is unlikely; therefore this date could be considered conservative.

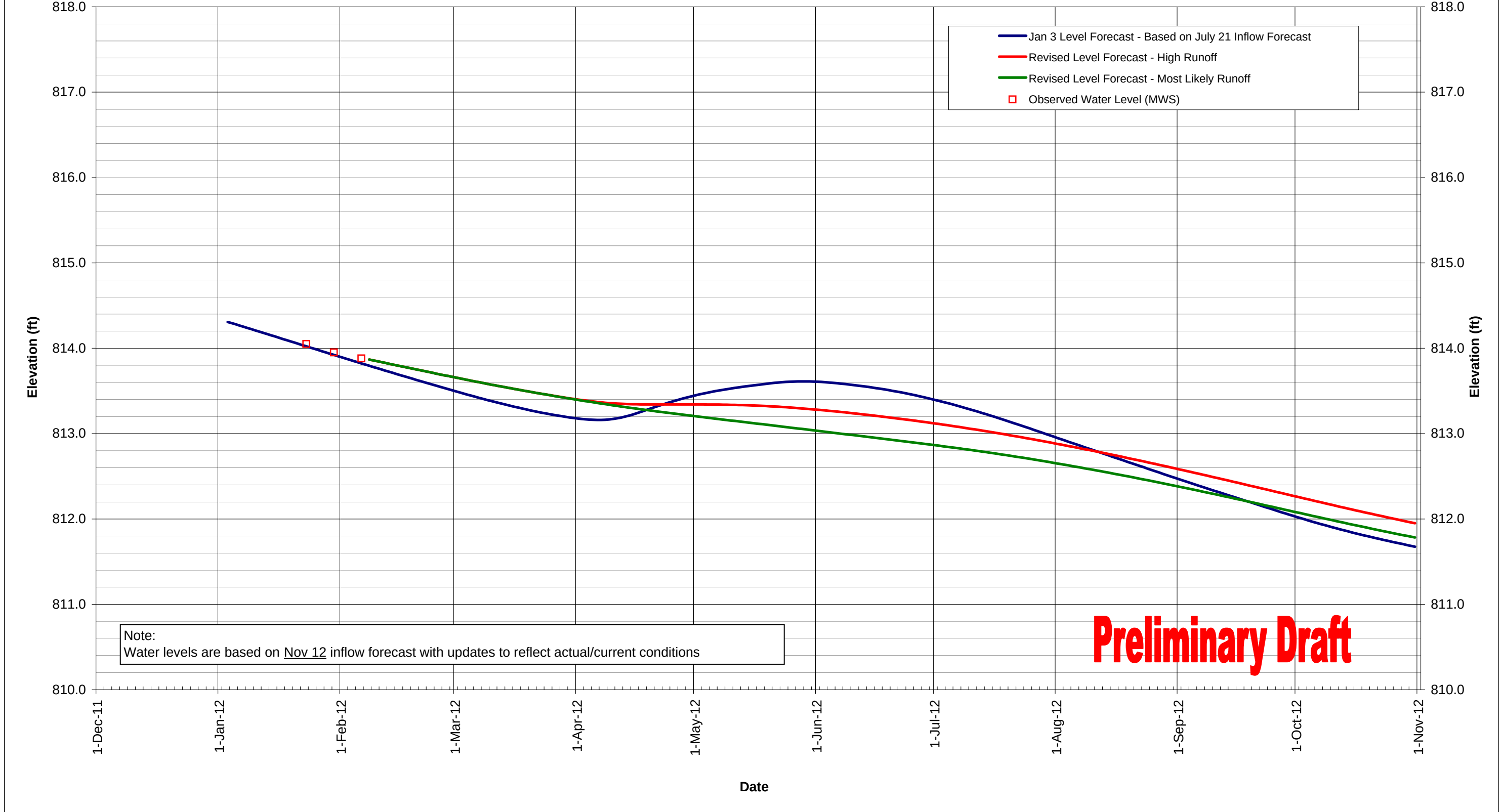
For the February 10 scenario, the water level in Lake St. Martin would reach 804.4 at spring ice breakup (Fig 2.13.1 RevB). Peak Reach 1 flow would be 7,600 cfs and the combined Dauphin River flow would be 24,000 cfs if Reach 3 is not operated (Fig 2.13.2 RevB & 2.13.2b RevB). As noted previously, the current Dauphin River Community dikes can accommodate a peak spring flow of 24,000 cfs.

Therefore, due to an extremely mild winter, we have reached the point where Reach 3 will not have to be operated to its full capacity of 4250 cfs and are close to the point where the Operation of Reach 3 will not be required.

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
Senior Project Manager
KGS Group

Figure 1.1.1 RevF
Computed Lake Manitoba Level
Fairford Fully Open



Note:
Water levels are based on Nov 12 inflow forecast with updates to reflect actual/current conditions

Preliminary Draft

Figure 2.13.1 RevC
Computed Lake St. Martin Level
Reach 1 Channel in Operation

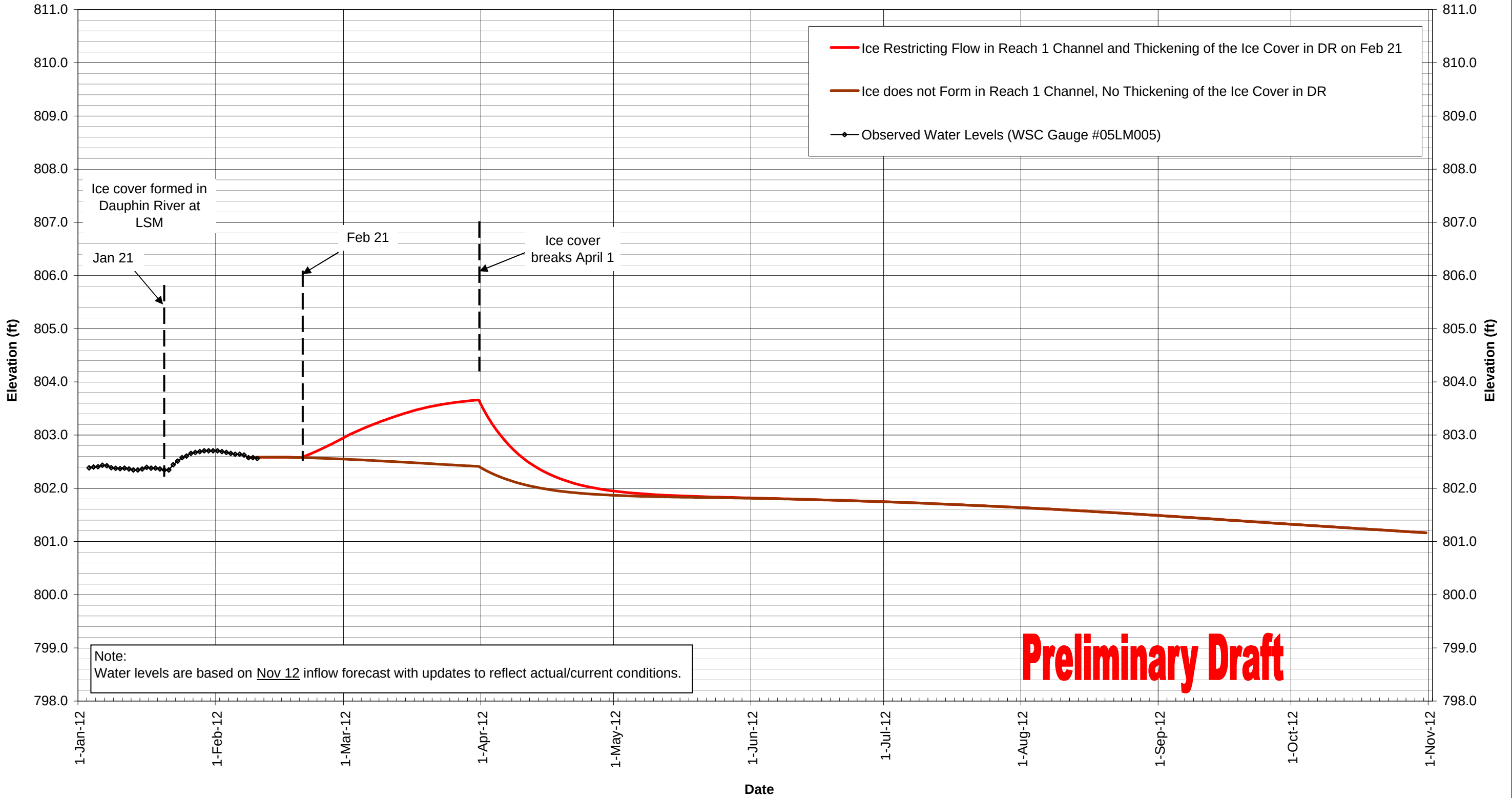


Figure 2.13.2 RevC
Computed Lake St. Martin Outflow
Reach 1 Channel in Operation

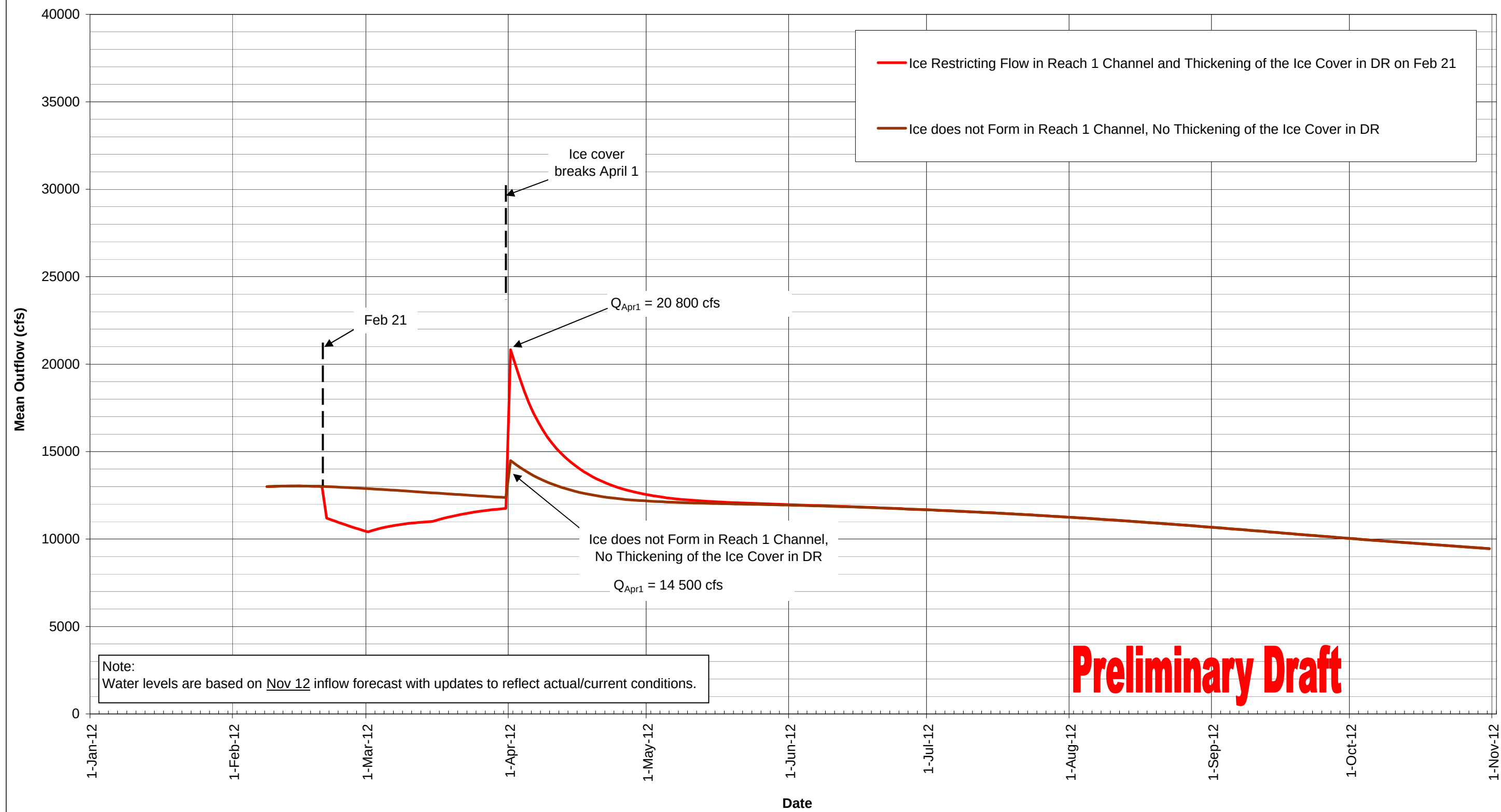
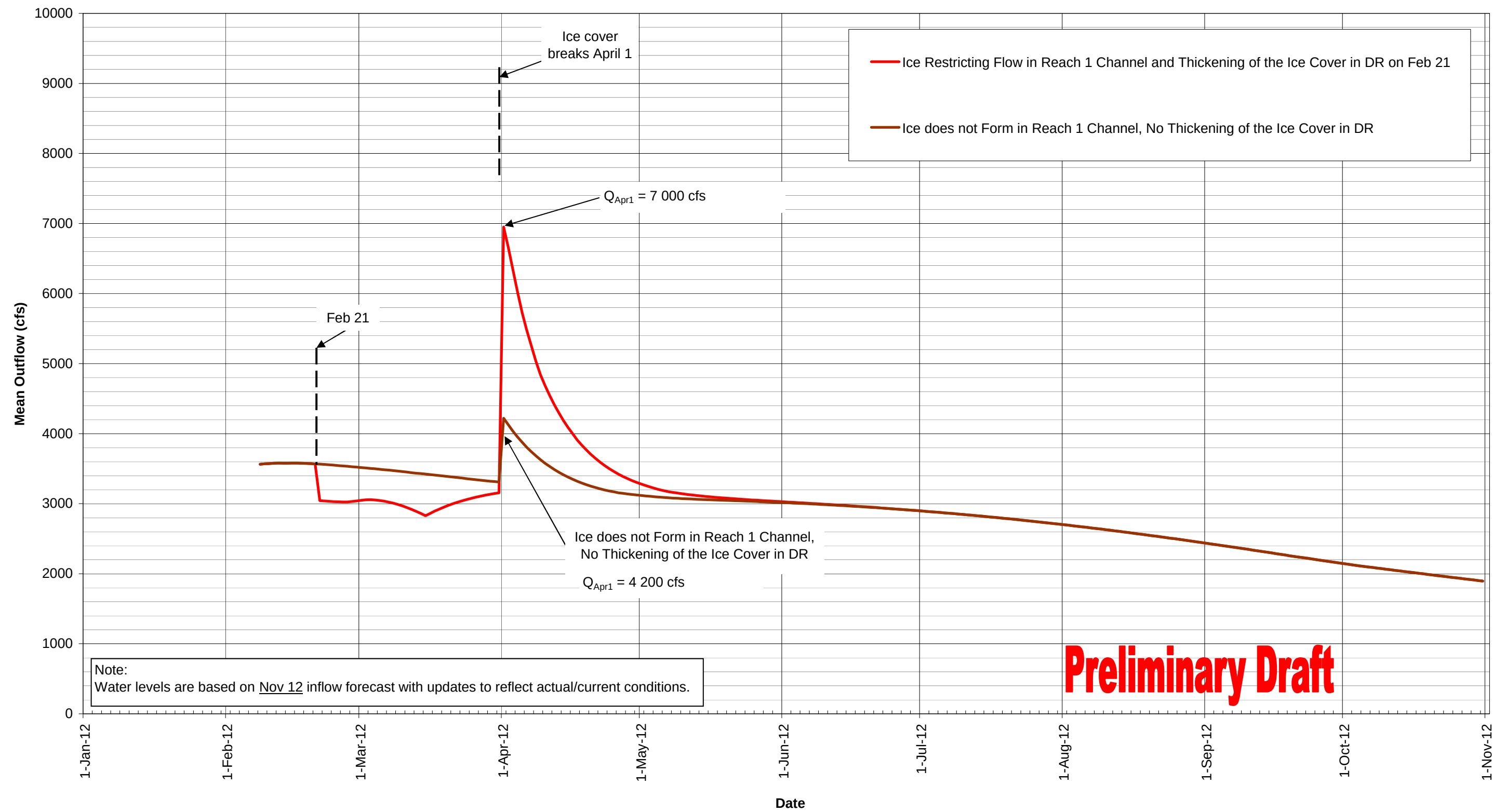


Figure 2.13.2b RevC
Computed Buffalo Creek Outflow
Reach 1 Channel in Operation



**Lake Manitoba Forecast
Correspondence and Figures**

February 14, 2012

Garrett Wellwood

From: Colin Siepman [CSiepman@kgsgroup.com]
Sent: Tuesday, February 14, 2012 5:52 PM
To: Mark Allard ; Doug McMahon; Ron Richardson; Ron Kaatz; Eric Christiansen; Rick Postlethwaite; Paul Graveline; Michael Foth; Doug McNeil
Cc: Bert Smith; Dave MacMillan; Rick Carson; Rob Kenyon; Tony Ng; Brian Bodnaruk; Patrice Leclercq; Steve Offman
Subject: RE: Forecast for the Operation of Reach 3 - Feb10 Update
Attachments: Figure 2.13.1 RevD.PDF; Figure 2.13.2 RevD.PDF

To help put things in perspective we have updated our Feb 10, 2012 graphs to include the original Sept 20, 2011 forecast, which was issued just prior to the decision to proceed with Reach 3.

The following is a summary of the previous “worst case” flow forecasts for the Dauphin River downstream of Buffalo Creek as we progressed through the winter and adapted to the above average weather conditions:

Sept 20 – 35,000 cfs
 Dec 1 – 29,000 cfs
 Jan 3 – 27,000 cfs
 Jan 31 – 24,000 cfs
 Feb 10 – 20,800 cfs

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
 Senior Project Manager
 KGS Group

From: Colin Siepman [mailto:CSiepman@kgsgroup.com]
Sent: February 11, 2012 11:31 AM
To: Mark Allard ; Doug McMahon; Ron Richardson; Ron Kaatz; Eric Christiansen; Rick Postlethwaite; Paul Graveline; Michael Foth
Cc: Bert Smith; Dave MacMillan; Rick Carson; Rob Kenyon; Tony Ng; Brian Bodnaruk; Patrice Leclercq; Steve Offman
Subject: Forecast for the Operation of Reach 3 - Feb10 Update

Find attached our updated Lake Manitoba and Lake St. Martin water level and outflow forecasts.

The Lake Manitoba water level forecast (Figure 1.1.1 RevF) was updated based on a revised inflow forecast to reflect current and expected conditions in Lake Winnipegosis and the Waterhen River. The water level in Lake Manitoba is expected to reach 813.4 ft by April 1st, and continue to drop thereafter.

The Lake St. Martin water level and outflow forecast was updated based on the revised Lake Manitoba outflow forecast, and calibrated by adjusting the Dauphin River and Reach 1 Channel outflow rating curves to represent actual conditions observed in the system.

Our revised forecast considers a “worst case” condition where the ice cover in the upper Dauphin River thickens beginning February 21, in conjunction with a restriction in flow in the Reach 1 Channel due to backwater effects from Buffalo Lake. The figures also consider a “best case” scenario where ice conditions as observed today would remain unchanged until ice breakup, where an ice cover does not form in Reach 1 Channel and the ice cover in the upper Dauphin River does not thicken.

Depending on weather conditions until ice breakup and how the Dauphin River and Reach 1 Channel respond to the possible thickening or formation of an ice cover, expected conditions at ice breakup will likely fall within the upper and lower bounds provided in our forecasts.

For the “worst case” scenario, the water level in Lake St. Martin would reach 803.7 ft at spring ice breakup (Fig 2.13.1 RevC). Peak Reach 1 flow would be 7,000 cfs and the combined Dauphin River flow would be 20,800 cfs if Reach 3 is not operated (Fig 2.13.2 RevC & 2.13.2b RevC). As noted previously, the current Dauphin River Community dikes can accommodate a peak spring flow of 24,000 cfs.

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
Senior Project Manager
KGS Group

From: Colin Siepman [mailto:CSiepman@kgsgroup.com]
Sent: January 31, 2012 10:39 PM
To: Mark Allard ; Doug McMahon; Ron Richardson; Ron Kaatz; Eric Christiansen; Rick Postlethwaite; Paul Graveline; Michael Foth
Cc: Bert Smith; Dave MacMillan; Rick Carson; Rob Kenyon; Tony Ng; Brian Bodnaruk; Patrice Leclercq; Steve Offman
Subject: Forecast for the Operation of Reach 3 - Jan31 Update - Confidential

Due to the rise of Lake St. Martin levels observed starting January 21, and an ice cover forming in the upper reaches of the Dauphin River, we have updated our Lake St. Martin water level and outflow forecasts (attached). Our routing model was calibrated by adjusting the Dauphin River and Reach 1 Channel outflow rating curves to represent actual conditions observed on Lake St. Martin.

Our revised forecasts consider three new ice formation dates at 2 week intervals of Feb 10, Feb 24 and Mar 9. The ice formation dates represent “worst case” conditions where an ice cover forms in the Reach 1 Channel and the ice cover in the upper Dauphin River thickens. The figures also consider a “best case” scenario where ice conditions as observed today would remain unchanged until ice breakup, where an ice cover does not form in Reach 1 Channel and the ice cover in the upper Dauphin River does not thicken.

Depending on weather conditions until ice breakup and how the Dauphin River and Reach 1 Channel respond to the possible thickening or formation of an ice cover, expected conditions at ice breakup will likely fall within the upper and lower bounds provided in our forecasts. Based on current long range weather forecasts, an ice formation date earlier than Feb 10 is unlikely; therefore this date could be considered conservative.

For the February 10 scenario, the water level in Lake St. Martin would reach 804.4 at spring ice breakup (Fig 2.13.1 RevB). Peak Reach 1 flow would be 7,600 cfs and the combined Dauphin River flow would be 24,000 cfs if Reach 3 is not operated (Fig 2.13.2 RevB & 2.13.2b RevB). As noted previously, the current Dauphin River Community dikes can accommodate a peak spring flow of 24,000 cfs.

Therefore, due to an extremely mild winter, we have reached the point where Reach 3 will not have to be operated to its full capacity of 4250 cfs and are close to the point where the Operation of Reach 3 will not be required.

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
Senior Project Manager
KGS Group

Figure 2.13.1 RevD
Computed Lake St. Martin Level
Reach 1 Channel in Operation

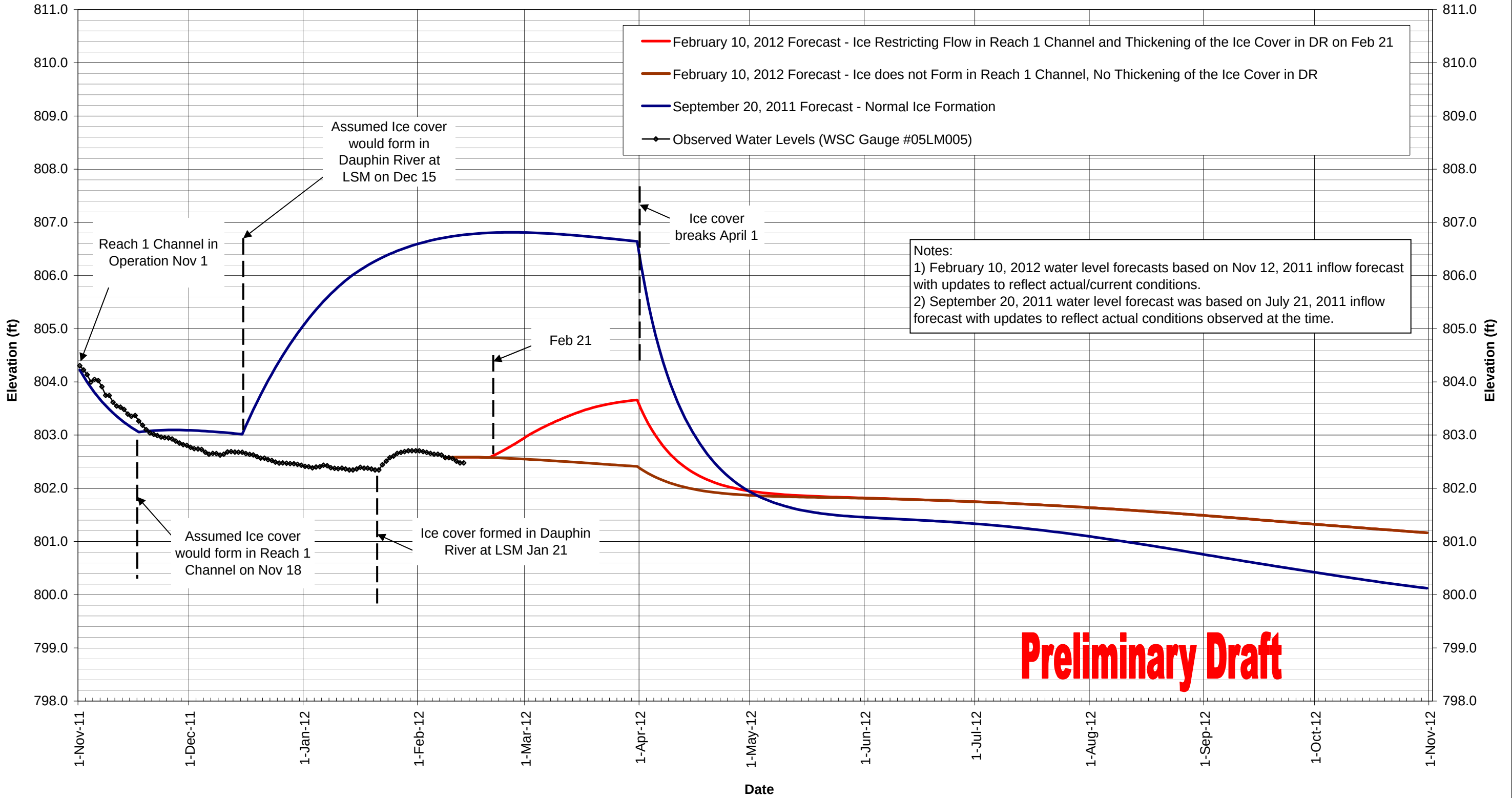
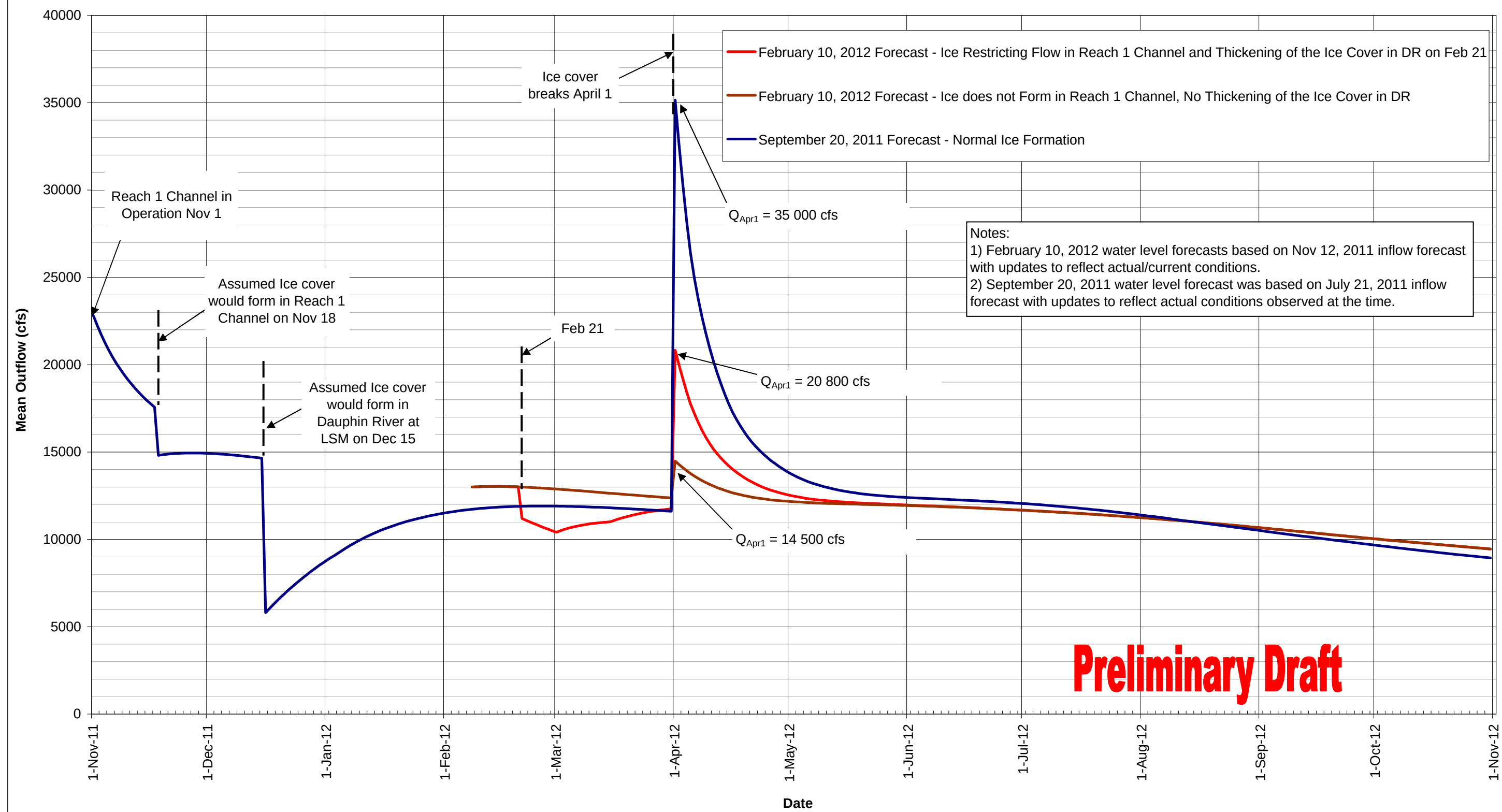


Figure 2.13.2 RevD
Computed Lake St. Martin Outflow
Reach 1 Channel in Operation



**Lake Manitoba Forecast
Correspondence and Figures**

February 22, 2012

Garrett Wellwood

From: Patrice Leclercq [PLeclercq@kgsgroup.com]
Sent: Friday, March 01, 2013 8:03 AM
To: 'Patrice Leclercq'
Subject: FW: Ministers briefing - Reach 3E questions
Attachments: AccumulatedFreezingDegreeDays_FisherBranch.pdf; Figure 1.1.1 RevG.PDF; Figure 2.13.1 RevE.PDF; Figure 2.13.2 RevE.PDF; Figure 2.13.2b RevD.PDF; Discharge Summary - 2012-02-22.xls

From: Colin Siepman [mailto:CSiepman@kgsgroup.com]
Sent: February-22-12 5:16 PM
To: 'Kaatz, Ron G (MIT)'
Cc: 'bsmith@kgsgroup.com'; 'Brian Bodnaruk'; 'Richardson, Ron (MIT)'; Mark Allard ; Rob Kenyon; Dave MacMillan; Rick Carson; Eric Christiansen
Subject: RE: Ministers briefing - Reach 3E questions

Ron,

Please see responses below in blue text.

In addition, to illustrate the above average temperature conditions during the 2011-2012 winter, we have included a graph of the Accumulated Degree-Days of Freezing based on temperature data from Fisher Branch. The graph indicates that, as of mid February, this has been the warmest winter in the Fisher Branch area in the last 30 years.

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
 Senior Project Manager
 KGS Group

From: Kaatz, Ron G (MIT) [<mailto:Ron.Kaatz@gov.mb.ca>]
Sent: February 22, 2012 8:27 AM
To: 'CSiepman@kgsgroup.com'
Cc: bsmith@kgsgroup.com; Brian Bodnaruk; Richardson, Ron (MIT)
Subject: Ministers briefing - Reach 3E questions
Importance: High

Hi Colin

There is a ministers briefing taking place tomorrow and there are a number of questions that must be confirmed by KGS, please. These questions are the following:

- 1) Status of Reach 3 Construction (Mark A to respond to)
- 2) Final result of KGS' analysis and decision on use of Reach 3; (KGS to provide analysis and make recommendation if Reach 3E should or should not be in use); The following is an updated summary of the "worst case" flow forecasts for the Dauphin River downstream of Buffalo Creek, assuming Reach 3 is not operated, as we progressed through the winter and adapted to the above average temperature conditions:

Sept 20 – 35,000 cfs
 Dec 1 – 29,000 cfs
 Jan 3 – 27,000 cfs
 Jan 31 – 24,000 cfs
 Feb 10 – 20,800 cfs

Feb 22 - 16,800 cfs

The current Dauphin River Community dikes can accommodate a peak spring flow of approximately 24,000 cfs with a freeboard of 2 ft. The Feb 22 “worst case” forecast of 16,800 cfs is now significantly less than this limit and therefore provides additional contingency to allow for minor variations in the forecasts and/or the Dauphin River spring ice jam models.

- 3) First Nation involvement on Reach 3 (do we have stats?); (Mark A to respond to)
 - 4) Current Lake Manitoba and Lake St. Martin Lake levels; (KGS to provide current graphs and projected tabled sheets of results- elevations forecast to August); We have updated our Lake Manitoba and Lake St. Martin water level and outflow forecasts as of Feb 22 (see attached).
 - 5) Current flows through Fairford River control structure and flows on Dauphin River and Reach 1; (KGS to provide current graphs and projected tabled sheets of results- elevations); We have provided current and projected flows in the attached table.
 - 6) Ice conditions on the above three channels;(KGS to provide current and projected ice conditions on all channels)
 - Fairford River is ice free from Lake Pineimuta to the Fairford Control Structure. No ice in this reach is expected this winter.
 - Dauphin River at Lake St Martin developed a weak cover on January 21, 2012 but it has gradually reduced in its effect (smoothing and thinning). The ice effects are unlikely to get worse.
 - Reach 1 is ice free and unlikely to form a cover.
 - Buffalo Creek has an ice jam that formed downstream of the inlet to Reach 3 but the jam has not progressed and has not affected flow forecasts. The ice effects are unlikely to get worse.
 - 7) Freeboard on Dauphin River dikes; (KGS to provide freeboard on Dauphin River dikes for current conditions and peak spring flow conditions); Current water levels in the Dauphin River communities have not been measured due to restricted access. However, the highest water levels likely occurred in December, at which time the minimum freeboard was approximately 6 ft.
- The Dauphin River Community dikes can accommodate a peak spring flow of approximately 24,000 cfs with a minimum freeboard of 2 ft. The Feb 22 “worst case” forecast of 16,800 cfs is less than this limit and therefore will have a freeboard greater than 2 ft. Since the predicted water levels due to a spring ice jam are based on a detailed RIVICE model by the Frazil Ice Team we are not able to provide the exact freeboard for the 16,800 cfs scenario at this time but could pursue this further if requested by MIT.
- 8) Approximate total expected costs of construction of Reach 1 (\$40M?) , Reach 3 (\$9M?) and Dauphin River dikes (\$10M?). Mark A to address

Please address the above question, and have the result sent directly to Ron R and Ron R, by 4:00 pm today, February 22, 2012, please?

Some of these questions are and have been touched upon in the past but we require current conditions or evaluations.

Thanks

Ron G. Kaatz, P. Eng.
Senior Hydraulic Engineer

Manitoba Infrastructure and Transportation
Engineering & Operations,
Water Control and Structures
Operations & Maintenance Branch
7th floor, 215 Garry St.
Winnipeg, Manitoba R3C 3P3
Ph: <personal information removed>
Cell: <personal information removed>
Fax: (204) 948-4503
e-mail: Ron.Kaatz@gov.mb.ca

Garrett Wellwood

From: Patrice Leclercq [PLEclercq@kgsgroup.com]
Sent: Friday, March 01, 2013 8:03 AM
To: 'Patrice Leclercq'
Subject: FW: Lake Manitoba testing
Attachments: Discharge Summary.xls; Figure 2.13.1 RevE.pdf; Figure 2.13.2 RevE.pdf; Figure 2.13.2b RevD.pdf

From: Brian Bodnaruk [mailto:BBodnaruk@kgsgroup.com]
Sent: February-22-12 6:05 PM
To: 'Mutulu, Phillip (MWS)'
Cc: 'Colin Siepman'; Richardson, Ron (MIT); Kaatz, Ron G (MIT)
Subject: RE: Lake Manitoba testing

Phillip, the information on Lake Manitoba outflows and Lake St Martin outflows was prepared for MIT for the review of the emergency flood channels from Lake St Martin to Lake Winnipeg. The flow estimates were prepared specifically for this project. A number of assumptions and qualifiers were assumed for these projections and were deemed to be suitable for the intended purpose. If this data is used for flow forecasting purposes, the assumptions and parameters used in preparing the flow estimates should be understood.

A complete set of water level charts on Lake Manitoba and Lake St Martin have been sent to Ron Richardson and R. Kaatz at MIT. I have provided a copy to you of these charts for your information, as you requested.

Brian Bodnaruk, P. Eng.

KGS Group - Consulting Engineers
 Winnipeg, Manitoba
 865 Waverley Street
 Direct Line - <personal information removed>
 Switch Board - 204.896.1209
 Fax - 204.896.0754
bbodnaruk@kgsgroup.com

From: Mutulu, Phillip (MWS) [<mailto:Phillip.Mutulu@gov.mb.ca>]
Sent: Wednesday, February 22, 2012 5:41 PM
To: Brian Bodnaruk
Subject: RE: Lake Manitoba testing

From: Brian Bodnaruk [<mailto:BBodnaruk@kgsgroup.com>]
Sent: December-13-11 4:03 PM
To: Mutulu, Phillip (MWS)
Subject: RE: Lake Manitoba

I have attached a chart showing forecasted Lake Manitoba water levels for 2 flow conditions at Fairford Control structure as listed on the chart. Please call me if you require further information.

Brian Bodnaruk, P. Eng.

3/4/2013

KGS Group - Consulting Engineers
Winnipeg, Manitoba
865 Waverley Street
Direct Line - <personal information removed>
Switch Board - 204.896.1209
Fax - 204.896.0754
bbodnaruk@kgsgroup.com

From: Mutulu, Phillip (MWS) [<mailto:Phillip.Mutulu@gov.mb.ca>]
Sent: Monday, December 12, 2011 3:35 PM
To: Brian Bodnaruk
Cc: Loukili, Youssef (MWS)
Subject: RE: Lake Manitoba

Is there any chance I could get this information today as you promised ?

From: Mutulu, Phillip (MWS)
Sent: December-09-11 1:43 PM
To: Brian Bodnaruk
Cc: Loukili, Youssef (MWS)
Subject: Lake Manitoba

Hi Brian:

I have had a number enquiries about L. Manitoba level projections. Do you have any updated forecasts. ?
Please send me the update if it is ready.

Phillip M. Mutulu, PhD
Drector,
Flood Forecasting & Coordination
Regulatory and Operational Services Division
Manitoba Water Stewardship
200 Saulteaux Crescent
Winnipeg, Manitoba R3J 3W3
Tel: <personal information removed>, Fax: 1-204-945-7419

Figure 1.1.1 RevG
Computed Lake Manitoba Level
Fairford Fully Open

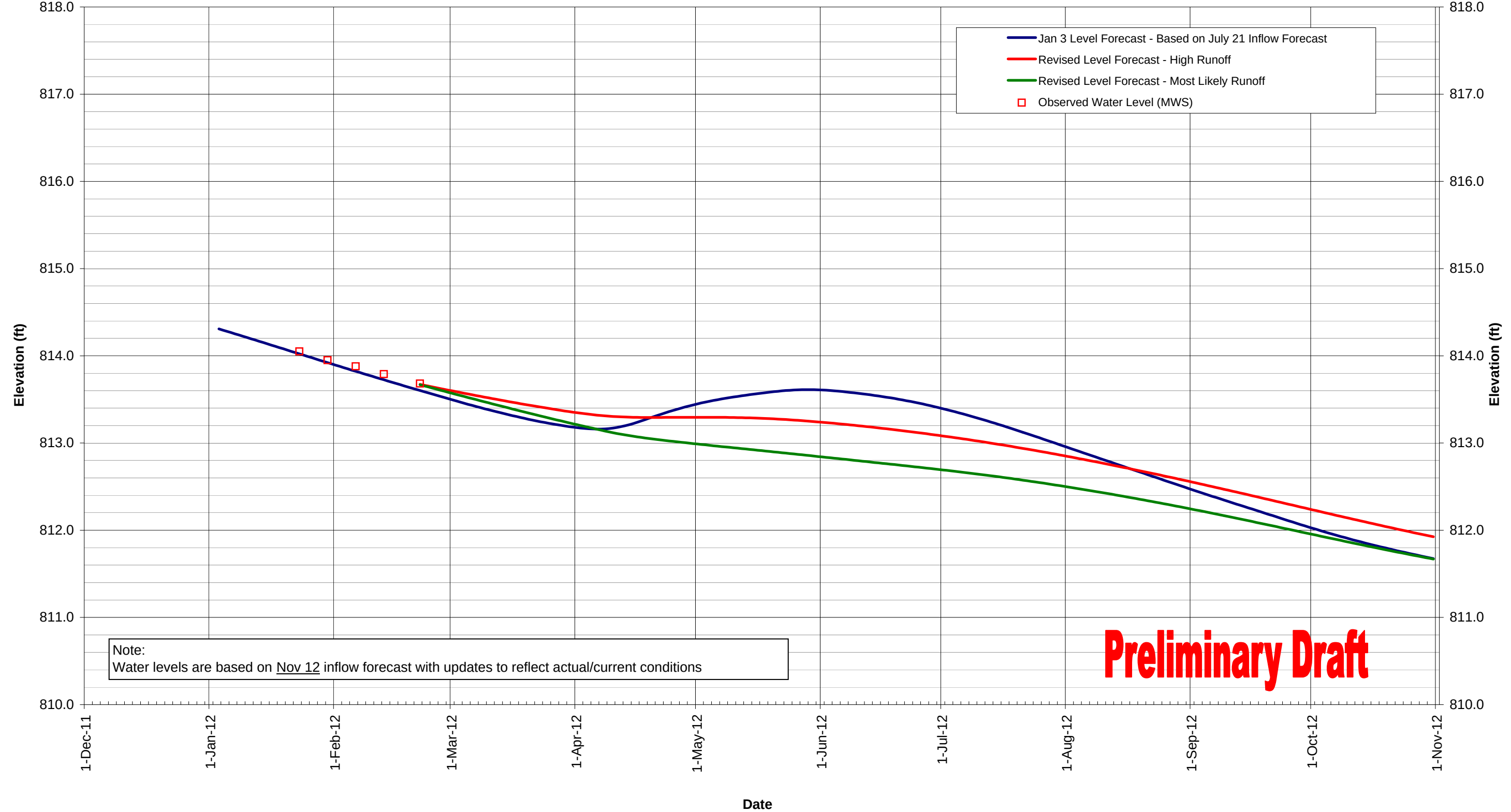


Figure 2.13.1 RevE
Computed Lake St. Martin Level
Reach 1 Channel in Operation

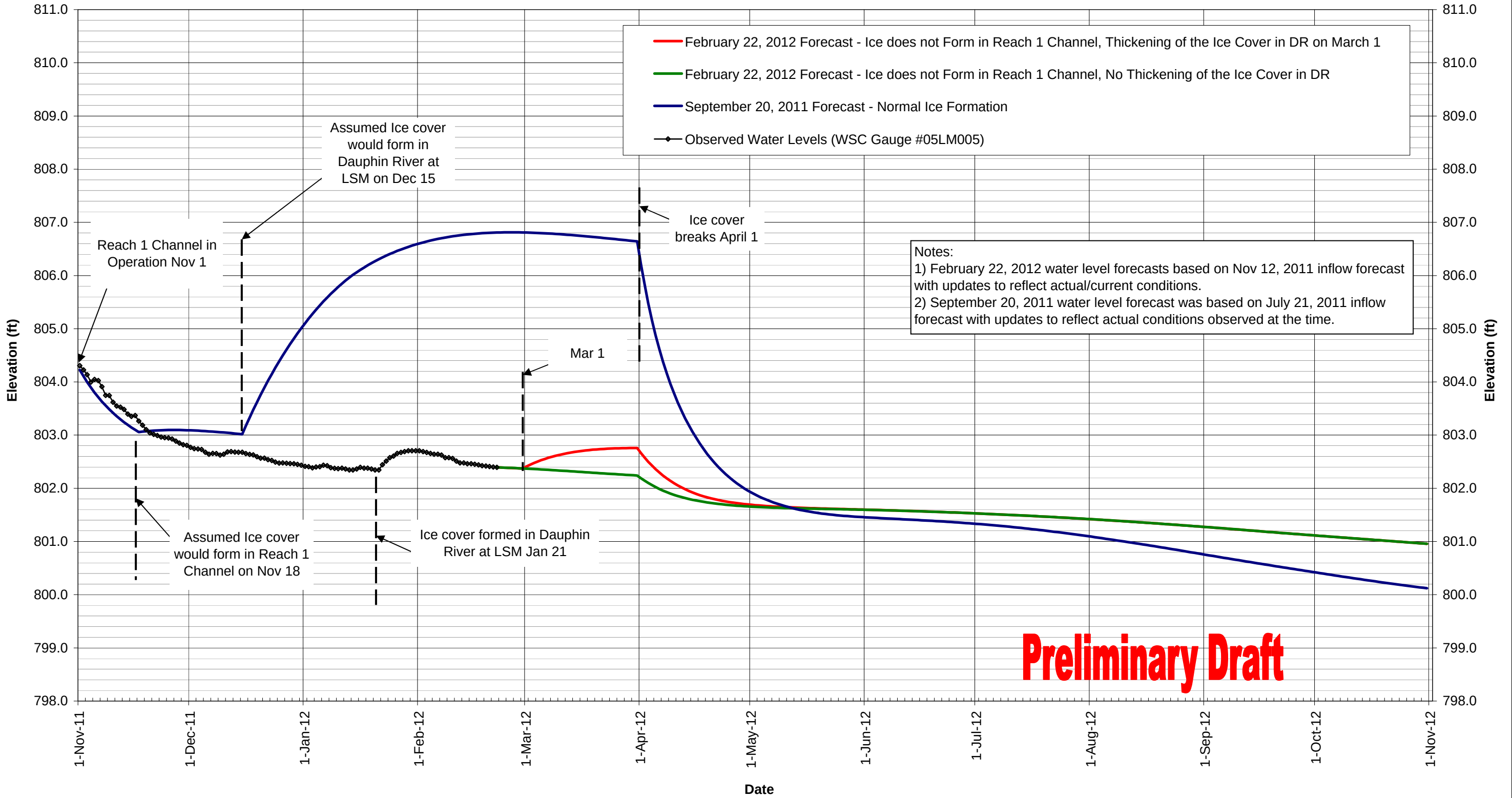


Figure 2.13.2 RevE
Computed Lake St. Martin Outflow
Reach 1 Channel in Operation

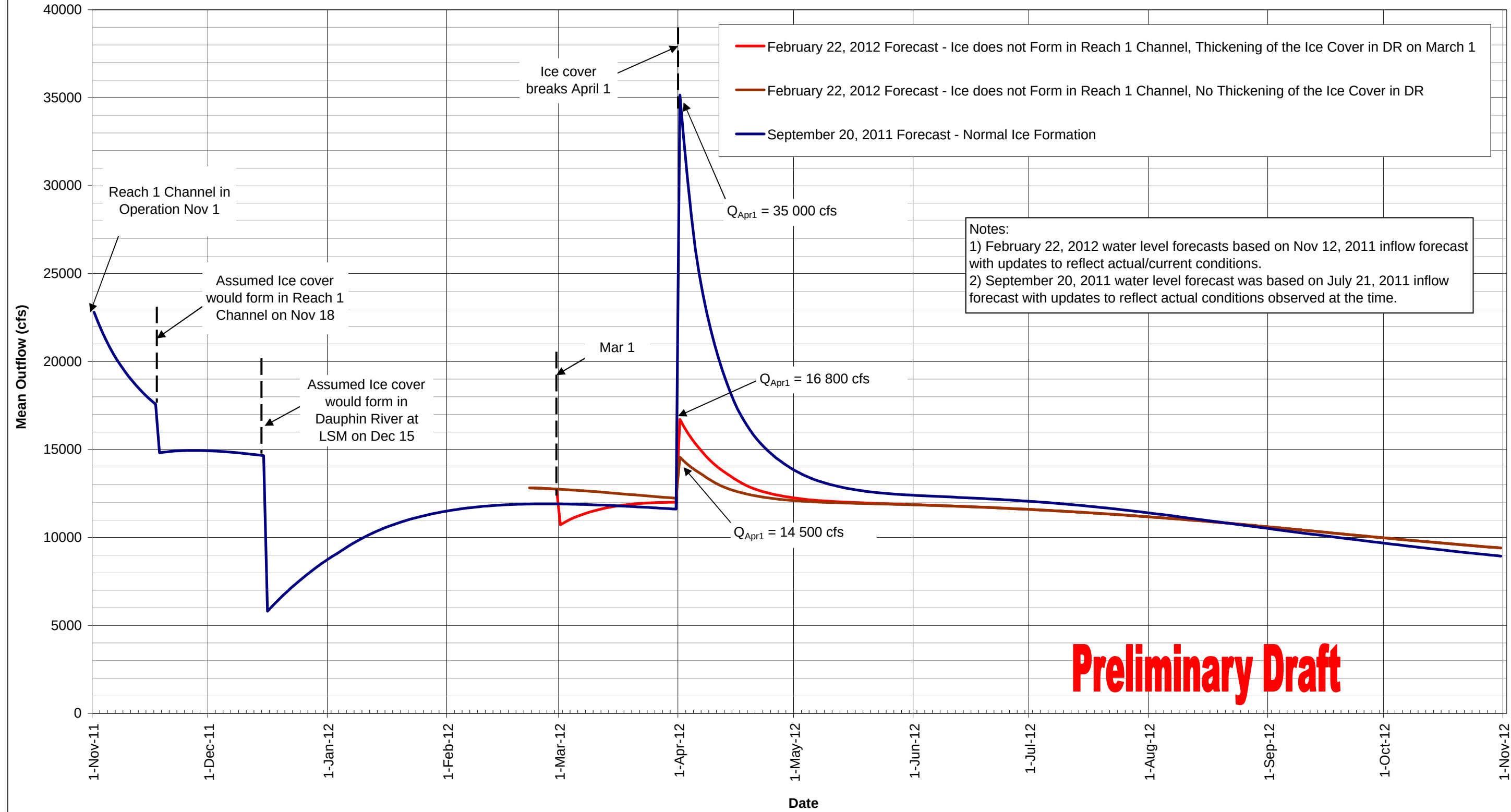
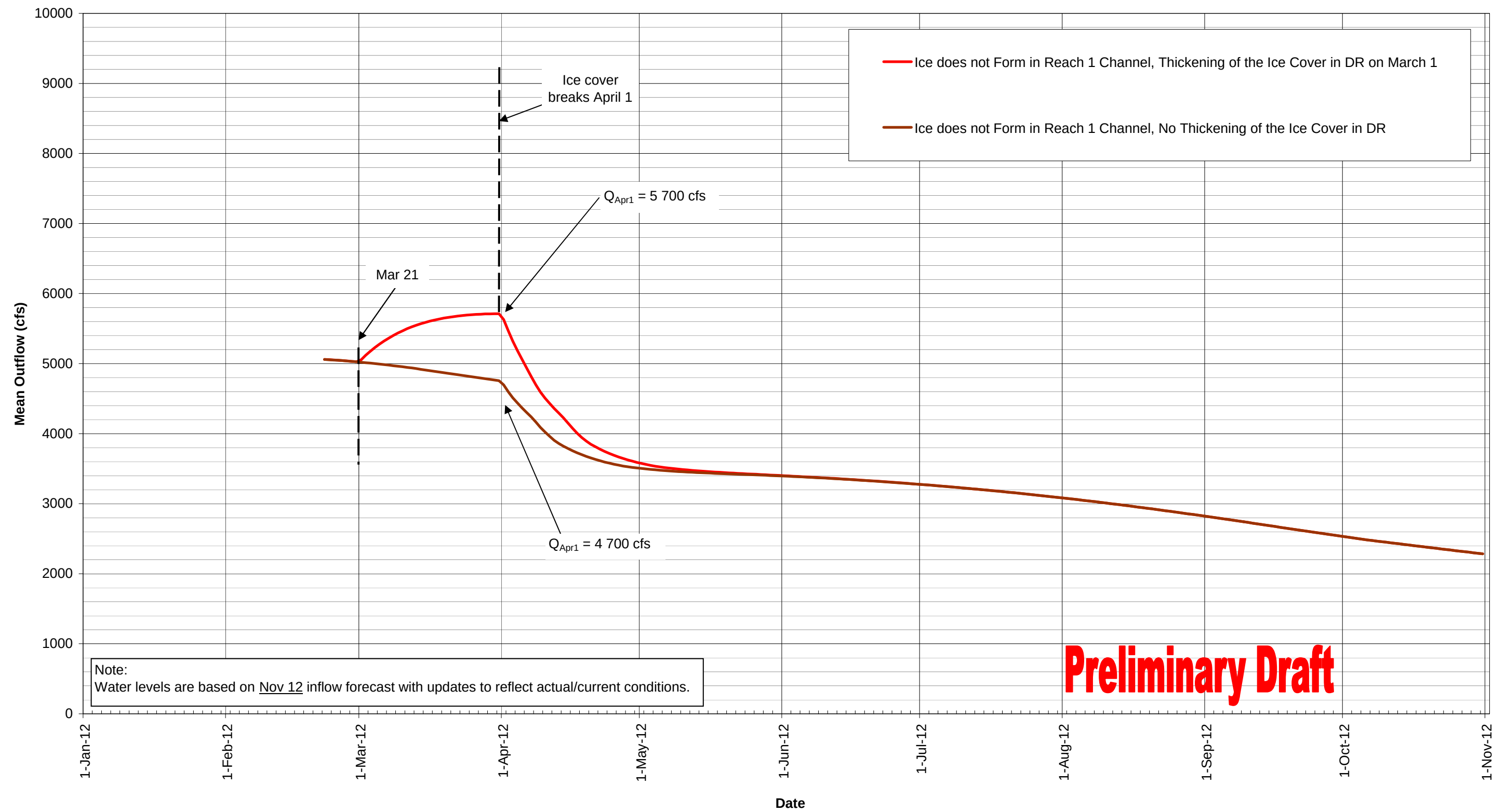


Figure 2.13.2b RevD
Computed Buffalo Creek Outflow
Reach 1 Channel in Operation



Preliminary Draft

Garrett Wellwood

From: Colin Siepman [CSiepman@kgsgroup.com]
Sent: Friday, February 24, 2012 5:55 PM
To: 'Allard, Mark (MIT)'
Cc: Patrice Leclercq; Brian Bodnaruk; Tony Ng; Steve Offman; Ron Kaatz; Ron Richardson; Rick Carson
Subject: RE: Closure of Reach 1
Attachments: Figure 2.15.2b.pdf; Figure 2.15.1.pdf; Figure 2.15.2.pdf

Mark,

Attached are figures for the Feb 22 LSM routing with options to raise the sill elevation at the Reach 1 inlet to 800 and 801 on March 15, 2012. Here is a brief summary of the results:

1. The forecast peak spring flow at the Dauphin River communities would not increase
2. LSM levels on April 1st would be 0.4 to 0.8 ft higher than the current forecast
3. LSM levels from May 1st to Sept 1st would be 0.5 to 0.9 ft higher than the current forecast
4. LSM level on Sept 1st would still be greater than the sill elevation, which means the flow would not naturally stop. Therefore equipment will still be required to complete the closure (unless the emergency operating exemption is extended).
5. The desirable operating range for Lake St. Martin is 797 to 800 ft and flood stage is 801.7 ft. Constructing the Reach 1 inlet sill on March 15 will increase LSM levels and could keep it above flood stage all summer.

Note that our LSM graphs to date only extend to Nov 1st, 2012 and do not yet account for the closure of Reach 1 on September 1st, as required by the current emergency operating license. If we close Reach 1 on Sept 1st, and keep Fairford fully open, Lake St. Martin would rise and cause Dauphin River flows to increase during the fall ice jam formation period.

Therefore we soon may have to start looking at scenarios for next fall as I suspect we may want to request an operating extension of a month or two. This may also impact how we remove the DRFN dikes, upgrade PR513, etc.

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
 Senior Project Manager
 KGS Group

From: Allard, Mark (MIT) [mailto:Mark.Allard@gov.mb.ca]
Sent: February 21, 2012 9:06 AM
To: Colin Siepman; Brian Bodnaruk
Subject: Closure of Reach 1

Gentlemen,

We are throwing around ideas for the closure of Reach 1 and had the thought of raising the inlet in early March to 800 or 801 and allowing the water to naturally stop when it hit that elevation.

If this was to be accomplished, what would this do to the LSM and Dauphin River forecast from March 1 to Sept 1? Can you run both scenarios?

Mark G. Allard, P. Eng.

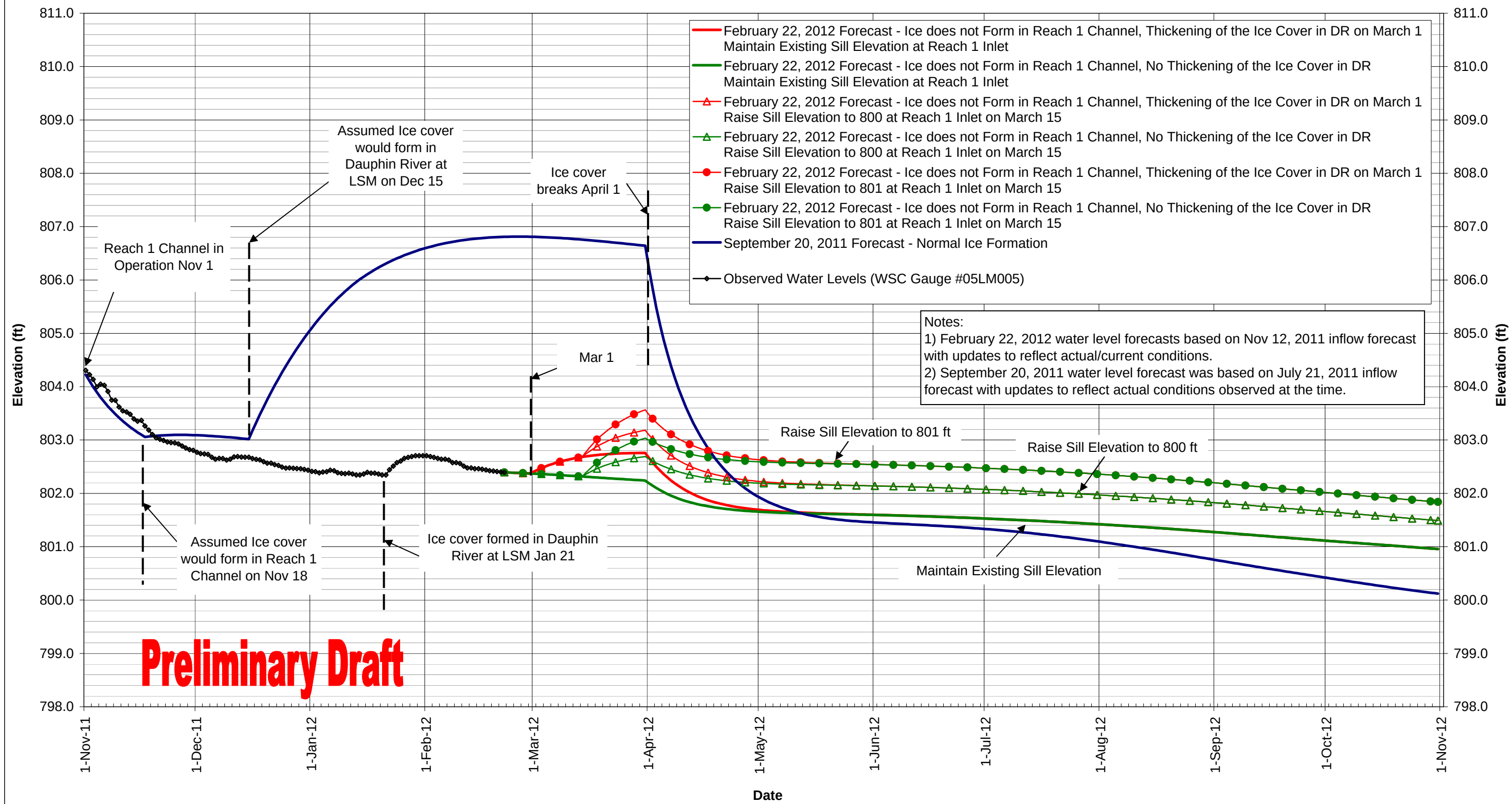
Director of Regional Operations
 Engineering and Operations, MIT
 West Central Region (04)
 Dauphin, MB

<personal information removed> (w)
 <personal information removed> (c)

**Lake Manitoba Forecast
Correspondence and Figures**

February 24, 2012

Figure 2.15.1
Computed Lake St. Martin Level
Comparison of Alternatives - Raising Reach 1 Inlet Sill Elevation



Preliminary Draft

Figure 2.15.2
Computed Lake St. Martin Outflow
Comparison of Alternatives - Raising Reach 1 Inlet Sill Elevation

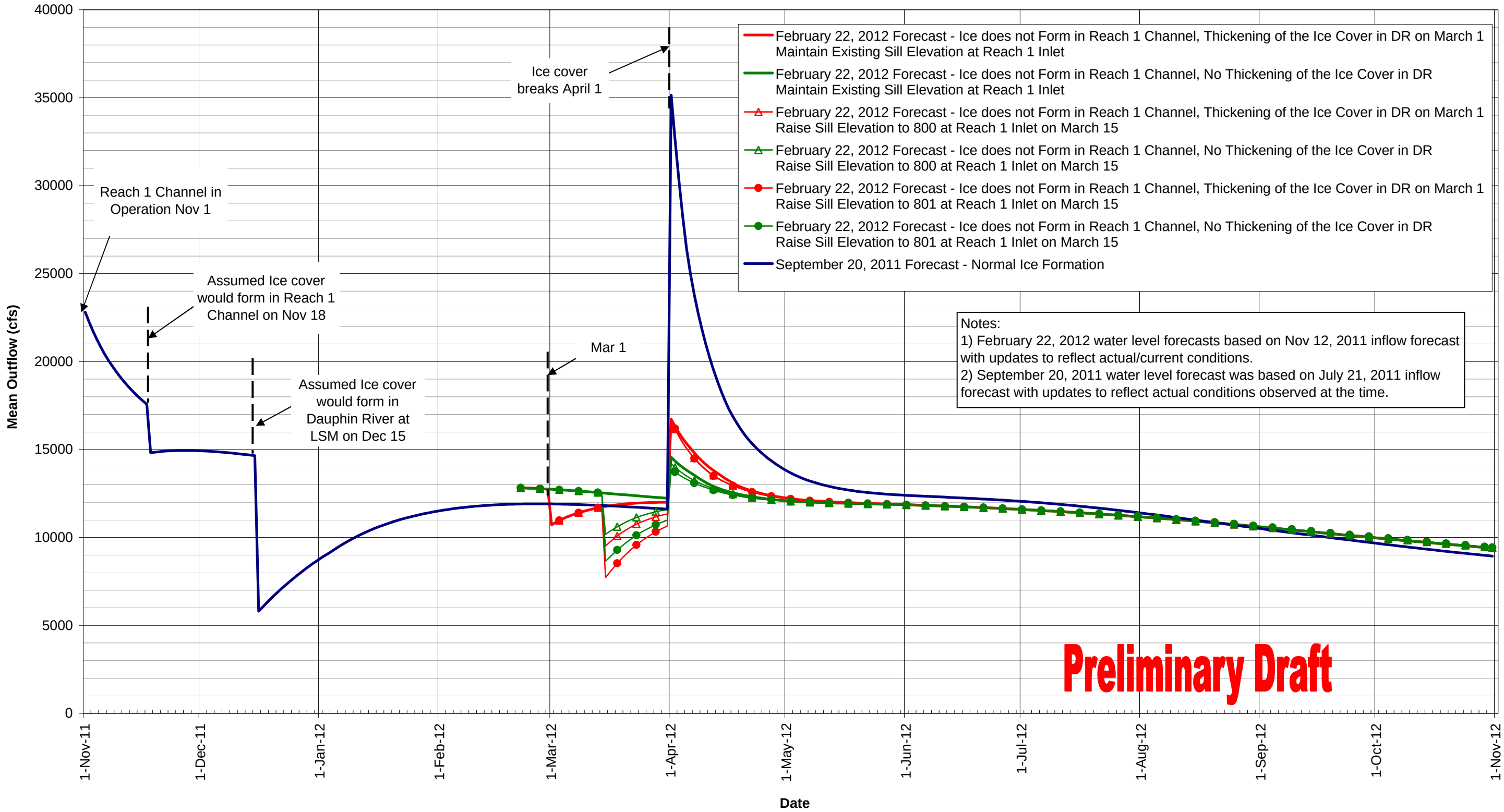
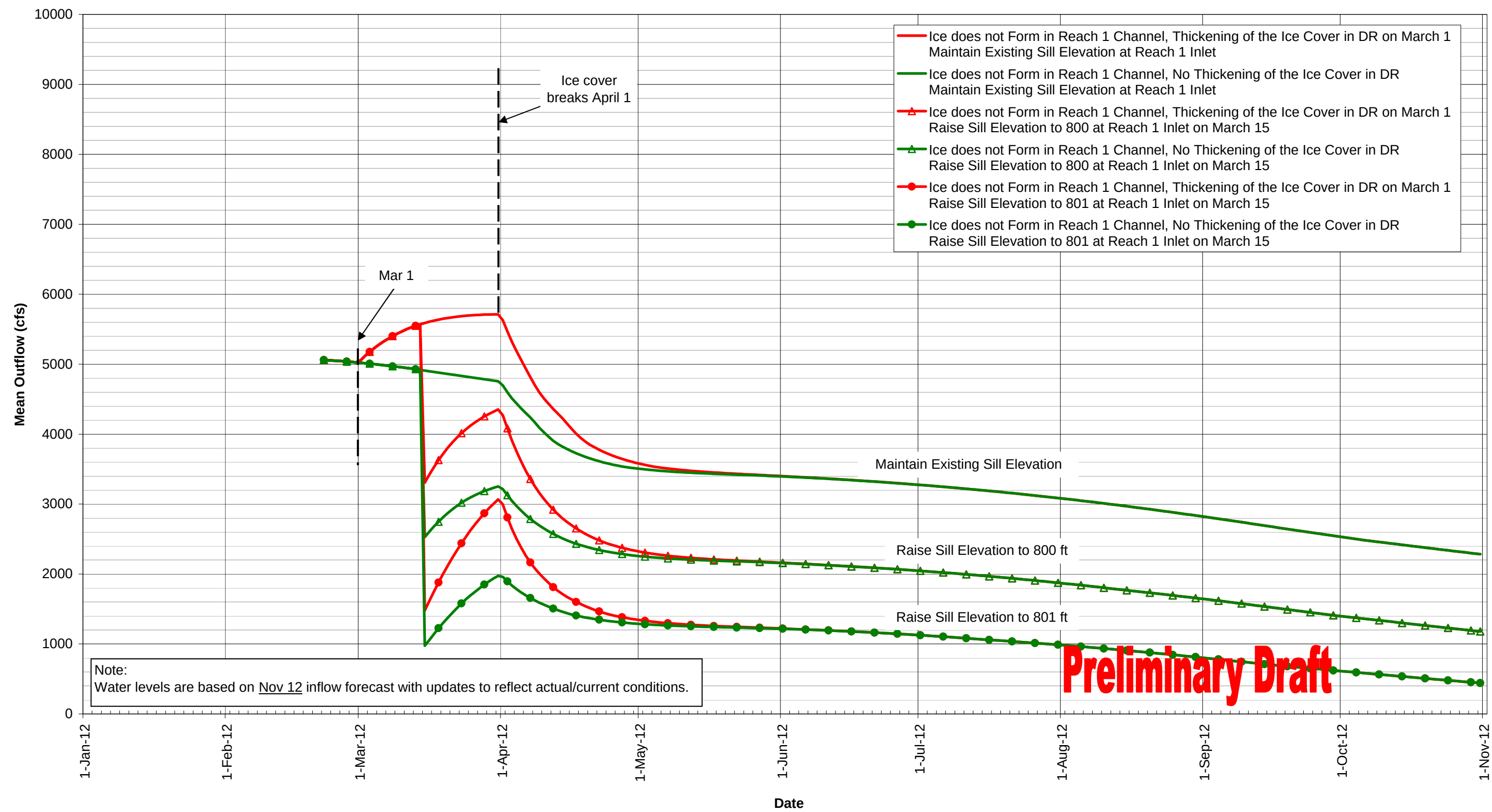


Figure 2.15.2b
Computed Buffalo Creek Outflow
Comparison of Alternatives - Raising Reach 1 Inlet Sill Elevation



**Lake Manitoba Forecast
Correspondence and Figures**

March 31, 2012

Garrett Wellwood

From: Patrice Leclercq [PLeclercq@kgsgroup.com]
Sent: Friday, March 01, 2013 8:03 AM
To: 'Patrice Leclercq'
Subject: FW: New Lake Manitoba Inflow Forecast & March 13, 2012 Hydrographs
Attachments: Figure 1.1.1 RevH.PDF; Figure 2.13.1 RevF.PDF; Figure 2.13.2 RevF.PDF

From: Colin Siepman [mailto:CSiepman@kgsgroup.com]
Sent: March-13-12 4:32 PM
To: Mark Allard ; Ron Kaatz; Ron Richardson
Cc: Brian Bodnaruk; Rob Kenyon; Bert Smith; Rick Carson; Dave MacMillan
Subject: New Lake Manitoba Inflow Forecast & March 13, 2012 Hydrographs

All,

Updated hydrographs are attached with discussion below as requested.

Impact on Lake Manitoba

The current hydrographs are based on a March 12, 2012 inflow forecast. These hydrographs indicate that the Fairford Water Control Structure must remain fully open throughout the 2012/2013 winter to reduce Lake Manitoba levels to roughly 811.5 by March 31st, 2013.

Impact on Lake St. Martin

The original hydrographs prior to the emergency exemption were based on a July 21, 2011 inflow forecast. These hydrographs indicated that Lake St. Martin levels would drop below elevation 801 by August 31, 2012.

The current hydrographs are based on a March 12, 2012 inflow forecast. These hydrographs indicate Lake St. Martin levels will not drop to 801 ft until the end of October 2012 assuming median inflow conditions. If the Reach 1 channel is closed on August 31 it would cause Lake St. Martin to quickly stage to approximately 802 ft, which is above the flood stage of 801.7 and well above the desirable operating range of 797 to 800 ft.

Further, depending on the timing of ice formation in the upper Dauphin River and the processes by which it happens, Lake St. Martin levels may begin to increase significantly in December 2012. If the Reach 1 channel is closed on August 31, 2012 and assuming an extreme ice jam forming on the Dauphin River at the outlet of the lake, the staging of Lake St. Martin could reach 805.5 during the 2012/2013 winter.

Impact on Dauphin River

Based on the current hydrographs, Lake St. Martin levels will drop to approximately 801 ft by the end of October if Reach 1 remains open. Assuming an early ice formation of Nov 10 in the Dauphin River Community, the total flow in the river in the community on that date would be approximately 9500 cfs.

Alternatively, if the Reach 1 channel is closed on August 31 it would cause Lake St. Martin to stage to approximately 802 ft by the end of October. Assuming the same early ice formation of Nov 10 in the Dauphin River Community, the total flow in the river in the community would also be approximately 9500 cfs

Therefore the closure of the Reach 1 channel does not impact the expected flows in the community, provided that Lake St. Martin has enough time to stage back to a level where the outflow is equal to inflow.

In 2010 the Dauphin River flow during the fall ice formation period was approximately 7000 cfs, which did

not result in flooding of the Communities, but came very close. KGS is currently evaluating the potential ice staging in the fall of 2012 due to a flow of 9500 cfs.

Recommendation

It is recommended to extend the operation of the Reach 1 channel from August 31 until the winter of 2012/13 to reduce Lake St. Martin levels. This may possibly extend until March 31 of 2013 if the Fairford Control Structure must remain fully open all winter to reduce Lake Manitoba Levels.

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
Senior Project Manager
KGS Group

From: Kaatz, Ron G (MIT) [<mailto:Ron.Kaatz@gov.mb.ca>]
Sent: March 12, 2012 3:47 PM
To: Colin Siepman; Brian Bodnaruk
Cc: Richardson, Ron (MIT); Allard, Mark (MIT)
Subject: FW: New Lake Manitoba Forecast

Hi Colin and Brian
Attached WSD numerical forecast to 31-Dec-12.

Do you know when your projections will be ready for viewing?
Thanks

Ron G. Kaatz, P. Eng.
Senior Hydraulic Engineer

Manitoba Infrastructure and Transportation
Engineering & Operations,
Water Control and Structures
Operations & Maintenance Branch
7th floor, 215 Garry St.
Winnipeg, Manitoba R3C 3P3
Ph: <personal information removed>
Cell: <personal information removed>
Fax: (204) 948-4503
e-mail: Ron.Kaatz@gov.mb.ca

From: Mutulu, Phillip (MWS)
Sent: March-12-12 1:32 PM
To: Kaatz, Ron G (MIT)
Subject: FW: New Lake Manitoba Forecast

Ron;

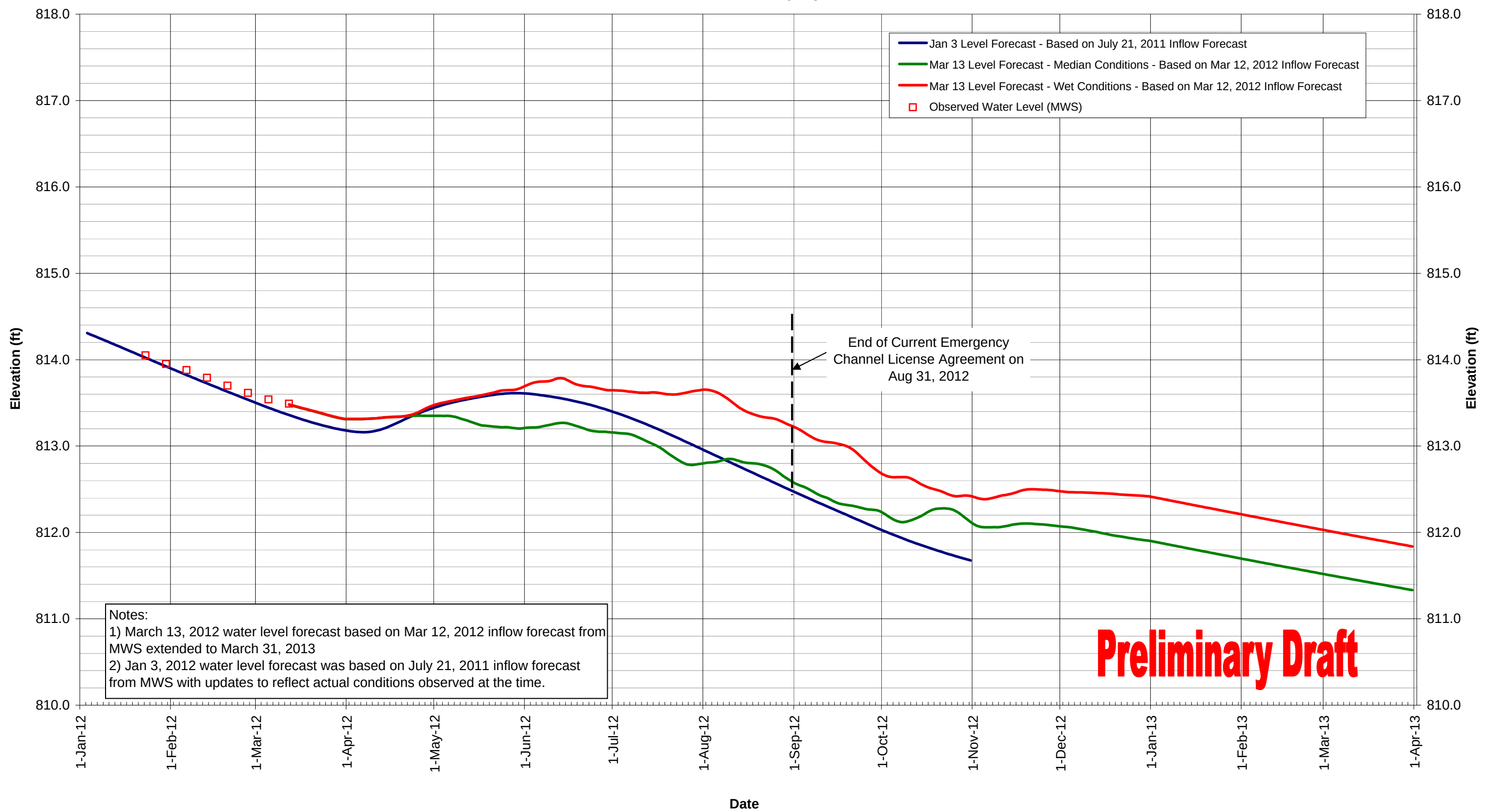
AS requested the graphics with their associated numerics are attached.

Thanks,

Phill

3/5/2013

Figure 1.1.1 RevH
Computed Lake Manitoba Level
Fairford Fully Open



Notes:
1) March 13, 2012 water level forecast based on Mar 12, 2012 inflow forecast from MWS extended to March 31, 2013
2) Jan 3, 2012 water level forecast was based on July 21, 2011 inflow forecast from MWS with updates to reflect actual conditions observed at the time.

Preliminary Draft

Figure 2.13.1 RevF
Computed Lake St. Martin Level
Reach 1 Channel in Operation

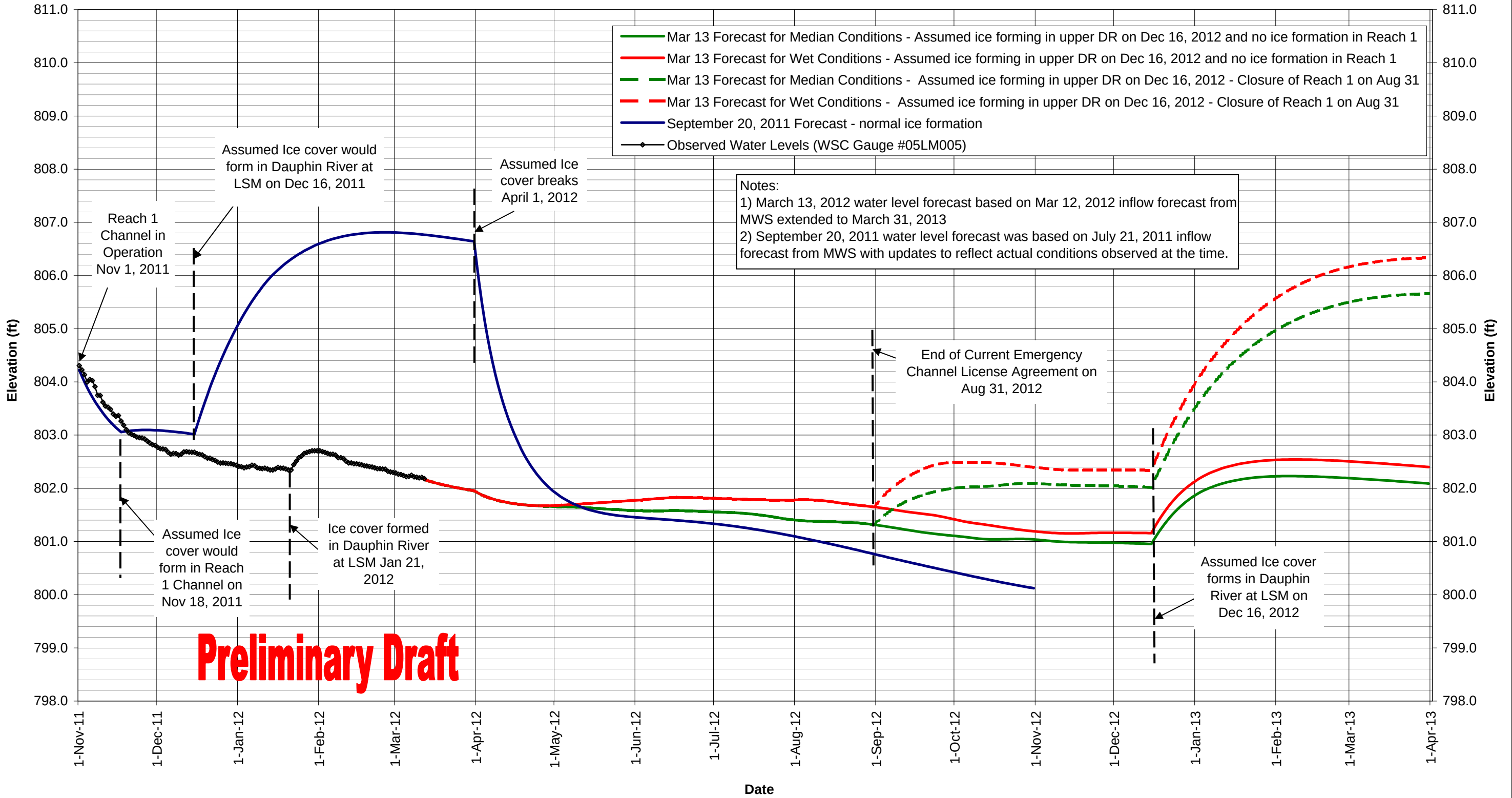
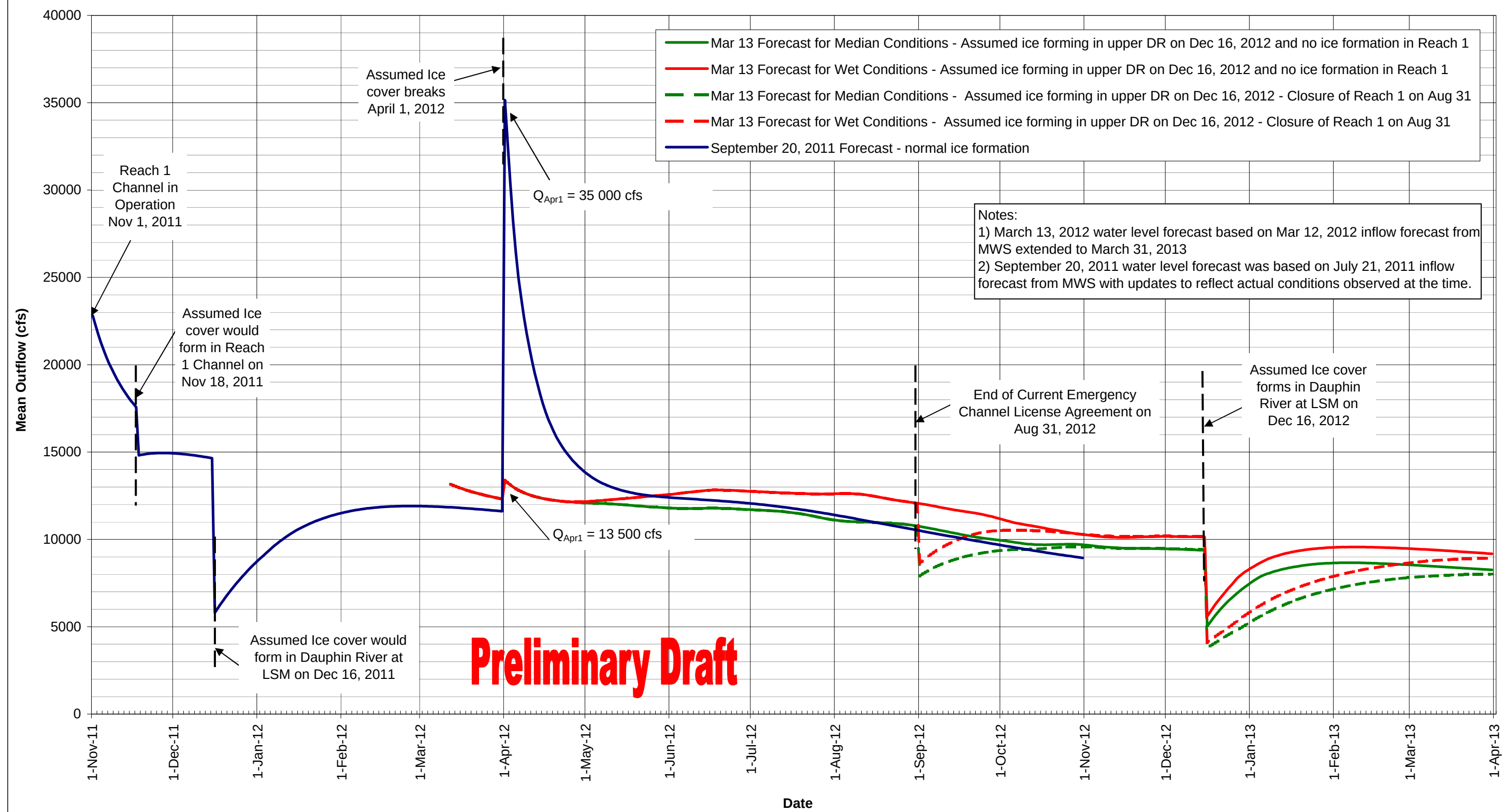


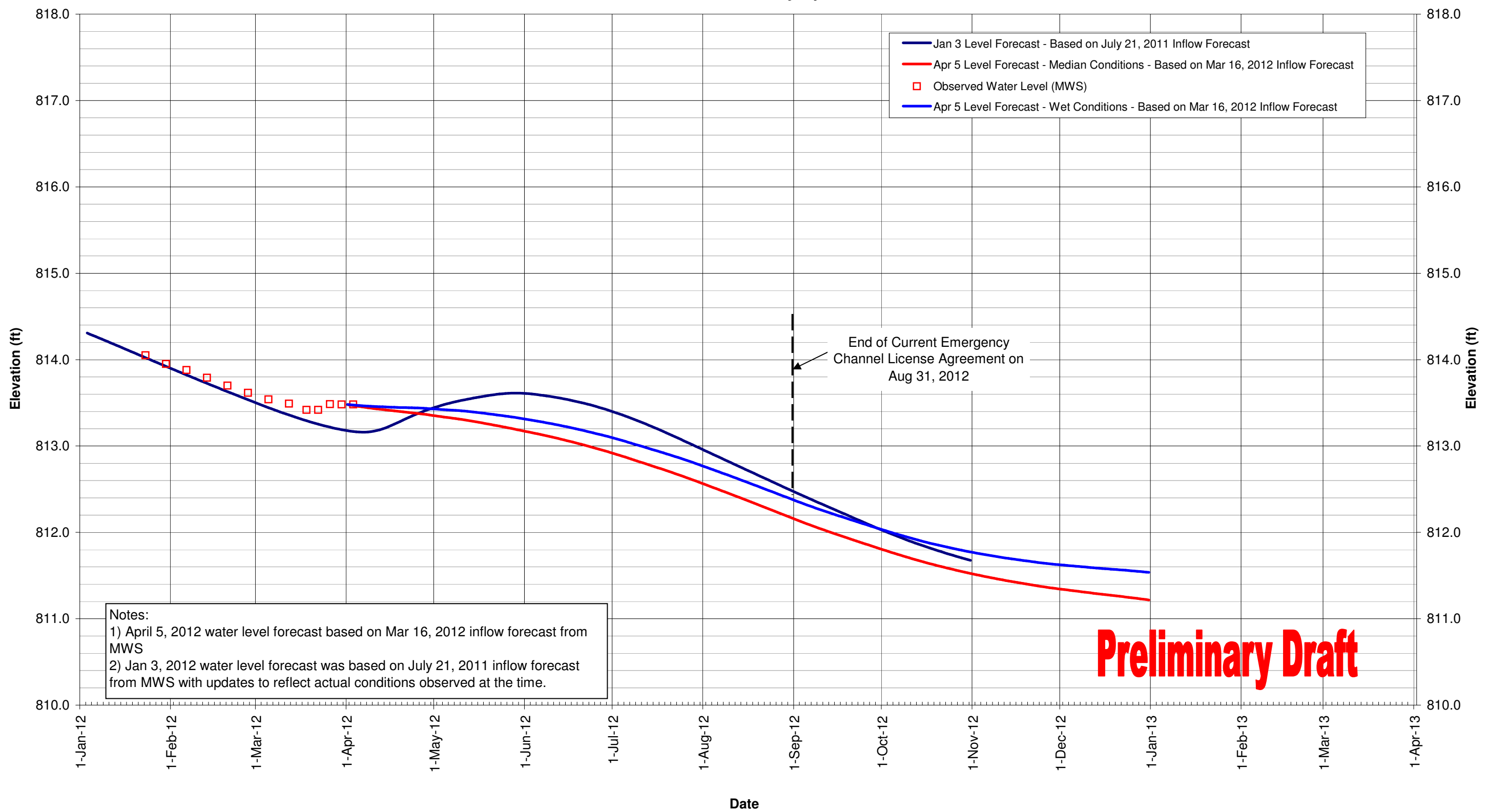
Figure 2.13.2 RevF
Computed Lake St. Martin Outflow
Reach 1 Channel in Operation



**Lake Manitoba Forecast
Correspondence and Figures**

April 5, 2012

Figure 1.1.1 Rev1
Computed Lake Manitoba Level
Fairford Fully Open



Notes:
1) April 5, 2012 water level forecast based on Mar 16, 2012 inflow forecast from MWS
2) Jan 3, 2012 water level forecast was based on July 21, 2011 inflow forecast from MWS with updates to reflect actual conditions observed at the time.

Preliminary Draft

**Lake Manitoba Forecast
Correspondence and Figures**

April 10, 2012

Figure 2.13.1 RevG
Computed Lake St. Martin Level
Reach 1 Channel in Operation

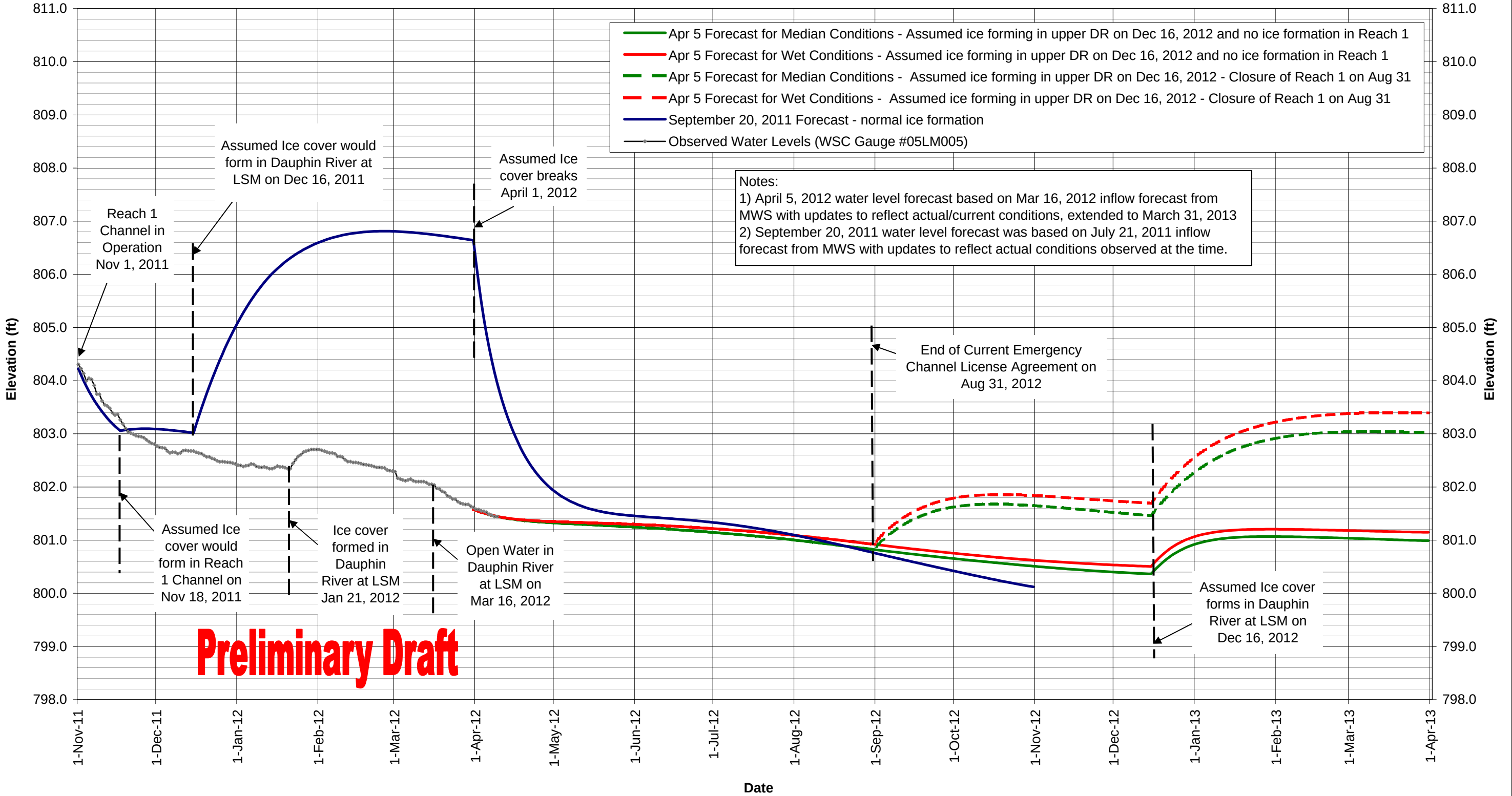
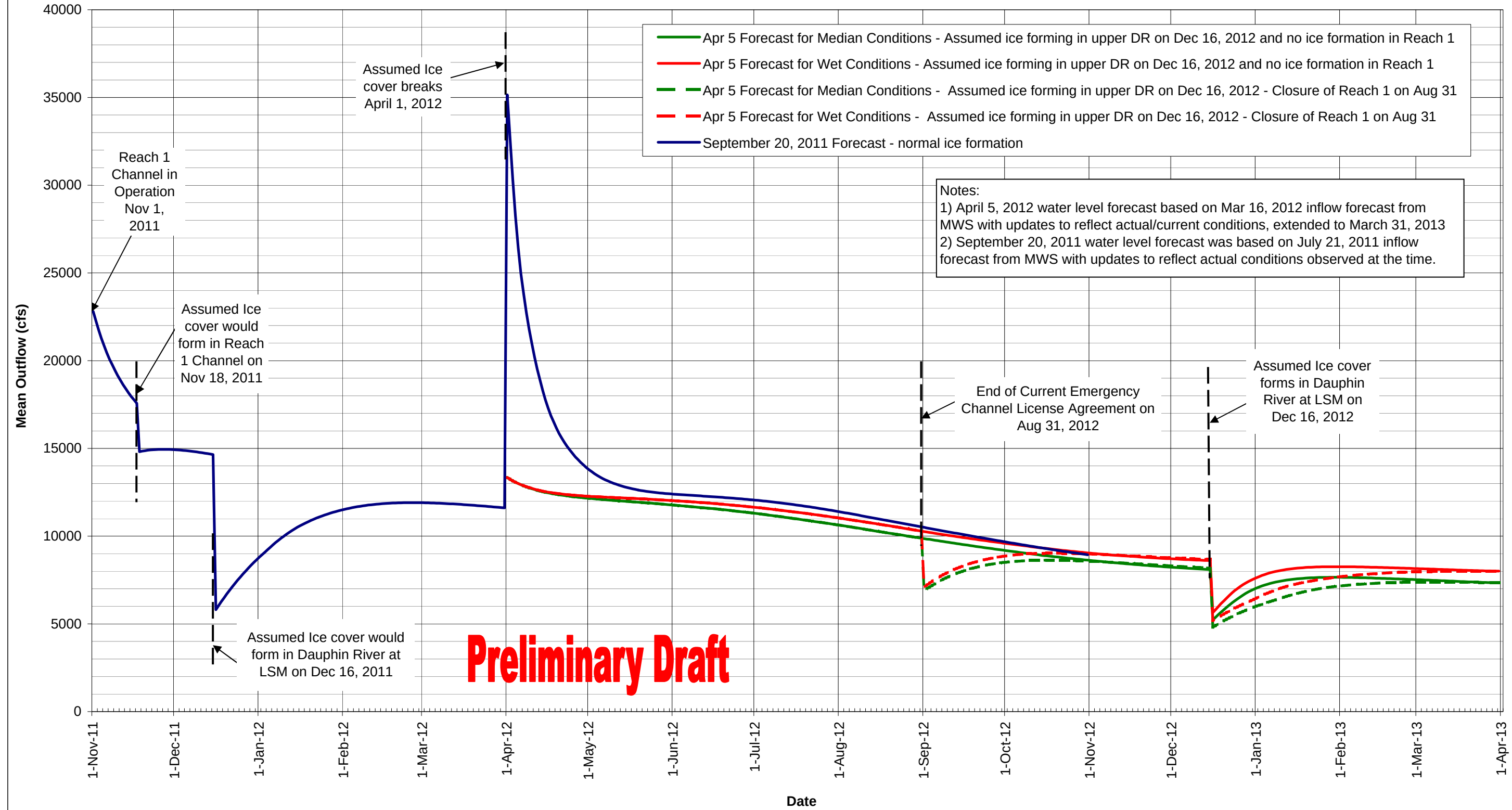


Figure 2.13.2 RevG
Computed Lake St. Martin Outflow
Reach 1 Channel in Operation



**Lake Manitoba Forecast
Correspondence and Figures**

April 12, 2012

Figure 2.13.1 RevH
Computed Lake St. Martin Level
Reach 1 Channel in Operation

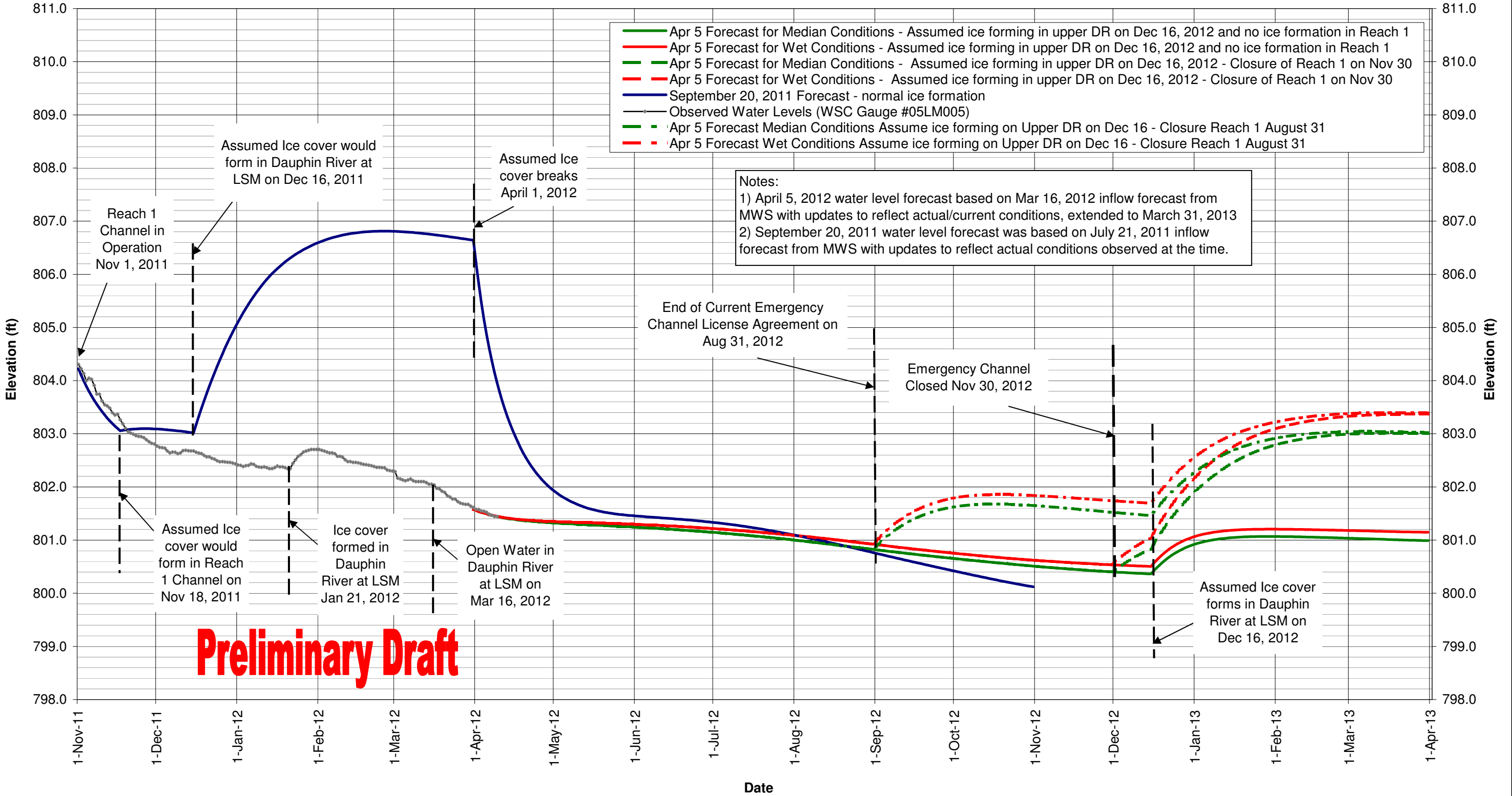
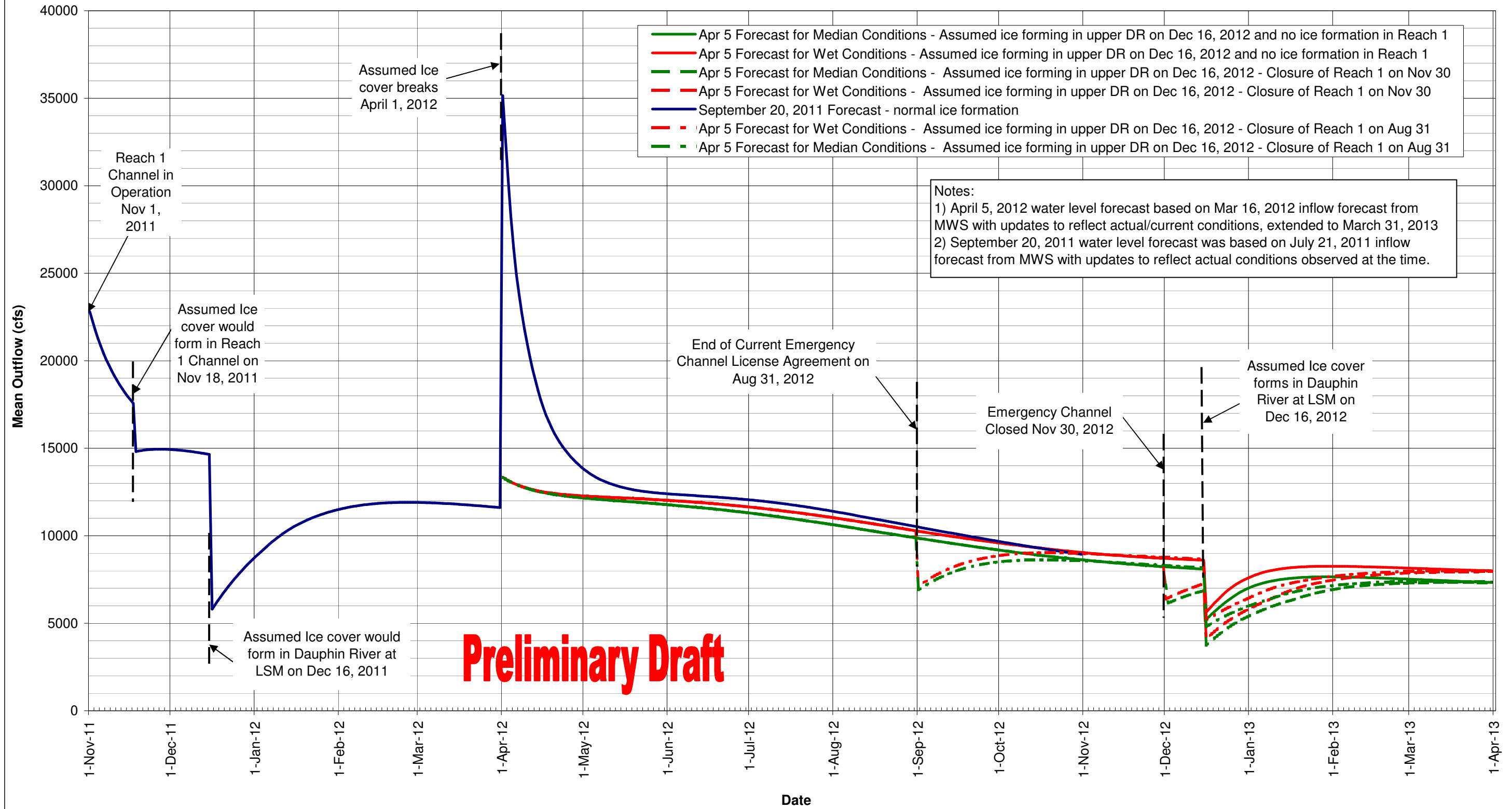


Figure 2.13.2 RevH
Computed Lake St. Martin Outflow
Reach 1 Channel in Operation



**Lake Manitoba Forecast
Correspondence and Figures**

June 30, 2012

Garrett Wellwood

From: Colin Siepman [CSiepman@kgsgroup.com]
Sent: Wednesday, July 04, 2012 4:15 PM
To: Ron Kaatz
Cc: Ron Richardson; Mark Allard ; Phillip Mutulu; Steve Topping; Brian Bodnaruk; Rick Carson; Bert Smith; Dave MacMillan; Rob Kenyon
Subject: End of June LMB and LSM Forecast
Attachments: Figure 2.13.2 RevI.pdf; Figure 1.1.1 RevJ.pdf; Figure 2.13.1 RevI.pdf

Ron,

Please find attached the revised Lake Manitoba and Lake St. Martin forecast for the end of June as requested. The water level forecast is based on the March 16 MWS inflow forecast updated to reflect actual / current conditions. As shown on the figures, we are currently tracking slightly above the wet forecast that was issued in April. This is due to the large amount of precipitation that occurred in May and June.

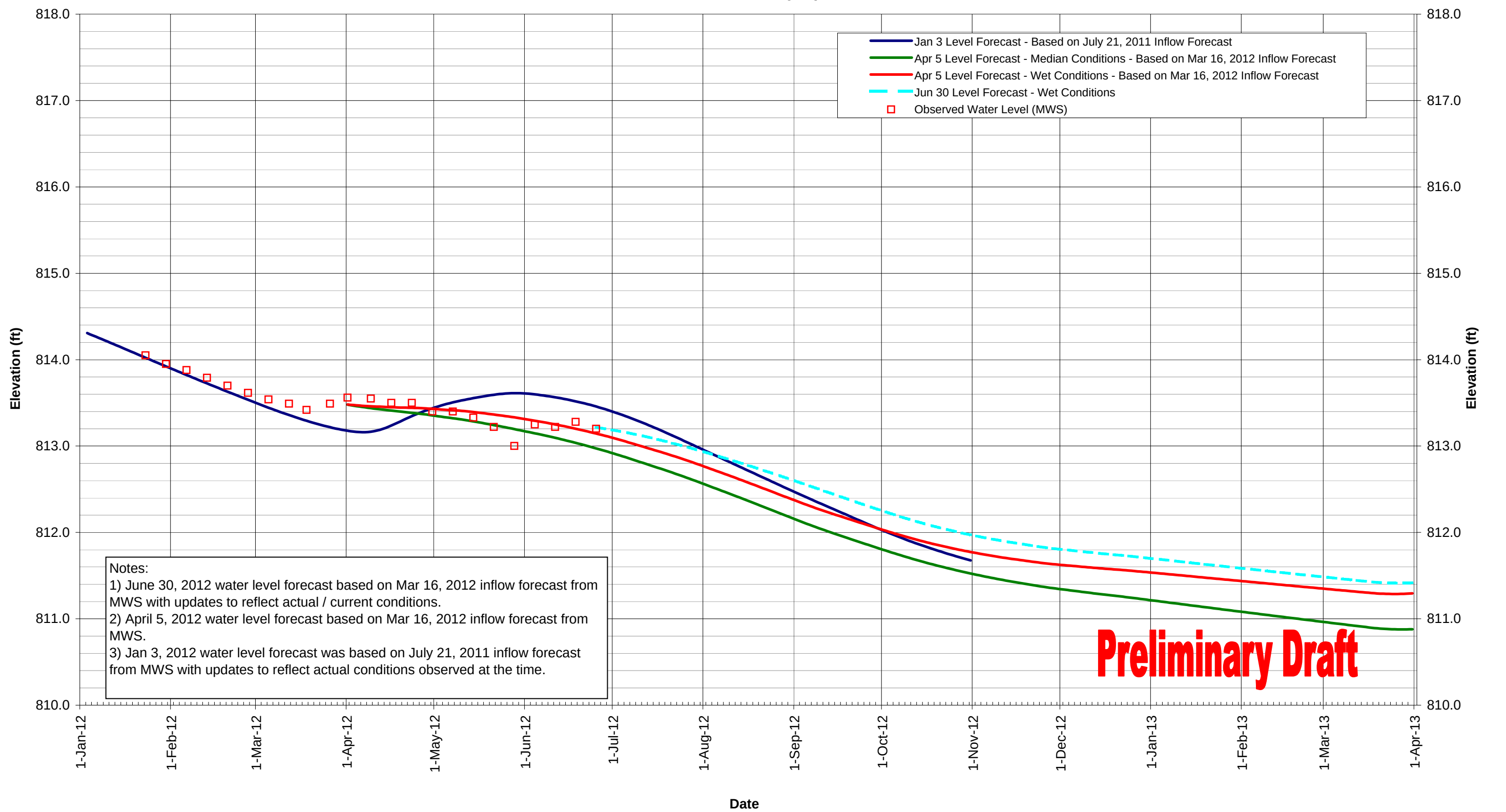
Note that, as per previous forecasts, the Lake St. Martin levels in the coming fall/winter are based on Fairford being fully open and are therefore subject to change pending a decision to operate the Fairford Control Structure.

Let us know if you have any questions or comments.

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
Senior Project Manager
KGS Group

Figure 1.1.1 RevJ
Computed Lake Manitoba Level
Fairford Fully Open



Notes:
1) June 30, 2012 water level forecast based on Mar 16, 2012 inflow forecast from MWS with updates to reflect actual / current conditions.
2) April 5, 2012 water level forecast based on Mar 16, 2012 inflow forecast from MWS.
3) Jan 3, 2012 water level forecast was based on July 21, 2011 inflow forecast from MWS with updates to reflect actual conditions observed at the time.

Preliminary Draft

Figure 2.13.1 RevI
Computed Lake St. Martin Level
Reach 1 Channel in Operation

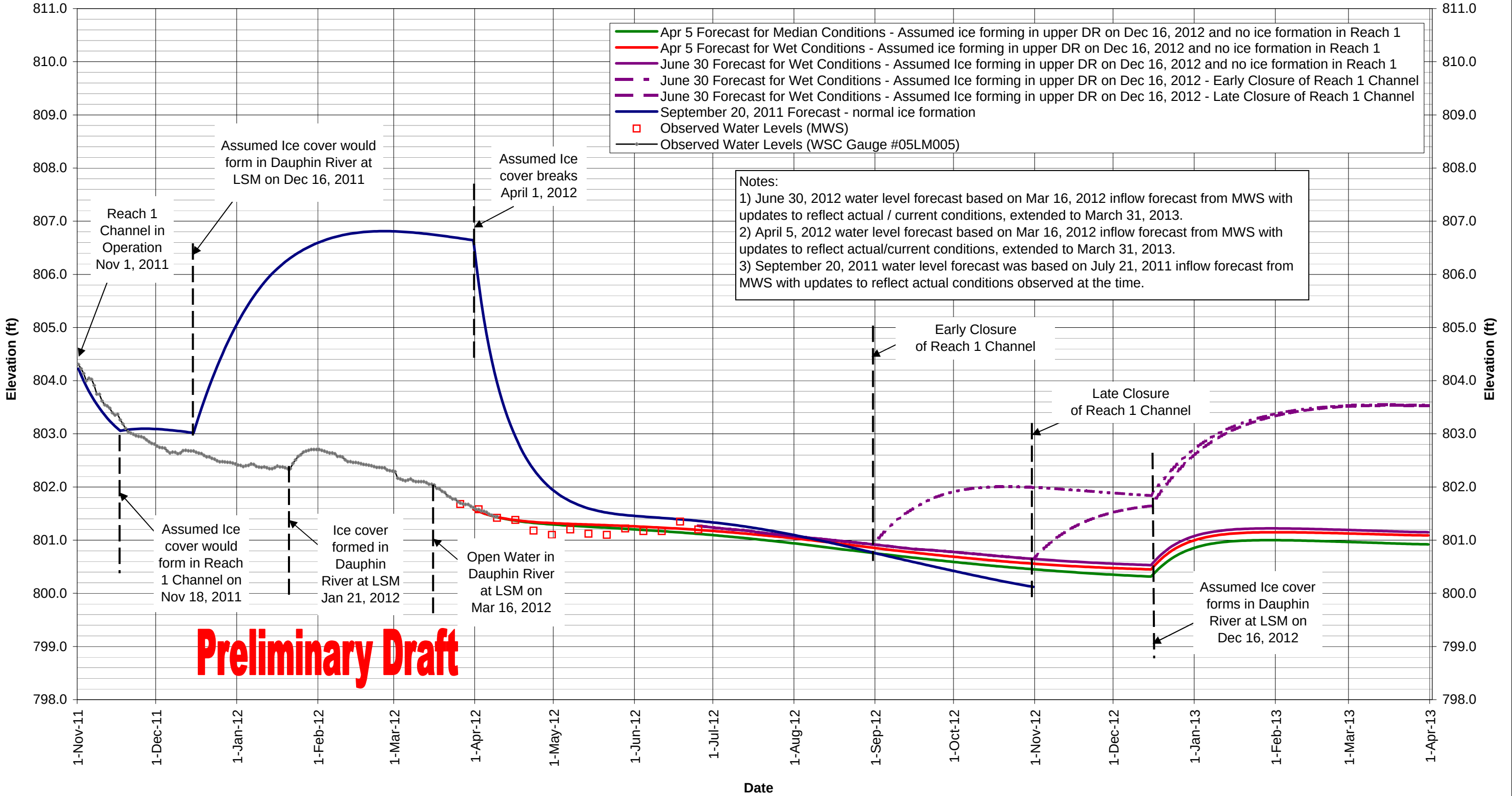
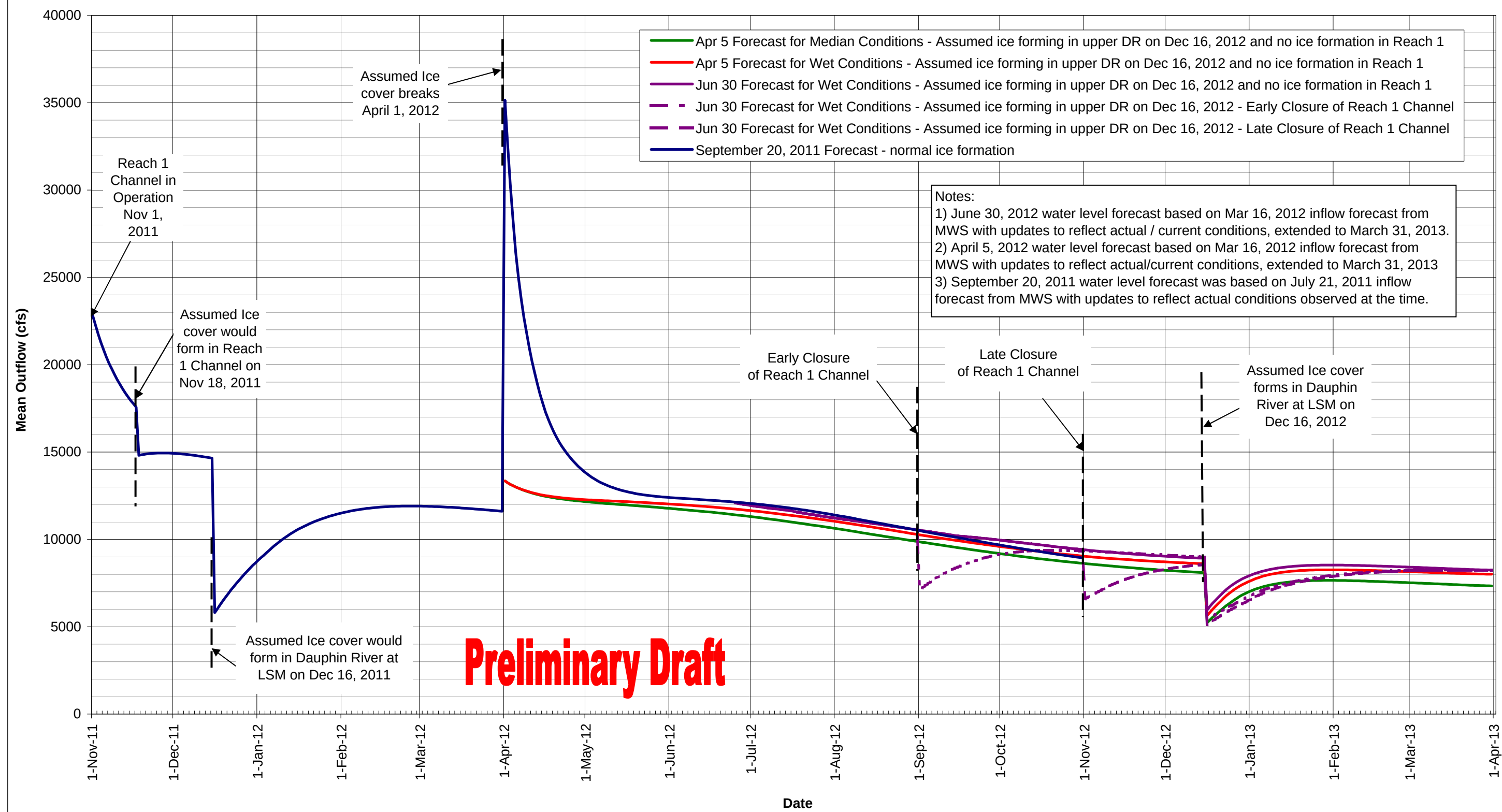


Figure 2.13.2 Rev1
Computed Lake St. Martin Outflow
Reach 1 Channel in Operation



**Lake Manitoba Forecast
Correspondence and Figures**

July 31, 2012

Garrett Wellwood

From: Colin Siepman [CSiepman@kgsgroup.com]
Sent: Thursday, August 02, 2012 3:14 PM
To: Ron Kaatz
Cc: Ron Richardson; Mark Allard ; Phillip Mutulu; Steve Topping; Brian Bodnaruk; Rick Carson; Bert Smith; Dave MacMillan; Rob Kenyon
Subject: End of July LMB and LSM Forecast & Figure for Flood Mailer
Attachments: LMB_With&Without LSMEOC.PDF; Figure 1.1.1 RevK.PDF; Figure 2.13.1 RevJ.PDF; Figure 2.13.2 RevJ.PDF

Ron,

Please find attached the updated Lake Manitoba and Lake St. Martin forecast for the end of July. The water level forecast is based on the March 16 MWS inflow forecast updated to reflect actual / current conditions. The end of July forecast has not changed significantly since our previous issue at the end of June. We are still tracking slightly above the wet forecast that was issued in April due to the large amount of precipitation that occurred in May and June.

Note that, as per previous forecasts, the lake levels in the coming fall/winter are based on Fairford being fully open and are therefore subject to change pending a decision to operate the Fairford River Water Control Structure.

Also attached is the figure requested by Steve Topping, which shows the benefits of operating the Lake St. Martin Emergency Channel to Lake Manitoba. The figure shows observed, estimated and forecasted water levels on Lake Manitoba between Aug. 1, 2011 and Nov. 1, 2012 with and without operation of the Lake St. Martin Emergency Channel.

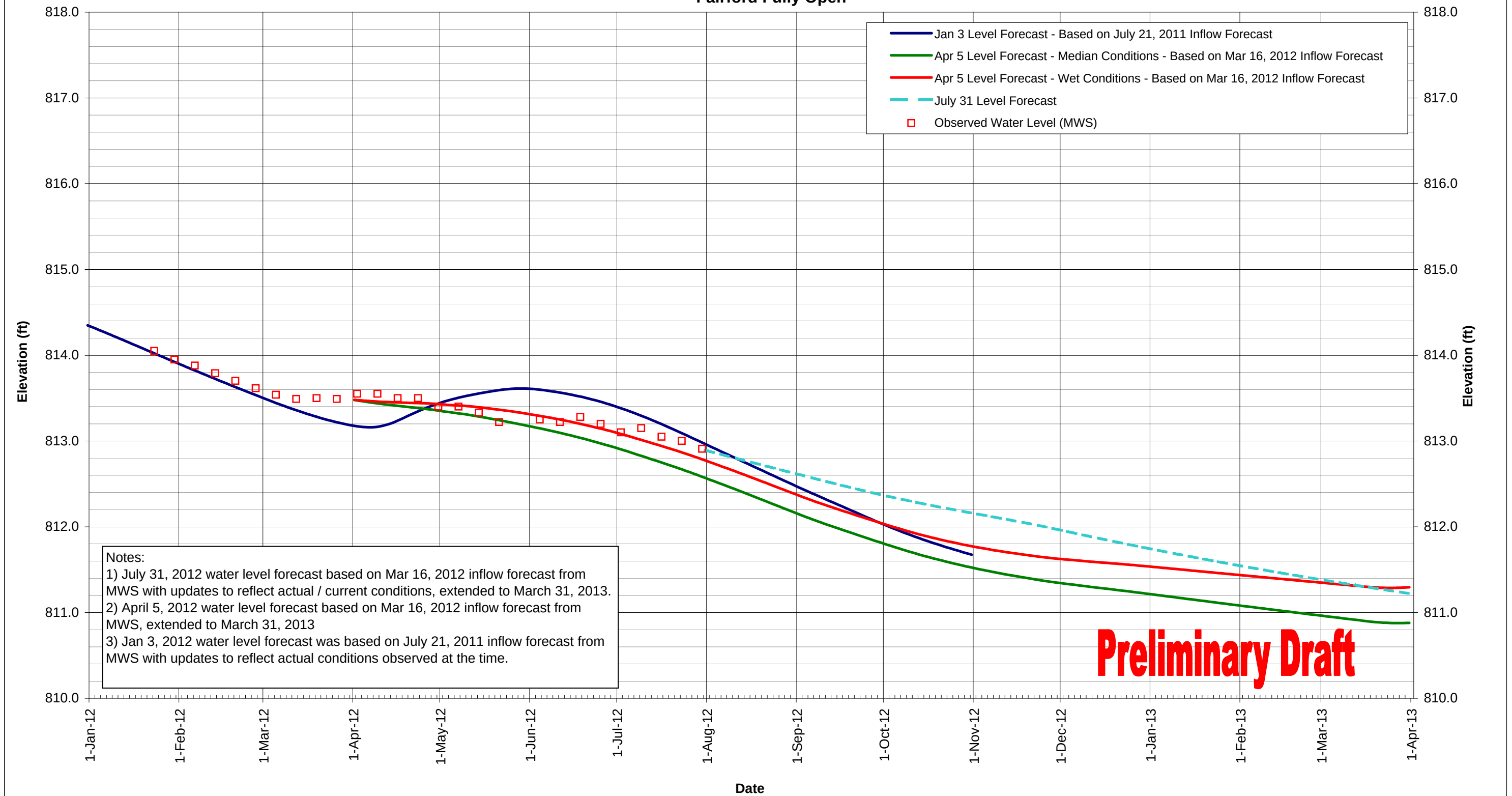
Let us know if you have any questions or comments.

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
Senior Project Manager
KGS Group

KGS Place
3rd Flr - 865 Waverley St.
Winnipeg, MB, R3T 5P4
Phone : (204) 896-1209
Fax : (204) 896-0754
CSiepman@kgsgroup.com

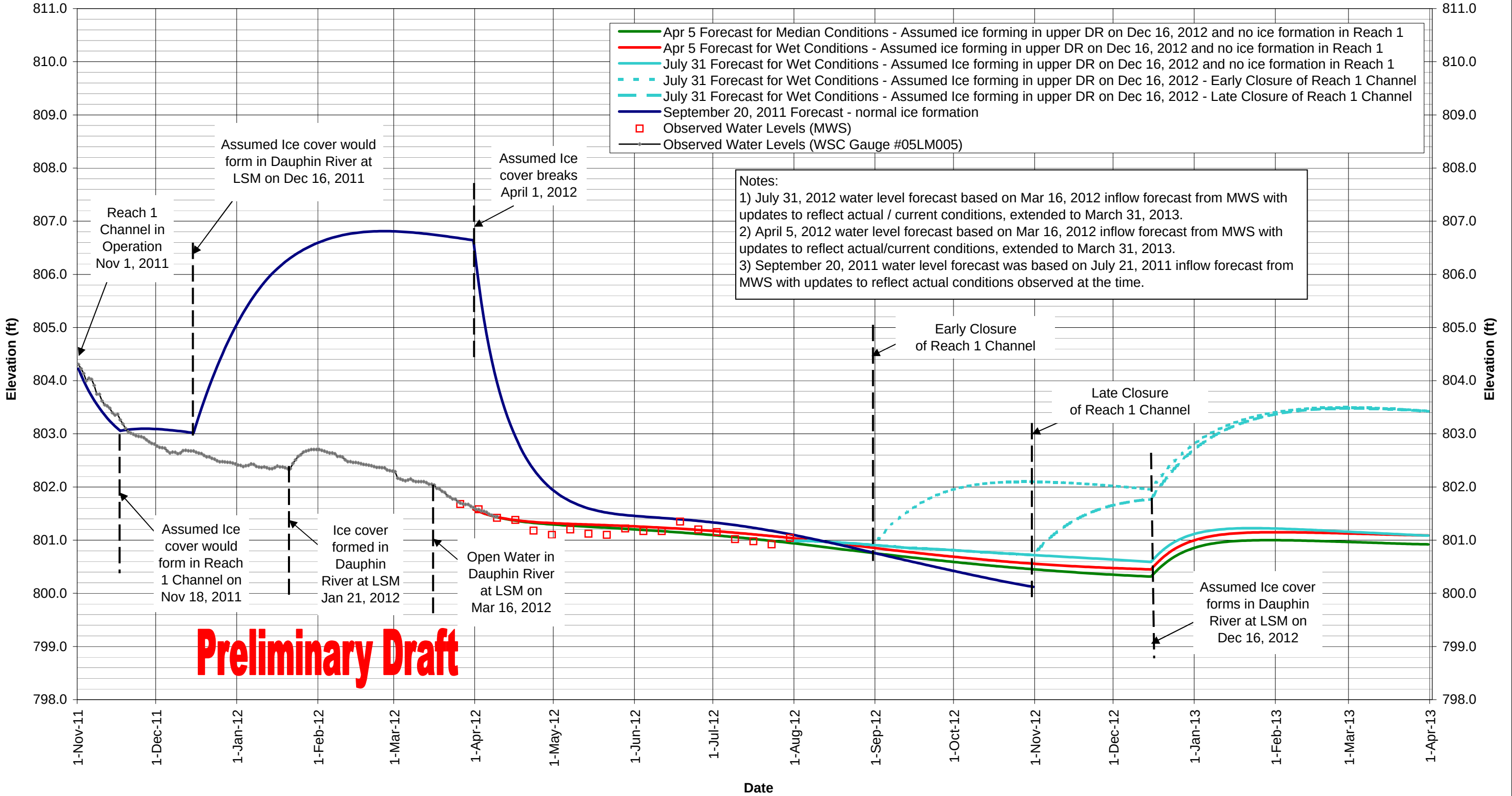
Figure 1.1.1 RevK
Computed Lake Manitoba Level
Fairford Fully Open



Notes:
1) July 31, 2012 water level forecast based on Mar 16, 2012 inflow forecast from MWS with updates to reflect actual / current conditions, extended to March 31, 2013.
2) April 5, 2012 water level forecast based on Mar 16, 2012 inflow forecast from MWS, extended to March 31, 2013
3) Jan 3, 2012 water level forecast was based on July 21, 2011 inflow forecast from MWS with updates to reflect actual conditions observed at the time.

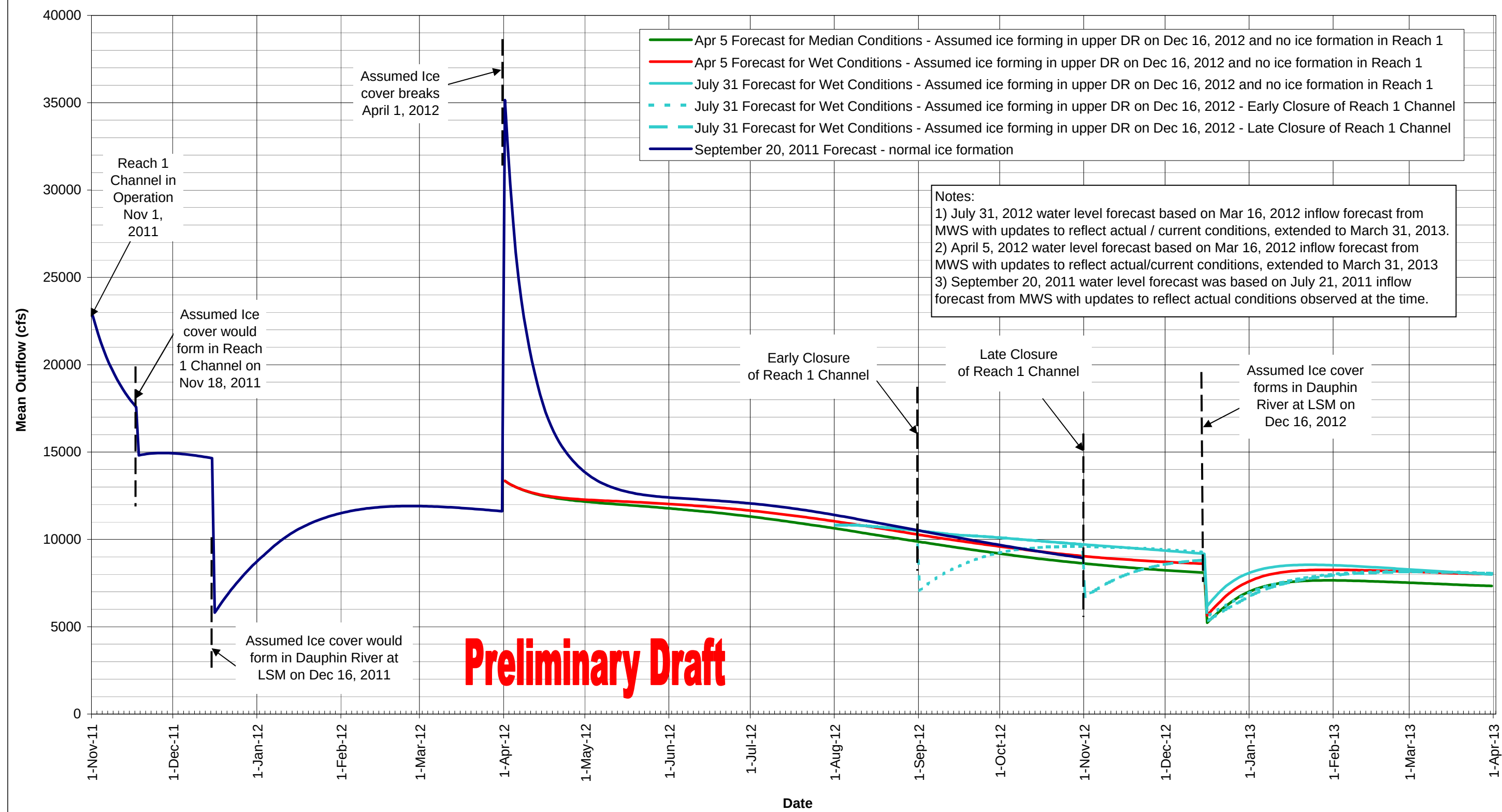
Preliminary Draft

Figure 2.13.1 RevJ
Computed Lake St. Martin Level
Reach 1 Channel in Operation



Preliminary Draft

Figure 2.13.2 RevJ
Computed Lake St. Martin Outflow
Reach 1 Channel in Operation



**Lake Manitoba Forecast
Correspondence and Figures**

August 15, 2012

Garrett Wellwood

From: Colin Siepman [CSiepman@kgsgroup.com]
Sent: Wednesday, August 15, 2012 3:14 PM
To: Steve Topping; Ron Kaatz
Cc: 'Richardson, Ron (MIT)'; Mark Allard ; 'Mutulu, Phillip (MWS)'; 'Brian Bodnaruk'; 'Rick Carson'; 'Bert Smith'; 'Dave MacMillan'; 'Rob Kenyon'
Subject: RE: End of July LMB and LSM Forecast - Updated with Fairford Winter Flow Restriction
Attachments: Figure 1.1.1 RevL.PDF; Figure 2.13.1 RevK.PDF; Figure 2.13.2 RevK.PDF

Steve & Ron,

As per your request a new water level forecast was added to the July 31 forecast, which assumes a late closure of the Reach 1 Emergency Channel (November 1, 2012) and winter flows restricted by the Fairford Control Structure to 5000 cfs from November 1, 2012 to February 14, 2013, and then increased to 8800 cfs from February 15, 2013 to March 31, 2013. The 5000 cfs & 8800 cfs flows were based on operating conditions during the winter of 2010-2011.

The water level forecast shows that Lake Manitoba levels would remain near 812.2 ft for the most part of the winter and decrease to 811.9 ft by March 31, 2013. Forecasted water levels in Lake St. Martin show similar levels to those observed in the winter of 2010-2011. Forecasted LSM levels on February 14 would be 801.4 ft compared to 801.2 ft in 2011 and 803.3 ft on March 31 compared to 802.8 ft in 2011.

If flows are held at 5000 cfs for the entire winter, levels on Lake St. Martin would be approximately 801.6 ft on March 31 instead of 803.3 ft. Levels on Lake Manitoba would remain at approximately 812.2 ft.

Note that the above values are still based on the March 16, 2012 inflow forecast from MWS with updates to reflect actual conditions. It is our understanding that MWS is currently generating an updated inflow forecast, which will be incorporated in our upcoming "End of August LMB and LSM Forecast".

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
 Senior Project Manager
 KGS Group

From: Colin Siepman [mailto:CSiepman@kgsgroup.com]
Sent: August 8, 2012 6:13 PM
To: 'Allard, Mark (MIT)'; 'Kaatz, Ron G (MIT)'
Cc: 'Richardson, Ron (MIT)'; 'Mutulu, Phillip (MWS)'; 'Topping, Steve (MWS)'; 'Brian Bodnaruk'; 'Rick Carson'; 'Bert Smith'; 'Dave MacMillan'; 'Rob Kenyon'
Subject: RE: End of July LMB and LSM Forecast & Figure for Flood Mailer

Mark,

Based on the July 31, 2012 water level forecast (Figure 2.13.1 RevJ attached), the projected water level on Lake St. Martin this upcoming winter, assuming closure of the Reach 1 channel, is 803.5 ft.

Based on the April 5, 2012 water level forecast (Figure 2.13.1 RevH attached), the projected water level on Lake St. Martin this upcoming winter, assuming closure of the Reach 1 channel and "median" conditions, was 803.0 ft.

Therefore the difference between the median forecast of April 5, 2012 and the recent forecast of July 31, 2012 is 0.5 ft.

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
Senior Project Manager
KGS Group

From: Allard, Mark (MIT) [mailto:Mark.Allard@gov.mb.ca]
Sent: August 8, 2012 1:11 PM
To: Colin Siepman; Kaatz, Ron G (MIT)
Cc: Richardson, Ron (MIT); Mutulu, Phillip (MWS); Topping, Steve (MWS); Brian Bodnaruk; Rick Carson; Bert Smith; Dave MacMillan; Rob Kenyon
Subject: RE: End of July LMB and LSM Forecast & Figure for Flood Mailer

Colin, would there be much of a difference in the projected water level on Lake St. Martin using the median forecast and the closure of Reach 1.

Mark G. Allard, P. Eng.

Director of Regional Operations
Engineering and Operations, MIT
West Central Region (04)
Dauphin, MB

<personal information removed> (w)
<personal information removed> (c)

From: Colin Siepman [mailto:CSiepman@ksgsgroup.com]
Sent: August-02-12 3:14 PM
To: Kaatz, Ron G (MIT)
Cc: Richardson, Ron (MIT); Allard, Mark (MIT); Mutulu, Phillip (MWS); Topping, Steve (MWS); Brian Bodnaruk; Rick Carson; Bert Smith; Dave MacMillan; Rob Kenyon
Subject: End of July LMB and LSM Forecast & Figure for Flood Mailer

Ron,

Please find attached the updated Lake Manitoba and Lake St. Martin forecast for the end of July. The water level forecast is based on the March 16 MWS inflow forecast updated to reflect actual / current conditions. The end of July forecast has not changed significantly since our previous issue at the end of June. We are still tracking slightly above the wet forecast that was issued in April due to the large amount of precipitation that occurred in May and June.

Note that, as per previous forecasts, the lake levels in the coming fall/winter are based on Fairford being fully open and are therefore subject to change pending a decision to operate the Fairford River Water Control Structure.

Also attached is the figure requested by Steve Topping, which shows the benefits of operating the Lake St. Martin Emergency Channel to Lake Manitoba. The figure shows observed, estimated and forecasted water levels on Lake Manitoba between Aug. 1, 2011 and Nov. 1, 2012 with and without operation of the Lake St. Martin Emergency Channel.

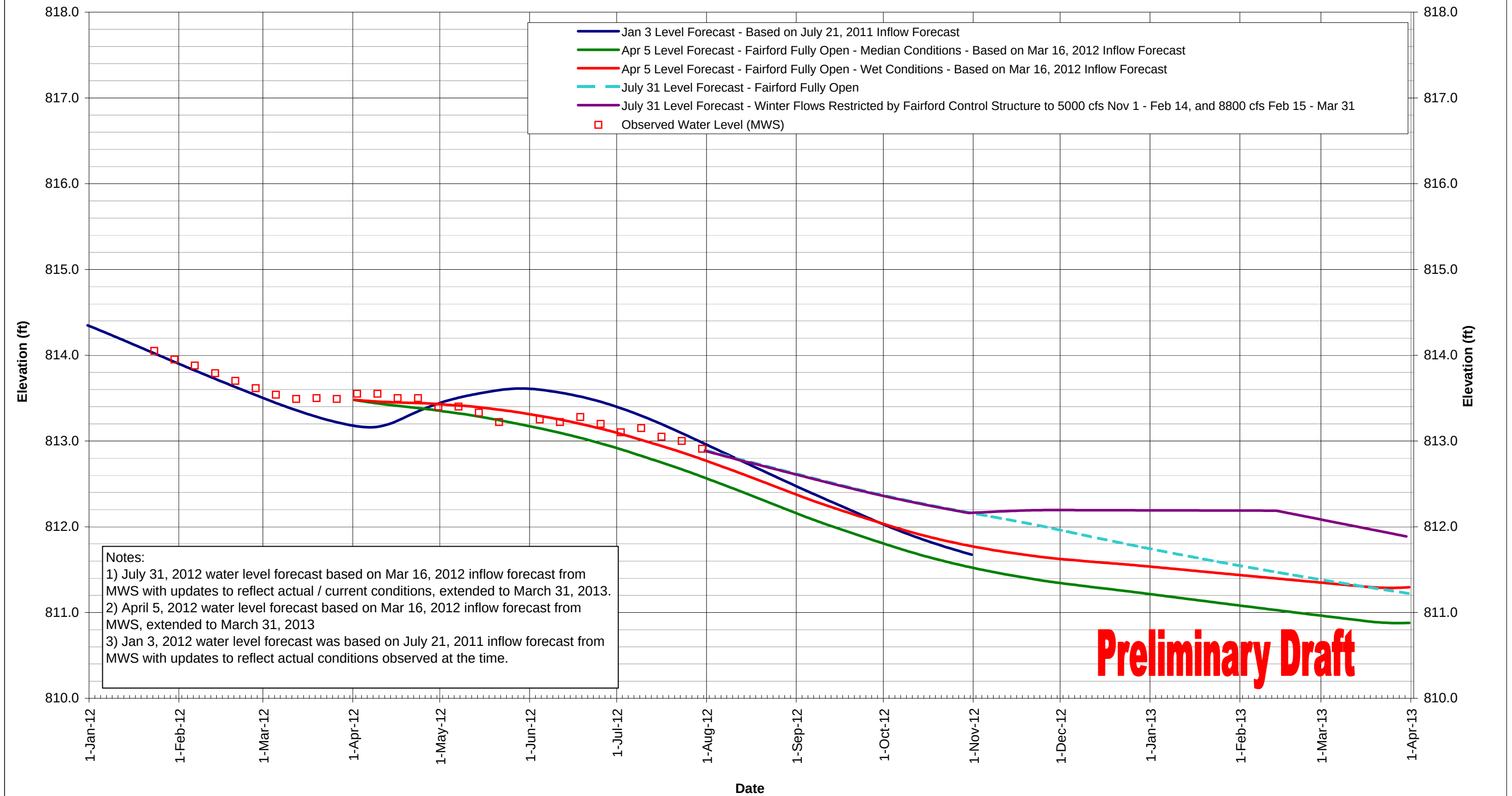
Let us know if you have any questions or comments.

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
Senior Project Manager
KGS Group

KGS Place
3rd Flr - 865 Waverley St.
Winnipeg, MB, R3T 5P4
Phone : (204) 896-1209
Fax : (204) 896-0754
CSiepman@ksgsgroup.com

Figure 1.1.1 RevL
Computed Lake Manitoba Level



Notes:
1) July 31, 2012 water level forecast based on Mar 16, 2012 inflow forecast from MWS with updates to reflect actual / current conditions, extended to March 31, 2013.
2) April 5, 2012 water level forecast based on Mar 16, 2012 inflow forecast from MWS, extended to March 31, 2013
3) Jan 3, 2012 water level forecast was based on July 21, 2011 inflow forecast from MWS with updates to reflect actual conditions observed at the time.

Preliminary Draft

Figure 2.13.1 RevK
Computed Lake St. Martin Level

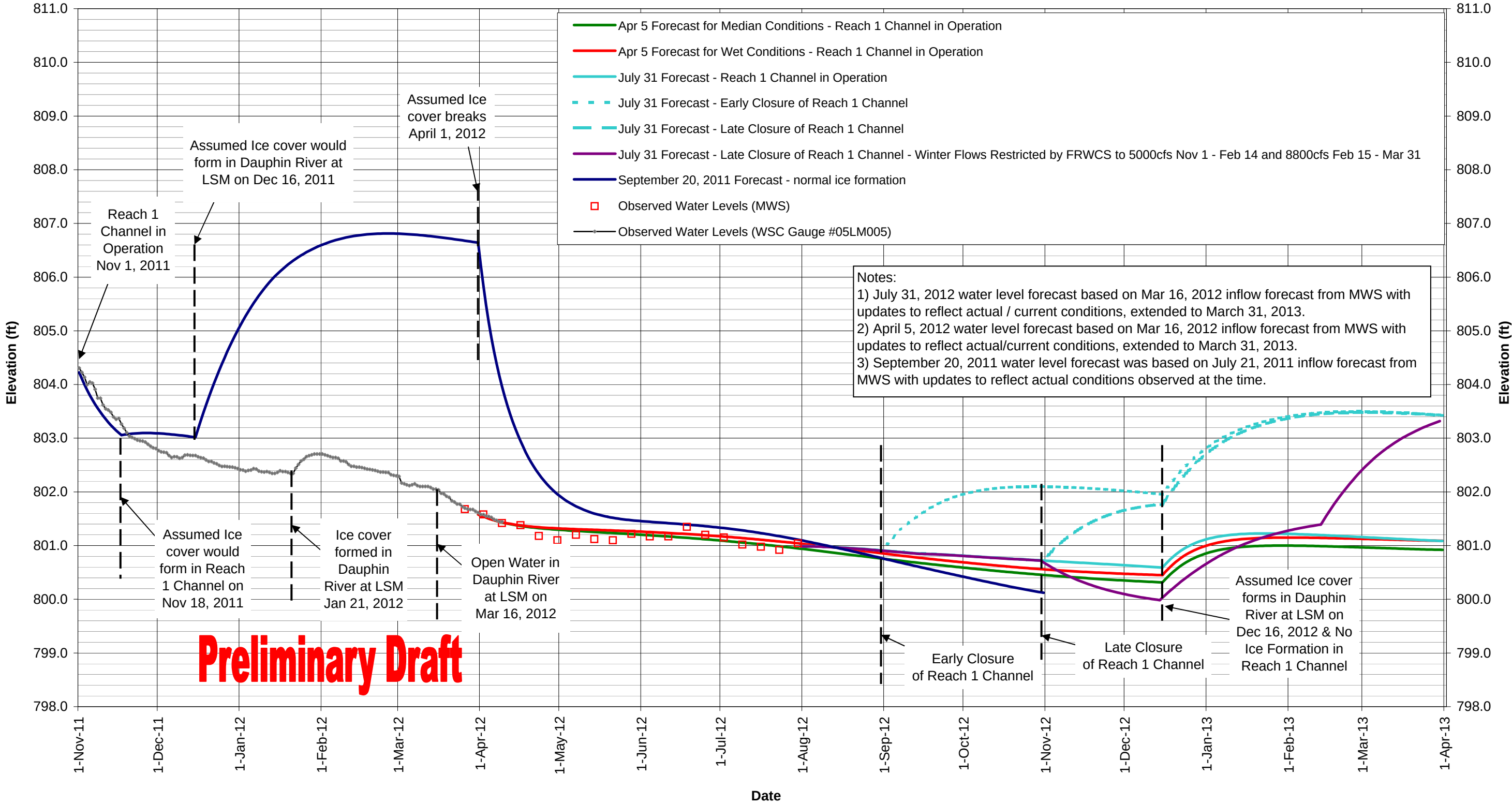
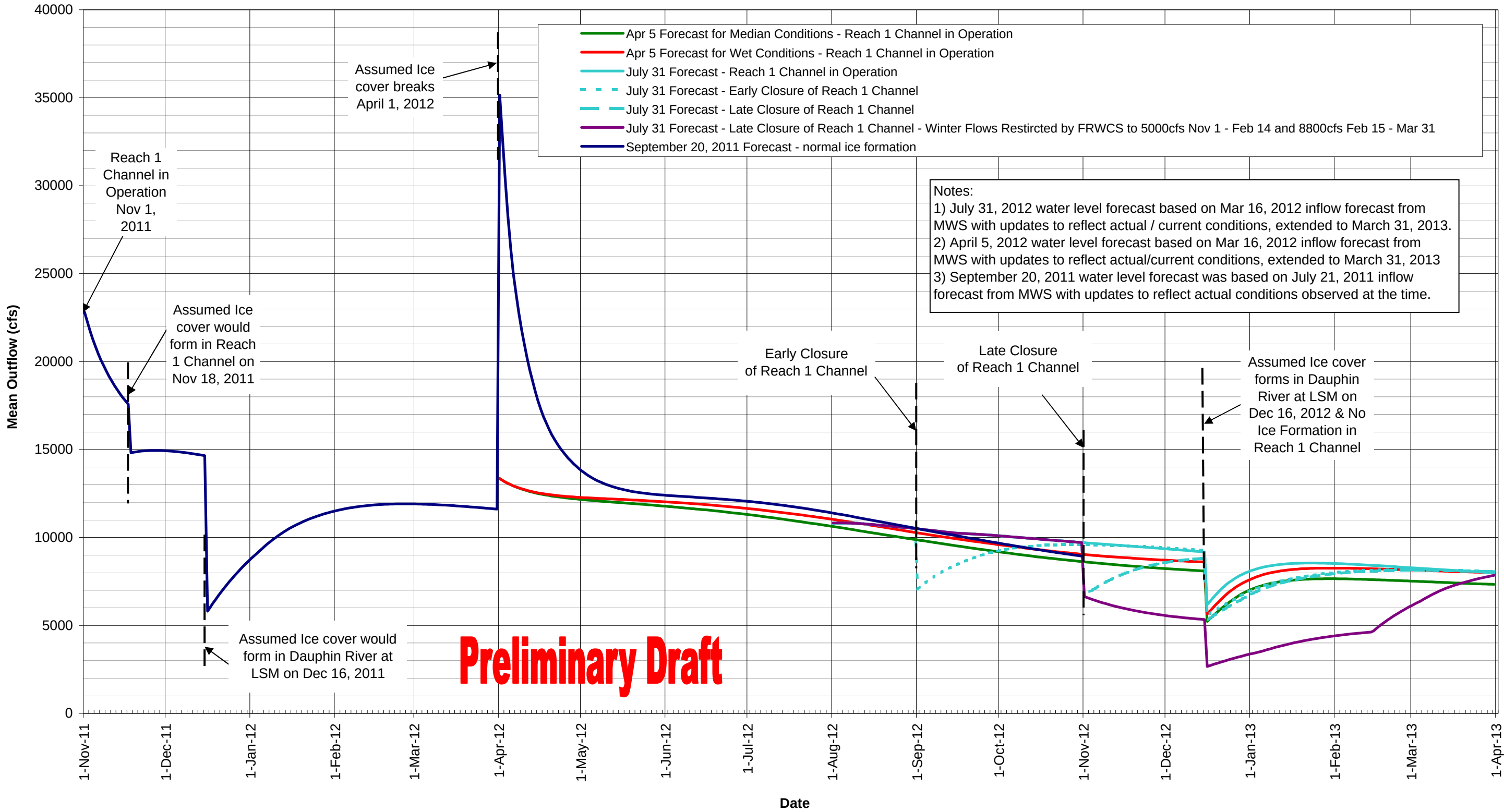


Figure 2.13.2 RevK
Computed Lake St. Martin Outflow



**Lake Manitoba Forecast
Correspondence and Figures**

August 31, 2012

Garrett Wellwood

From: Colin Siepman [CSiepman@ksgsgroup.com]
Sent: Thursday, September 06, 2012 10:06 AM
To: 'Topping, Steve (MIT)'; Ron Kaatz
Cc: 'Mutulu, Phillip (MIT)'; 'McMahon, Doug (MIT)'; 'Richardson, Ron (MIT)'; Mark Allard ; Brian Bodnaruk; Rick Carson; Bert Smith; Dave MacMillan; Rob Kenyon
Subject: End of August LMB and LSM Forecast

Attachments: Figure 1.1.1 RevM.PDF; Figure 2.13.1 RevL.PDF; Figure 2.13.2 RevL.PDF

Please find attached the updated Lake Manitoba and Lake St. Martin forecast for the end of August. The water level forecast is based on the Lake Manitoba inflow forecast that was provided by the Hydrologic Forecast Centre, Manitoba Infrastructure and Transportation on August 28, 2012.

As requested, a forecast was prepared for the following three operating scenarios:

- Lake St. Martin Emergency Channel (LSMEC) in operation with Fairford River Water Control Structure (FRWCS) fully open
- Closure of LSMEC on November 1 with FRWCS fully open
- Closure of LSMEC on November 1 with flows restricted by FRWCS to 5000 cfs Nov 1 to Feb 14 and 8000 cfs Feb 15 to Mar 31

Each scenario considered lower decile, median and upper decile weather conditions and flows. A summary of the forecast for the median weather conditions and flows is provided below.

Lake Manitoba

The Lake Manitoba water level at the end of August was 812.5 ft. The median water level is expected to recede to approximately 811.9 ft by November 1, 2012. After November 1, the Lake would continue to recede to approximately 811.3 ft by March 31, 2013 with the FRWCS fully open. However, if flows are restricted by the FRWCS during the winter the median water level is expected to rise to approximately 812.1 ft by February 14, 2013 and then recede back to approximately 811.9 ft by March 31, 2013.

Lake St. Martin

The Lake St. Martin water level at the end of August was 800.7 ft. The median water level is forecasted to recede to approximately 800.5 ft by November 1, 2012. After November 1, the Lake is expected to rise during the winter due to ice formation in the upper Dauphin River and the median water level on March 31, 2013 is forecasted to be approximately 801.0 ft with the LSMEC in operation. With the closure of LSMEC on November 1 and with FRWCS fully open, the forecasted median Lake level on March 31 is expected to rise to approximately 803.4 ft. With the closure of LSMEC on November 1, and flows restricted by the FRWCS during the winter, the Lake St. Martin water level on March 31 is forecasted to be approximately 803.0 ft. Note that with closure of the LSMEC, the forecasted median Lake St. Martin water level on March 31, 2013 with FRWCS fully open is only 0.4 ft higher than the forecasted water level with flows restricted by the FRWCS.

Dauphin River

Median flows in the Dauphin River during an early ice formation in the DRFN Community on November 10, 2012, are forecasted to be approximately 9,000 cfs with the LSMEC in operation. Flows are expected to be less on November 10 with closure of the LSMEC or with the winter flows being restricted by the FRWCS. A review of the potential maximum ice staging in the DRFN community for a flow of 9500 cfs was previously completed by the Frazil Ice Team to assess the potential inundation in the DRFN community without the dikes in place (e-mail sent April 2, 2012). This review indicated that the freeboard above the water surface profile was greater than 0.5 m for all buildings.

At ice breakup on April 1, 2013, median flows in the DRFN Community are forecasted to peak at approximately 13,500 cfs with closure of the LSMEC and with FRWCS fully open. Peak flows at ice

breakup on April 1 would be less with LSMEC in operation or with winter flows restricted by the FRWCS due to a lower Lake St. Martin level at ice breakup. The median forecasted peak flow of 13,500 cfs is substantially less than the forecasted 24,710 cfs peak flow that we prepared for in the spring of 2012. However, a detailed review of the potential inundation in the community without the dikes in place for a flow of 13,500 cfs at ice breakup has not been completed.

Let us know if you have any questions or comments. We are also available for a meeting to further discuss the forecast and the potential impacts of the different operating scenarios to Lake Manitoba, Lake St. Martin and the Dauphin River.

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
Senior Project Manager
KGS Group

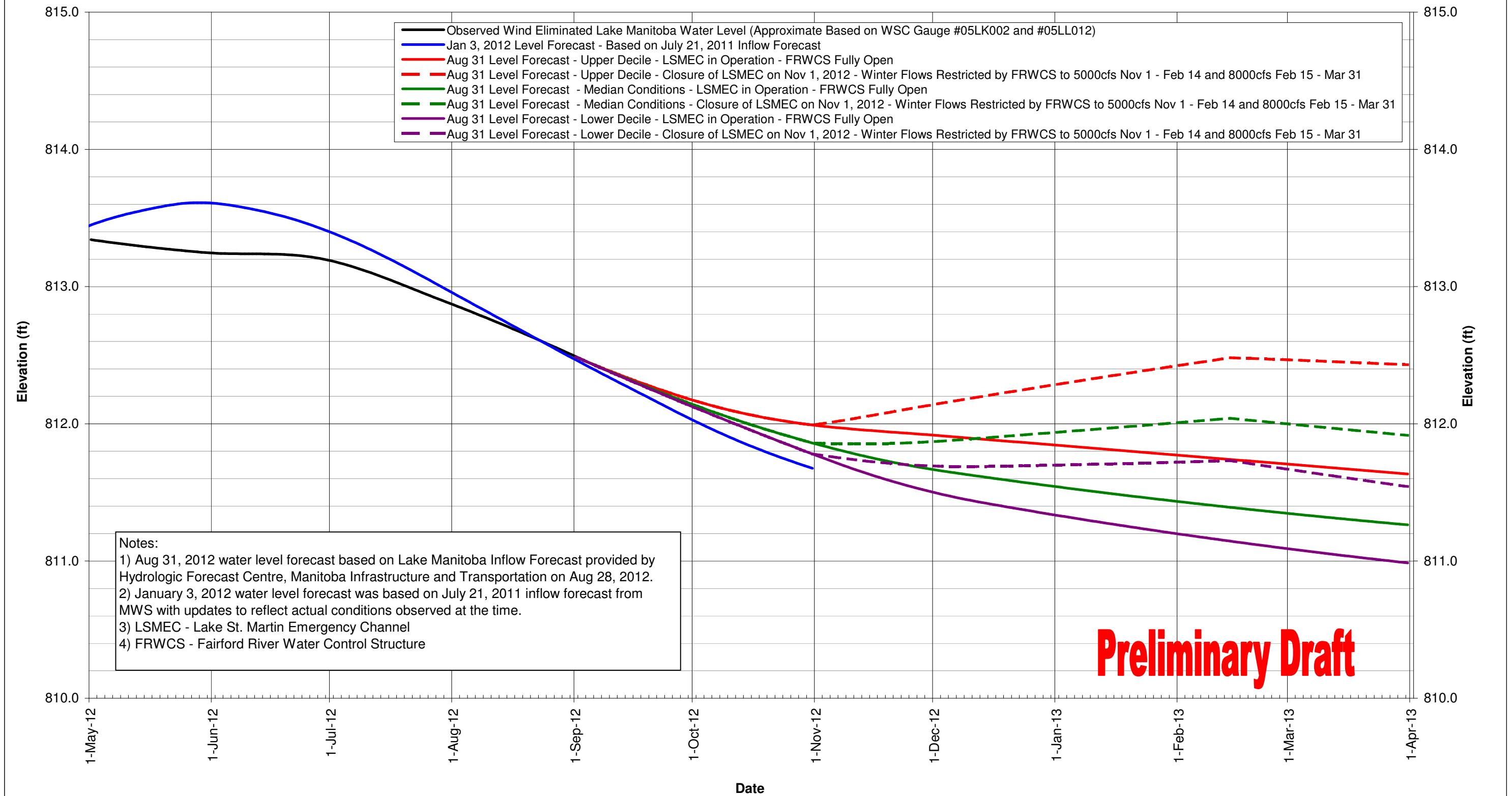
From: Topping, Steve (MIT) [mailto:Steve.Topping@gov.mb.ca]
Sent: August 22, 2012 10:34 AM
To: Colin Siepman
Cc: Kaatz, Ron G (MIT); Mutulu, Phillip (MIT); McMahon, Doug (MIT); Richardson, Ron (MIT)
Subject: FW: Lake Manitoba Forecast - Aug 21, 2012

The Hydrologic Forecast Center has prepared a new forecast for Lake Manitoba. Could you prepare forecasts for the three scenarios once again. The three scenarios are closing the LSMEO November 1st, operating the LSMEO at full capacity thru the winter and finally cutting back Fairford flows to 5000cfs from Nov 1st- Feb 15 and 8000 cfs from Feb 15th to March 31st. If you have any questions please feel free to contact Philip.

Thank you

Steven D. Topping, P. Eng.
Executive Director
Hydrologic Forecasting and Water Management
Manitoba Infrastructure and Transportation
Phone: <personal information removed>
Fax: (204) 945-7419
e-mail: steve.topping@gov.mb.ca

Figure 1.1.1 RevM
Computed Lake Manitoba Level



Notes:
1) Aug 31, 2012 water level forecast based on Lake Manitoba Inflow Forecast provided by Hydrologic Forecast Centre, Manitoba Infrastructure and Transportation on Aug 28, 2012.
2) January 3, 2012 water level forecast was based on July 21, 2011 inflow forecast from MWS with updates to reflect actual conditions observed at the time.
3) LSMEC - Lake St. Martin Emergency Channel
4) FRWCS - Fairford River Water Control Structure

Preliminary Draft

Figure 2.13.1 RevL
Computed Lake St. Martin Level

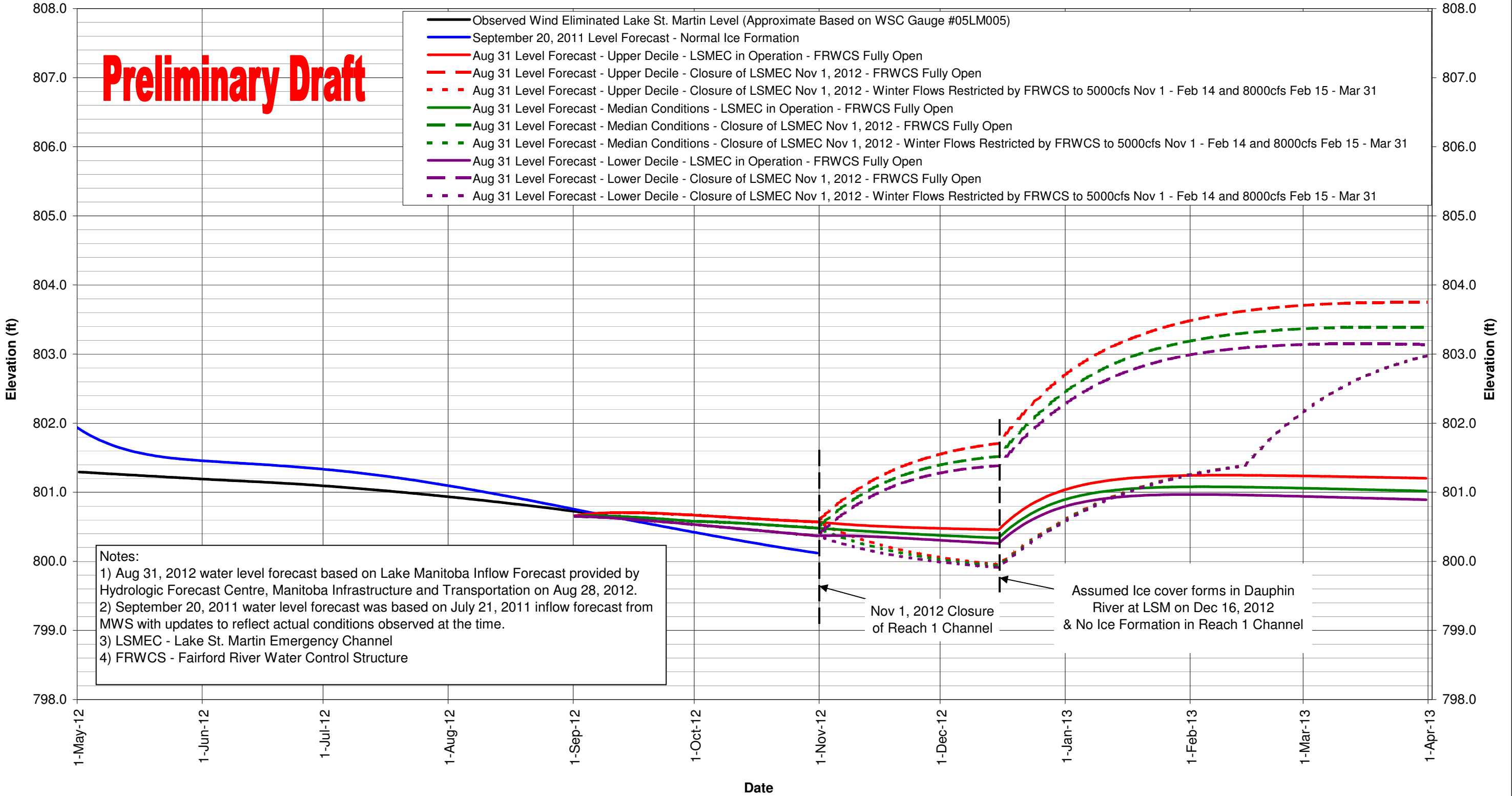
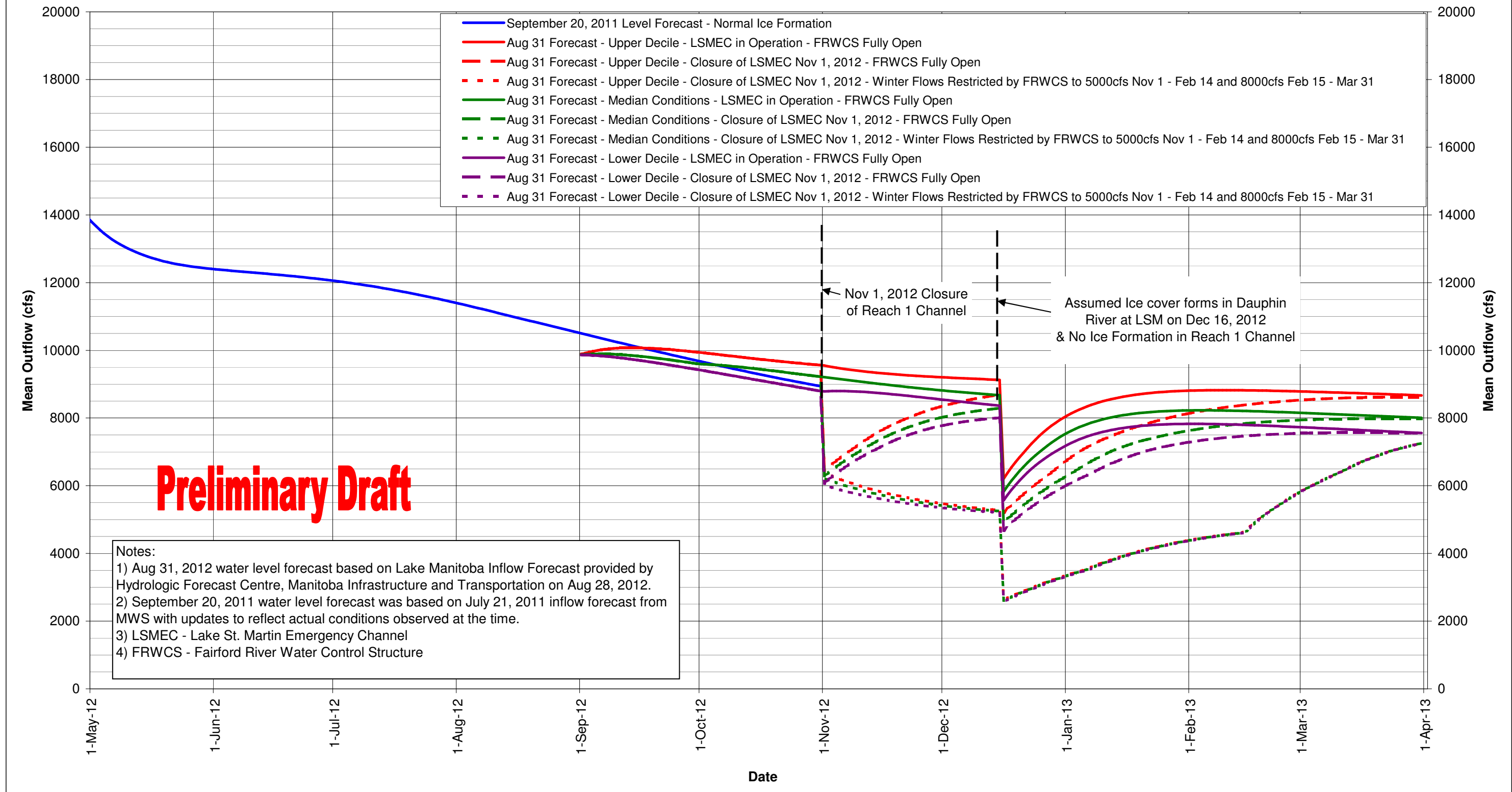


Figure 2.13.2 RevL
Computed Lake St. Martin Outflow



**Lake Manitoba Forecast
Correspondence and Figures**

September 30, 2012

Garrett Wellwood

From: Colin Siepman [CSiepman@kgsgroup.com]
Sent: Sunday, September 30, 2012 9:25 PM
To: 'Topping, Steve (MIT)'; Ron Kaatz
Cc: 'Mutulu, Phillip (MIT)'; 'McMahon, Doug (MIT)'; 'Richardson, Ron (MIT)'; Mark Allard ; Bob Harrison; Brian Bodnaruk; Rick Carson; Bert Smith; Dave MacMillan; Rob Kenyon
Subject: End of September LMB and LSM Forecast
Attachments: Figure 1.1.1 RevN.PDF; Figure 1.1.2 RevF.PDF; Figure 2.13.1 RevM.PDF; Figure 2.13.2 RevM.PDF

Please find attached the updated Lake Manitoba and Lake St. Martin forecast for the end of September. Two forecasts are provided on the figures:

- A revised August 31 Forecast, based on the Lake Manitoba inflow forecast that was provided by the Hydrologic Forecast Centre, MIT on August 28, 2012, with updates to reflect actual conditions.
- The September 28 Forecast, prepared by KGS Group based on recent observations of current inflow conditions.

The September 28 Forecast accounts for a higher evaporation rate on Lake Manitoba than what was originally anticipated in the August 31 Forecast and are based on the current "dry" conditions in the system. This was discussed between Brian Bodnaruk and Philip Mutulu last week and is to be confirmed by the Hydrologic Forecast Centre.

Additionally, the forecast model was updated for Lake Manitoba water level conditions of approximately 812.5 ft and lower. The Lake Manitoba outflow rating curve in the model was adjusted to reflect the current stage-discharge relationship observed between Lake Manitoba and the Fairford River.

As before, the forecast was prepared for the following three operating scenarios:

- Lake St. Martin Emergency Outlet Channel (LSMEOC) in operation with Fairford River Water Control Structure (FRWCS) fully open
- Closure of LSMEOC on November 1 with FRWCS fully open
- Closure of LSMEOC on November 1 with flows restricted by FRWCS to 5000 cfs Nov 1 to Feb 14 and 8000 cfs Feb 15 to Mar 31

Depending on the forecast, and at lower Lake Manitoba water levels, the Lake Manitoba outflow after November 1 was at times forecasted to be less than the proposed 5000 cfs or 8000 cfs restriction. In this case, the actual outflow for the "winter flows restricted by FRWCS" scenario was based on the actual outflow capacity of the Fairford River.

The current water level in Lake Manitoba and Lake St. Martin is lower than what was originally anticipated in the August 31 Forecast and is trending below the lower decile forecast prepared by the Hydrologic Forecast Centre on August 28. A summary of conditions is provided below.

Lake Manitoba

The September 28, 2012 water level on Lake Manitoba was approximately 812.0 ft. Based on the September 28 Forecast, the water level is forecasted to recede to approximately 811.7 ft by November 1, 2012 and continue to recede to approximately 811.5 ft by March 31, 2013 with the FRWCS fully open. The exact same water levels are forecasted for the "winter flows restricted by the FRWCS" scenario since the natural Lake Manitoba outflow after November 1, 2012 is forecasted to be lower than the proposed 5000 cfs restriction.

Lake St. Martin

The September 28, 2012 water level on Lake St. Martin was approximately 799.8 ft. Based on the September 28 Forecast, the water level is forecasted to recede to approximately 799.4 ft by November 1,

2012. After November 1, the Lake is forecasted to rise during the winter due to ice formation in the upper Dauphin River and the water level on March 31, 2013 (based on the September 28 Forecast) is forecasted to be approximately 799.8 ft with the LSMEOC in operation. With the closure of LSMEOC on November 1 and with FRWCS fully open, the forecasted Lake level on March 31 (based on the September 28 Forecast) is expected to rise to approximately 801.0 ft. Since the natural Lake Manitoba outflow after November 1, 2012 is expected to be lower than the proposed 5000 cfs restriction, the Lake St. Martin water level on March 31 for the "winter flow restricted by FRWCS" scenario does not change and is also forecasted to be approximately 801.0 ft.

Dauphin River

Based on the September 28 Forecast, flows in the Dauphin River during an early ice formation in the DRFN Community on November 10, 2012, are forecasted to be approximately 5,000 cfs with the LSMEOC in operation. Flows are expected to be slightly less on November 10 with closure of the LSMEOC or with the winter flows being restricted by the FRWCS. A review of the potential maximum ice staging in the DRFN community for a flow of 9500 cfs was previously completed by the Frazil Ice Team to assess the potential inundation in the DRFN community without the dikes in place (e-mail sent April 2, 2012). This review indicated that the freeboard above the water surface profile was greater than 0.5 m for all buildings.

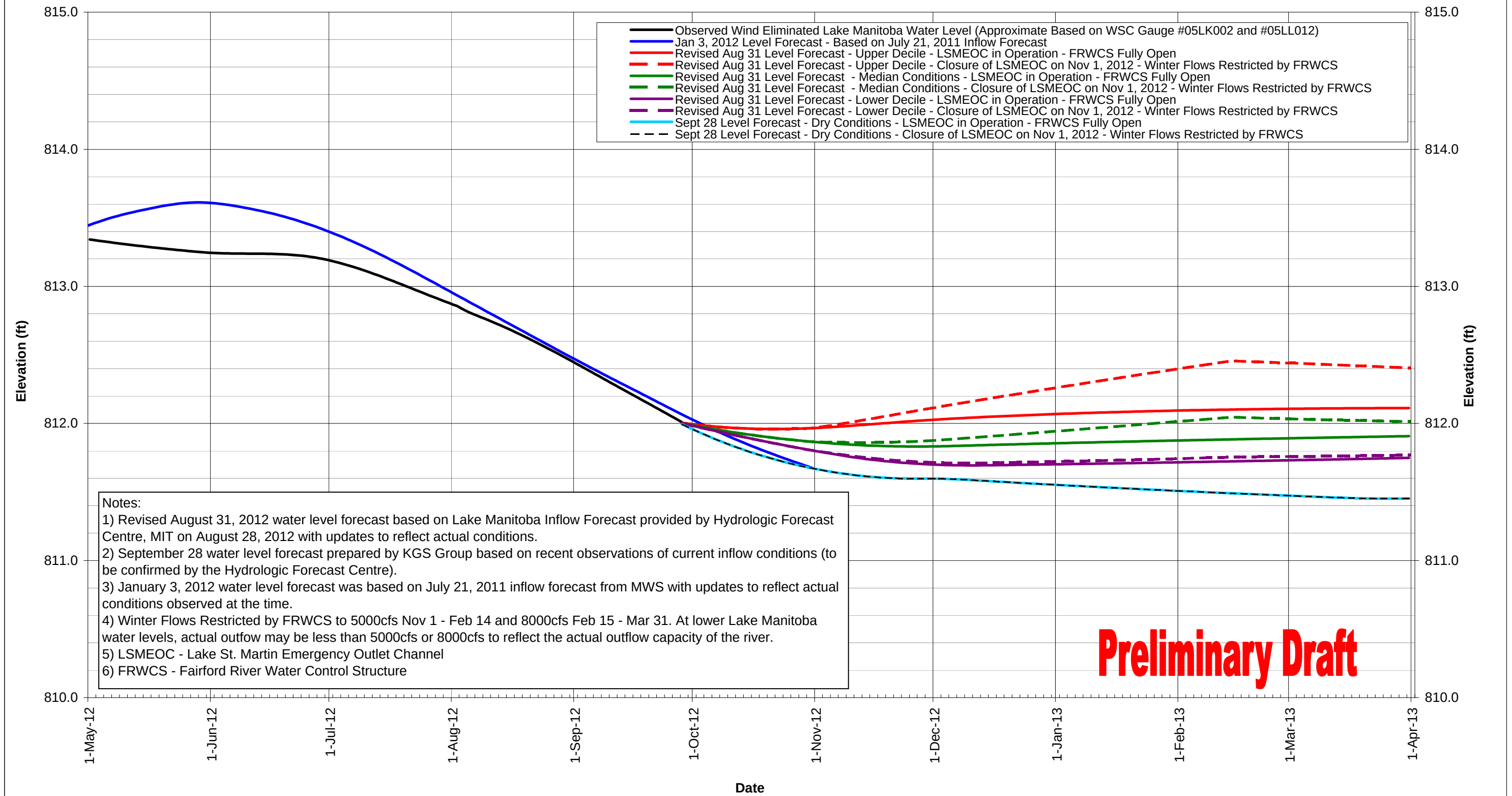
At ice breakup on April 1, 2013, flows in the DRFN Community (based on the September 28 Forecast) are forecasted to peak at approximately 7,500 cfs with closure of the LSMEOC and with FRWCS fully open. Peak flows at ice breakup on April 1 would be less with LSMEOC in operation or with winter flows restricted by the FRWCS due to a lower Lake St. Martin level at ice breakup. The forecasted peak flow of 7,500 cfs is substantially less than the forecasted 24,710 cfs peak flow that we prepared for in the spring of 2012.

Brian & I both plan to attend the review meeting October 1st at 2 pm if you have any questions or comments.

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
Senior Project Manager
KGS Group

Figure 1.1.1 RevN
Computed Lake Manitoba Level



Preliminary Draft

Figure 1.1.2 RevF
Computed Lake Manitoba Outflow

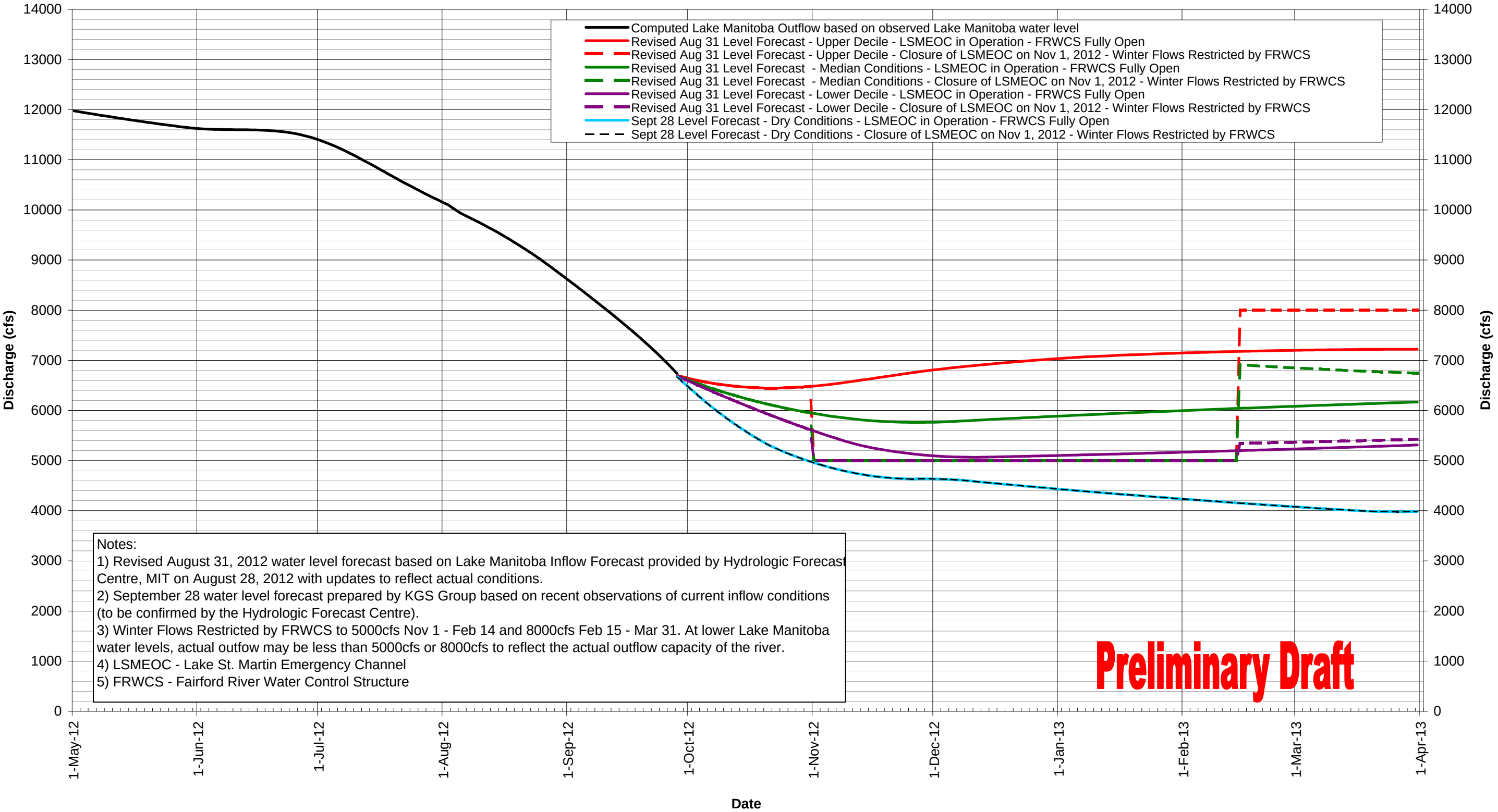


Figure 2.13.1 RevM
Computed Lake St. Martin Level

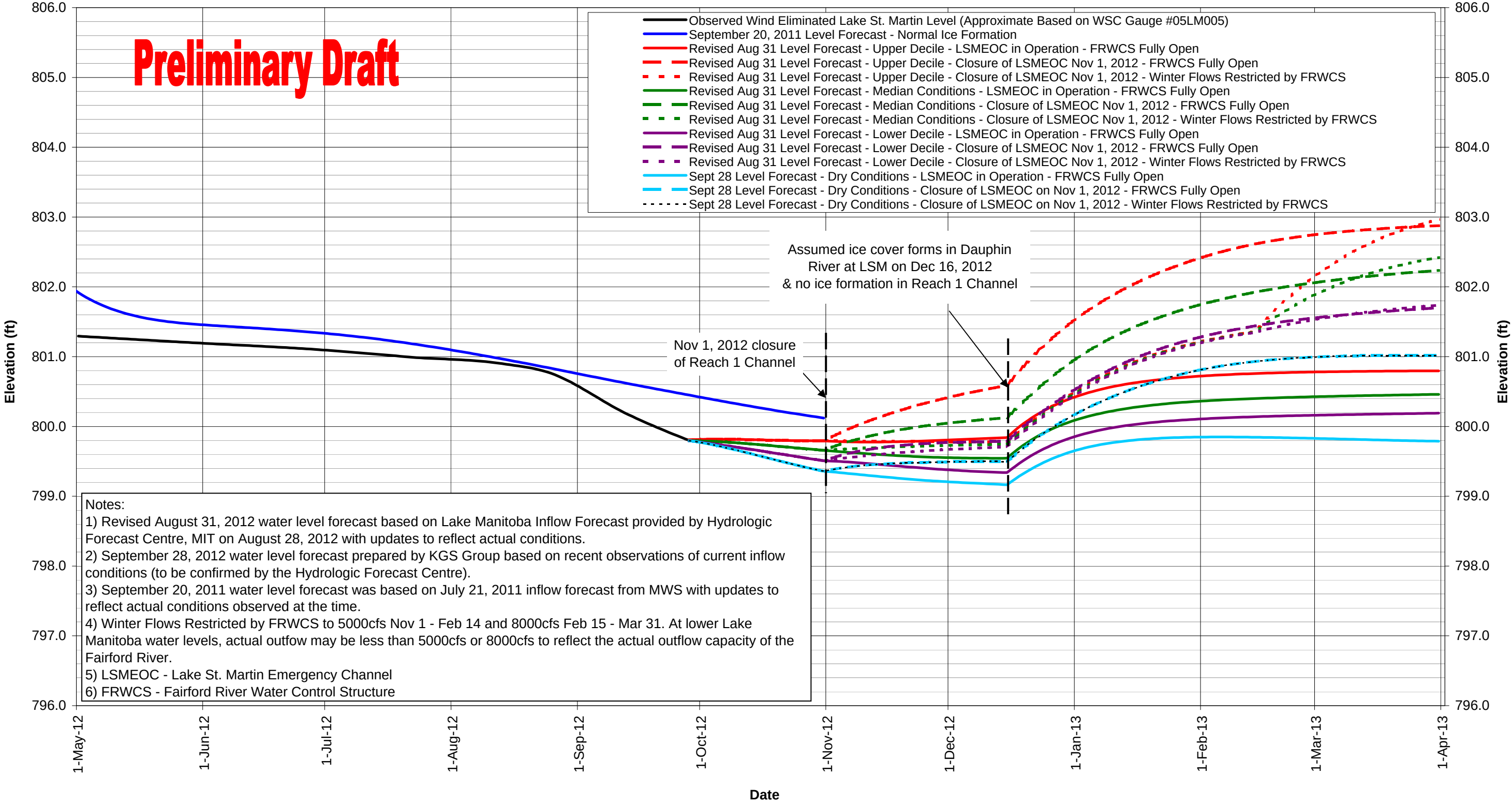
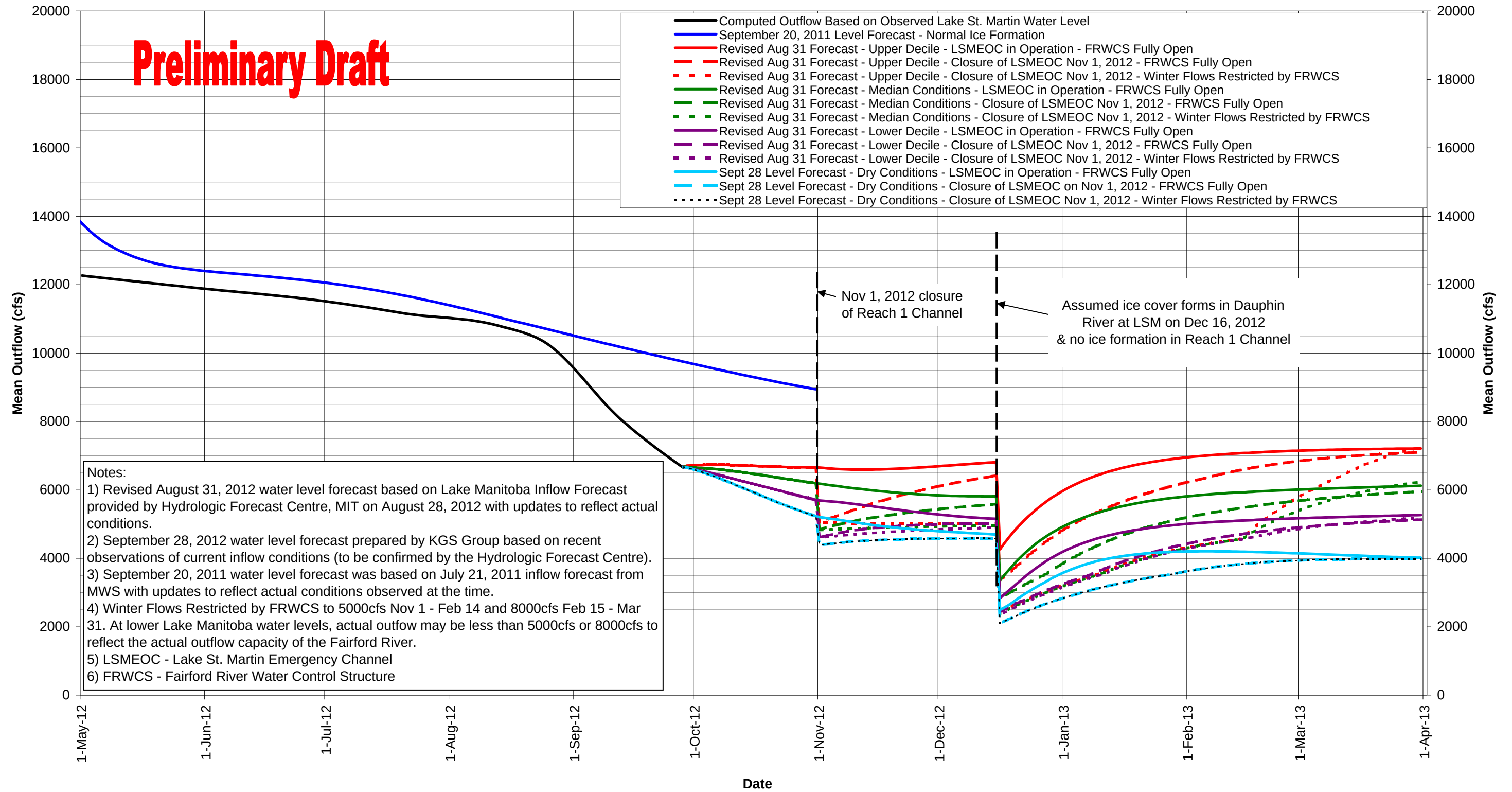


Figure 2.13.2 RevM
Computed Lake St. Martin Outflow



**Lake Manitoba Forecast
Correspondence and Figures**

October 12, 2012

Garrett Wellwood

From: Colin Siepman [CSiepman@ksgsgroup.com]
Sent: Friday, October 12, 2012 3:33 PM
To: 'Topping, Steve (MIT)'; Ron Kaatz
Cc: 'McMahon, Doug (MIT)'; Don Norquay; 'Richardson, Ron (MIT)'; Mark Allard ; Eric Christiansen; 'Mutulu, Phillip (MIT)'; Bob Harrison; Jason Senyk; Brian Bodnaruk; Rick Carson; Bert Smith; Dave MacMillan; Rob Kenyon; Hannon, Gord (JUS)
Subject: Early October LMB and LSM Forecast
Attachments: Figure 1.1.1 RevO.PDF; Figure 1.1.2 RevG.PDF; Figure 2.13.1 RevN.PDF; Figure 2.13.2 RevN.PDF

Please find attached the most recent Lake Manitoba (LMB) and Lake St. Martin (LSM) forecast (October 10, 2012) based on the LMB inflow forecast that was provided by the Hydrologic Forecast Centre, MIT on October 4, 2012.

As before, the forecast considered lower decile, median and upper decile weather conditions and flows. The following four operating scenarios were included in the forecast:

- Lake St. Martin Emergency Outlet Channel (LSMEOC) in operation with Fairford River Water Control Structure (FRWCS) fully open
- Closure of LSMEOC on November 15 with FRWCS fully open
- Closure of LSMEOC on November 15 with flows restricted by FRWCS to 5000 cfs Nov 1 to Feb 14 and 8000 cfs Feb 15 to Mar 31
- Closure of LSMEOC on November 15 with flows restricted by FRWCS using 41 logs Nov 1, based on a proposed operating scenario provided by the Hydrologic Forecast Centre, MIT on October 4, 2012.

An assumed LSMEOC closure date of November 15, 2012 was selected for the forecast as the emergency exemption expires Nov 30 (the initial LSMEOC closure would stop flows in 2 or 3 days but the permanent closure activities could take two weeks to complete). The impact of closing LSMEOC later or earlier is discussed under the Lake St. Martin section below.

Depending on the forecast, and at lower LMB water levels, the LMB outflow after November 1 was at times forecasted to be less than the proposed 5000 cfs or 8000 cfs restriction. In this case, the actual outflow for the "winter flows restricted by FRWCS (5000-8000 cfs scenario)" was based on the actual outflow capacity of the Fairford River. This is evident for the lower decile and median conditions forecast as both the 5000-8000 cfs restriction scenario and the FRWCS fully open scenario forecast appear the same on the figures.

The "winter flows restricted by FRWCS (41 logs scenario)" was proposed by the Hydrologic Forecast Centre to reduce the risk of having a shortage of water in LMB and LSM in the event that the spring brings normal to below normal runoff to the lake. The Hydrologic Forecast Centre noted that the FRWCS was operated using 41 logs from April 7, 2009 to November 1, 2010 and that our current end of March 2013 median water level forecast on LMB is similar to the observed water levels on LMB that occurred at the end of March in 2009 and 2010. The impact of having winter flows restricted by FRWCS using 41 logs is discussed below.

The LMB inflow forecast that was provided by the Hydrologic Forecast Centre, MIT on October 4, 2012 is lower than the forecast that was provided on August 28, 2012. As such, the lower decile, median and upper decile October 10, 2012 LMB and LSM water level and outflow forecasts are lower than the revised August 31, 2012 forecasts provided at the end of September.

The current water level and outflow on LMB and LSM follows closely the September 28, 2012 "dry conditions" forecast provided at the end of September, and the October 10, 2012 median forecast is now slightly lower than the September 28, 2012 "dry conditions" forecast. A summary of median conditions is provided below.

Lake Manitoba

The October 10, 2012 water level on LMB was approximately 811.9 ft. Based on the median conditions forecast, the water level is forecasted to recede to approximately 811.3 ft by March 31, 2013 with the FRWCS fully open. The exact same water levels are forecasted for the “winter flows restricted by the FRWCS (5000-8000 cfs scenario)” since the median conditions natural LMB outflow after November 1, 2012 is forecasted to be lower than the proposed 5000 cfs restriction. The forecasted median water level on March 31, 2013 for the “winter flows restricted by the FRWCS (41 logs scenario)” is approximately 811.4 ft, which is approximately 0.1ft higher than the FRWCS fully open scenario.

Lake St. Martin

The October 10, 2012 water level on LSM was approximately 799.6 ft. Based on the median conditions forecast, the water level is forecasted to recede to approximately 799.3 ft by November 15, 2012. After November 15, the Lake is forecasted to rise during the winter due to ice formation in the upper Dauphin River and the median conditions water level on March 31, 2013 is forecasted to be approximately 799.6 ft with the LSMEOC in operation. With the closure of LSMEOC on November 15 and with FRWCS fully open, the forecasted median conditions water level on March 31 is expected to rise to approximately 800.7 ft. Since the natural LMB outflow after November 1, 2012 is expected to be lower than the proposed 5000 cfs restriction, the LSM median conditions water level on March 31 for the “winter flow restricted by FRWCS (5000-8000 cfs scenario)” does not change and is also forecasted to be approximately 800.7 ft. The forecasted median water level on March 31, 2013 for the “winter flows restricted by the FRWCS (41 logs scenario)” is approximately 800.5 ft, which is approximately 0.2 ft lower than the FRWCS fully open scenario.

The impact to the LSM water level of closing the LSMEOC on November 1 or November 30 instead of November 15, 2012 is virtually negligible on March 31, 2013 (less than 0.1 ft). The short term impact (i.e the difference in LSM water level on November 30, 2012) between a November 1 closure date compared to a November 30 closure date is approximately 0.4 ft (or 0.2 ft per half month).

Dauphin River

Based on the median October 10, 2012 Forecast, flows in the Dauphin River during an early ice formation in the DRFN Community on November 10, 2012, are forecasted to be approximately 5,000 cfs with the LSMEOC in operation. Flows are expected to be slightly less on November 10 with winter flows being restricted by the FRWCS. A review of the potential maximum ice staging in the DRFN community for a flow of 9500 cfs was previously completed by the Frazil Ice Team to assess the potential inundation in the DRFN community without the dikes in place (e-mail sent April 2, 2012). This review indicated that the freeboard above the water surface profile was greater than 0.5 m for all buildings.

At ice breakup on April 1, 2013, median conditions flows in the DRFN Community are forecasted to peak at approximately 6,600 cfs with closure of the LSMEOC and with FRWCS fully open. Peak flows at ice breakup on April 1 would be less with LSMEOC in operation or with winter flows restricted by the FRWCS due to a lower LSM level at ice breakup. The forecasted peak flow of 6,600 cfs is substantially less than the forecasted 24,710 cfs peak flow that we prepared for in the spring of 2012.

Regards,

Colin Siepmann, B.Sc. CE, M.Eng, P.Eng
Senior Project Manager
KGS Group

Figure 1.1.1 RevO
Computed Lake Manitoba Level

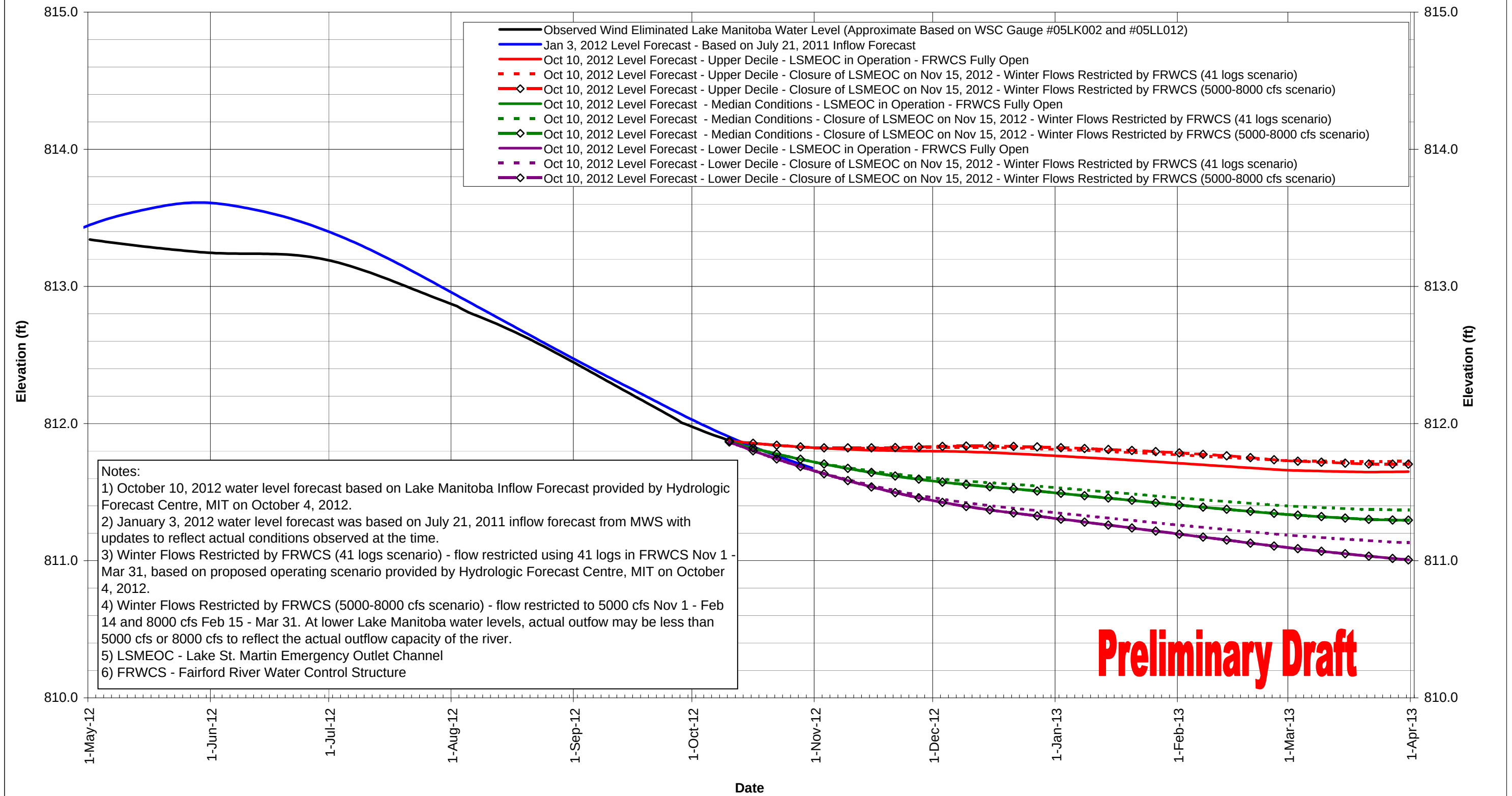


Figure 1.1.2 RevG
Computed Lake Manitoba Outflow

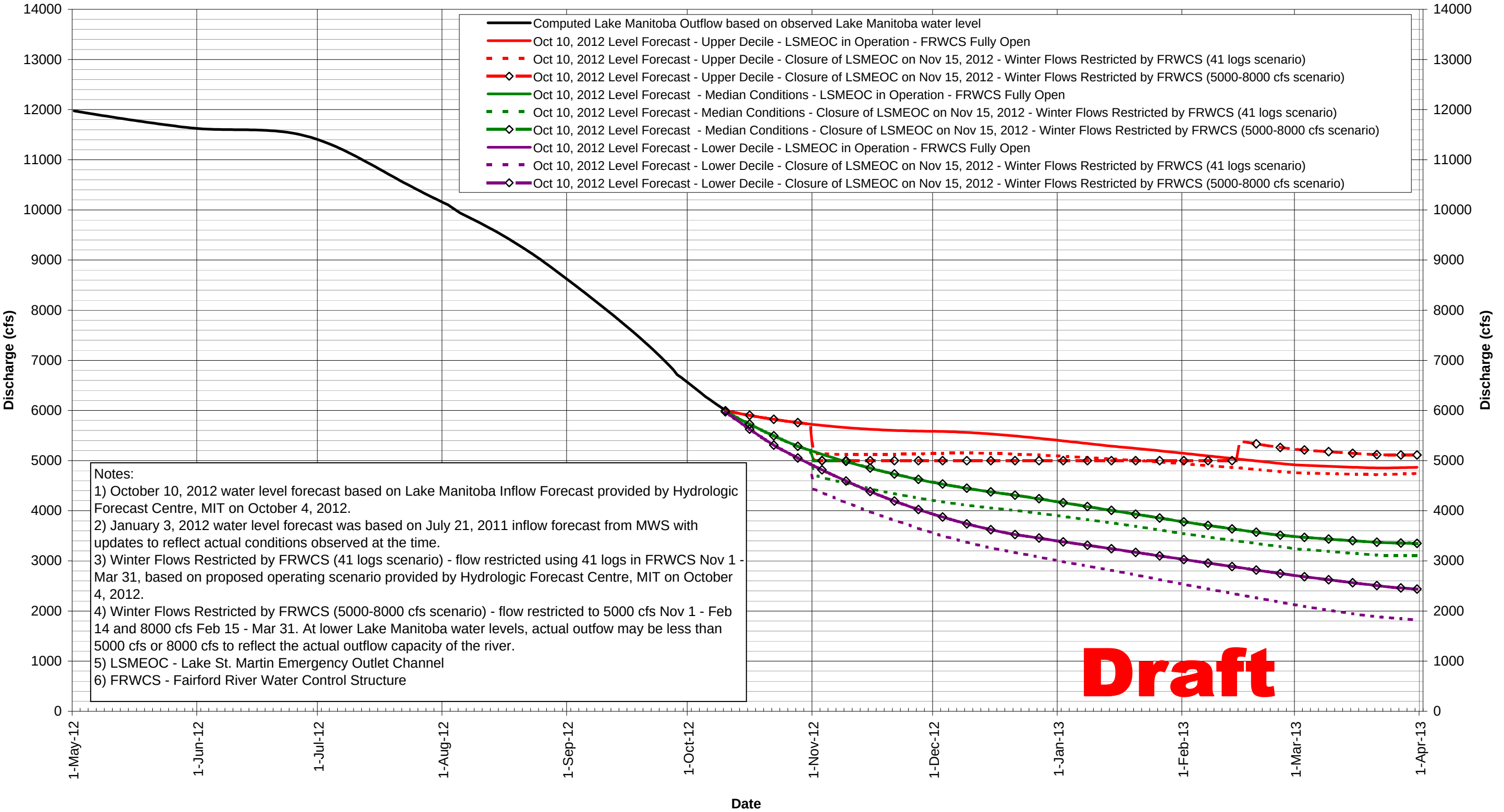


Figure 2.13.1 RevN
Computed Lake St. Martin Level

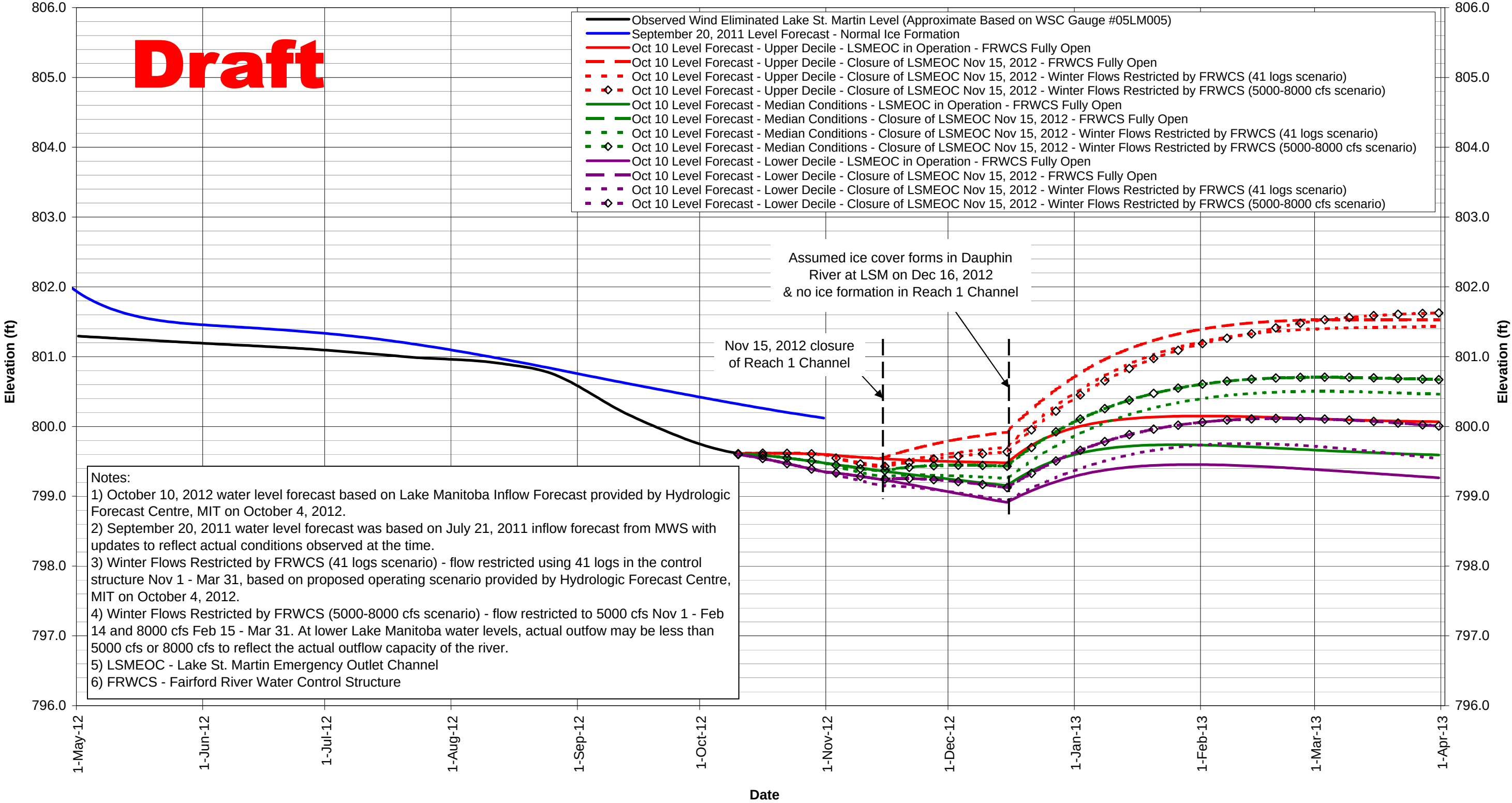
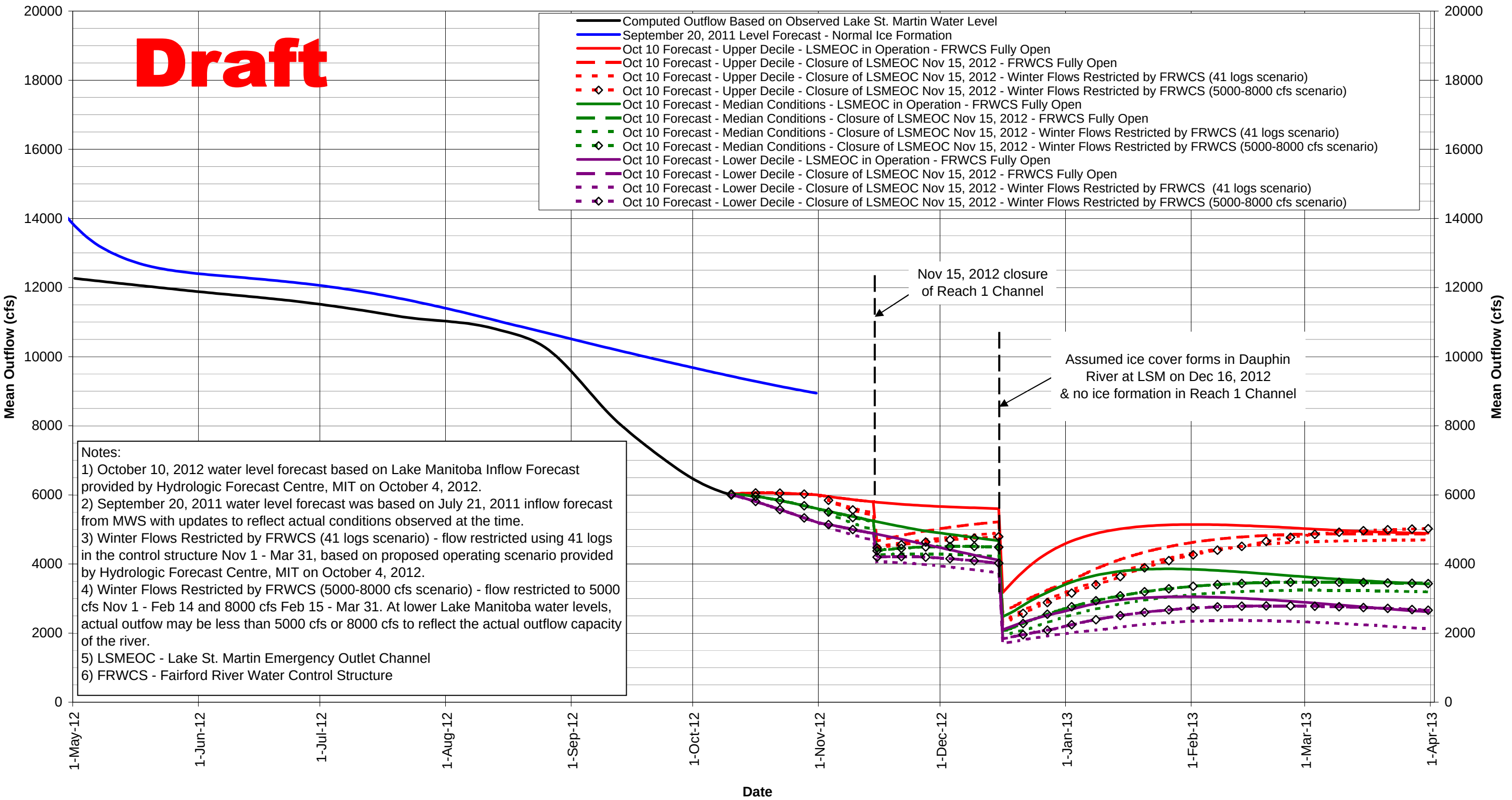


Figure 2.13.2 RevN
Computed Lake St. Martin Outflow



**Lake Manitoba Forecast
Correspondence and Figures**

October 31, 2012

Garrett Wellwood

From: Colin Siepman [CSiepman@ksgsgroup.com]
Sent: Thursday, November 01, 2012 3:05 PM
To: 'Topping, Steve (MIT)'; Ron Kaatz
Cc: 'McMahon, Doug (MIT)'; Don Norquay; 'Richardson, Ron (MIT)'; Mark Allard ; Eric Christiansen; 'Mutulu, Phillip (MIT)'; Bob Harrison; Jason Senyk; Brian Bodnaruk; Rick Carson; Bert Smith; Dave MacMillan; Rob Kenyon; Hannon, Gord (JUS)
Subject: End of October LMB and LSM Forecast
Attachments: Figure 1.1.1 RevP.PDF; Figure 1.1.2 RevH.PDF; Figure 2.13.1 RevO.PDF; Figure 2.13.2 RevO.PDF

Please find attached the most recent Lake Manitoba (LMB) and Lake St. Martin (LSM) forecast (October 31, 2012) based on the LMB inflow forecast that was provided by the Hydrologic Forecast Centre, MIT on October 4, 2012, updated to reflect current conditions.

As before, the forecast considered lower decile, median and upper decile weather conditions and flows. The following three operating scenarios were included in the forecast:

- Lake St. Martin Emergency Outlet Channel (LSMEOC) in operation with Fairford River Water Control Structure (FRWCS) fully open
- Closure of LSMEOC on November 15 with FRWCS fully open
- Closure of LSMEOC on November 15 with flows restricted by FRWCS to 5000 cfs Nov 15 to Feb 14 and 8000 cfs Feb 15 to Mar 31

Note that the current MIT operational plan is to leave FRWCS at maximum discharge (i.e. no change in stoplogs). For the scenario where flows are restricted by the FRWCS, the November 1 date of operation was moved to November 15 as this was deemed to be a more likely scenario if a decision was made to operate the control structure. Additionally, at lower LMB water levels, the LMB outflow after November 15 was at times forecasted to be less than the potential 5000 cfs or 8000 cfs restriction. In this case, the actual outflow for the "winter flows restricted by FRWCS (5000-8000 cfs scenario)" was based on the actual outflow capacity of the Fairford River.

All LMB scenarios now consider a potential natural restriction due to ice effects upstream of the FRWCS. For the analysis, it was assumed that the effects of the ice would begin on January 1, 2013 and remain until ice breakup on April 1, 2013. The potential ice effects were based on historic records of discharges and water levels in the Fairford River and Lake Manitoba during winter months, and were assumed to be representative of "normal" ice conditions in the river with FRWCS fully open.

The current water level and outflow on LMB and LSM are slightly above the October 10, 2012 forecast due to higher inflow from precipitation that occurred in October than originally anticipated and a lower evaporation rate on the lakes. A summary of the October 31, 2012 median conditions forecast is provided below.

Lake Manitoba

The October 31, 2012 water level on LMB was approximately 812.0 ft. Based on median conditions, the water level is forecasted to recede to approximately 811.5 ft by March 31, 2013 with the FRWCS fully open. A water level of 811.5ft is also forecasted for the median conditions "winter flows restricted by the FRWCS (5000-8000 cfs scenario)" since natural LMB outflow is forecasted to be similar to the potential 5000 cfs restriction for the most part of the winter.

The October 31, 2012 LMB outflow was approximately 6800 cfs and under median conditions, the outflow is expected to recede to approximately 5000 cfs by December 31, 2012.

Lake St. Martin

The October 31, 2012 water level on LSM was approximately 799.7 ft. Based on median conditions, the

water level is forecasted to rise during the winter due to ice formation in the upper Dauphin River to approximately 799.9 ft with the LSMEOC in operation and then recede to approximately 799.5 ft by March 31, 2013. With the closure of LSMEOC on November 15 and with FRWCS fully open, the forecasted median conditions water level is expected to rise to approximately 800.8 ft and then recede to approximately 800.5 ft by March 31, 2013. Since the natural LMB outflow during the winter is expected to be similar to the potential 5000 cfs restriction, the LSM median conditions water level for the "winter flow restricted by FRWCS (5000-8000 cfs scenario)" is also expected to rise to 800.8 ft and then recede to approximately 800.5 ft by March 31.

The October 31, 2012 LSM total outflow was approximately 6400 cfs, with approximately 1500 cfs through LSMEOC and 4900 cfs through the upper Dauphin River.

Dauphin River

Based on the median October 31, 2012 Forecast, flows in the Dauphin River during an early ice formation in the DRFN Community on November 10, 2012, are forecasted to be approximately 6,500 cfs with the LSMEOC in operation. A review of the potential maximum ice staging in the DRFN community for a flow of 9500 cfs was previously completed by the Frazil Ice Team to assess the potential inundation in the DRFN community without the dikes in place (e-mail sent April 2, 2012). This review indicated that the freeboard above the water surface profile was greater than 0.5 m for all buildings.

At ice breakup on April 1, 2013, median condition flows in the DRFN Community are forecasted to peak at approximately 6,400 cfs with closure of the LSMEOC and with flows restricted by the FRWCS. Peak flows at ice breakup on April 1 would be less with LSMEOC in operation or with FRWCS fully open. Note that for the upper decile forecast, with flows restricted by FRWCS, flows in the DRFN Community at ice breakup on April 1, 2013 are forecasted to peak at approximately 8,400 cfs, which is substantially less than the forecasted 24,710 cfs peak flow that we prepared for in the spring of 2012.

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
Senior Project Manager
KGS Group

Figure 1.1.1 RevP
Computed Lake Manitoba Level

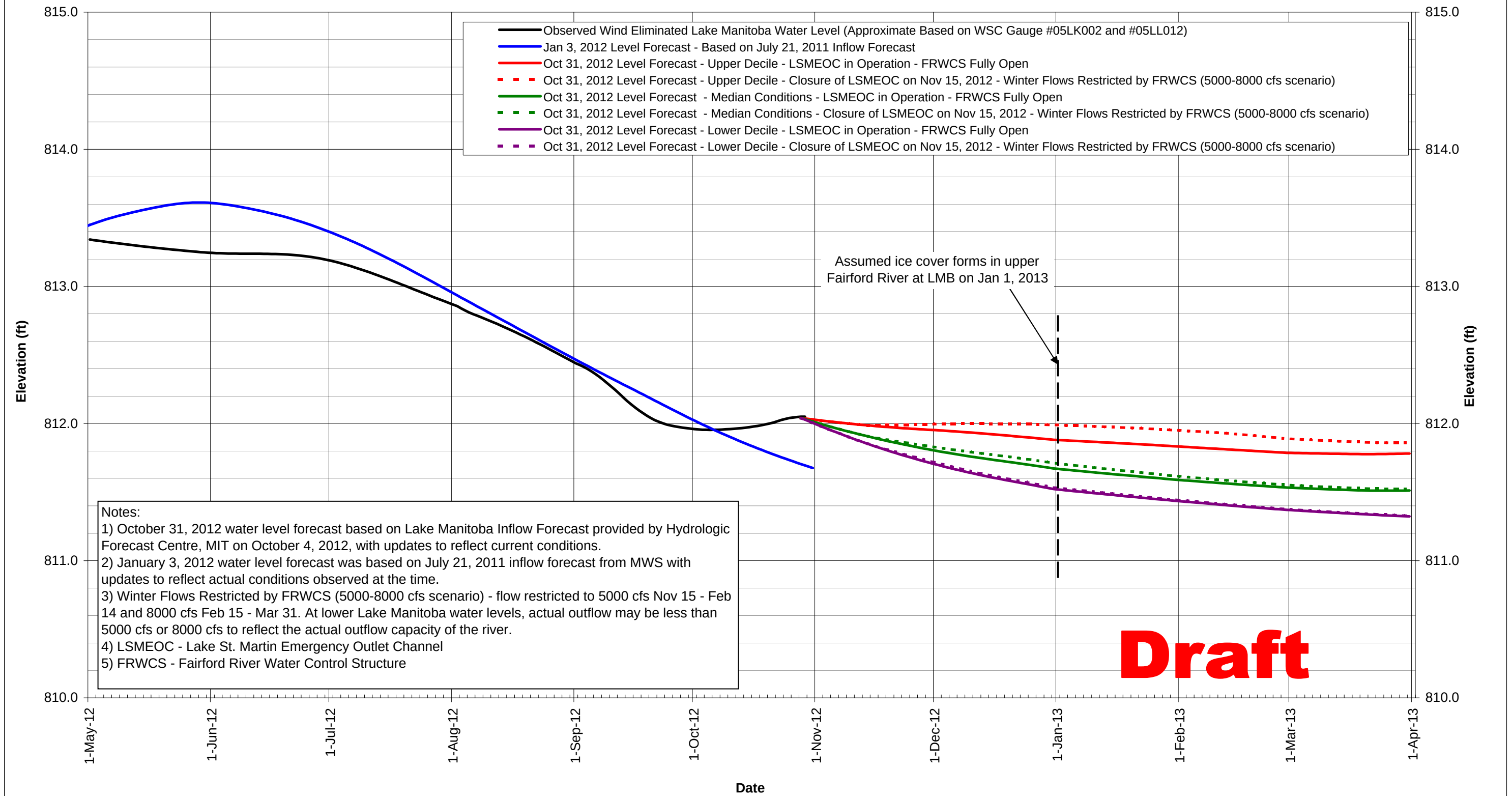


Figure 1.1.2 RevH
Computed Lake Manitoba Outflow

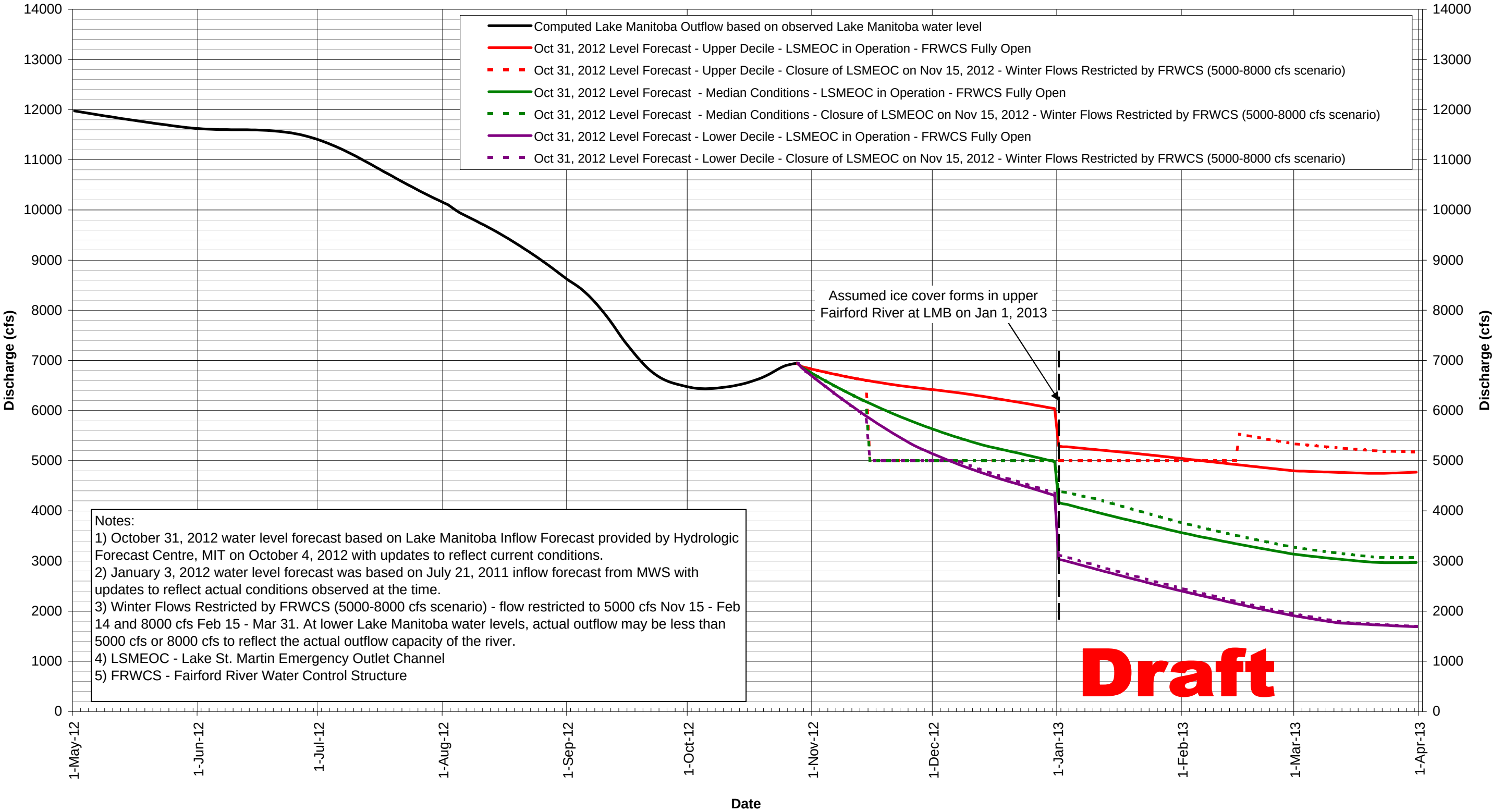


Figure 2.13.1 RevO
Computed Lake St. Martin Level

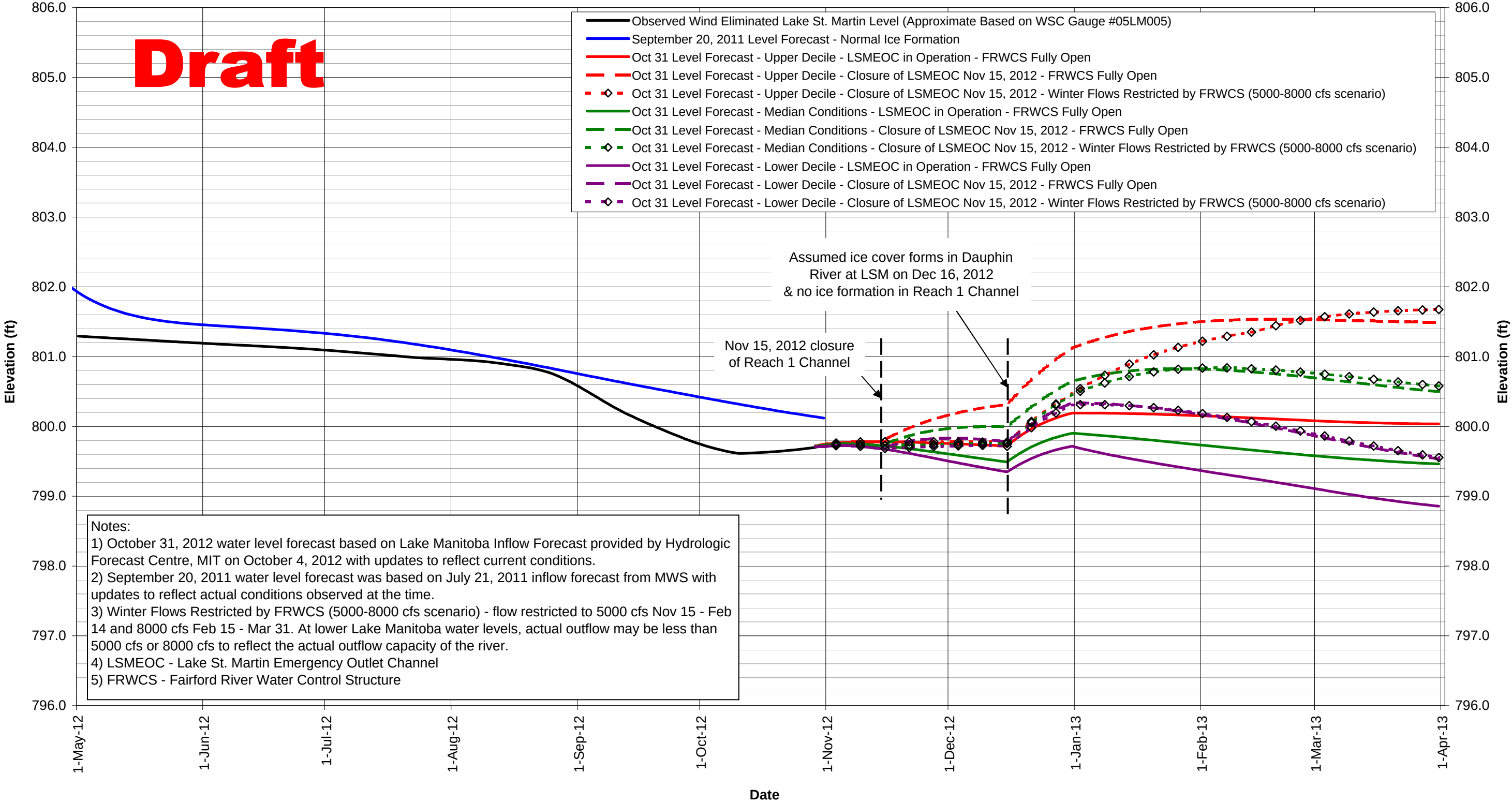
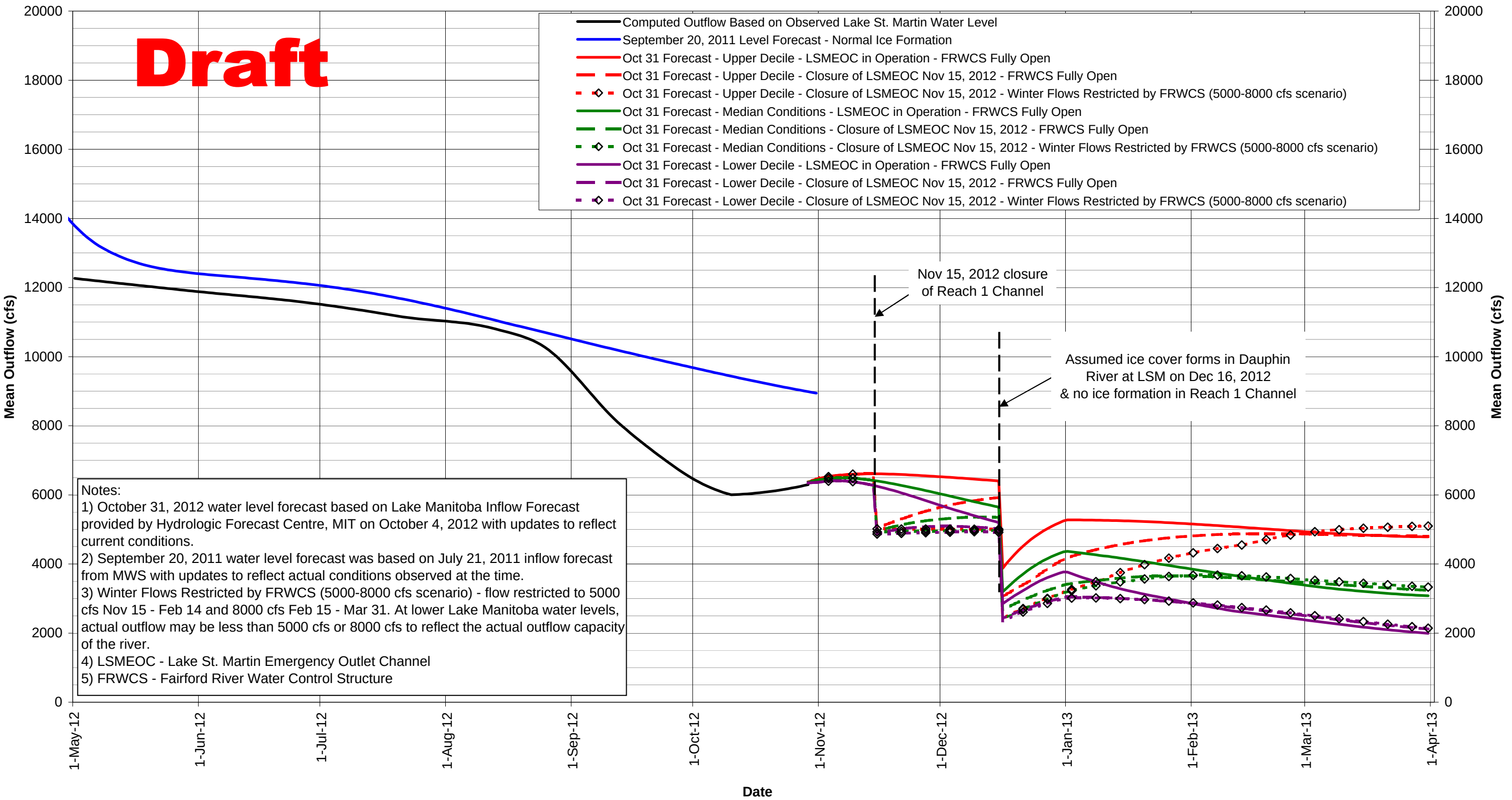


Figure 2.13.2 RevO
Computed Lake St. Martin Outflow



**Lake Manitoba Forecast
Correspondence and Figures**

November 30, 2012

Garrett Wellwood

From: Colin Siepman [CSiepman@ksgsgroup.com]
Sent: Thursday, November 29, 2012 4:53 PM
To: 'Topping, Steve (MIT)'; Ron Kaatz
Cc: 'McMahon, Doug (MIT)'; Don Norquay; 'Richardson, Ron (MIT)'; Mark Allard ; Eric Christiansen; 'Mutulu, Phillip (MIT)'; Jason Senyk; Brian Bodnaruk; Rick Carson; Bert Smith; Dave MacMillan; Rob Kenyon; Hannon, Gord (JUS)
Subject: End of November LMB and LSM Forecast
Attachments: Figure 1.1.1 RevQ.PDF; Figure 1.1.2 RevI.PDF; Figure 2.13.1 RevP.PDF; Figure 2.13.2 RevP.PDF; Reach 1 Closure Nov 28.JPG; Reach 1 at Buffalo Lake.JPG; Buffalo Creek at Reach 3 - Nov 28.JPG; Partial Ice Cover in Upper Dauphin River Nov 28.JPG

Please find attached the end of November Lake Manitoba (LMB) and Lake St. Martin (LSM) forecast figures based on the LMB inflow forecast that was provided by the Hydrologic Forecast Centre, MIT on October 4, 2012, updated to reflect current conditions. Note that the current LMB inflow forecast does not extend beyond April 1st 2013. When the Hydrologic Forecast Centre is able to provide an extended LMB inflow forecast and spring 2013 operating scenarios for the FRWCS we will extend the figures accordingly.

As before, the forecast considered lower decile, median and upper decile weather conditions and flows. The following two operating scenarios were included in the forecast:

- Lake St. Martin Emergency Outlet Channel (LSMEOC) closed with Fairford River Water Control Structure (FRWCS) fully open
- LSMEOC closed with flows restricted by FRWCS to 5000 cfs Dec 15 to Feb 14 and 8000 cfs Feb 15 to Mar 31

Note that the current MIT operational plan is to leave FRWCS at maximum discharge (i.e. no change in stoplogs). For the hypothetical scenario where flows are restricted by the FRWCS, the November 15 date of operation was moved to December 15. Additionally, at lower LMB water levels, the LMB outflow after December 15 was at times forecasted to be less than the potential 5000 cfs or 8000 cfs restriction. In this case, the actual outflow for the "winter flows restricted by FRWCS (5000-8000 cfs scenario)" was based on the actual outflow capacity of the Fairford River.

All LMB scenarios once again consider a potential natural restriction due to ice effects upstream of the FRWCS. For the analysis, it was assumed that the effects of the ice would begin on January 1, 2013 and remain until ice breakup on April 1, 2013. The potential ice effects were based on historic records of discharges and water levels in the Fairford River and Lake Manitoba during winter months, and were assumed to be representative of "normal" ice conditions in the river with FRWCS fully open.

The current water level and outflow on LMB and LSM are slightly above the October 31, 2012 forecast due to higher inflow than originally anticipated in the October 4 inflow forecast. A summary of the November 29, 2012 median conditions forecast is provided below.

Lake Manitoba

The November 29, 2012 water level on LMB was approximately 812.1 ft. Based on median conditions, the water level is forecasted to recede to approximately 811.6 ft by March 31, 2013 with the FRWCS fully open. A water level of 811.6 ft is also forecasted for the median conditions "winter flows restricted by the FRWCS (5000-8000 cfs scenario)" since natural LMB outflow is forecasted to be similar to the potential restriction scenario for the most part of the winter.

The November 29, 2012 LMB outflow was approximately 7100 cfs under median conditions, the outflow is expected to recede to approximately 5000 cfs by early January 2013 with "normal" ice conditions in the river.

Lake St. Martin

The November 29, 2012 water level on LSM was approximately 800.2 ft. Based on median conditions, the water level is forecasted to rise during the winter due to ice formation in the upper Dauphin River to approximately 801.5 ft and then recede to approximately 801.0 ft by March 31, 2013. For the hypothetical "winter flow restricted by FRWCS (5000-8000 cfs scenario)" the median conditions water level is expected to rise to approximately 801.4 ft and then recede to approximately 801.0 ft by March 31. As indicated on the figures, a partial ice cover was observed in the Dauphin River at LSM on November 28, 2012. Depending on the extents of the current partial ice cover in the upper Dauphin River, and the timing at which a full ice cover forms, the rate and speed at which the LSM water level actually rises may differ then what is shown on the forecast. However, when only considering the forecasted peak water level on the lake, ice forming in the upper Dauphin River two to three weeks earlier or later than assumed has negligible effects to the forecast peak water level provided on the figure.

Due to current ice conditions in the upper Dauphin River, the November 29, 2012 LSM outflow is difficult to predict. However based on our forecast and assumed effects of the partial ice cover, the LSM outflow into the upper Dauphin River was estimated to be approximately 4000 cfs. Under open water conditions, the LSM outflow would be approximately 5700 cfs. The LSMEOC is now closed and therefore no longer contributes to the LSM outflow (with the exception of minor seepage through the closure dike).

Dauphin River

Based on observed Lake St. Martin water levels, the peak flow in the lower Dauphin River during ice formation in the DRFN was approximately 6,500 cfs (with the LSMEOC in operation). The current discharge in the community is much less due to the closure of the LSMEOC and ice effects in the upper Dauphin River, and are expected to remain below the 6,500 cfs peak for the rest of the winter. A review of the potential maximum ice staging in the DRFN community for a flow of 9500 cfs was previously completed by the Frazil Ice Team to assess the potential inundation in the DRFN community without the dikes in place (e-mail sent April 2, 2012). This review indicated that the freeboard above the water surface profile was greater than 0.5 m for all buildings.

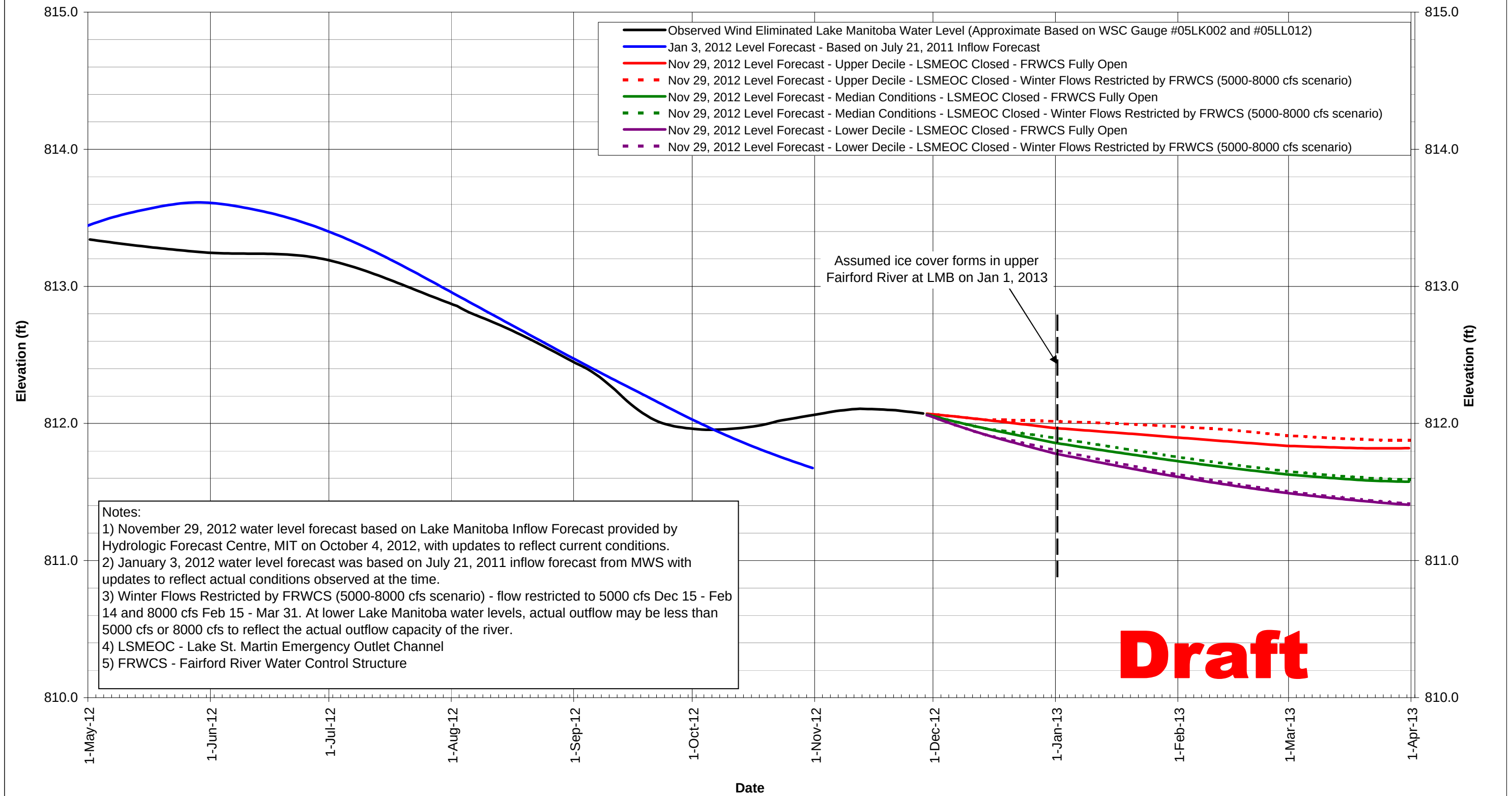
At ice breakup on April 1, 2013, median condition flows in the DRFN Community are forecasted to peak at approximately 7,100 cfs. Peak flows at ice breakup on April 1 would be slightly more (approximately 7,200 cfs) for the median "winter flow restricted by FRWCS (5000-8000 cfs scenario)". For the upper decile forecast, flows in the DRFN Community at ice breakup on April 1, 2013 are forecasted to peak at approximately 8,600 cfs, which is substantially less than the forecasted 24,710 cfs peak flow that we prepared for in the spring of 2012. Note that the forecasted peak does not consider local runoff from Buffalo Creek.

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
Senior Project Manager
KGS Group

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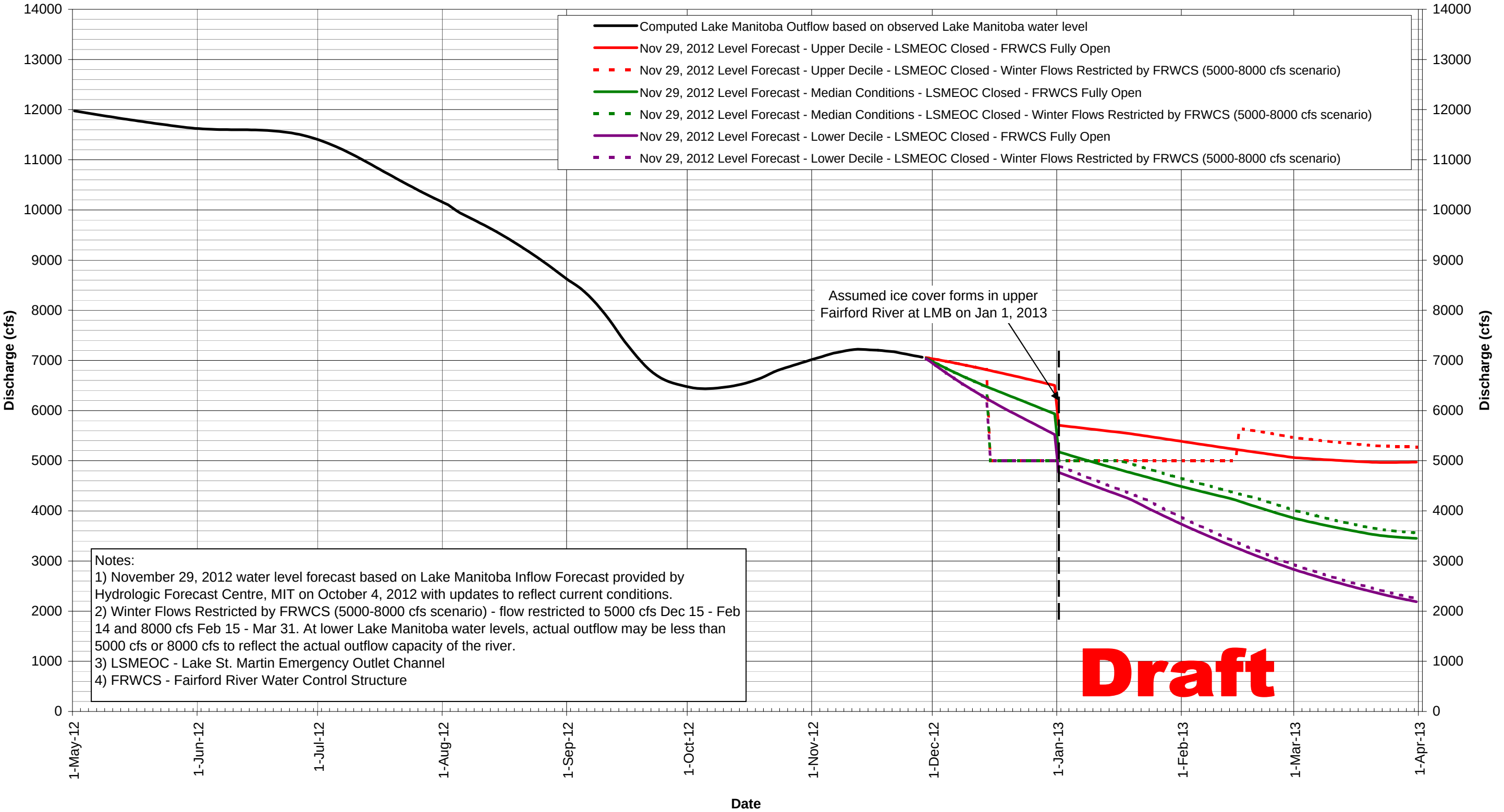
Figure 1.1.1 RevQ
Computed Lake Manitoba Level



Notes:
1) November 29, 2012 water level forecast based on Lake Manitoba Inflow Forecast provided by Hydrologic Forecast Centre, MIT on October 4, 2012, with updates to reflect current conditions.
2) January 3, 2012 water level forecast was based on July 21, 2011 inflow forecast from MWS with updates to reflect actual conditions observed at the time.
3) Winter Flows Restricted by FRWCS (5000-8000 cfs scenario) - flow restricted to 5000 cfs Dec 15 - Feb 14 and 8000 cfs Feb 15 - Mar 31. At lower Lake Manitoba water levels, actual outflow may be less than 5000 cfs or 8000 cfs to reflect the actual outflow capacity of the river.
4) LSMEOC - Lake St. Martin Emergency Outlet Channel
5) FRWCS - Fairford River Water Control Structure

Draft

Figure 1.1.2 RevI
Computed Lake Manitoba Outflow



Draft

Figure 2.13.1 RevP
Computed Lake St. Martin Level

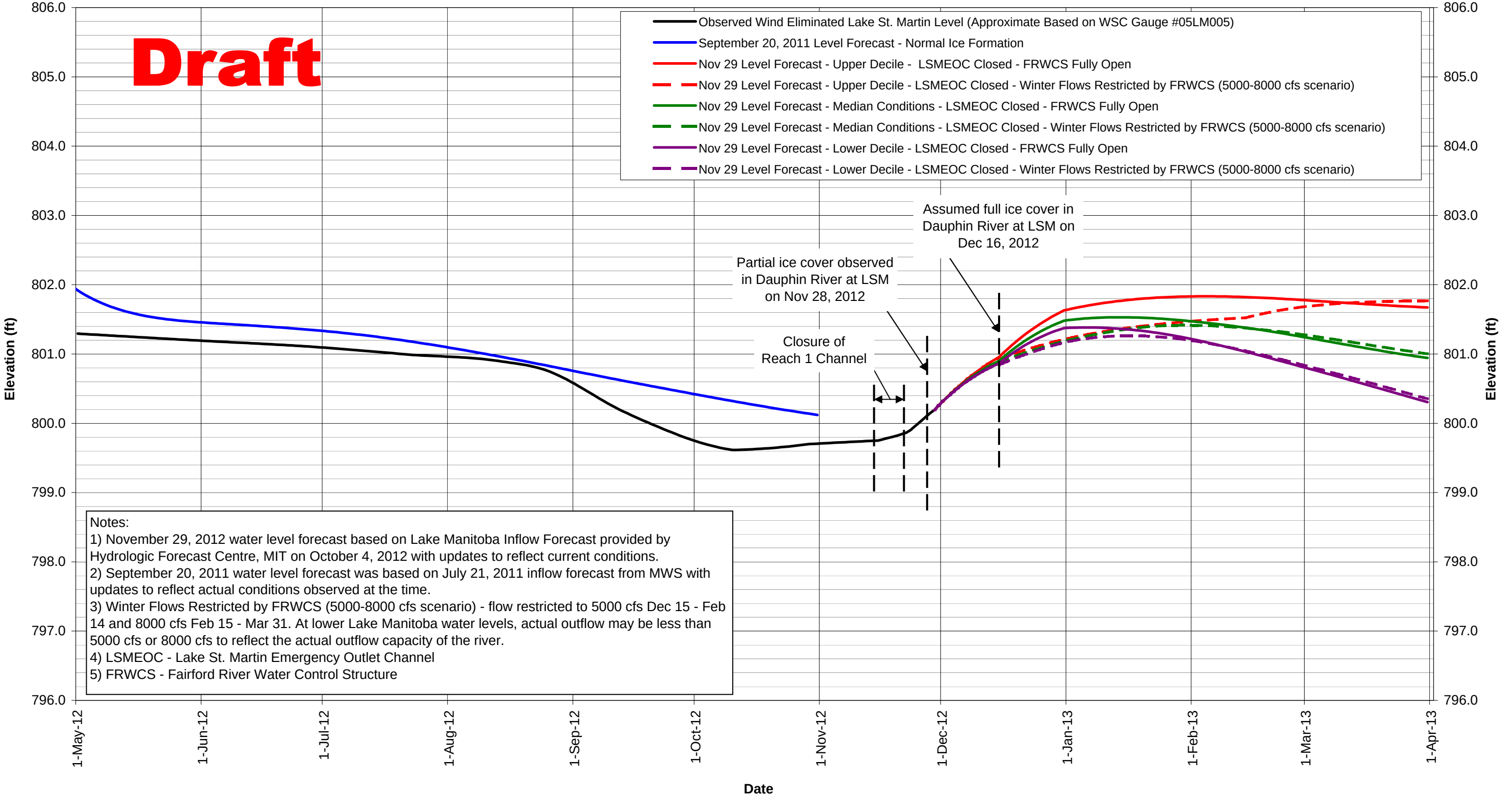
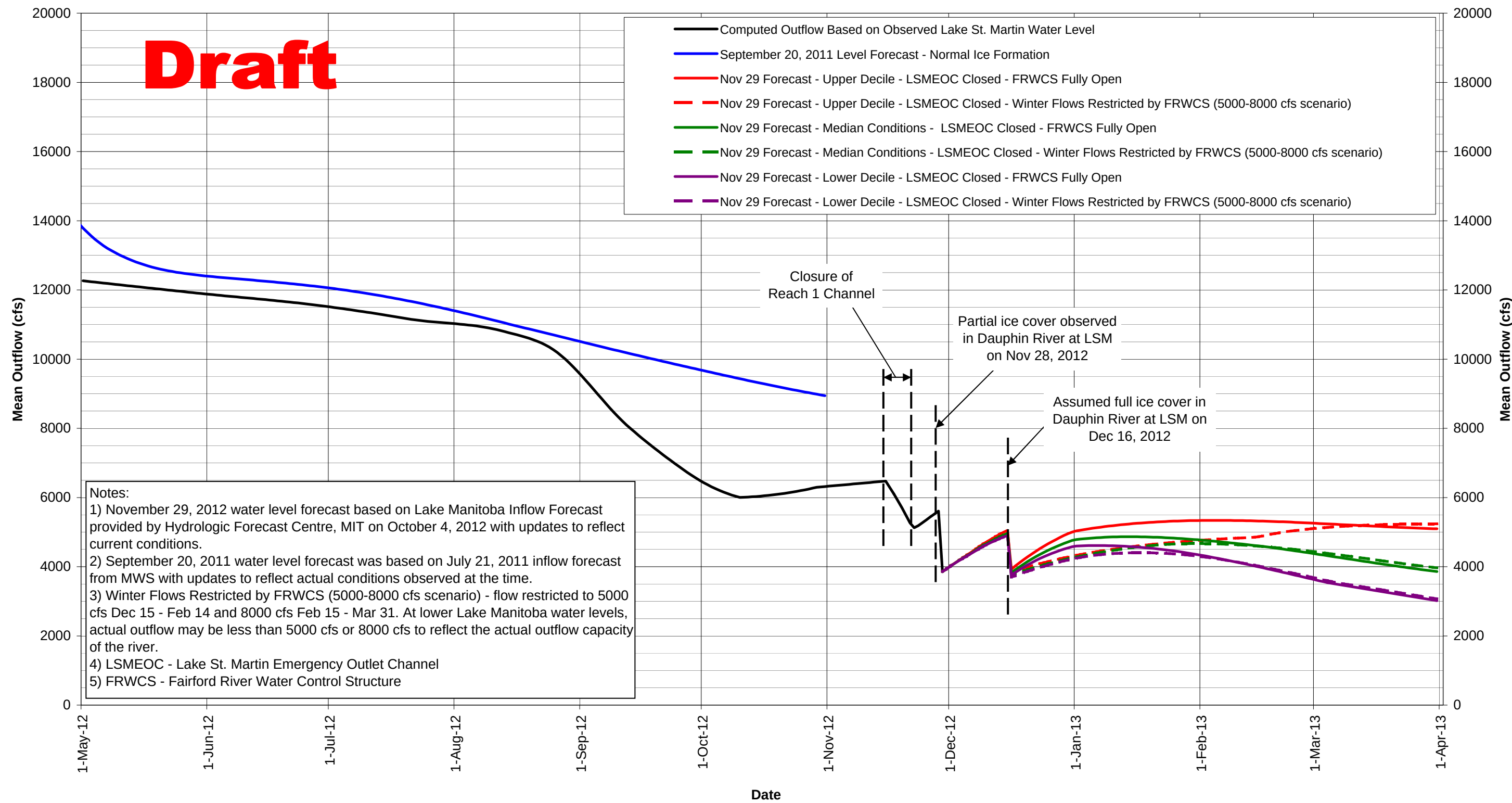


Figure 2.13.2 RevP
Computed Lake St. Martin Outflow



**Lake Manitoba Forecast
Correspondence and Figures**

December 31, 2012

Garrett Wellwood

From: Colin Siepman [CSiepman@ksgsgroup.com]
Sent: Tuesday, January 08, 2013 2:19 PM
To: 'Topping, Steve (MIT)'; Ron Kaatz
Cc: 'McMahon, Doug (MIT)'; Don Norquay; 'Richardson, Ron (MIT)'; Mark Allard ; Eric Christiansen; 'Mutulu, Phillip (MIT)'; Jason Senyk; Brian Bodnaruk; Rick Carson; Bert Smith; Dave MacMillan; Rob Kenyon; Hannon, Gord (JUS)
Subject: End of December LMB and LSM Forecast
Attachments: Figure 1.1.1 RevR.PDF; Figure 1.1.2 RevJ.PDF; Figure 2.13.1 RevQ.PDF; Figure 2.13.2 RevQ.PDF; Dauphin River Inlet at LSM.JPG; Fairford River at HWY 6.jpg; Dauphin River at Frenchman's Rapids.jpg; R1 Closure Seepage - 1.JPG

Please find attached the end of December Lake Manitoba (LMB) and Lake St. Martin (LSM) forecast figures based on the LMB inflow forecast that was provided by the Hydrologic Forecast Centre, MIT on October 4, 2012, updated to reflect current conditions. Note that the current LMB inflow forecast does not extend beyond April 1st 2013. When the Hydrologic Forecast Centre is able to provide an extended LMB inflow forecast and spring 2013 operating scenarios for the FRWCS we will extend the figures accordingly.

As before, the forecast considered lower decile, median and upper decile weather conditions and flows. The forecast also considered that the Lake St. Martin Emergency Outlet Channel (LSMEOC) is closed and that the Fairford River Water Control Structure (FRWCS) is fully open.

Since the current MIT operational plan is to leave FRWCS at maximum discharge (i.e. no change in stoplogs), and the current LMB outflows are near 5000 cfs, the hypothetical scenario where flows are restricted by the FRWCS to 5000 cfs until February 15 was not considered in this forecast.

The forecast once again considered a potential natural restriction due to ice effects upstream of the FRWCS. For the analysis, it was assumed that the effects of the ice would begin on January 20, 2013 and remain until ice breakup on April 1, 2013. The potential ice effects were based on historic records of discharges and water levels in the Fairford River and Lake Manitoba during winter months, and were assumed to be representative of "normal" ice conditions in the river with FRWCS fully open. During a flyover of the Fairford River conducted on December 20, 2012, open water conditions were observed upstream of the FRWCS (see photos attached).

The end of December forecast remains similar to the November 29, 2012 forecast and the current water levels and outflows are trending near median conditions. A summary of the median conditions forecast is provided below.

Lake Manitoba

The January 7, 2013 water level on LMB was approximately 811.8 ft and the outflow was approximately 5600 cfs. Based on median conditions, the water level is forecasted to recede to approximately 811.6 ft by March 31, 2013 with the FRWCS fully open.

Lake St. Martin

The January 7, 2013 water level on LSM was approximately 801.2 ft. Based on median conditions and current ice conditions in the upper Dauphin River, the water level is forecasted to rise to approximately 801.3 ft within the next few weeks. The water level is then forecasted to recede to approximately 800.8 ft by March 31, 2013. As indicated on the figures, a partial ice cover was observed in the Dauphin River at LSM on November 28, 2012. Similar conditions were observed during a flyover of the Dauphin River conducted on December 20, 2012 (see photos attached). Depending on the extents of the current partial ice cover in the upper Dauphin River, and the timing at which a full ice cover forms, the rate at which the LSM water levels continue to rise or begin to fall may differ then what is shown on the forecast. However, when only considering the forecasted peak water level on the lake, ice forming in the upper Dauphin River earlier or later than assumed has negligible effects to the forecasted peak water level provided on the

figure.

Due to current ice conditions in the upper Dauphin River, the Jan 7, 2013 LSM outflow is difficult to predict. However based on our forecast and assumed effects of the ice cover, the LSM outflow into the upper Dauphin River was estimated to be approximately 5500 cfs. The LSMEOC is now closed and therefore no longer contributes to the LSM outflow (with the exception of minor seepage through the closure dike).

Dauphin River

Based on observed Lake St. Martin water levels, the peak flow in the lower Dauphin River during ice formation in the DRFN was approximately 6,500 cfs (with the LSMEOC in operation). The current discharge in the community is much less due to the closure of the LSMEOC and ice effects in the upper Dauphin River, and are expected to remain below the 6,500 cfs peak for the rest of the winter. A review of the potential maximum ice staging in the DRFN community for a flow of 9500 cfs was previously completed by the Frazil Ice Team to assess the potential inundation in the DRFN community without the dikes in place (e-mail sent April 2, 2012). This review indicated that the freeboard above the water surface profile was greater than 0.5 m for all buildings.

At ice breakup on April 1, 2013, median condition flows in the DRFN Community are forecasted to peak at approximately 6,800 cfs. For the upper decile forecast, flows in the DRFN Community at ice breakup on April 1, 2013 are forecasted to peak at approximately 7,900 cfs, which is substantially less than the forecasted 24,710 cfs peak flow that we prepared for in the spring of 2012. Note that the forecasted peak does not consider local runoff from Buffalo Creek.

From: Colin Siepman [mailto:CSiepman@kgsgroup.com]

Sent: November-29-12 4:53 PM

To: 'Topping, Steve (MIT)'; Ron Kaatz

Cc: 'McMahon, Doug (MIT)'; Don Norquay; 'Richardson, Ron (MIT)'; Mark Allard ; Eric Christiansen; 'Mutulu, Phillip (MIT)'; Jason Senyk; Brian Bodnaruk; Rick Carson; Bert Smith; Dave MacMillan; Rob Kenyon; Hannon, Gord (JUS)

Subject: End of November LMB and LSM Forecast

Please find attached the end of November Lake Manitoba (LMB) and Lake St. Martin (LSM) forecast figures based on the LMB inflow forecast that was provided by the Hydrologic Forecast Centre, MIT on October 4, 2012, updated to reflect current conditions. Note that the current LMB inflow forecast does not extend beyond April 1st 2013. When the Hydrologic Forecast Centre is able to provide an extended LMB inflow forecast and spring 2013 operating scenarios for the FRWCS we will extend the figures accordingly.

As before, the forecast considered lower decile, median and upper decile weather conditions and flows. The following two operating scenarios were included in the forecast:

- Lake St. Martin Emergency Outlet Channel (LSMEOC) closed with Fairford River Water Control Structure (FRWCS) fully open
- LSMEOC closed with flows restricted by FRWCS to 5000 cfs Dec 15 to Feb 14 and 8000 cfs Feb 15 to Mar 31

Note that the current MIT operational plan is to leave FRWCS at maximum discharge (i.e. no change in stoplogs). For the hypothetical scenario where flows are restricted by the FRWCS, the November 15 date of operation was moved to December 15. Additionally, at lower LMB water levels, the LMB outflow after December 15 was at times forecasted to be less than the potential 5000 cfs or 8000 cfs restriction. In this case, the actual outflow for the "winter flows restricted by FRWCS (5000-8000 cfs scenario)" was based on the actual outflow capacity of the Fairford River.

All LMB scenarios once again consider a potential natural restriction due to ice effects upstream of the FRWCS. For the analysis, it was assumed that the effects of the ice would begin on January 1, 2013 and remain until ice breakup on April 1, 2013. The potential ice effects were based on historic records of discharges and water levels in the Fairford River and Lake Manitoba during winter months, and were assumed to be representative of "normal" ice conditions in the river with FRWCS fully open.

The current water level and outflow on LMB and LSM are slightly above the October 31, 2012 forecast due to

higher inflow than originally anticipated in the October 4 inflow forecast. A summary of the November 29, 2012 median conditions forecast is provided below.

Lake Manitoba

The November 29, 2012 water level on LMB was approximately 812.1 ft. Based on median conditions, the water level is forecasted to recede to approximately 811.6 ft by March 31, 2013 with the FRWCS fully open. A water level of 811.6 ft is also forecasted for the median conditions "winter flows restricted by the FRWCS (5000-8000 cfs scenario)" since natural LMB outflow is forecasted to be similar to the potential restriction scenario for the most part of the winter.

The November 29, 2012 LMB outflow was approximately 7100 cfs under median conditions, the outflow is expected to recede to approximately 5000 cfs by early January 2013 with "normal" ice conditions in the river.

Lake St. Martin

The November 29, 2012 water level on LSM was approximately 800.2 ft. Based on median conditions, the water level is forecasted to rise during the winter due to ice formation in the upper Dauphin River to approximately 801.5 ft and then recede to approximately 801.0 ft by March 31, 2013. For the hypothetical "winter flow restricted by FRWCS (5000-8000 cfs scenario)" the median conditions water level is expected to rise to approximately 801.4 ft and then recede to approximately 801.0 ft by March 31. As indicated on the figures, a partial ice cover was observed in the Dauphin River at LSM on November 28, 2012. Depending on the extents of the current partial ice cover in the upper Dauphin River, and the timing at which a full ice cover forms, the rate and speed at which the LSM water level actually rises may differ then what is shown on the forecast. However, when only considering the forecasted peak water level on the lake, ice forming in the upper Dauphin River two to three weeks earlier or later than assumed has negligible effects to the forecast peak water level provided on the figure.

Due to current ice conditions in the upper Dauphin River, the November 29, 2012 LSM outflow is difficult to predict. However based on our forecast and assumed effects of the partial ice cover, the LSM outflow into the upper Dauphin River was estimated to be approximately 4000 cfs. Under open water conditions, the LSM outflow would be approximately 5700 cfs. The LSMEOC is now closed and therefore no longer contributes to the LSM outflow (with the exception of minor seepage through the closure dike).

Dauphin River

Based on observed Lake St. Martin water levels, the peak flow in the lower Dauphin River during ice formation in the DRFN was approximately 6,500 cfs (with the LSMEOC in operation). The current discharge in the community is much less due to the closure of the LSMEOC and ice effects in the upper Dauphin River, and are expected to remain below the 6,500 cfs peak for the rest of the winter. A review of the potential maximum ice staging in the DRFN community for a flow of 9500 cfs was previously completed by the Frazil Ice Team to assess the potential inundation in the DRFN community without the dikes in place (e-mail sent April 2, 2012). This review indicated that the freeboard above the water surface profile was greater than 0.5 m for all buildings.

At ice breakup on April 1, 2013, median condition flows in the DRFN Community are forecasted to peak at approximately 7,100 cfs. Peak flows at ice breakup on April 1 would be slightly more (approximately 7,200 cfs) for the median "winter flow restricted by FRWCS (5000-8000 cfs scenario)". For the upper decile forecast, flows in the DRFN Community at ice breakup on April 1, 2013 are forecasted to peak at approximately 8,600 cfs, which is substantially less than the forecasted 24,710 cfs peak flow that we prepared for in the spring of 2012. Note that the forecasted peak does not consider local runoff from Buffalo Creek.

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
Senior Project Manager
KGS Group

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Figure 1.1.1 RevR
Computed Lake Manitoba Level

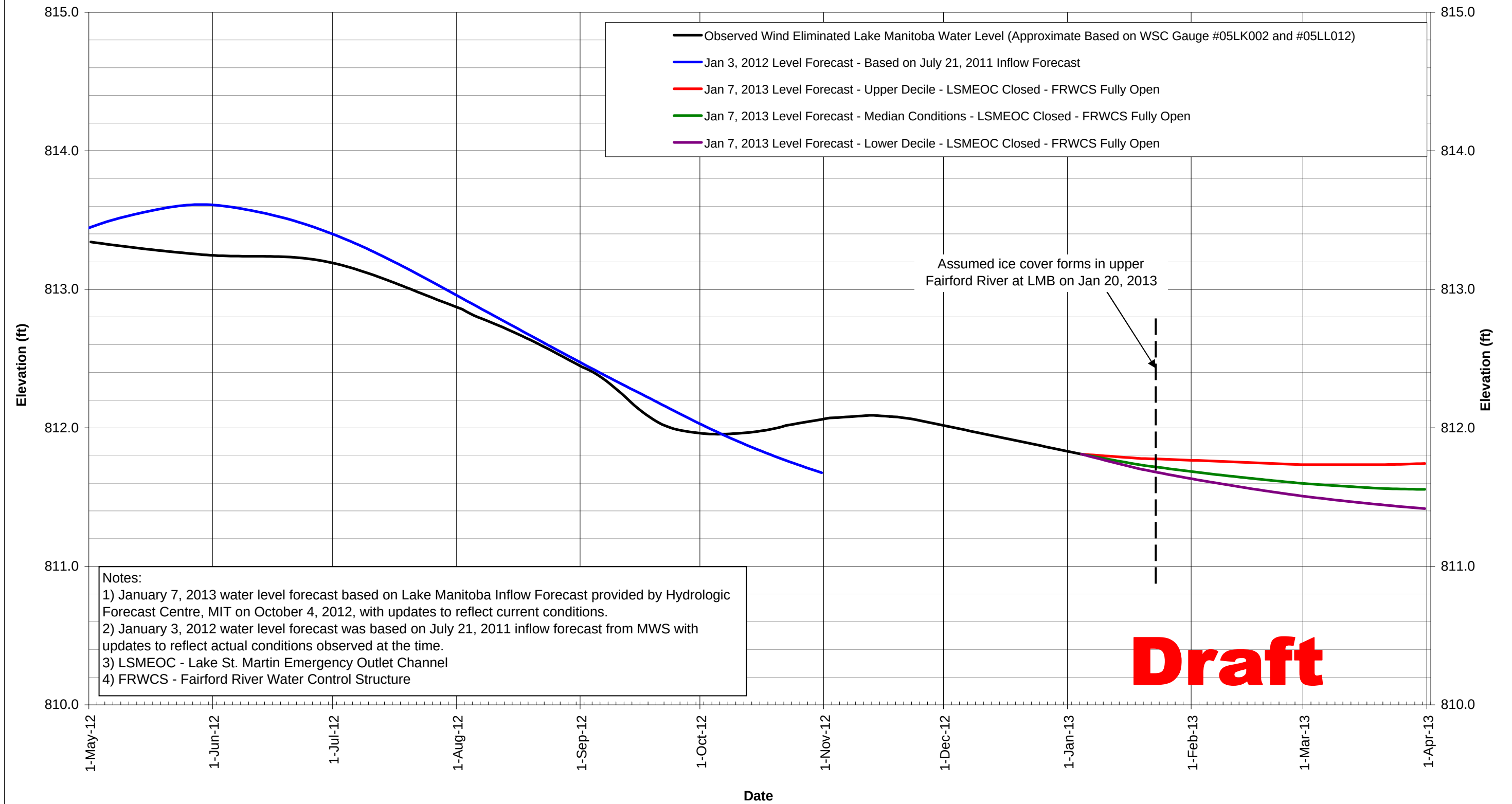


Figure 1.1.2 RevJ
Computed Lake Manitoba Outflow

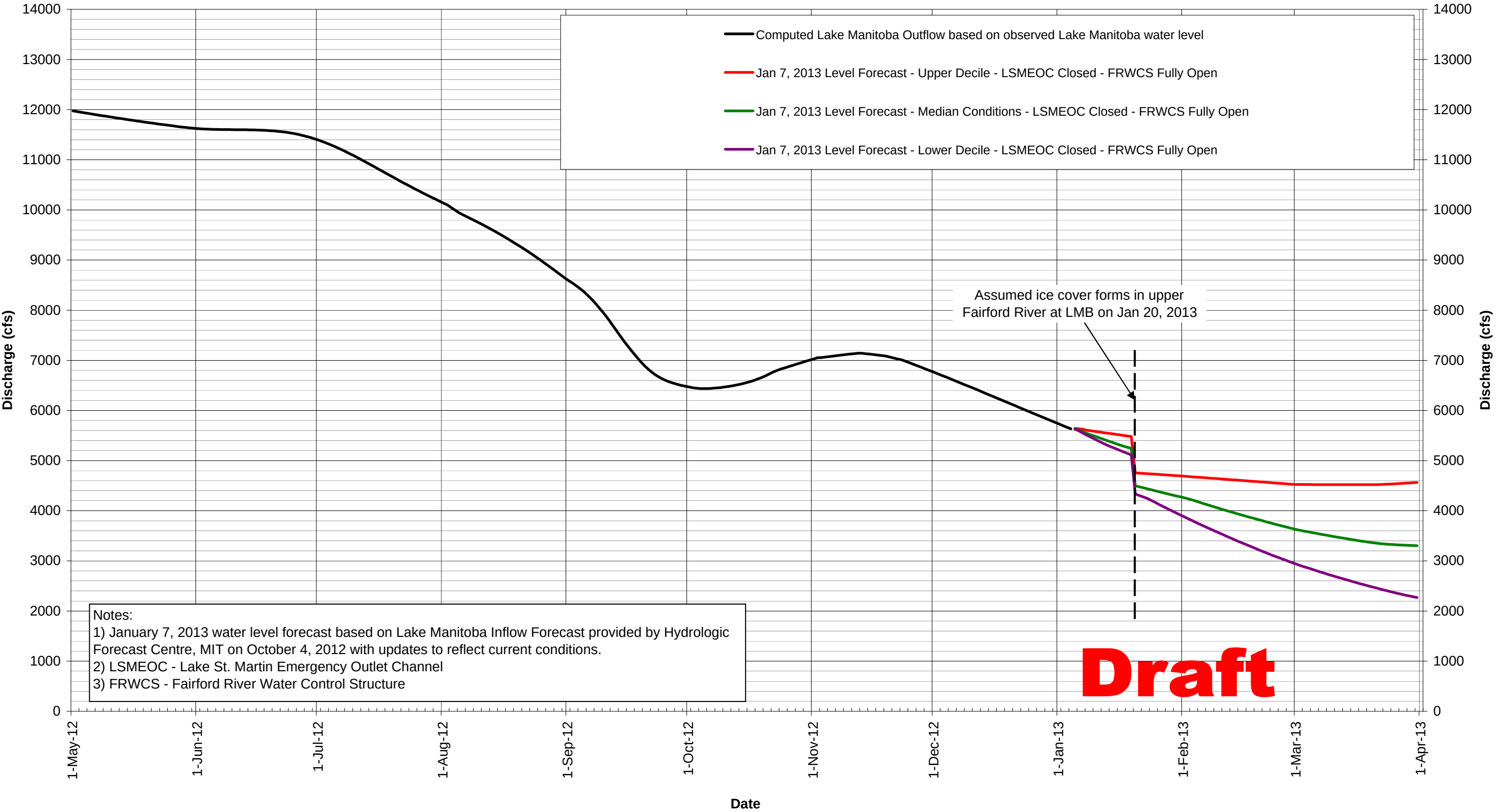


Figure 2.13.1 RevQ
Computed Lake St. Martin Level

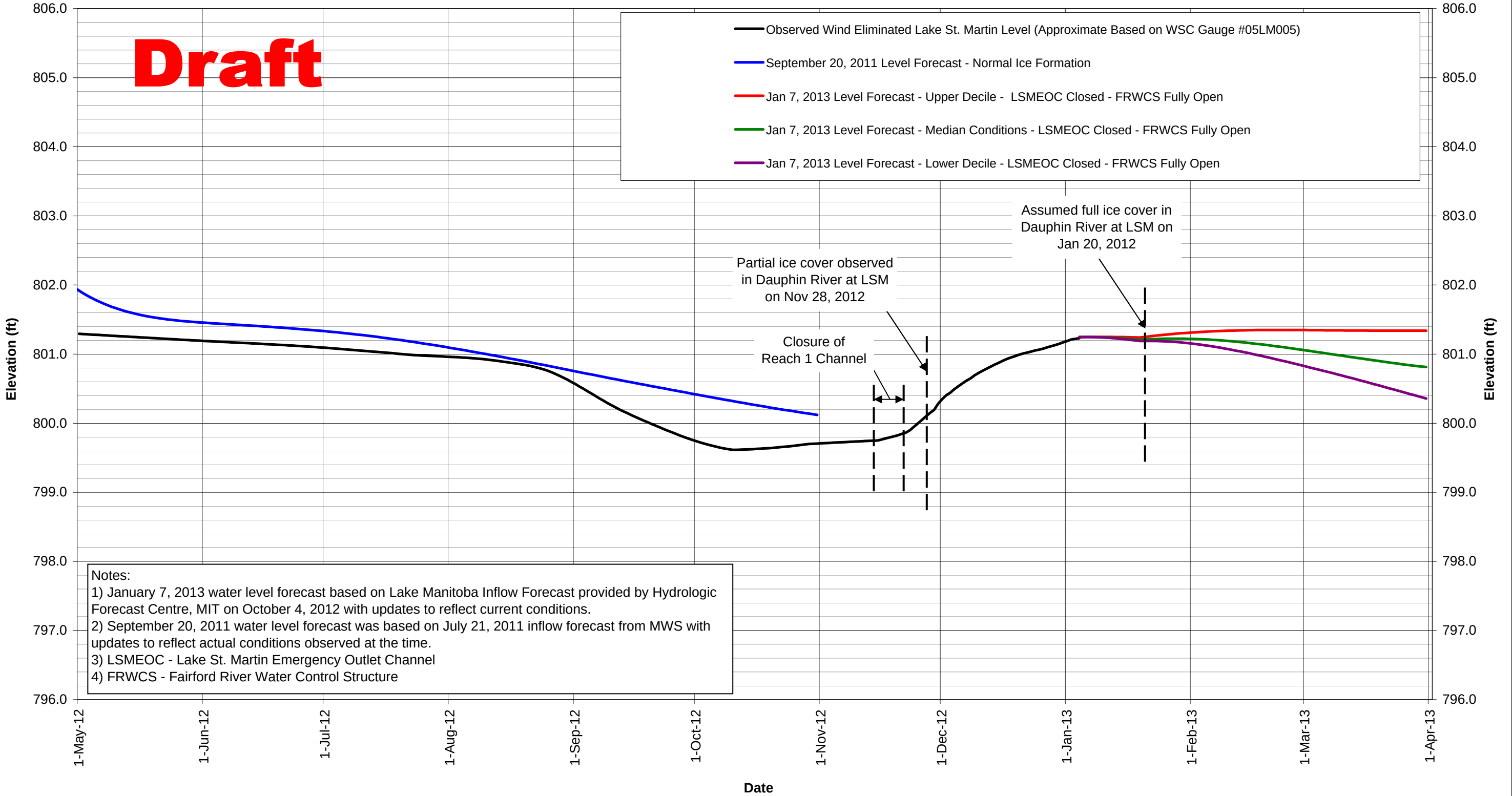
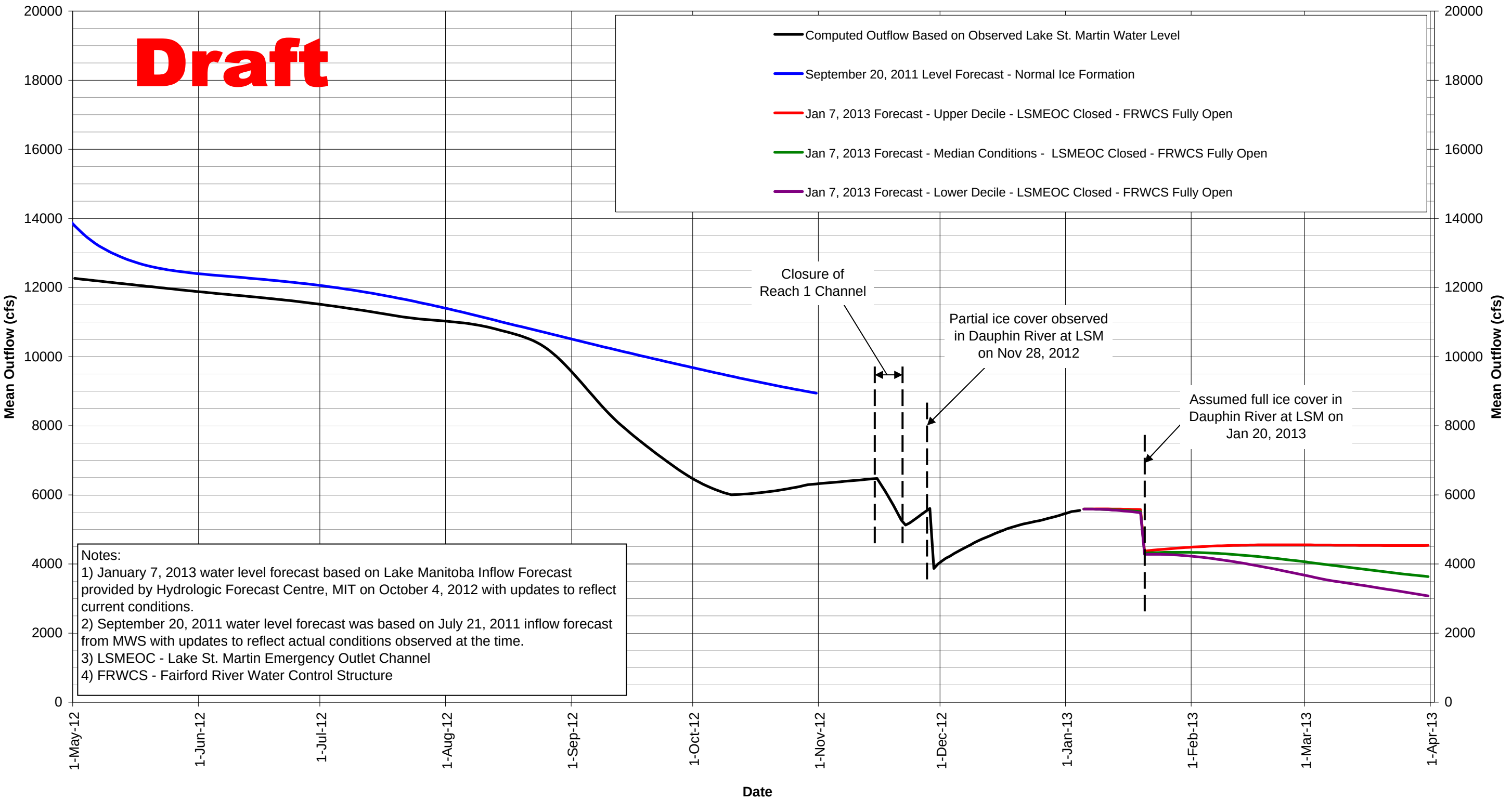


Figure 2.13.2 RevQ
Computed Lake St. Martin Outflow



**Lake Manitoba Forecast
Correspondence and Figures**

January 31, 2013

Garrett Wellwood

From: Colin Siepman [CSiepman@ksgsgroup.com]
Sent: Friday, February 08, 2013 4:47 PM
To: 'Topping, Steve (MIT)'; Ron Kaatz
Cc: 'McMahon, Doug (MIT)'; Don Norquay; 'Richardson, Ron (MIT)'; Mark Allard ; Eric Christiansen; 'Mutulu, Phillip (MIT)'; Jason Senyk; Brian Bodnaruk; Rick Carson; Bert Smith; Dave MacMillan; Rob Kenyon; Hannon, Gord (JUS)
Subject: End of January LMB and LSM Forecast
Attachments: Figure 1.1.1 RevS.PDF; Figure 1.1.2 Revk.pdf; Figure 2.13.1 RevR.PDF; Figure 2.13.2 RevR.PDF

Please find attached the end of January Lake Manitoba (LMB) and Lake St. Martin (LSM) forecast figures based on the LMB inflow forecast that was provided by the Hydrologic Forecast Centre, MIT on October 4, 2012, updated to reflect current conditions. Note that the current LMB inflow forecast does not extend beyond April 1st 2013. When the Hydrologic Forecast Centre is able to provide an extended LMB inflow forecast and spring 2013 operating scenarios for the FRWCS we will extend the figures accordingly (we anticipate this will be provided in late February).

As before, the forecast considered lower decile, median and upper decile weather conditions and flows. The forecast also considered that the Lake St. Martin Emergency Outlet Channel (LSMEOC) is closed and that the Fairford River Water Control Structure (FRWCS) is fully open.

Ice effects upstream of the FRWCS were once again considered for this forecast. However, based on current conditions in the Fairford River and water levels in Lake Manitoba, the ice effects were determined to be negligible, and were assumed to remain unchanged for the remainder of the winter. During a flyover of the Fairford River conducted on December 20, 2012, open water conditions were observed upstream of the FRWCS.

This forecast remains similar to the January 7, 2012 forecast, however the current water levels and outflows are trending near upper decile conditions due to higher inflows to Lake Manitoba than the inflow forecast provided by MIT on October 4, 2012. A summary of the upper decile forecast is provided below.

Lake Manitoba

The February 7, 2013 water level on LMB was approximately 811.8 ft and the outflow was approximately 5700 cfs. Based on upper decile conditions, the water level is forecasted to recede to approximately 811.7 ft by March 31, 2013 with the FRWCS fully open.

Lake St. Martin

The February 7, 2013 water level on LSM was approximately 801.4 ft. Based on upper decile conditions and current ice conditions in the upper Dauphin River, the water level is forecasted to rise to approximately 801.5 ft by March 31, 2013.

Due to current ice conditions in the upper Dauphin River, the Feb 7, 2013 LSM outflow is difficult to predict. However based on our forecast and assumed effects of the ice cover, the LSM outflow into the upper Dauphin River was estimated to be approximately 5300 cfs. The LSMEOC is now closed and therefore no longer contributes to the LSM outflow (with the exception of minor seepage through the closure dike).

Dauphin River

Based on observed Lake St. Martin water levels, the peak flow in the lower Dauphin River during ice formation in the DRFN was approximately 6,500 cfs (with the LSMEOC in operation). To our knowledge there was no impact on infrastructure within the community or access, with the exception of a localized area where inundation approached the centerline of PR513. The current discharge in the community is now less due to the closure of the LSMEOC and ice effects in the upper Dauphin River, and is expected

to remain below the 6,500 cfs peak for the rest of the winter. A review of the potential maximum ice staging in the DRFN community for a flow of 9500 cfs was previously completed by the Frazil Ice Team to assess the potential inundation in the DRFN community without the dikes in place (e-mail sent April 2, 2012). This review indicated that the freeboard above the water surface profile was greater than 0.5 m for all buildings.

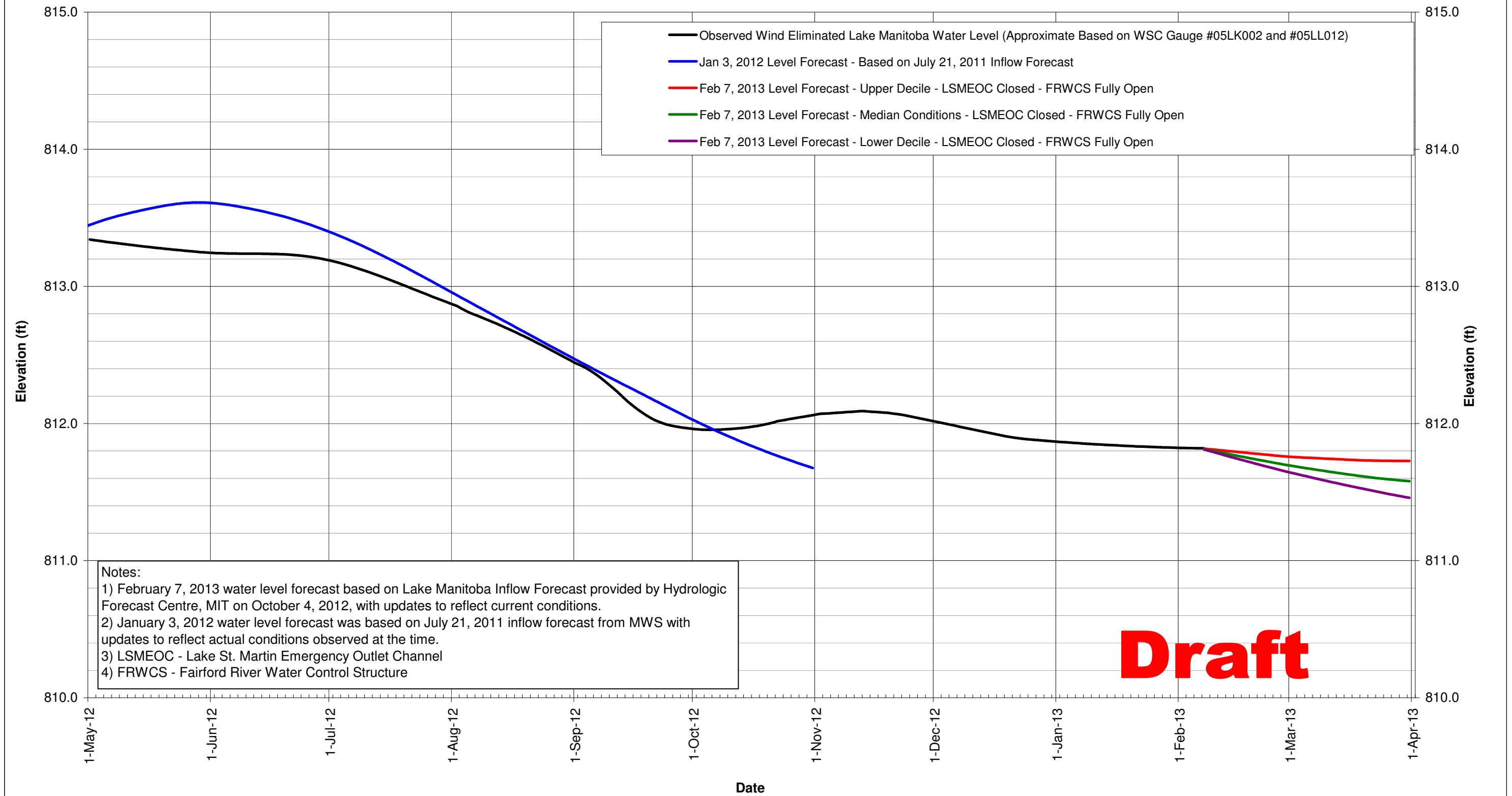
At ice breakup on April 1, 2013, flows in the DRFN Community are forecasted to peak at approximately 8,100 cfs, which is substantially less than the forecasted 24,710 cfs peak flow that we prepared for in the spring of 2012. Note that the forecasted peak does not consider local runoff from Buffalo Creek.

Regards,

Colin Siepman, B.Sc. CE, M.Eng, P.Eng
Senior Project Manager
KGS Group

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Figure 1.1.1 RevS
Computed Lake Manitoba Level



Notes:
1) February 7, 2013 water level forecast based on Lake Manitoba Inflow Forecast provided by Hydrologic Forecast Centre, MIT on October 4, 2012, with updates to reflect current conditions.
2) January 3, 2012 water level forecast was based on July 21, 2011 inflow forecast from MWS with updates to reflect actual conditions observed at the time.
3) LSMEOC - Lake St. Martin Emergency Outlet Channel
4) FRWCS - Fairford River Water Control Structure

Draft

Figure 1.1.2 RevK
Computed Lake Manitoba Outflow

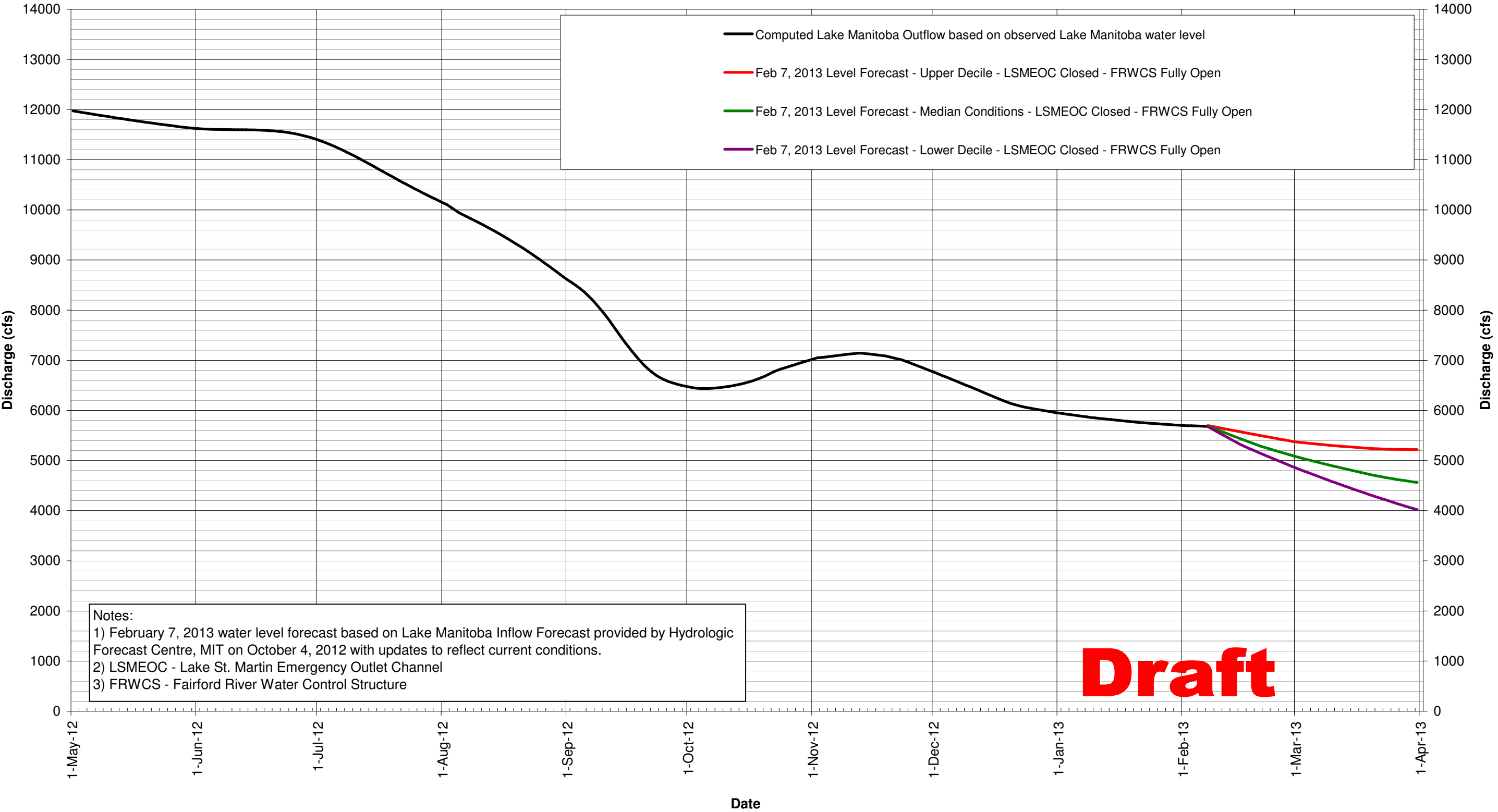


Figure 2.13.1 RevR
Computed Lake St. Martin Level

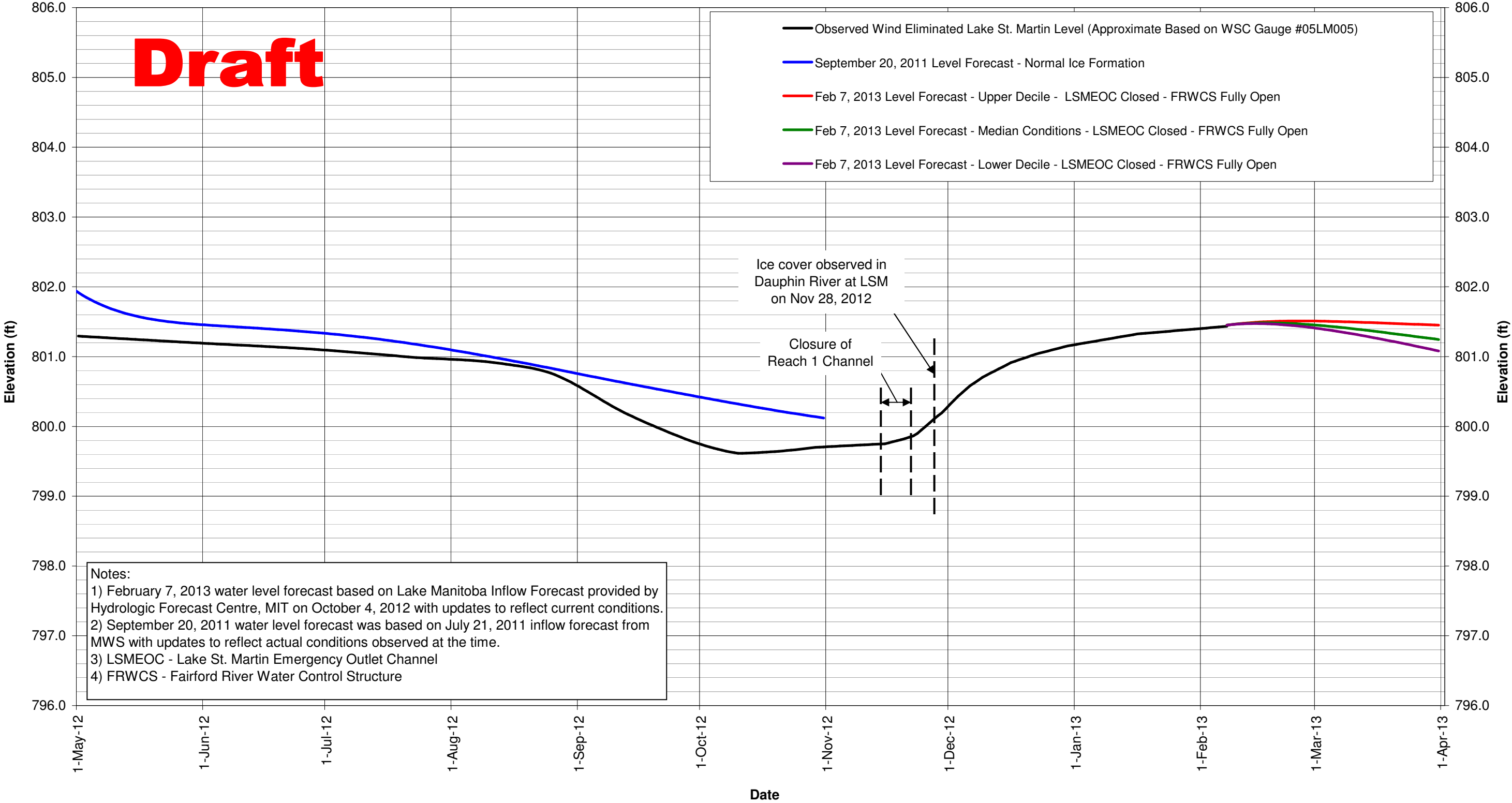
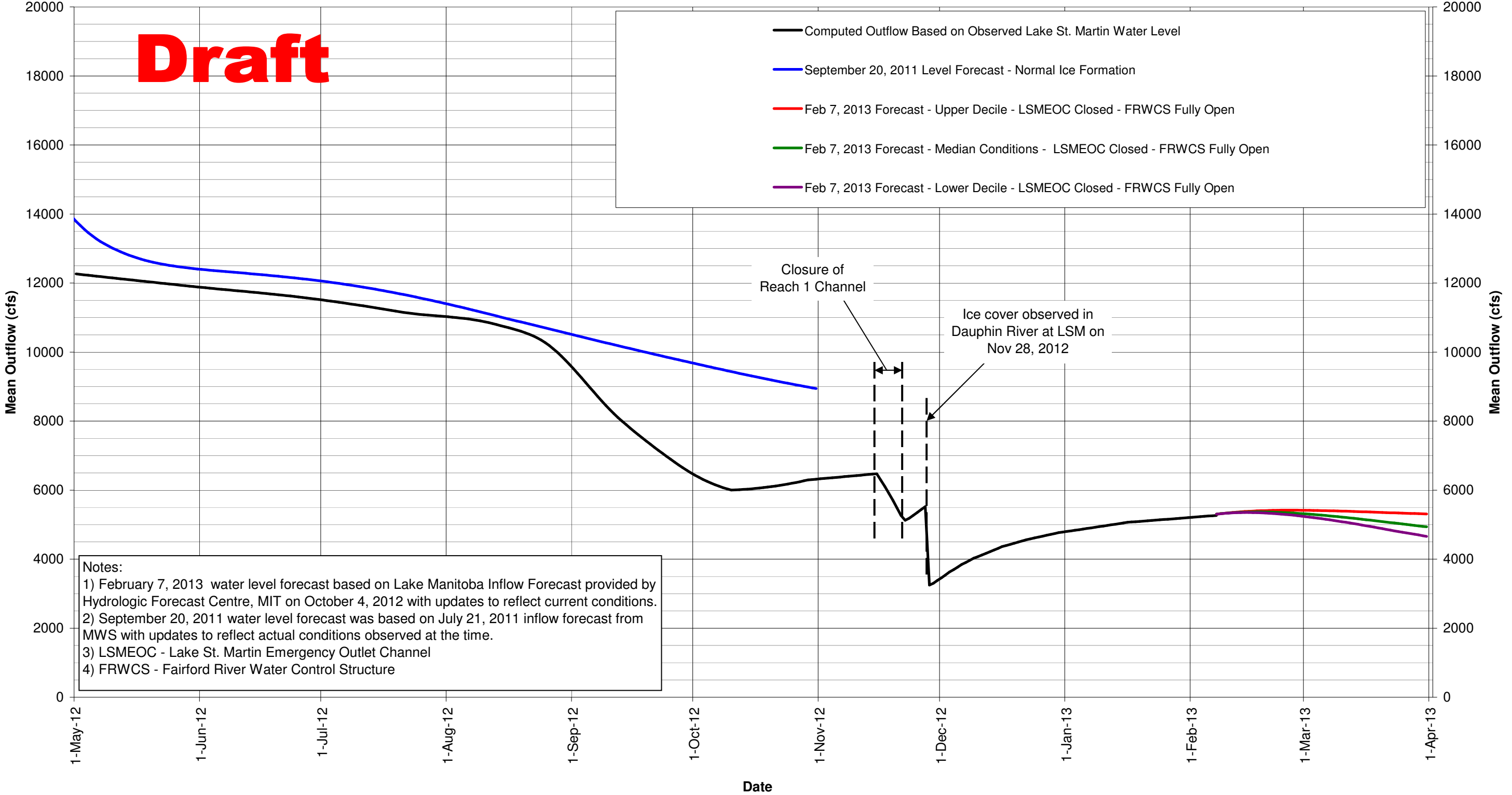


Figure 2.13.2 RevR
Computed Lake St. Martin Outflow



APPENDIX B

FLOW METERING AND WATER LEVEL MEASUREMENT OF THE LAKE ST. MARTIN EMERGENCY CHANNEL SYSTEM



March 6, 2014

File No: 11-0300-18

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ATTENTION: Mr. Ron Kaatz
Senior Hydraulic Engineer

RE: Emergency Reduction of Lake St. Martin and Lake Manitoba Water Levels
Flow Metering and Water Level Measurement of the Lake St. Martin
Emergency Channel System

Dear Mr. Kaatz:

1.0 INTRODUCTION

As part of the hydraulic studies for the Emergency Reduction of Lake St Martin and Lake Manitoba Water Levels project, KGS Group completed flow meterings and water level measurements along the Lake St. Martin Emergency Channel System. The flow meterings were conducted in the Reach 1 Emergency Channel on November 18, 2011, March 21, 2012, April 17, 2012 and August 9, 2012. Water levels were surveyed at various stations along the Reach 1 channel and on Buffalo Creek on the days of the meterings and also on five more occasions between February 7 and 28, 2012.

The purpose of this program was to obtain instantaneous measurements of flow in the Reach 1 Emergency Channel during its operation to calibrate flood routing and backwater models, and confirm the true capacity of Reach 1 under open water conditions.

The channel was initially put into operation on November 1, 2011, with a partial opening of the inlet plug which took multiple days to complete. After a short delay to create a new barge access channel to the east, the remainder of the plug was removed starting on November 16, 2011. Additional work was completed at the inlet between January 24 and February 1 to complete the plug or "finger" removal towards the barge access channel and cleanup the inlet area.

A description of the equipment and procedures used for data collection during this program is included in Section 2.0. Section 3.0 provides the procedure for data processing and review and also presents a summary of results.

2.0 EQUIPMENT AND PROCEDURES

2.1 FLOW METERING INSTRUMENTATION

Flows were recorded using an Acoustic Doppler Current Profiler (ADCP). KGS Group used the Teledyne RDI RiverRay – 600 kHz for this metering, coupled with the Hemisphere A100 Differential Global Positioning System (DGPS) on November 18, 2011 and March 21, 2012. The ADCP was mounted on a tethered miniature boat and was either operated while crossing the channel anchored on the side of a power boat or manually pulled across the watercourse from a cableway.

The ADCP technology relies on the transmission of acoustic energy and the analysis of the sound echoes reflected back from particles in the water columns. By analyzing the change in frequency of the sound echoes, the ADCP makes continuous measurements of the speed and direction of water currents through the water column and depth. This technology provides real-time flow velocities and a bathymetric representation of the river bottom.

The data recorded by the ADCP is continuously transmitted via a Bluetooth connection to a field computer, which integrates the information and provides flow velocity, water depth and cumulative discharge on a real time basis. With the RDI RiverRay unit, the Teledyne RDI's software WinRiver II (version 2.07) was used for this purpose. The DGPS records real time positioning information which is continuously transmitted directly to the ADCP.

2.2 FLOW METERING PROCEDURE

The flow metering followed the widely accepted Water Survey of Canada (WSC) [Ref 1] and United States Geological Survey (USGS) [Ref 2] Guidelines for the operation of the ADCP as well as for the post processing [Ref 3 and 4] of the collected information.

The November 18, 2011 flow metering was completed by anchoring the tethered ADCP boat to the side of a power boat while crossing the channel at approximately station 5+500. The March 21, April 17 and August 9, 2012 flow meterings were conducted by manually pulling the tethered ADCP boat across the watercourse from a cableway installed at approximately station 2+000. A description of the cableway installation is included in Section 3.0. A plan showing the location of both metering sites is provided on Figure 1.

The ADCP parameters were set according to the conditions observed at this site by the operator. These parameters included:

- **Compass Calibration** – The calibration of the built-in compass of the RiverRay ADCP was carried out on site away from any local source of magnetic fields or potential interferences according to RDI's recommendations.
- **Cell or Bin Sizes and Maximum Water Depth of Transect** – The RDI RiverRay software does not require the specification of bin sizes since these are automatically selected on a real time basis as the depth is recorded.
- **Edge Distances and Shape of Section** – The location of the starting and ending points of each transect was determined by the operator according to the conditions observed on site and when a minimum depth, at a minimum equal to 2 valid cells, was achieved. The edge

distances were measured and the shape parameters for the calculation of the edge discharges were input by the operator.

Each measurement was comprised of four valid transects (i.e. two reciprocal pairs) in which the total exposure time on the channel lasted a minimum of 12 minutes. The computed discharges were targeted to be within 5% of each other. While operating the ADCP from the power boat, the path across the watercourse taken during each of the ADCP transects was maintained identical as much as possible by the boat operator. For measurements taken from the cableway, the path across the watercourse was essentially fixed by the orientation of the cableway setup.

The bottom tracking feature was selected to measure the positioning of the ADCP for discharge calculations. The DGPS coupled with the ADCP was used as an alternative means to measure positioning.

2.3 WATER LEVEL MEASUREMENTS

KGS Group surveyed water levels at various stations along the Reach 1 Emergency Channel and on Buffalo Creek on the days of the flow meterings and on five more occasions between February 7, and 28, 2012. The location of the water level surveys are shown on Figure 1. A list of all water levels obtained during the surveys is provided in Table 1. Water surface profiles in Reach 1 generated from the measurements provided in Table 1 are provided on Figure 2.

Water levels were either measured on the east side of Reach 1 using Global Positioning System (GPS) survey equipment or surveyed from temporary benchmarks using a rod and level. Temporary benchmarks were first established on February 10, 2012 at the water level measurement sites along Reach 1 and Buffalo Creek by driving 1-foot nails into the ground or on a nearby tree stump. On March 21, 2012, five temporary benchmarks were re-established on Reach 1 by driving 3-foot rebar into the ground. An additional temporary benchmark was also installed at the cableway site. The coordinates and elevation of the most recent temporary benchmark installed at each water level measurement site is provided on Table 2.

During the November 18, 2011 flow metering, a water level measurement was taken from the gauge board installed at station 5+200 (Gauge 3). The water level was measured relative to the zero of the gauge and is included on Table 1. Survey information for the gauge was obtained from the Lake St. Martin Emergency Channel Outlet Drawings Issued for Record by AECOM on May 8, 2012. Water level measurements were not taken at any of the gauge boards installed on Reach 1 during the subsequent water level surveys and flow meterings in 2012 as the gauges were damaged due to the formation of border ice along Reach 1.

In addition to surveyed water levels discussed above, Water Survey of Canada maintains a continuous water level recorder on Lake St. Martin near Hilbre at gauge no. 05LM005. These levels were included with the rest of the water level measurements discussed above to extend the Reach 1 water surface profiles to Lake St. Martin.

3.0 CABLEWAY INSTALLATION

A cableway system was installed at approximately station 2+000 for the purpose of safely operating an ADCP on a straight line to obtain measurements of flow in the Reach 1 Emergency Channel during its operation. The cableway setup took place between March 12 and 21, 2012.

Photos illustrating the installation of the cableway are included in Appendix B. A drawing showing the as-built configuration of the cableway and the materials utilized is also included in Appendix B.

The cableway installation began on March 12 with Maple Leaf Drilling providing drilling services under the direction of KGS Group. The cableway configuration included a steel post, tie-back anchor, pulley platform and pulley installed on both sides of Reach 1, as well as a hand operated winch on the East bank. Maple Leaf drilled two holes on both the East and West banks of the Reach 1 Emergency Channel. A 9" diameter vertical hole was drilled to install a 4" diameter X16 ft long galvanized pipe to support the cableway pulley system. A second 9" diameter hole was drilled at a 45 degree angle to approximately 5 ft depth, and an 8' groundhog anchor with a "screw" end was installed to give additional support to the 4" diameter pipe when the cable is strung and tensioned. Both holes for the 4" diameter pipe and ground hog anchor were filled with readycrete. Each groundhog anchor was attached to its corresponding post with the use of a tensioned steel cable and a turnbuckle for future adjustment (see Photos in Appendix B). The turnbuckle connects to a pulley platform with a D-ring. The pulley platform is connected to the galvanized post with U-bolts. The pulley platform is comprised of a steel tee welded to a steel plate. The steel tee connects the anchor cable and the turnbuckle with the post, while the steel plate support carries the bolted-on pulley.

On March 21, after the readycrete had cured, the cable and pulley system was installed to allow for flow monitoring. During installation of the 4" diameter pipe on the East bank, the bottom 3 ft of the drill hole was not vertical and would have affected the vertical alignment of the pipe if it was installed to full depth. Therefore, the pipe was raised 3 ft so the pipe could be set vertically. Before installation of the pulley system the pipe was cut down the 3 ft it had been raised during initial installation. During the initial installation, a tag line (fishing line) was launched over the channel from East bank to West bank. Bailer twine was attached to the fishing line and then the 1/4" diameter steel cable attached to the bailer twine. When the steel cable was pulled across another tag line was attached to the steel cable to repeat the steps to get the steel cable around the pulley and back to the East bank. The steel cable was then tensioned to manufacturer specifications using a winch and then connected to the spanmaster travelling block with turnbuckles.

4.0 MEASUREMENTS AND RESULTS

4.1 DATA PROCESSING AND REVIEW

Post processing and quality review of the data with the ADCP was done according to the WSC Procedure for the Review and Approval of ADCP Discharge Measurement [Ref 3]. The quality review of the collected data included, but was not limited to, a detailed review of each transect and of the combination of the valid transects.

Individual quality control and review of each transect recorded with the ADCP consisted of the independent check of the following components:

- Bottom track and ship track
- Ambiguity velocities
- Ratio of bad vertical profiles
- Ratio of lost vertical profiles
- Bad bins

- Top and bottom discharge estimates
- Shore discharge estimates
- Ratio of measured discharge relative to the total discharge
- Extrapolation techniques

The final unadjusted discharge measurement was calculated as an average of a minimum of four transects constituted of two reciprocal pairs. The overall quality of the measurement was reviewed by combining the valid transects (corrected if necessary) together.

During a metering, it is possible for the site to exhibit signs of a moving riverbed. This phenomenon generates a systematic bias in discharge measurements made with an ADCP that is attributed to the movement of sediment near the streambed. This leads to an underestimation of the measured velocity and discharge.

Standard WSC and USGS procedures to test for a moving bed (loop test) were applied during the metering. Results from the loop test showed that there were no signs of a moving bed at this site for any of the flow measurements.

4.2 SUMMARY OF RESULTS

The flows measured during the four meterings were 172 m³/s (6070 cfs), 158 m³/s (5580 cfs), 129 m³/s (4560 cfs) and 115 m³/s (4060 cfs), respectively. The standard deviation between individual transects for each metering ranged between 0.9% and 1.3%, which are well within the recommended target value of 5%.

Results from the metering are included on Table 1. A summary of the results for each flow measurement are provided in Appendix A, which contains the following information, in order:

- A summary sheet with general site identification details, date, equipment used, and final discharge value. As well, the summary sheet also contains details of the measured discharge values and the final discharge calculation and deviation from the average.
- A computer screen shot of the results obtained from the WinRiver II software, showing typical velocity profile, ship track, and discharge summary.
- A computer screen shot of the loop test from the WinRiver II software.
- Results from the loop test.
- Site photos taken on the measurement day.

During the November 18, 2011 metering, some border ice was present along the shore of the Reach 1 Emergency Channel. Additionally, an ice cover was present on Lake St. Martin and portions of Buffalo Lake Bog. However, ice conditions during the metering did not appear sufficiently advanced to have a significant impact on the capacity of the channel. During the March 21, 2012 metering, some ice was present on Lake St. Martin and in Buffalo Lake Bog. However, the ice cover had significantly decayed due to the spring thaw, and therefore did not have an impact on the capacity of the channel. The results obtained during all meterings were therefore assured to be representative of open water conditions.

A rating curve for Reach 1 is provided in Figure 3, and was developed based on the metering data presented in this report and the WSC water levels on Lake St. Martin. As shown on the Figure, there was a shift in the rating curve between the November 18, 2011 measurement and the March 21, 2012 measurement. This shift was attributed to additional excavation work that occurred at the inlet between January 24, and February 1, 2012 to complete the plug and

“finger” removal towards the barge access channel, which increased the capacity of the channel inlet.

5.0 REFERENCES

1. Hydrometric Technician, Career Development Program, Water Survey of Canada, Environment Canada, 1999.
2. Measuring Discharge with Acoustic Doppler Current Profilers from a Moving Boat, Chapter 22 of Book 3, Section A, USGS, 2009.
3. Procedures for the Review and Approval of ADCP Discharge Measurements, Water Survey of Canada, Environment Canada, 2004.
4. Application of the Loop Method for Correcting Acoustic Doppler Current Profiler Discharge Measurements Biased by Sediment Transport, USGS, 2006.

Prepared by:

<original signed by>

Patrice Leclercq, EIT
Water Resources Designer



Reviewed by: 

<original signed by>

Ambroise Percheron, P.Eng.
Water Resources Designer

Approved by: 

<original signed by>

Colin Siepman, P. Eng
Senior Project Manager

SO/nf

TABLES

TABLE 1
LAKE ST. MARTIN EMERGENCY CHANNEL SYSTEM – 2011 TO 2012 SURVEYED WATER LEVELS

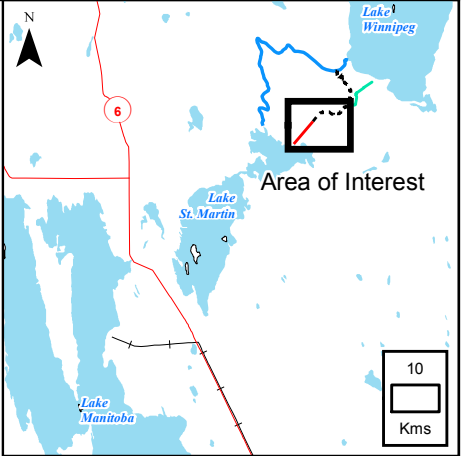
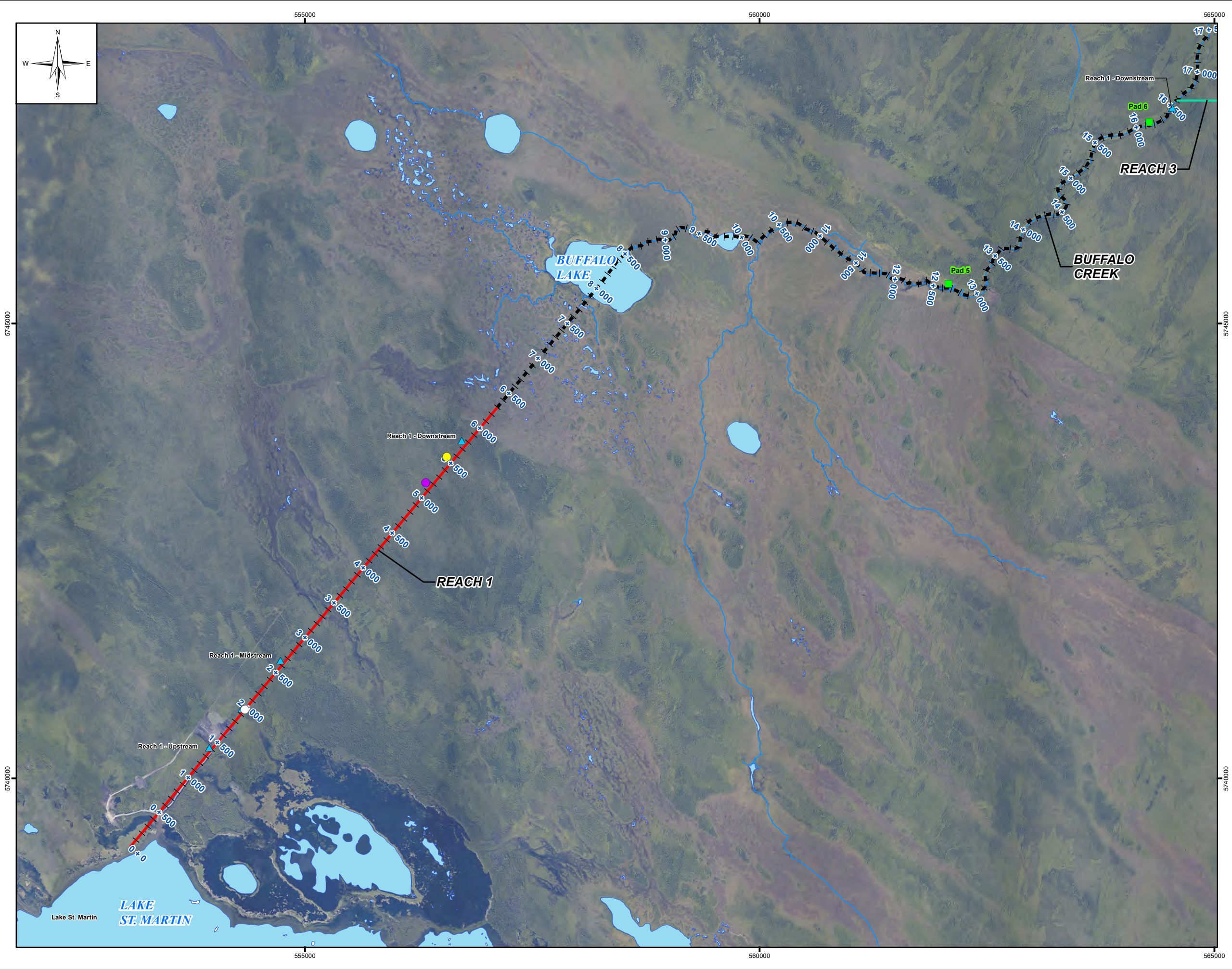
Station Metric	Point Description	Northing	Easting	November 18, 2011 WSE	February 7, 2012 WSE	February 10, 2012 WSE	February 14, 2012 WSE	February 21, 2012 WSE	February 28, 2012 WSE	March 21, 2012 WSE	April 17, 2012 WSE	August 9, 2012 WSE
N/A	Lake St. Martin Near Hilbre WSC Gauge # 05LM005	5706523	532695.0	244.810	244.630	244.610	244.595	244.572	244.543	244.395	244.245	244.140
0+000	Reach 1 Inlet from Lake St. Martin	5738450	552111.8	N/R	N/R	N/R	244.490	N/R	N/R	N/R	N/R	N/R
1+430	Reach 1 Upstream	5740338	553947.0	N/R	N/A	244.073	243.903	243.865	243.815	243.668	243.400	243.280
2+000	Reach 1 Cableway	5740768	554317.7	N/R	N/R	N/R	N/R	N/R	N/R	N/R	243.307	243.231
2+670	Reach 1 Midstream	5741297	554732.1	N/R	N/R	N/R	243.563	243.579	243.541	243.365	243.130	243.070
5+200	AECOM Gauge 3	5743252	556329.3	243.052	N/R	N/R	N/R	N/R	N/R	N/R	N/R	N/R
5+800	Reach 1 Downstream	5743731	556737.0	N/R	N/A	243.181	243.016	242.909	243.002	242.635	242.530	242.520
16+450	Buffalo Creek at Reach 3	5747371	564538.4	N/R	N/R	235.643	235.484	235.338	235.436	N/R	234.580	234.580
Metered Discharge m ³ /s (cfs)				172 (6070 cfs)	N/R	N/R	N/R	N/R	N/R	158 (5560 cfs)	129 (4560 cfs)	115 (4060 cfs)

Notes: N/A: Not Applicable / Data considered invalid during post processing
N/R: Data was not recorded
WSC: Water Survey of Canada
WSE: Water Surface Elevation (m)

TABLE 2
LAKE ST. MARTIN EMERGENCY CHANNEL SYSTEM – SUMMARY OF BENCHMARKS

Station	Benchmark ID	Location Description	Type	Northing (m)	Easting (m)	Elevation (m)
1+428	R1_1_TBM1	Reach 1 Upstream	Rebar	5740319.795	553962.785	247.068
1+431	R1_1_TBM2	Reach 1 Upstream	Rebar	5740304.253	553985.531	248.109
2+000	R1_CWY_TBM1	Reach 1 Cableway	Rebar	5740767.598	554317.703	247.094
2+670	R1_2_TBM1	Reach 1 Midstream	Rebar	5741289.95	554739.82	246.384
2+670	R1_2_TBM2	Reach 1 Midstream	Rebar	5741264.56	554771.178	247.726
5+816	R1_3_TBM1	Reach 1 Downstream	Rebar	5743710.771	556748.337	243.409
16+453	R3_1_TBM1	Buffalo Creek at Reach 3	Nail	5747351.594	564547.786	236.393
16+446	R3_1_TBM2	Buffalo Creek at Reach 3	Nail	5747342.955	564556.59	236.621
16+538	R3_1_TBM3	Buffalo Creek at Reach 3	Nail	5747373.237	564583.161	237.765

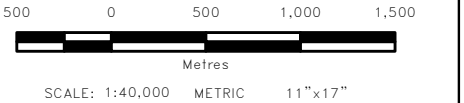
FIGURES



- LEGEND:
- Water Levels
 - AECOM Gauge 3
 - Nov 18, 2011 Flow Metering Location
 - Cableway - 2012 Flow Metering Location
 - Constructed Helicopter Landing Pad
 - Buffalo Creek Channel
 - Reach 1 Emergency Channel
 - Reach 3 Emergency Channel
 - Watercourse
 - Waterbody
 - Island

NOTES:

1. Aerial Imagery: July 2011.



All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
0	14/03/05	ISSUED WITH FLOW METERING REPORT	PAL

REVISIONS / ISSUE

EMERGENCY REDUCTION OF
LAKE MANITOBA & LAKE ST. MARTIN
WATER LEVELS
FLOW METERING AND WATER LEVEL
MONITORING LOCATIONS

MARCH 2014	FIGURE 1	REV: 0

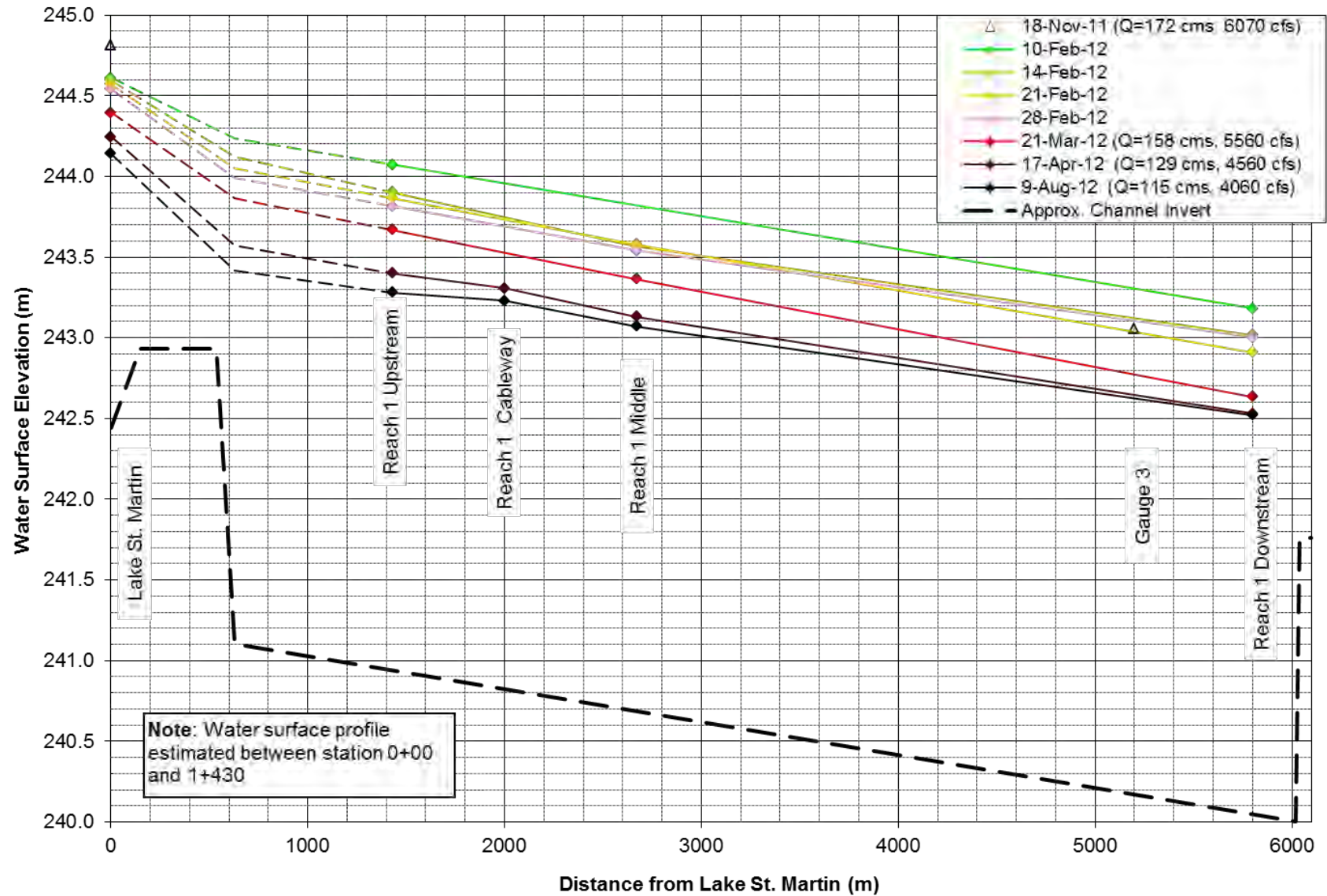


Figure 2 - Reach 1 Water Surface Profiles

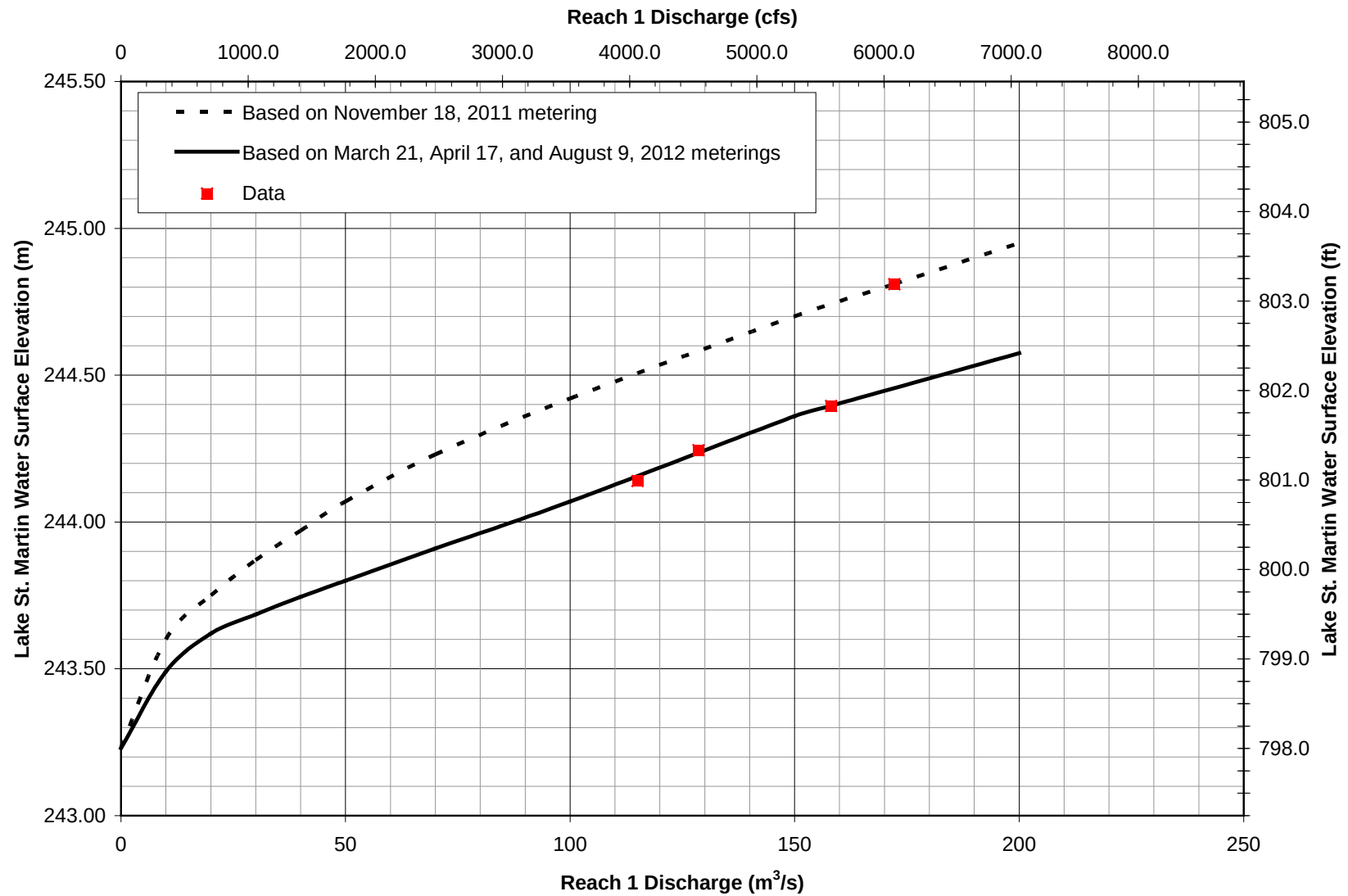


Figure 3 - Estimated Reach 1 Rating Curve

APPENDICES

APPENDIX A
FLOW METERING RESULTS

Station: 5+500
Description: Lake St-Martin Emergency Channel System
Reach 1

Date: November 18, 2011
Time: 12:00 PM to 1:00 PM

Measurement

Info: Lake St-Martin Emergency Channel System Reach 1
 Date: 18-Nov-11
 Time: 12:00:00 PM to 13:00:00 PM
 Station: 5+500

Crew Patrice Leclercq
 Ambroise Percheron

Discharge Summary for Flow in Channel

Equipment: ADCP - RDI River Ray 600 with Hemisphere A100 DGPS
 Metering Location: Station 5+500

Transect	Start Bank	Total Q (m ³ /s)	Delta Q %	Corrected Q for Bed Movement (m ³ /s)
001	Right	175.1	1.7	-
002	Left	171.9	-0.2	-
003	Right	172.2	0.0	-
004	Left	169.7	-1.5	-

Average (m ³ /s):	172.2	-
St. Dev. (m ³ /s):	2.2	-
St. Dev. / avg:	0.013	-

Gauge: 0.25 m

Notes: Gauge board located approximately 300m U/S (AECOM Gauge 3)
 Some border ice along banks
 No bed movement observed

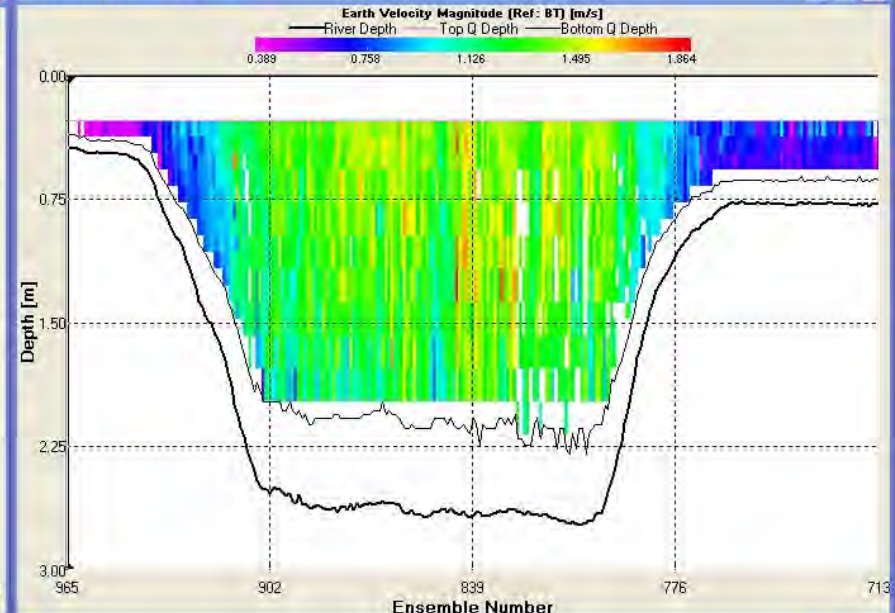
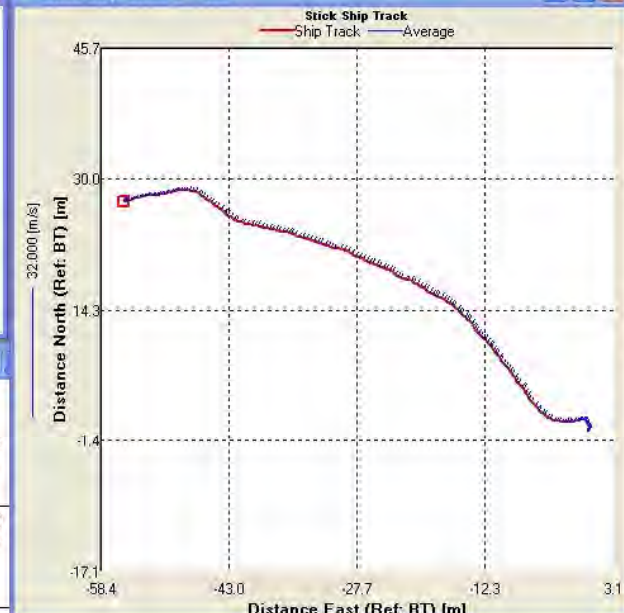
Final Discharge: 172 m³/s
 6080 ft³/s

5300_0.mmt

- Site Information
- Site Discharge
 - Transect 000
 - Transect 001**
 - Transect 002
 - Transect 003
 - Transect 004
 - Transect 005
 - Transect 006
- Discharge Summary
- QA/QC
 - Compass Calibration
 - Test Result - 11/11/18 10:30:08
 - Collect Data

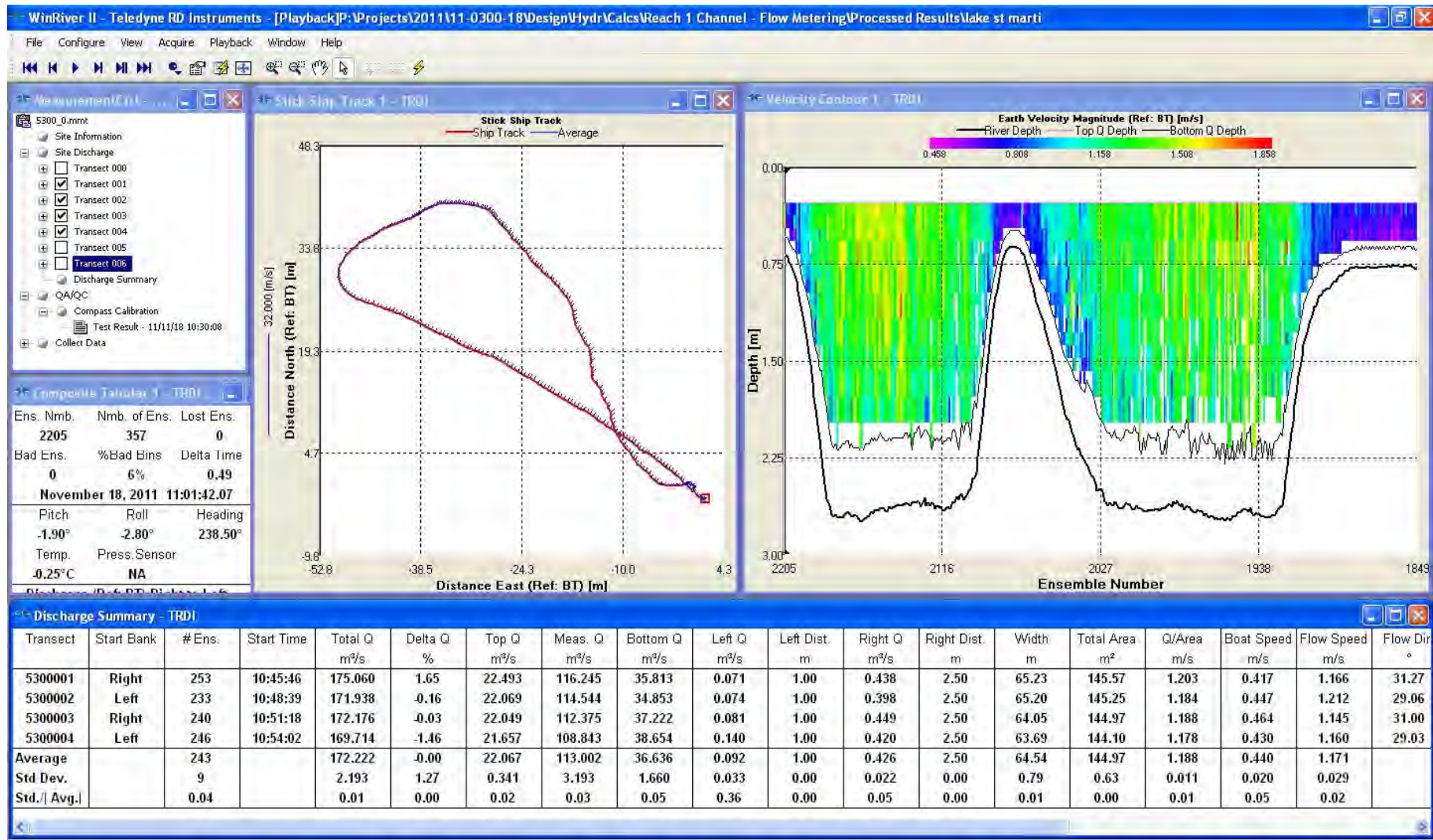
Composite Statistics 1 - TRDI

Ens. Nmb.	Nmb. of Ens.	Lost Ens.
965	253	0
Bad Ens.	%Bad Bins	Delta Time
5	4%	0.45
November 18, 2011 10:48:30.17		
Pitch	Roll	Heading
-0.90°	-2.30°	260.50°
Temp.	Press. Sensor	
-0.38°C	NA	



Discharge Summary - TRDI

Transect	Start Bank	# Ens.	Start Time	Total Q m³/s	Delta Q %	Top Q m³/s	Meas. Q m³/s	Bottom Q m³/s	Left Q m³/s	Left Dist. m	Right Q m³/s	Right Dist. m	Width m	Total Area m²	Q/Area m/s	Boat Speed m/s	Flow Speed m/s	Flow Dir °
5300001	Right	253	10:45:46	175.060	1.65	22.493	116.245	35.813	0.071	1.00	0.438	2.50	65.23	145.57	1.203	0.417	1.166	31.27
5300002	Left	233	10:48:39	171.938	-0.16	22.069	114.544	34.853	0.074	1.00	0.398	2.50	65.20	145.25	1.184	0.447	1.212	29.06
5300003	Right	240	10:51:18	172.176	-0.03	22.049	112.375	37.222	0.081	1.00	0.449	2.50	64.05	144.97	1.188	0.464	1.145	31.00
5300004	Left	246	10:54:02	169.714	-1.46	21.657	108.843	38.654	0.140	1.00	0.420	2.50	63.69	144.10	1.178	0.430	1.160	29.03
Average		243		172.222	-0.00	22.067	113.002	36.636	0.092	1.00	0.426	2.50	64.54	144.97	1.188	0.440	1.171	
Std Dev.		9		2.193	1.27	0.341	3.193	1.660	0.033	0.00	0.022	0.00	0.79	0.63	0.011	0.020	0.029	
Std./ Avg.		0.04		0.01	0.00	0.02	0.03	0.05	0.36	0.00	0.05	0.00	0.01	0.00	0.01	0.05	0.02	



LC Version 3.20, July 8, 2010

Processed on: 21-Nov-2011

Loop File: 5300_0_006_11-11-18_ASC.TXT

Distance Made Good (m)	Loop Time (sec)	Moving Bed Velocity (m/s)	Moving Bed Direction (degrees)	Flow Direction (degrees)	Estimated Percent Correction (percent)
2.32	236.43	0.01	133.60	30.70	0.94

Percent Bad Bottom Track: 0.0

Difference in flow direction between out and back sections: 1.7 deg

Loop Closure Error not in Upstream Direction -- No Correction
Recommended

Photo Summary – November 18, 2011



Photo 1
Reach 1 Emergency Channel Looking Downstream of Metering Location



Photo 2
Reach 1 Emergency Channel Looking Upstream of Metering Location

Photo Summary – November 18, 2011



**Photo 3
Reach 1 Emergency Channel Inlet**



**Photo 4
Reach 1 Emergency Channel Outlet**

Photo Summary – November 18, 2011



**Photo 5
AECOM 3 Gauge**

Station: 2+000
Description: Lake St-Martin Emergency Channel System
Reach 1

Date: March 21, 2012
Time: 3:30 PM to 4:30 PM

Measurement

Info: Lake St-Martin Emergency Channel System Reach 1
 Date: 21-Mar-12
 Time: 3:30 PM to 4:30 PM
 Station: 2+000

Crew Patrice Leclercq
 Ambroise Percheron

Discharge Summary for Flow in Channel

Equipment: ADCP - RDI River Ray 600 with Hemisphere A100 DGPS
 Metering Location: Measurement taken at cableway location

Transect	Start Bank	Total Q (m ³ /s)	Delta Q %	Corrected Q for Bed Movement (m ³ /s)
002	Right	160.0	1.2	-
005	Left	156.2	-1.2	-
006	Right	158.4	0.2	-
007	Left	157.7	-0.2	-

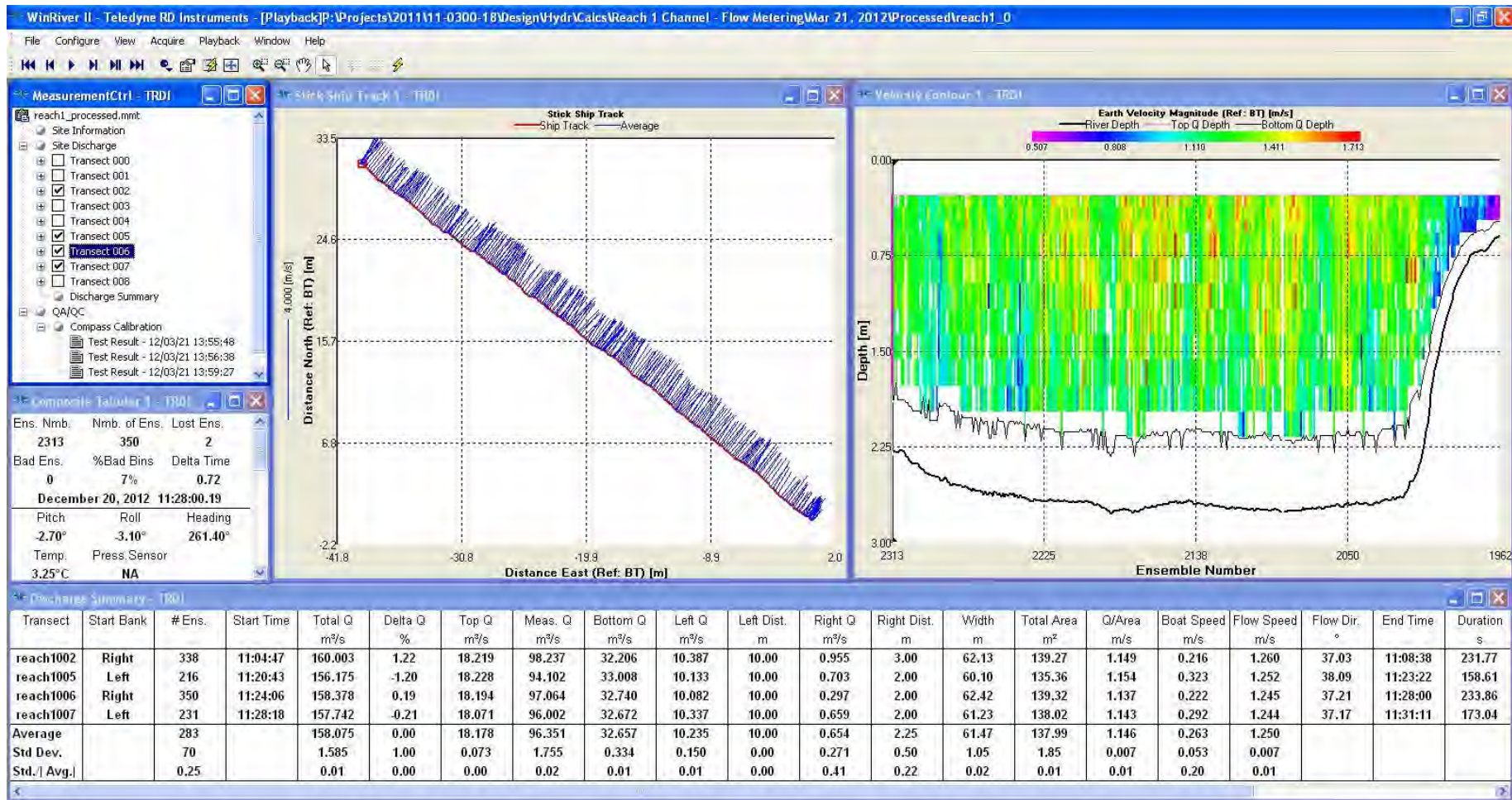
Average (m ³ /s):	158.1	-
St. Dev. (m ³ /s):	1.6	-
St. Dev. / avg:	0.010	-

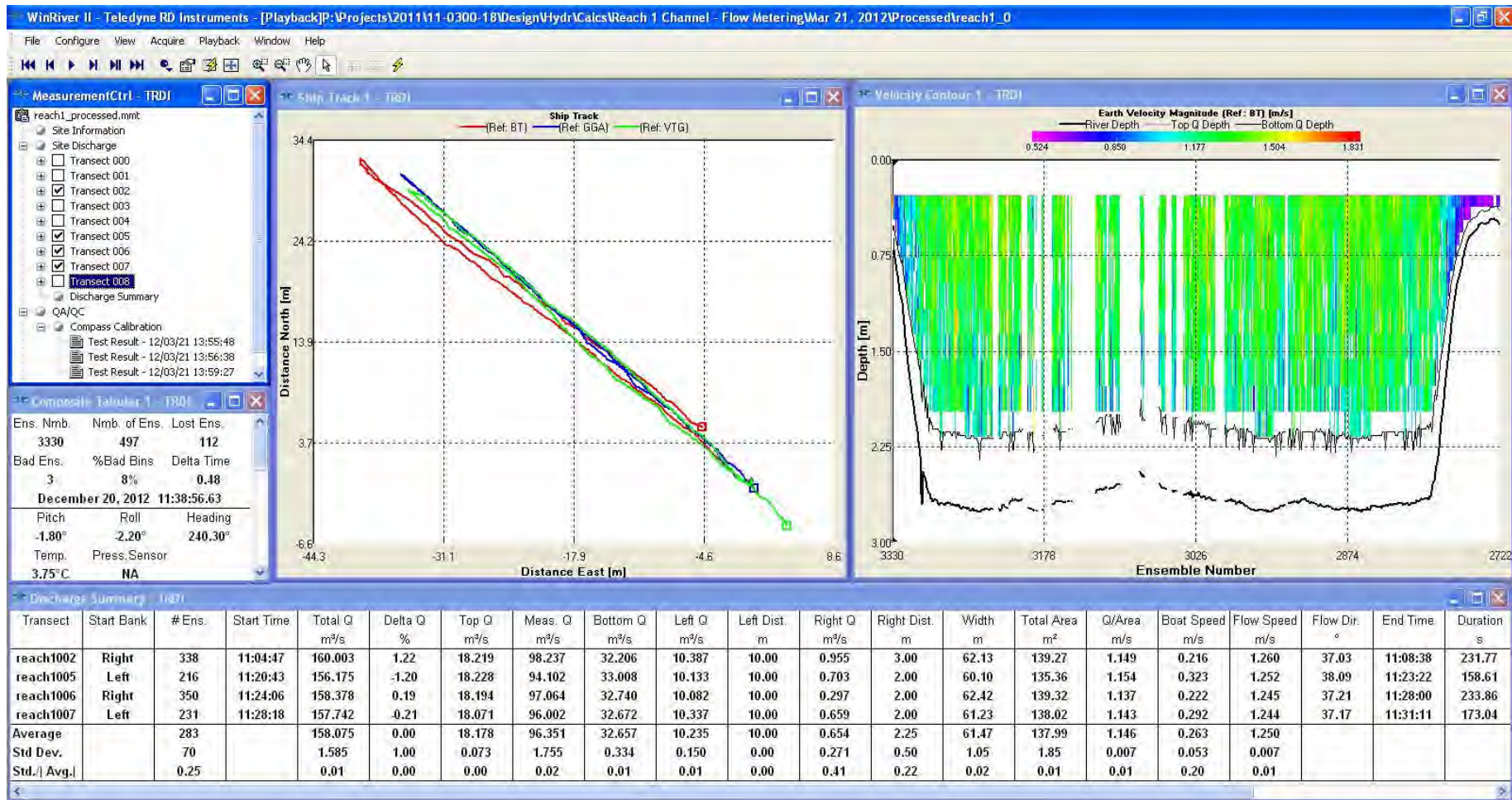
Gauge: n/a

Notes: No bed movement observed

Gauge Boards Damaged

Final Discharge: 158 m³/s
 5,580 ft³/s





LC Version 3.20, July 8, 2010

Processed on: 06-Jun-2012

Loop File: reach1_0_008_12-03-21_ASC.TXT

Distance Made Good (m)	Loop Time (sec)	Moving Bed Velocity (m/s)	Moving Bed Direction (degrees)	Flow Direction (degrees)	Estimated Percent Correction (percent)
7.15	402.75	0.02	317.49	36.83	1.71

Percent Bad Bottom Track: 18.4

WARNING: Percentage of bad bottom track values exceeds 5.
Loop may not be accurate. Please review data.

Difference in flow direction between out and back sections: 0.7 deg

Loop Closure Error not in Upstream Direction -- No Correction
Recommended

Photo Summary – March 21, 2012



Photo 1
Reach 1 Emergency Channel Looking Upstream



Photo 2
Reach 1 Emergency Channel Looking Downstream

Photo Summary – March 21, 2012



Photo 3
Reach 1 Emergency Channel Inlet



Photo 4
Reach 1 Emergency Channel Outlet

Station: 2+000
Description: Lake St-Martin Emergency Channel System
Reach 1

Date: April 17, 2012
Time: 1:00 PM to 1:30 PM

Measurement

Info: Lake St-Martin Emergency Channel System Reach 1
 Date: 17-Apr-12
 Time: 1:00 PM to 1:30 PM
 Station: 2+000

Crew Patrice Leclercq
 Ambroise Percheron

Discharge Summary for Flow in Channel

Equipment: ADCP - RDI River Ray 600
 Metering Location: Measurement taken at cableway location

Transect	Start Bank	Total Q (m ³ /s)	Delta Q %	Corrected Q for Bed Movement (m ³ /s)
001	Right	128.9	0.2	-
002	Left	128.3	-0.3	-
003	Right	127.3	-1.0	-
004	Left	129.9	1.0	-

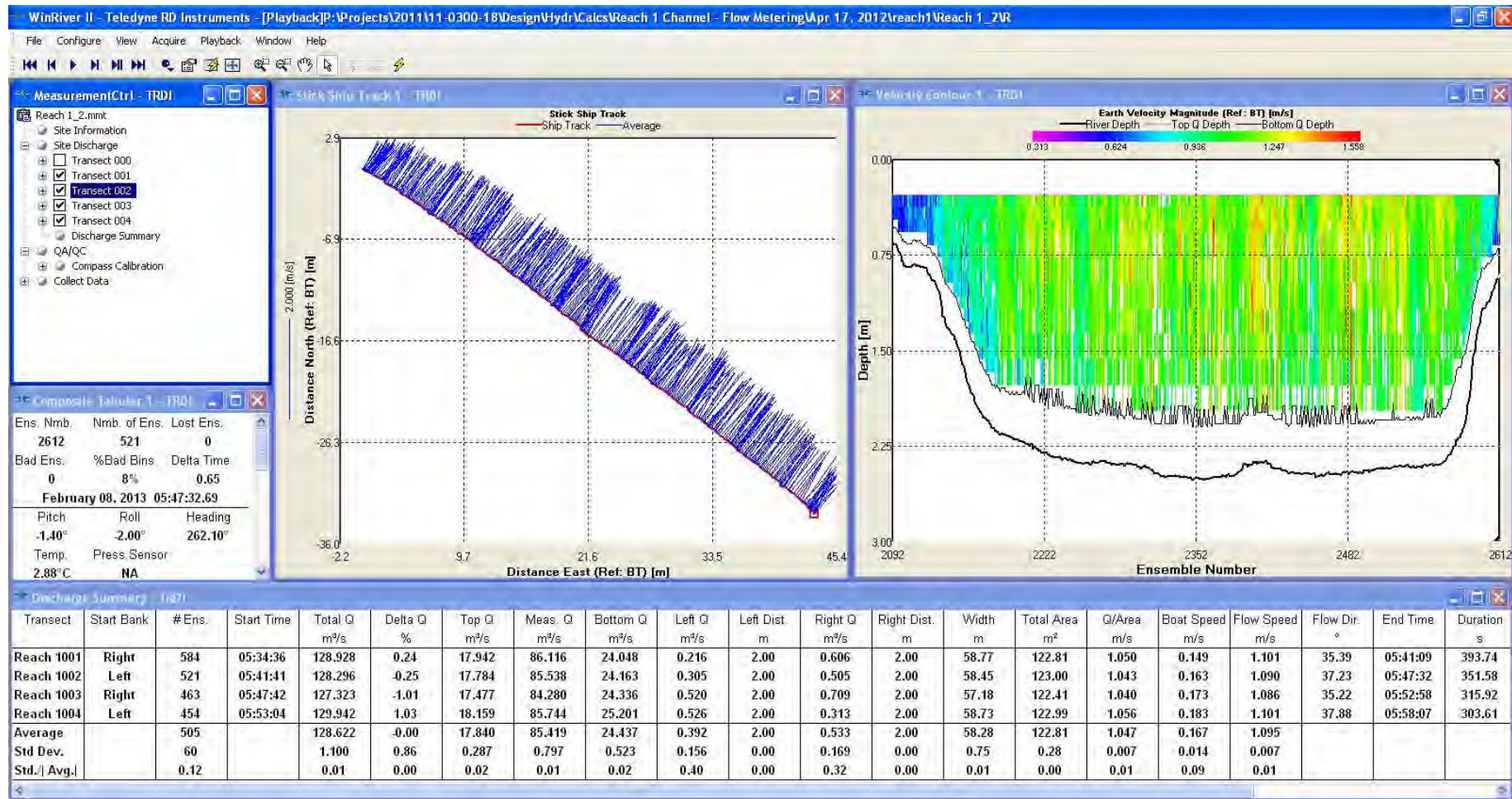
Average (m ³ /s):	128.6	-
St. Dev. (m ³ /s):	1.1	-
St. Dev. / avg:	0.009	-

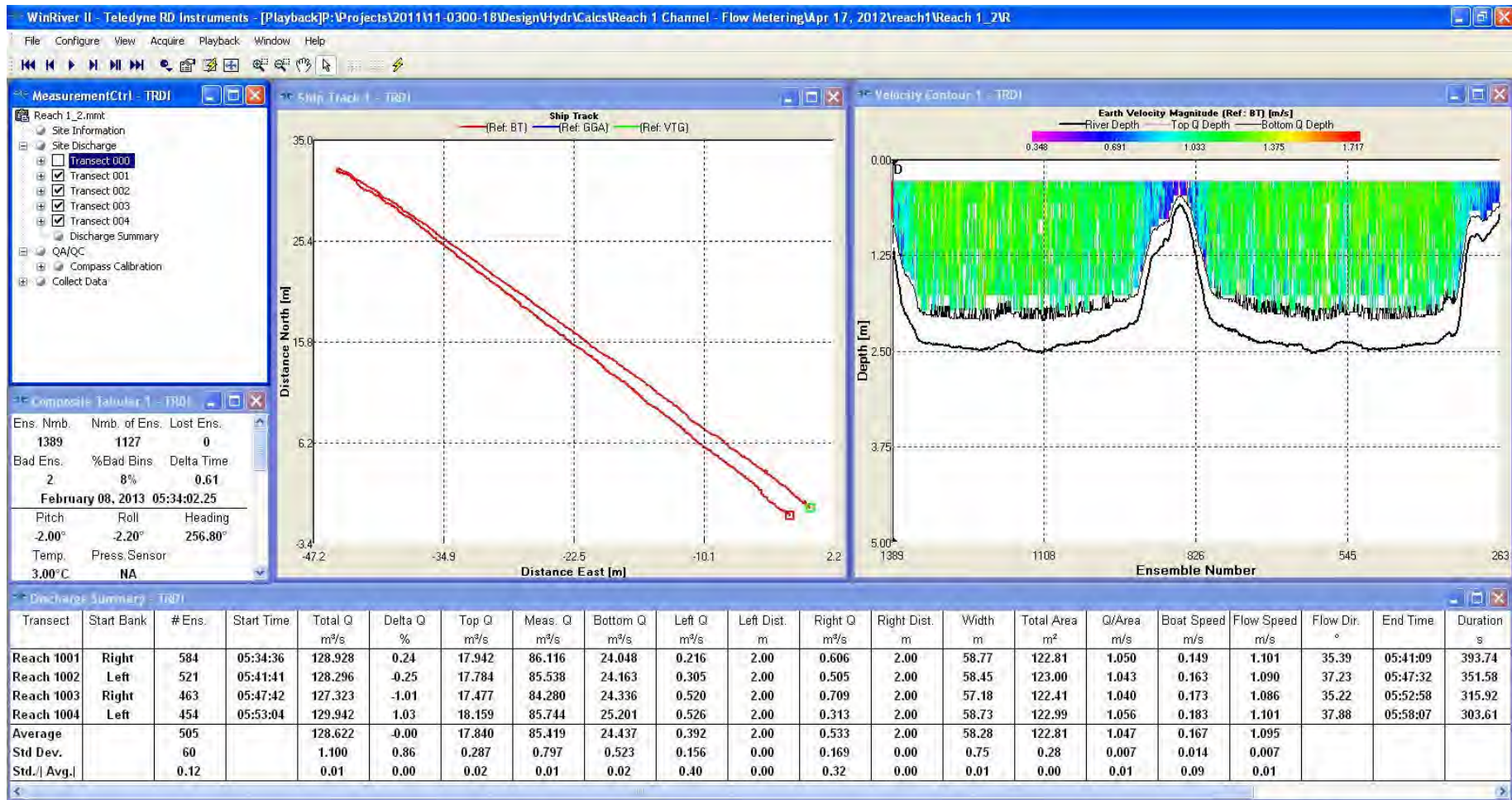
Gauge: n/a

Notes: No bed movement observed

Gauge Boards Damaged

Final Discharge: 129 m³/s
 4,540 ft³/s





LC Version 3.20, July 8, 2010

Processed on: 06-Jun-2012

Loop File: Reach 1_2_000_12-04-17_ASC.TXT

Distance Made Good (m)	Loop Time (sec)	Moving Bed Velocity (m/s)	Moving Bed Direction (degrees)	Flow Direction (degrees)	Estimated Percent Correction (percent)
2.05	759.44	0.00	251.48	36.36	0.27

Percent Bad Bottom Track: 0.0

Difference in flow direction between out and back sections: 1.6 deg

Moving Bed Vel. (MBV) < Minimum MBV Criteria -- No Correction
Recommended

Photo Summary – April 17, 2012



Photo 1
Reach 1 Emergency Channel Looking Upstream of Metering Location



Photo 2
Reach 1 Emergency Channel Looking Downstream of Metering Location