2012 Report on Artificial Flooding due to Operation of the Shellmouth Dam

Manitoba Infrastructure and Transportation

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This report was prepared in fulfillment of the requirements of s. 12.7(1) of The Water Resources Administration Act, and s. 3(1) of the Shellmouth Dam Regulation.

Table of Contents

Introduction 3

Artificial Flooding in 2012 8

2012 Shellmouth Dam Operations 18

List of Figures and Tables

Figures

Figure 1: Conceptual hydrograph showing the reduction in peak flow (A) and reduction in duration of flooding (B-C) 5
Figure 2: Hydrograph illustrating a conceptual example of artificial flooding 6
Figure 3: Conceptual hydrograph illustrating how to determine the duration (A) and extent (B) of artificial flooding 7
Figure 4: Shellmouth Reservoir annual peak inflows and outflows 8
Figure 5: Hydrograph showing 2012 reservoir levels, inflows and outflows at the Shellmouth Dam 11
Figure 6: Hydrograph showing regulated and unregulated discharge at Russell, and cumulative precipitation at Pelly 2 weather station 12
Figure 7: Hydrograph showing regulated and unregulated water levels at Russell, and cumulative precipitation at Pelly 2 weather station 12
Figure 8: Hydrograph showing regulated and unregulated flows at St. Lazare 13
Figure 9: Hydrograph showing regulated and unregulated water levels at St. Lazare 13
Figure 10: Hydrograph showing regulated and unregulated flows at Miniota 14
Figure 11: Hydrograph showing regulated and unregulated water levels at Miniota 14
Figure 12: Hydrograph showing regulated and unregulated flows at Virden 15
Figure 13: Hydrograph showing regulated and unregulated water levels at Virden 15
Figure 14: Hydrograph showing regulated and unregulated flows at Griswold 16
Figure 15: Hydrograph showing regulated and unregulated water levels at Griswold 16
Figure 16: Hydrograph showing regulated and unregulated flows at Brandon 17
Figure 17: Hydrograph showing regulated and unregulated water levels at Brandon 17
Figure 18: Percent of normal precipitation, November 2011 to March 2012 18
Figure 19: Percent of normal soil moisture at freeze up in 2011 19
Figure 20: April-June precipitation based on Pelly/Pelly-2 Stations in Saskatchewan 20

Tables

Table 1: Summary of flooding under unregulated flows 9
Table 2: Summary of flooding under regulated flows 9
Table 3: Summary of effect of Shellmouth Dam operation 10
Table 4: Shellmouth Reservoir seasonal operation guidelines 21
Table 5: Tabulation of 2012 conduit operations 23

Introduction

Legislative Background

In 2008, the Government of Manitoba amended *The Water Resources Administration Act* to establish compensation for damages due to artificial flooding caused by the operation of designated water control works. More specifically, the amendments establish the Shellmouth Dam as a designated water control work, define “artificial flooding” and other key terms, establish a requirement for Manitoba to report on artificial flooding which causes damages, and establish eligibility for compensation. Regulations under the Act stipulate the information that must be included in the artificial flood report and outline how compensation is to be administered. The amended Act came into force in February, 2011.

The following definitions from the Act are pertinent to this report:

"artificial flooding", in relation to a given event, means flooding of a water body

(a) that is caused by the operation of a designated water control work, or the operation of a designated water control work and one or more other water control works, and

(b) whereby the water body exceeds its unregulated level at the time of the event;

"designated water control work" means

(a) the Shellmouth Dam, or

(b) any other water control work designated in the regulations for the purpose of this definition, not including the "floodway" as defined in *The Red River Floodway Act* insofar as it relates to "spring flooding" as defined in that Act;

"unregulated level", in relation to artificial flooding, means the scientifically demonstrable level that would be expected in the water body at a given time

(a) in the absence of the designated water control work, or

(b) if specified by regulation in respect of the water body, in the absence of the designated water control work and one or more other specified water control works;

Put more simply, artificial flooding in the Assiniboine River valley downstream of the Shellmouth Dam occurs when the regulated water level is above flood stage and is higher than the unregulated water level. Unregulated water levels are those that would have occurred if the Shellmouth Dam did not exist. Regulated water levels are those that did occur, and which were influenced by the operation of the Shellmouth Dam.

The Water Resources Administration Act stipulates that once it is determined that damage to eligible property or economic loss has occurred as a result of an artificial flooding event on the Assiniboine River caused by the operation of the Shellmouth Dam, a report must be prepared on the artificial flooding. The report must include:

- A statement of the period reported on
- A statement that the Minister responsible for *The Water Resources Administration Act* has determined that damages due to the artificial flooding have occurred
- For the regulated and the unregulated conditions, charts of the discharges from the Shellmouth Dam and river water levels at relevant hydrometric monitoring stations
- Charts showing the dates that artificial flooding began and ended
- A description of how the regulated and unregulated levels were determined
- A description of all Dam operations and any technical issues that arose
- A description of how the operation did or did not conform to the operating guidelines
- A tabulation of the Dam gate adjustments, including the dates and times of the adjustments, the reservoir levels and volume stored at each adjustment, and the flows resulting from each adjustment

Within this report, all flows and levels are shown in imperial units. Flows can be converted from cubic feet per second (cfs) to cubic metres per second (m^3/s) by dividing by 35.3148. River levels can be converted from feet to metres by dividing by a factor of 3.28084. All data in this report is real-time data with quality control provided by the Hydrologic Forecasting and Water Management Branch of Manitoba Infrastructure and Transportation.

Benefits of Shellmouth Dam Operation and the Nature of Artificial Flooding

Operation of the Shellmouth Dam provides a significant flood reduction benefit to communities, agricultural producers and other interests downstream of the Dam. Operation of the Dam results in a reduction in the peak flows downstream on the Assiniboine River, and therefore the extent and height of flooding experienced, and it generally provides a reduction in the net length of flooding. In some years, operation of the Shellmouth Dam does not completely eliminate flooding downstream of the Dam but it does reduce the height of flood waters (usually by a significant amount) and often reduces the total duration of flooding. The conceptual hydrograph in Figure 1 illustrates the reduction in peak flow (A), the duration of flooding under unregulated flow conditions (B), the duration of flooding under regulated flow conditions (C), and the reduction in the duration of flooding (difference in the lengths of lines B & C).

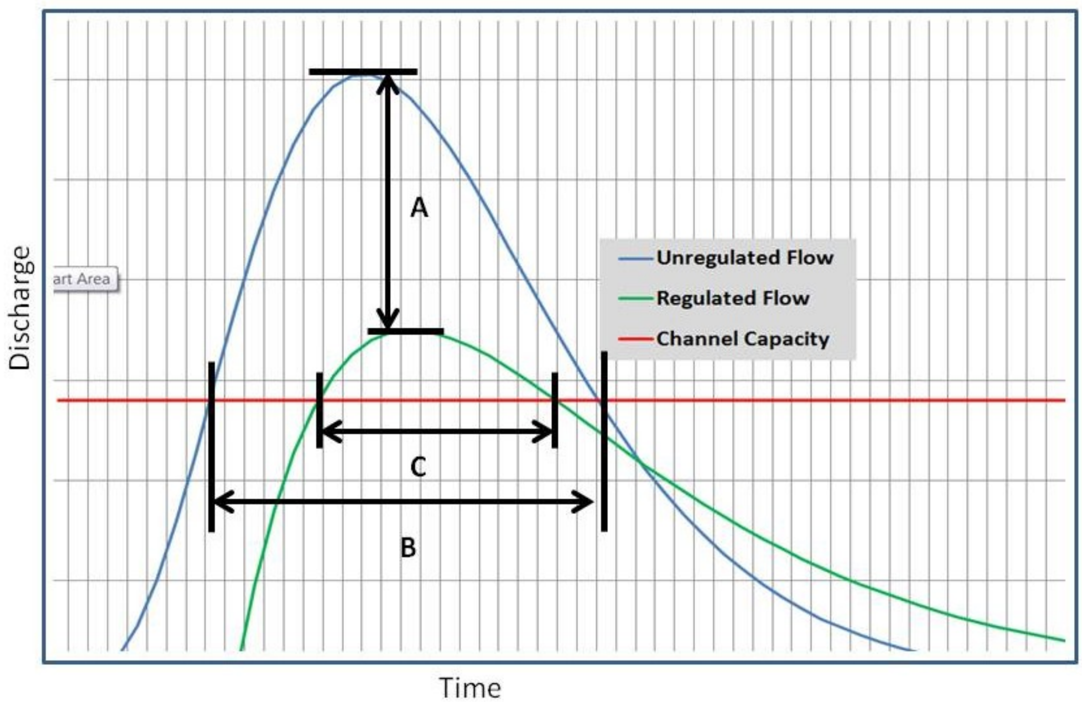

Figure 1: Conceptual hydrograph showing the reduction in peak flow (A) and reduction in duration of flooding (B-C)

Unfortunately, the Shellmouth Dam and Reservoir have a finite water storage capacity and in some years the inflows to the Reservoir can cause the water level to rise above spillway elevation, resulting in uncontrolled flows over the spillway that increase as the level of the Reservoir rises. Reservoir levels generally only rise above spillway elevation as a result of significant snowmelt runoff and/or rainfall events which cause high reservoir inflows. The Reservoir level will only begin to fall when total outflows exceed inflows, and it is under these conditions that artificial flooding may occur. Once inflows to the reservoir begin to fall, uncontrolled flows over the spillway will continue until the reservoir water level falls below spillway elevation. This can result in a situation where regulated outflows from the reservoir (over the spillway) exceed the unregulated flows that would have occurred in the absence of the dam (the inflows to the reservoir), resulting in artificially high flows downstream of the dam. If these artificially high flows exceed the channel capacity of the river, which is approximately 1,600 cfs immediately below the dam, then artificial flooding is deemed to have occurred.

Artificial flooding caused by operation of the Shellmouth Dam will typically occur after the regulated and unregulated flood peaks have occurred (see Figure 2). Following the peak of a flood event, as the flows on the river are decreasing and the flood waters recede towards the river channel, in cases where artificial flooding occurs the regulated water level will be higher than the unregulated water level (due to the influence of the spillway flows explained in the previous paragraph). Thus it can be useful to visualize artificial flooding caused by the operation of the Shellmouth Dam as a delay in the recession of flood waters or as a delay in the overall timing of a flood event that would have otherwise occurred under unregulated conditions. Since artificial flooding does not begin until a flood event begins to recede, it can be difficult to differentiate artificial flooding from flooding that would have occurred under unregulated flows. It is also important to note that flooding that occurs in the Assiniboine River Valley downstream of the Shellmouth Dam is not always artificial flooding. Only in the circumstances described above, at times where regulated flows exceed unregulated flows, does artificial flooding occur.

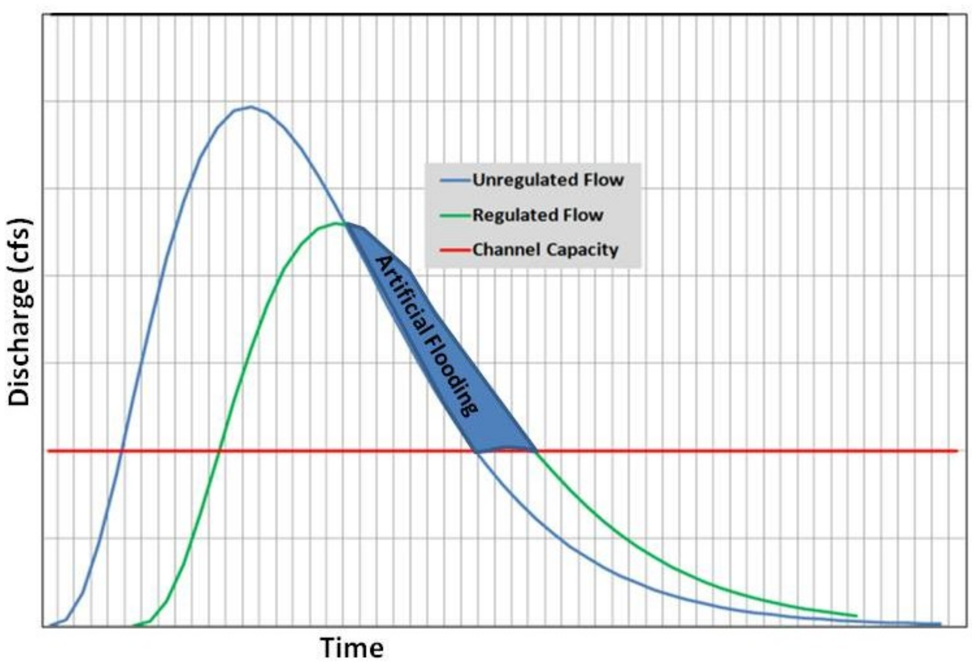

Figure 2: Hydrograph illustrating a conceptual example of artificial flooding

The duration of artificial flooding at an elevation of land can be determined by comparing the date when the regulated hydrograph crosses the elevation of that land versus the date when the unregulated hydrograph crosses the same elevation (on a horizontal line); see line A in Figure 3. Similarly, the incremental height of artificial flood waters at a given time can be observed by comparing the water level on the unregulated hydrograph versus the regulated hydrograph (along a vertical line); see line B in Figure 3.

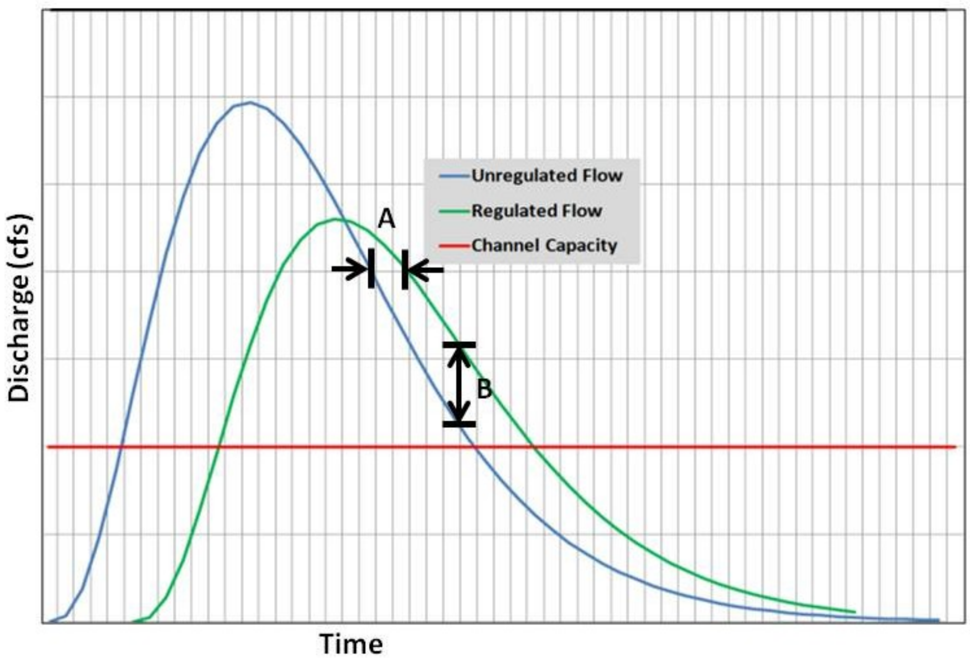

Figure 3: Conceptual hydrograph illustrating how to determine the duration (A) and extent (B) of artificial flooding

Artificial Flooding in 2012

This report covers the period of artificial flooding that occurred in 2012, which generally occurred for a period of two to seven days at different points in the valley, starting as early as July 2 and ending as late as August 7. As was announced on November 16, 2012 Manitoba Infrastructure and Transportation, the department responsible for *The Water Resources Administration Act,* has determined that damages due to artificial flooding did occur in 2012.

In the upstream reaches immediately below the Dam, artificial flooding occurred as early as July 2 at higher elevations and ended as late as August 7 in lower areas closer to the Assiniboine River channel. Depending on the elevation of land, artificial flooding in this reach of the valley lasted between one and seven days, with most areas affected for approximately four days. The analogous start and end dates for artificial flooding are July 18 and July 26 for downstream reaches in the vicinity of Brandon. Depending on the elevation of land, artificial flooding in this lower reach of the valley lasted up to two days. In general, moving downstream from the Dam the extent and duration of artificial flooding decreased, the artificial flooding occurred later and for a shorter period of time. This is due to the increasing influence of tributaries and other inflows to the Assiniboine River as the river moves downstream.

In summary, as in previous years, operation of the Shellmouth Dam in 2012 reduced the flood peak and the total duration of flooding downstream in the Assiniboine River Valley (see Figure 4). However, operation of the Dam did cause some artificial flooding as the flood waters receded more slowly than they would have in absence of the dam. The duration, peak flows and peak stages for the regulated and unregulated flood events are summarized in tables 1 and 2 below. Table 3 presents a summary of the effect of Shellmouth Dam operation, including artificial flooding.

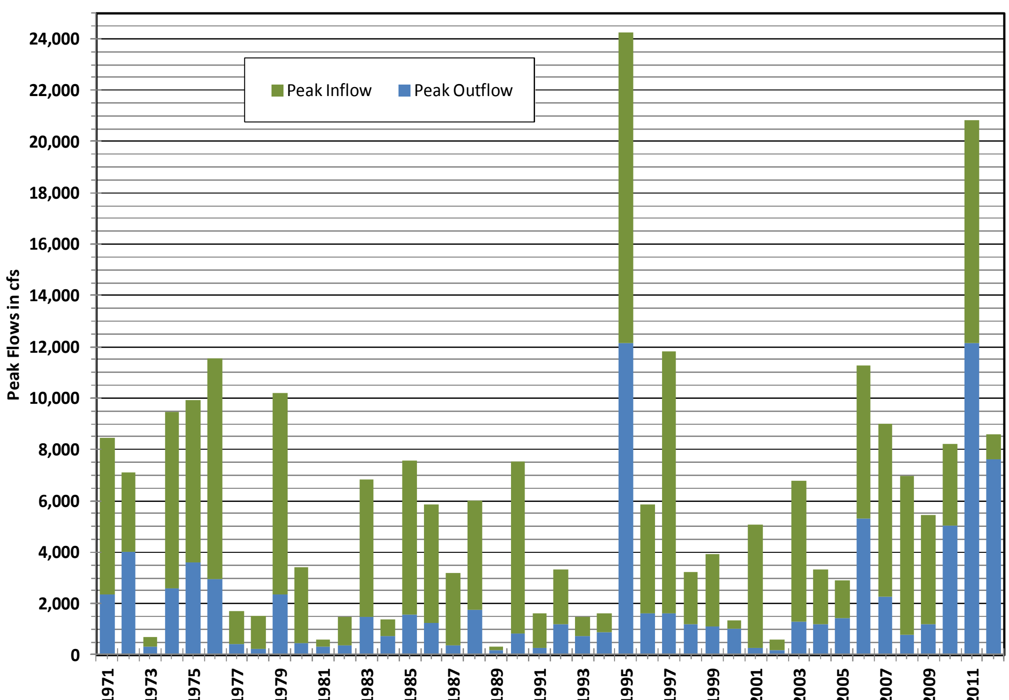

Figure 4: Shellmouth Reservoir annual peak inflows and outflows

Table 1: Summary of flooding under unregulated flows

	Channel Capacity (cfs)	Unregulated Flows				
		Start of Flooding	End of Flooding	Length of flooding (days)	Peak Flow (cfs)	Peak Stage (ft)
Shellmouth	1600	19-Mar-12	04-Aug-12	139	8580	
Russell	3000	08-Jun-12	13-Jul-12	36	8078	1349.58
St. Lazare	5000	11-Jun-12	12-Jul-12	32	10406	1286.87
Miniota	5250	12-Jun-12	14-Jul-12	33	10844	1243.26
Virden	5400	18-Jun-12	20-Jul-12	33	10007	1219.41
Griswold	5900	24-Jun-12	21-Jul-12	28	9664	1199.58
Grand Valley near Brandon	5800	24-Jun-12	24-Jul-12	31	9867	1185.42

Table 2: Summary of flooding under regulated flows

	Channel Capacity (cfs)	Regulated Flows				
		Start of Flooding	End of Flooding	Length of flooding (days)	Peak Flow (cfs)	Peak Stage (ft)
Shellmouth	1600	14-Jun-12	07-Aug-12	55	7632	
Russell	3000	18-Jun-12	20-Jul-12	33	7828	1349.04
St. Lazare	5000	19-Jun-12	15-Jul-12	27	9525	1286.50
Miniota	5250	20-Jun-12	17-Jul-12	28	10000	1242.73
Virden	5400	24-Jun-12	23-Jul-12	30	9131	1218.33
Griswold	5900	29-Jun-12	24-Jul-12	26	8817	1199.23
Grand Valley near Brandon	5800	30-Jun-12	26-Jul-12	27	8972	1184.94

Table 3: Summary of effect of Shellmouth Dam operation

	Effect of Shellmouth Dam Operation					
	Change in Peak Flow (cfs)	Change in Peak Stage (ft)	Net Change in Length of flooding (days)	First Day with some Artificial Flooding	Day when all Artificial Flooding Ended	Approximate Maximum duration of Artificial Flooding (days)
Shellmouth	-948		-84	02-Jul-12	07-Aug-12	7
Russell	-250	-0.54	-3	02-Jul-12	20-Jul-12	7
St. Lazare	-881	-0.37	-5	04-Jul-12	15-Jul-12	5
Miniota	-844	-0.53	-5	06-Jul-12	17-Jul-12	4
Virden	-876	-1.08	-3	11-Jul-12	23-Jul-12	4
Griswold	-847	-0.35	-2	15-Jul-12	24-Jul-12	3
Grand Valley near Brandon	-895	-0.48	-4	18-Jul-12	26-Jul-12	2

Note: The effect of artificial flooding is site specific based on the location of the land within the river valley and the elevation of the land in question.

Regulated levels are the water levels that actually occurred. At Shellmouth, Russell and Brandon, these levels were observed/measured by hydrometric gauging on the river. At St. Lazare, Miniota, Virden and Griswold, the water levels and flows were computed using Muskingum routing, a modelling technique used to predict the movement of water down the river. Manual measurements of water levels were taken during the 2012 flood event to verify that the model provided accurate predictions at each of these four locations.

Unregulated levels and flows must be computed at each site since the operation of the Dam means that only regulated levels are available for measurement. The unregulated levels and flows at the Shellmouth Dam site are computed based on the actual inflows into the Shellmouth Reservoir, including over reservoir precipitation. The rationale for this approach is that if the Dam was not in place, the flows that would be observed on the river at this location would be made up of the Assiniboine River flows plus the flows that tributaries would have provided to the river. The unregulated levels and flows at each of the sites downstream of the Shellmouth Dam were computed by using Muskingum routing to model the movement of the inflows downstream from the Shellmouth site, while incorporating the addition of tributary runoff.

In Figure 5, the regulated discharges from the Shellmouth Dam are labelled as “Total Outflow”. The unregulated discharges are labelled as “Total Inflows Including Over-Reservoir Precipitation”. A number of other relevant parameters, including reservoir level and spillway elevation, are also shown in this figure.

Figures 6 to 17 are hydrographs that show the unregulated and regulated water levels and flows at six locations downstream of the Shellmouth Dam. Figures 6 and 7 also show the normal and 2012 cumulative precipitation at a weather station in Saskatchewan, called Pelly 2 (see Figure 18 for the station’s location). The station is also discussed later in this report.

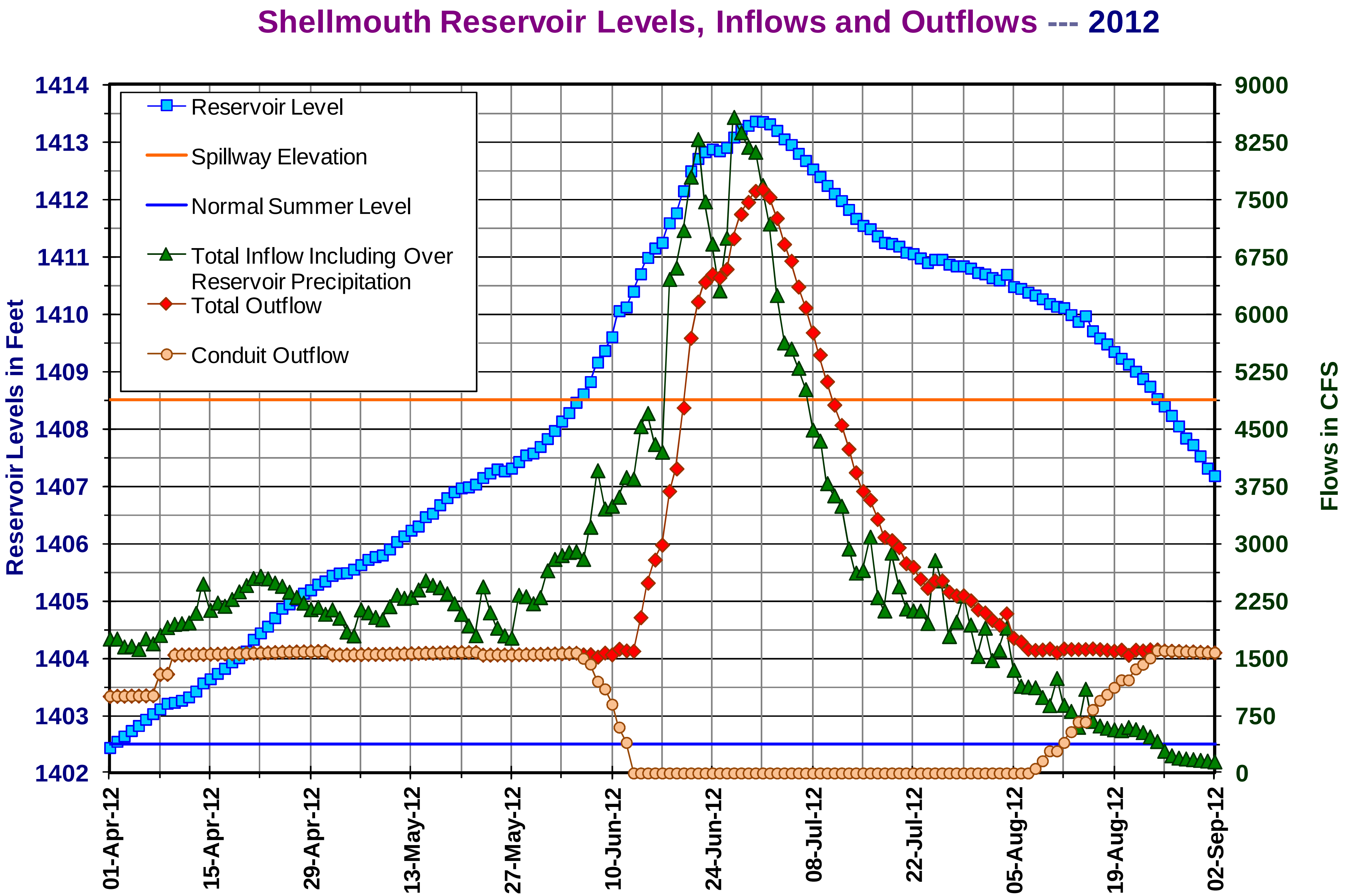

Figure 5: Hydrograph showing 2012 reservoir levels, inflows and outflows at the Shellmouth Dam

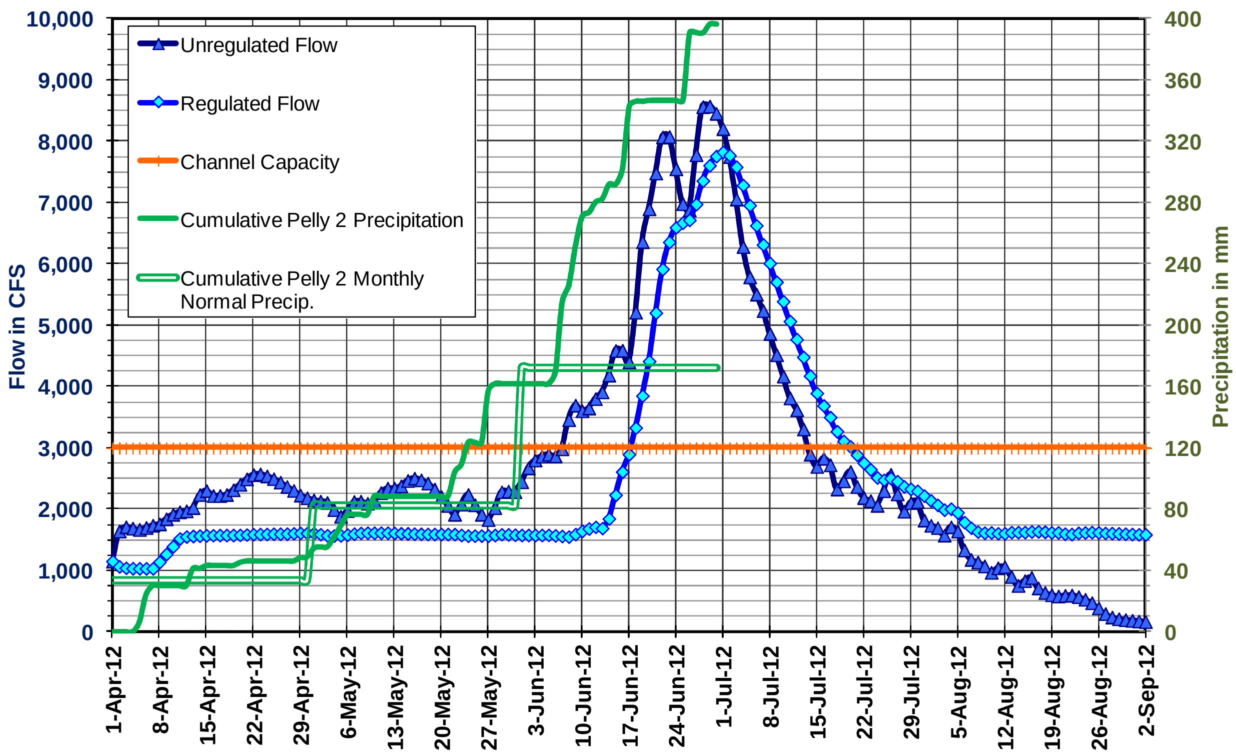

Figure 6: Hydrograph showing regulated and unregulated discharge at Russell, and cumulative precipitation at Pelly 2 weather station

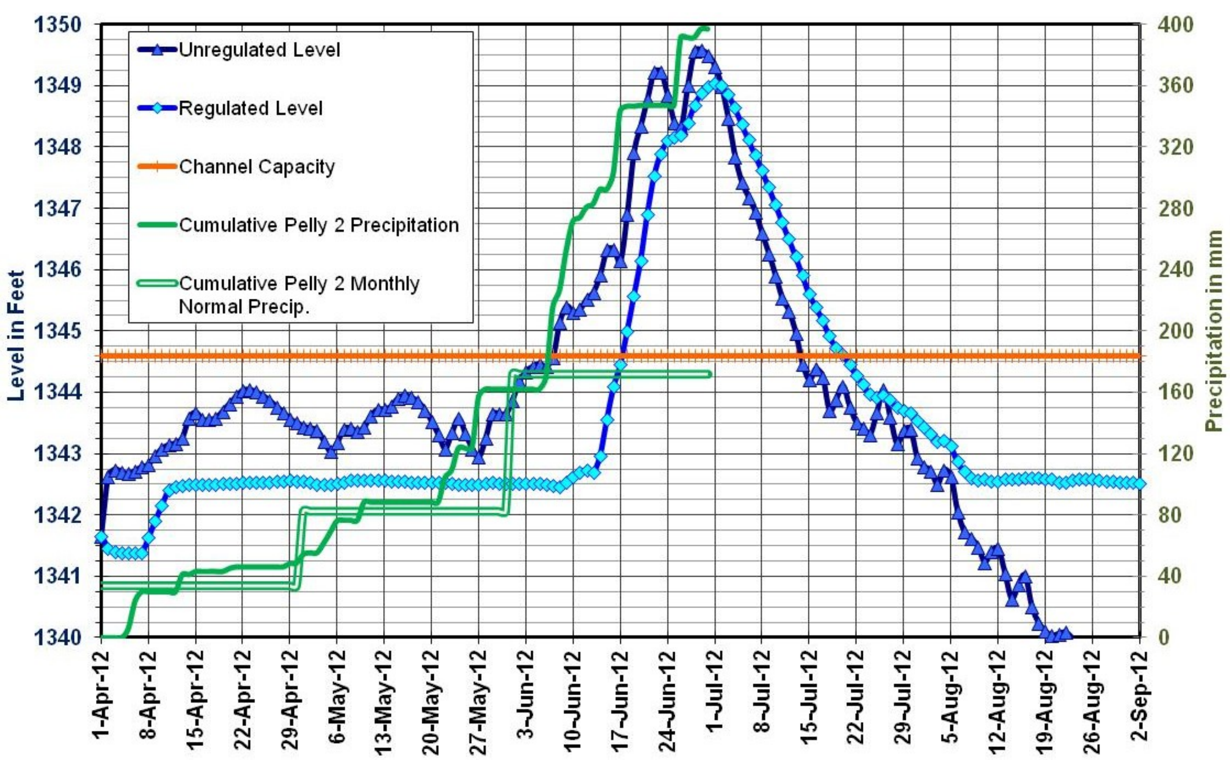

Figure 7: Hydrograph showing regulated and unregulated water levels at Russell, and cumulative precipitation at Pelly 2 weather station

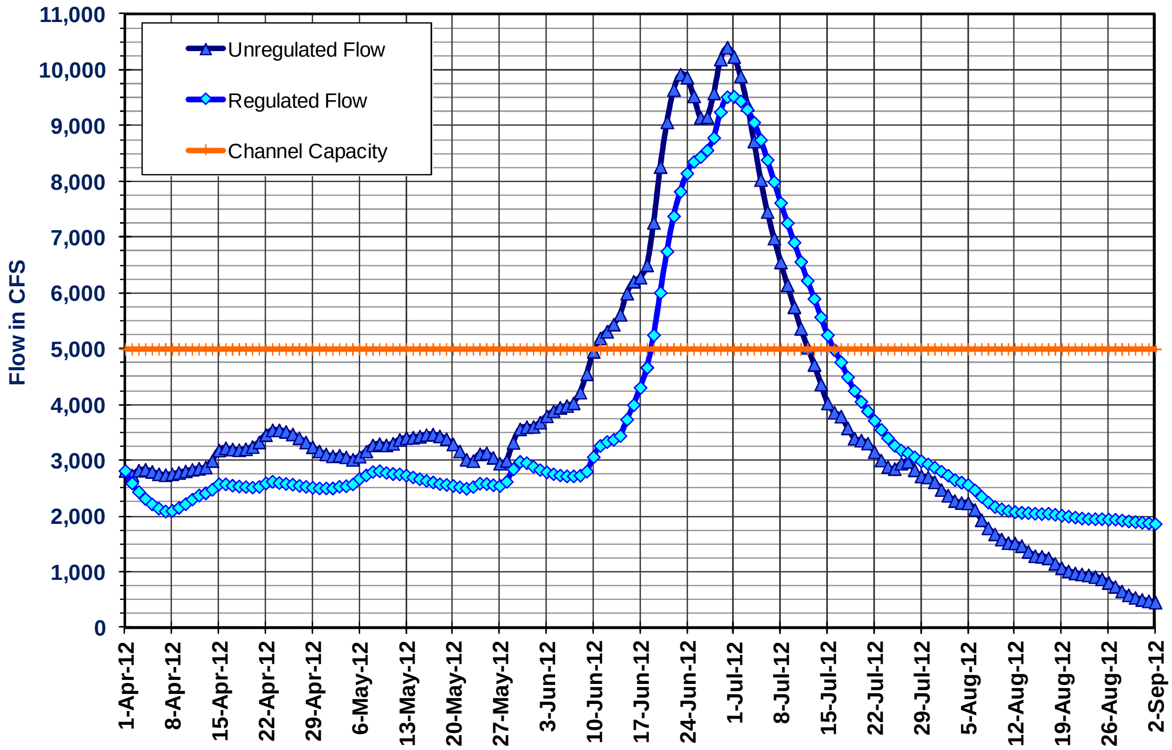

Figure 8: Hydrograph showing regulated and unregulated flows at St. Lazare

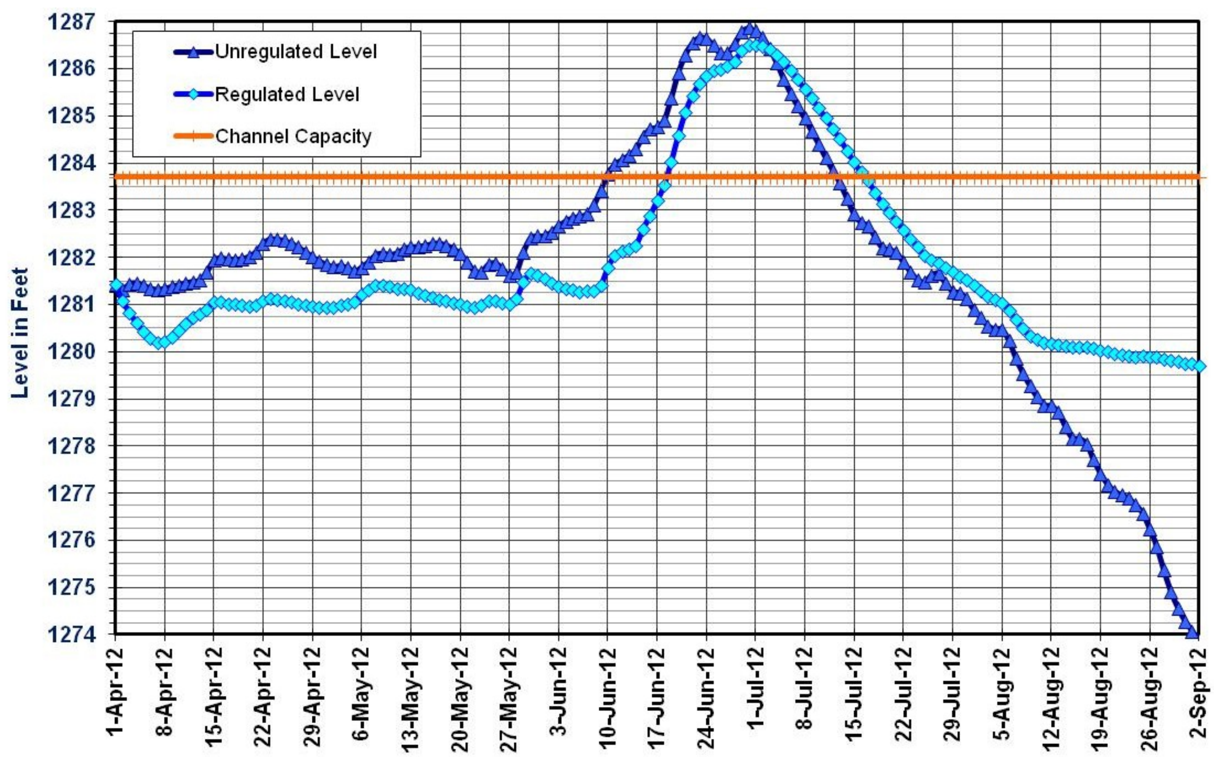

Figure 9: Hydrograph showing regulated and unregulated water levels at St. Lazare

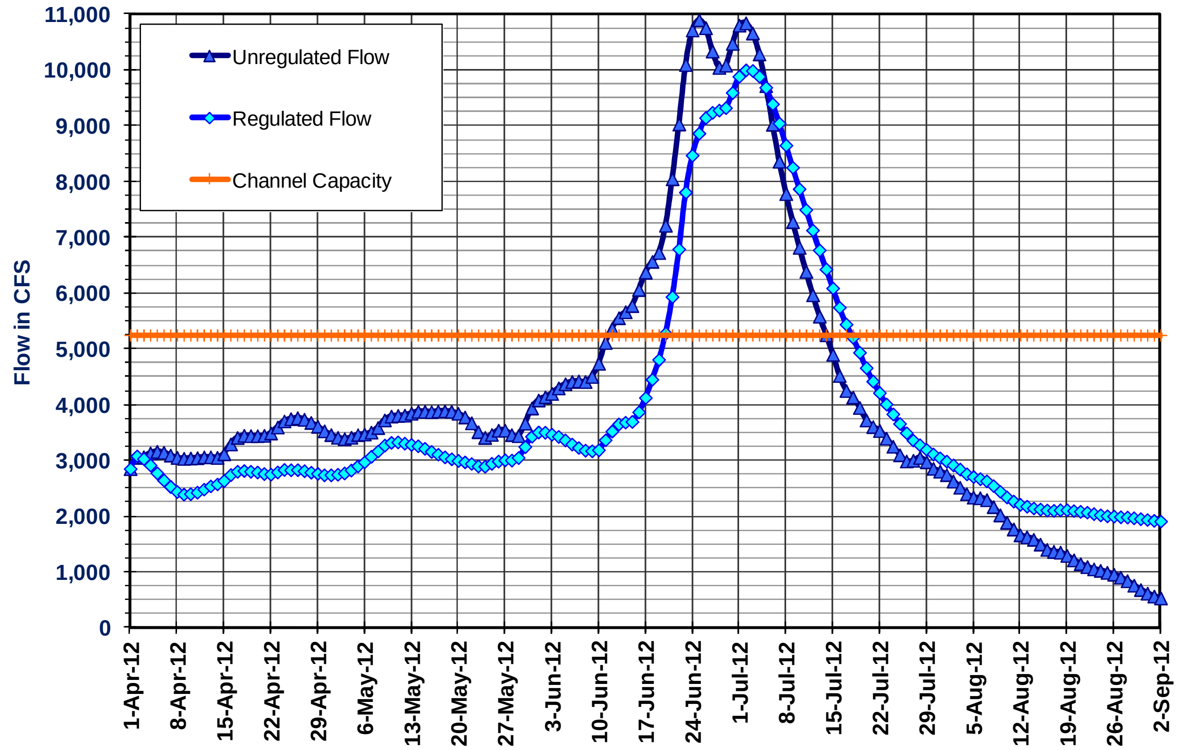

Figure 10: Hydrograph showing regulated and unregulated flows at Miniota

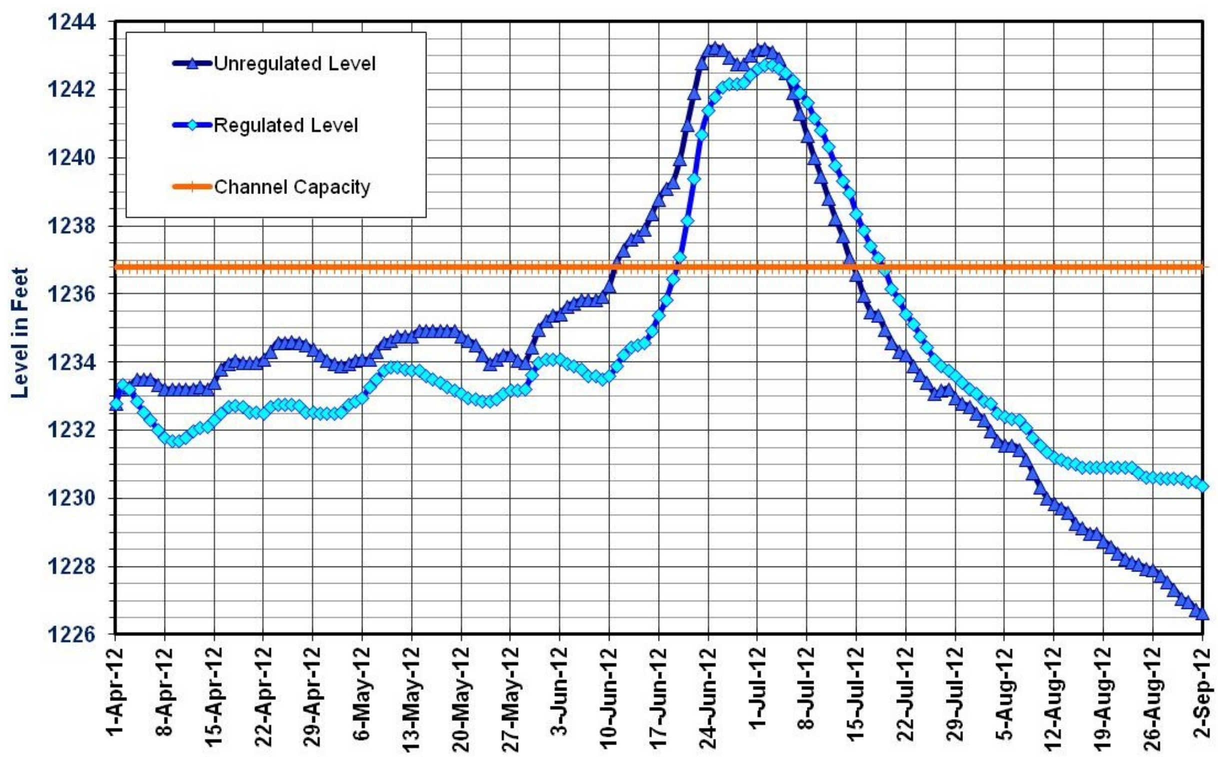

Figure 11: Hydrograph showing regulated and unregulated water levels at Miniota

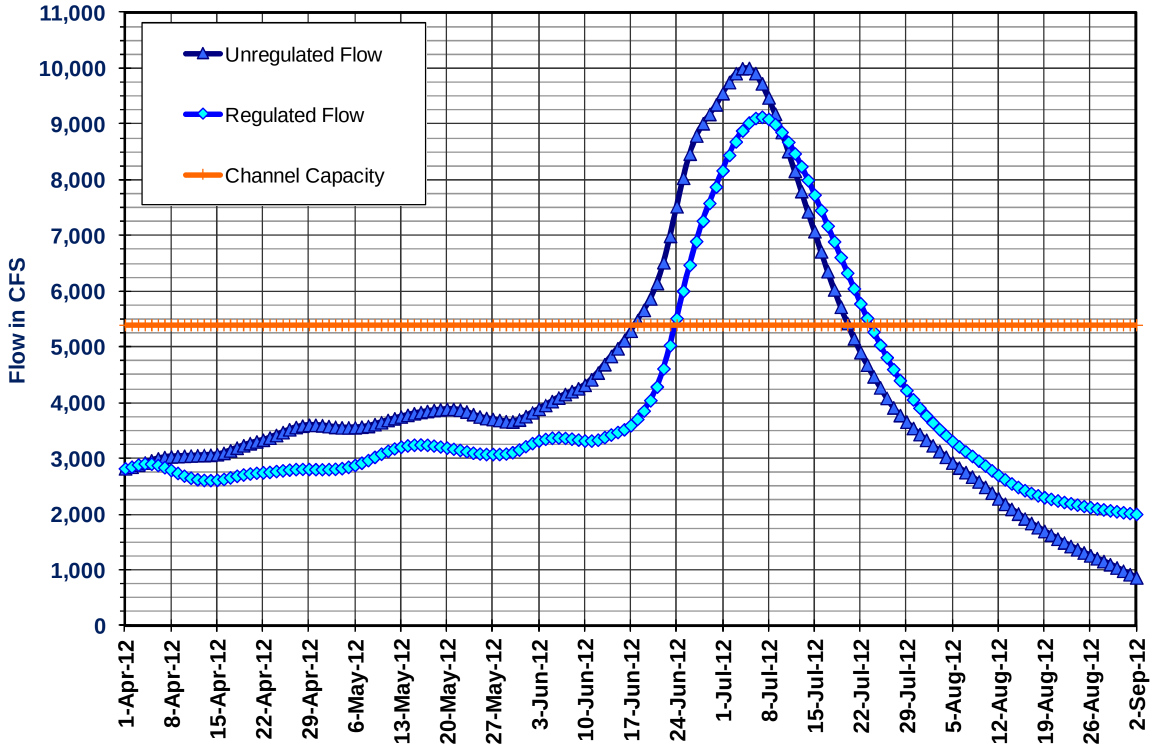

Figure 12: Hydrograph showing regulated and unregulated flows at Virden

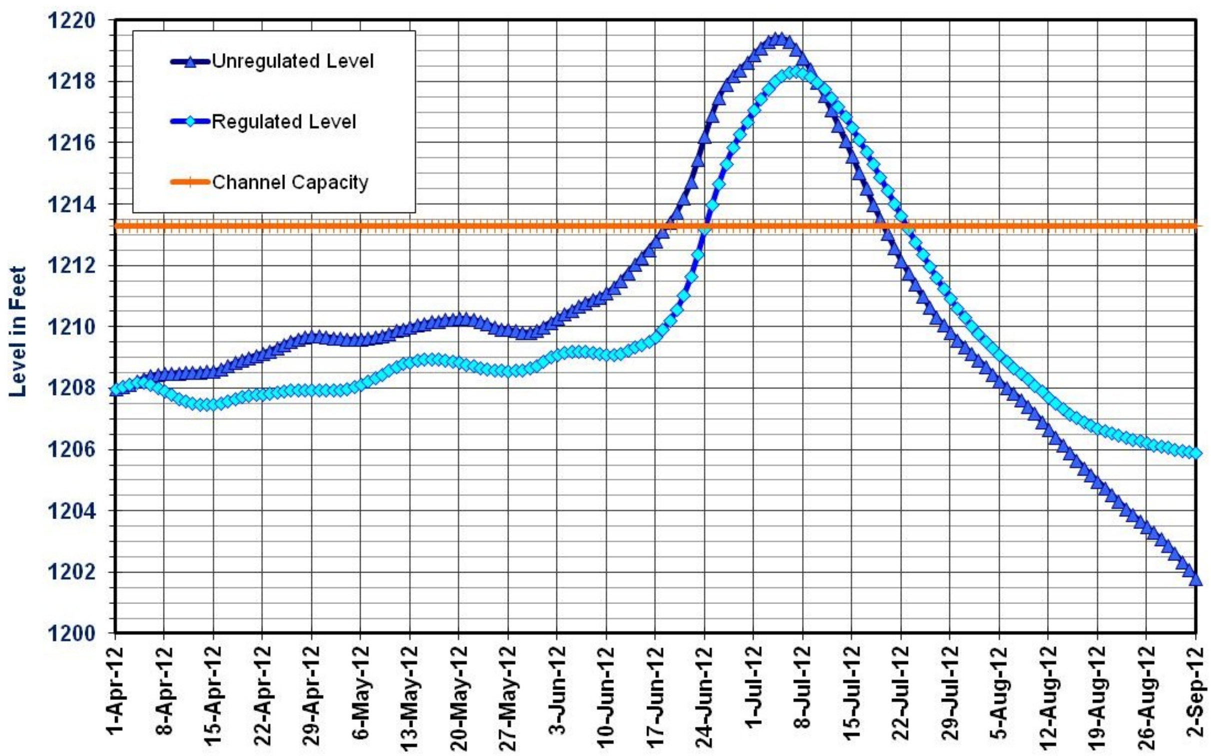

Figure 13: Hydrograph showing regulated and unregulated water levels at Virden

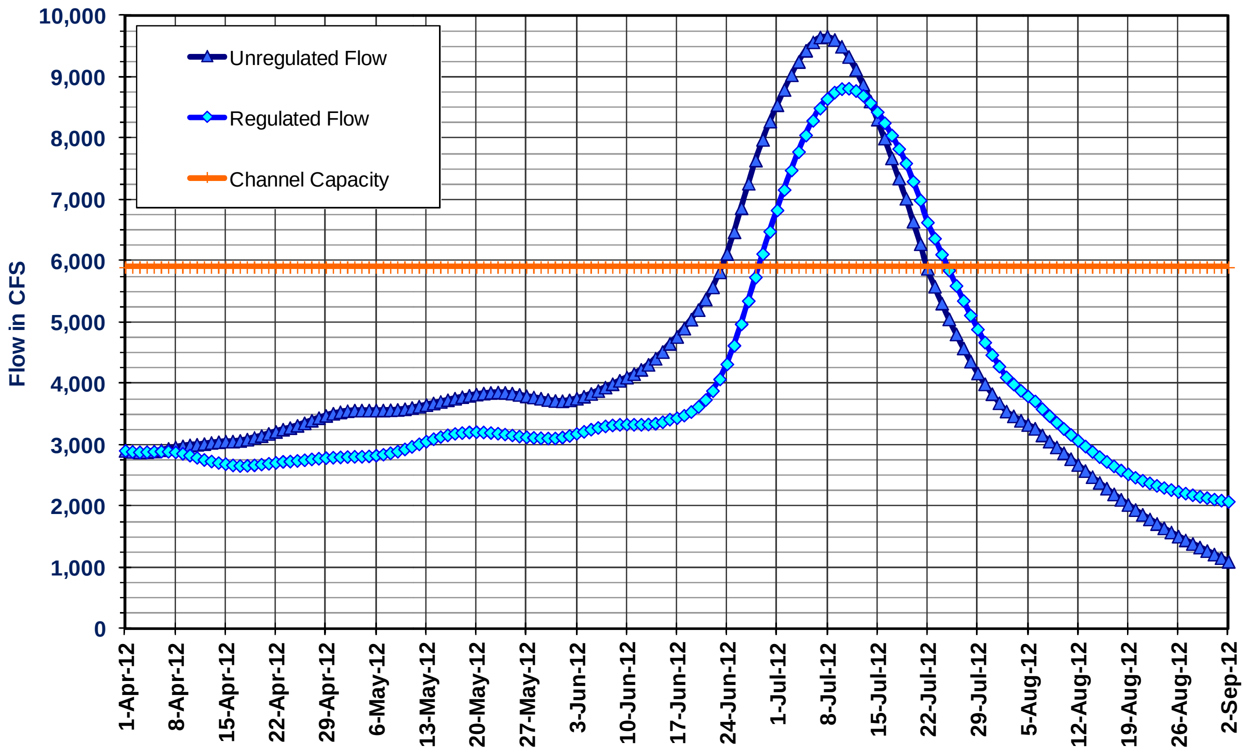

Figure 14: Hydrograph showing regulated and unregulated flows at Griswold

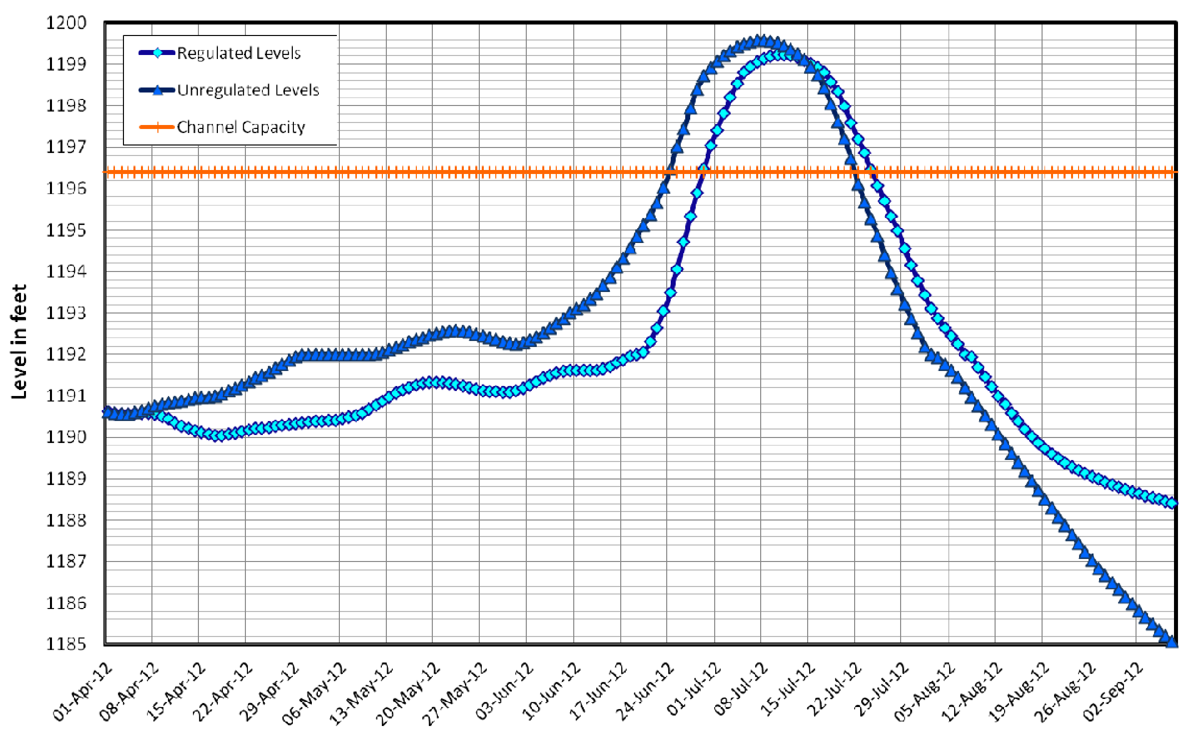

Figure 15: Hydrograph showing regulated and unregulated water levels at Griswold

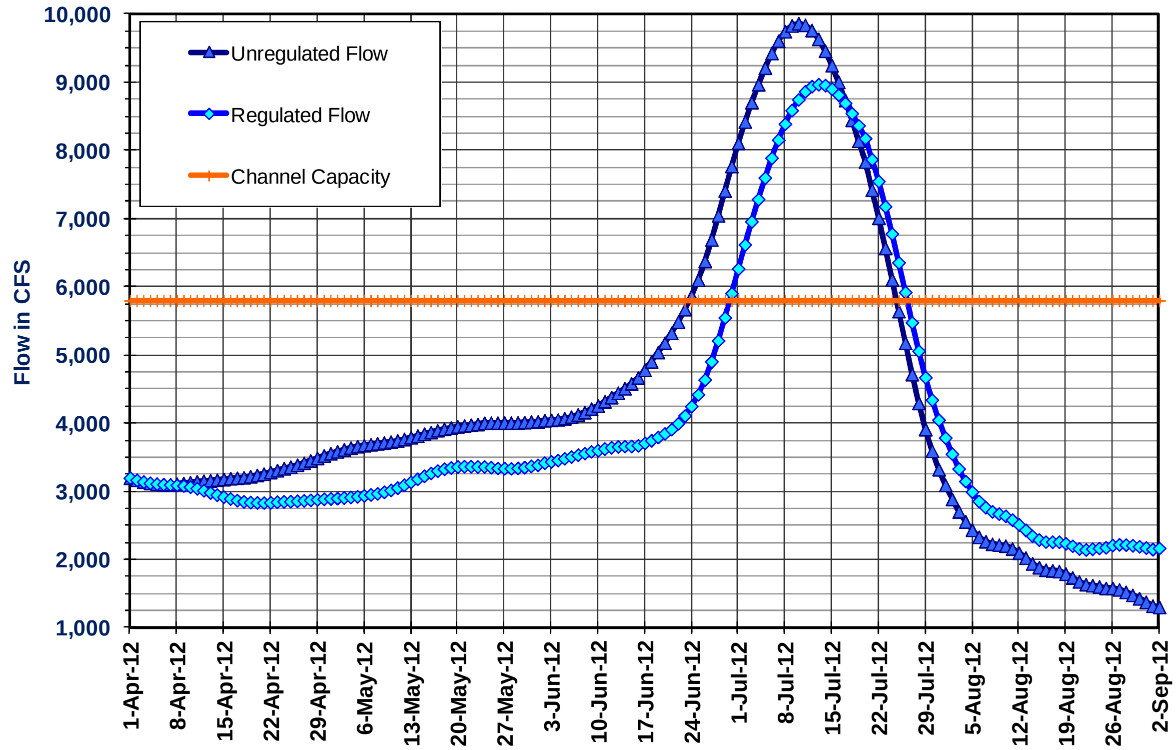

Figure 16: Hydrograph showing regulated and unregulated flows at Brandon

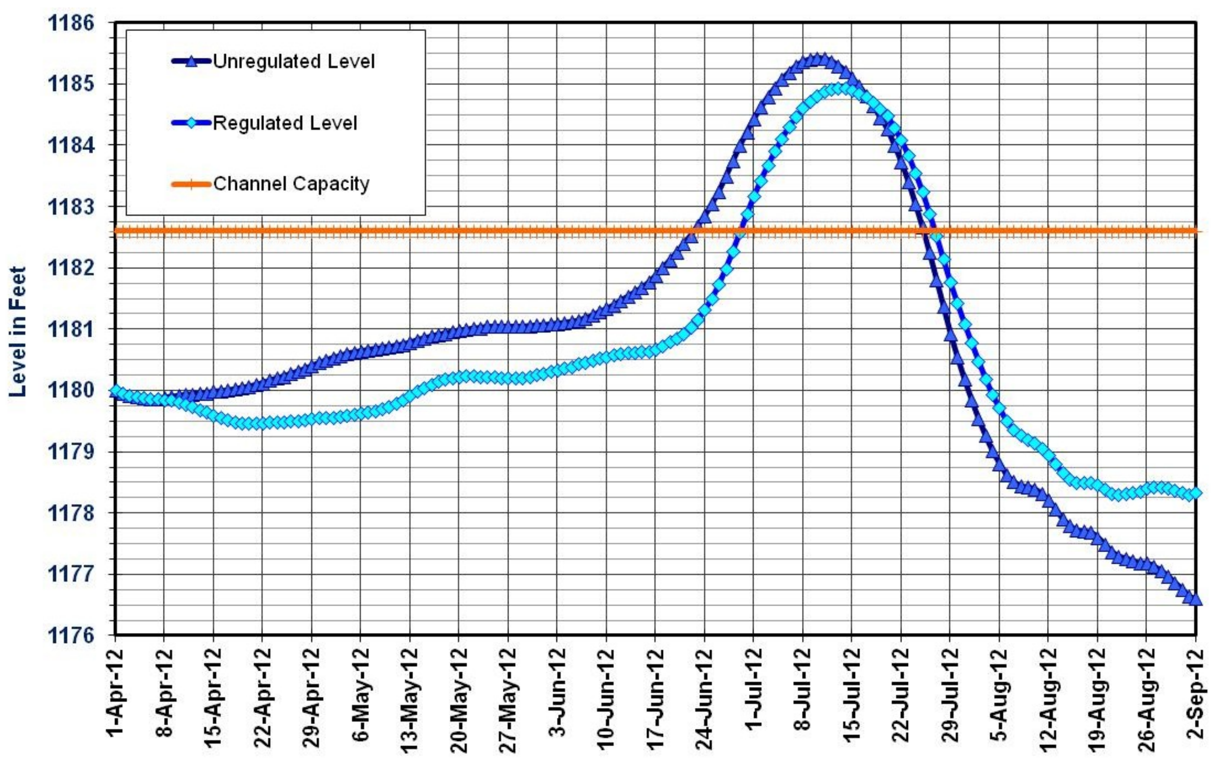

Figure 17: Hydrograph showing regulated and unregulated water levels at Brandon

2012 Shellmouth Dam Operations

From November 2011 to March 2012 the area around the Shellmouth Dam received an average of 25 % of the normal winter precipitation (see Figure 18). Soil moisture at freeze-up in the fall of 2011 was above normal in the upper Assiniboine River watershed but well below normal in the lower portions of the Assiniboine River watershed (see Figure 19).

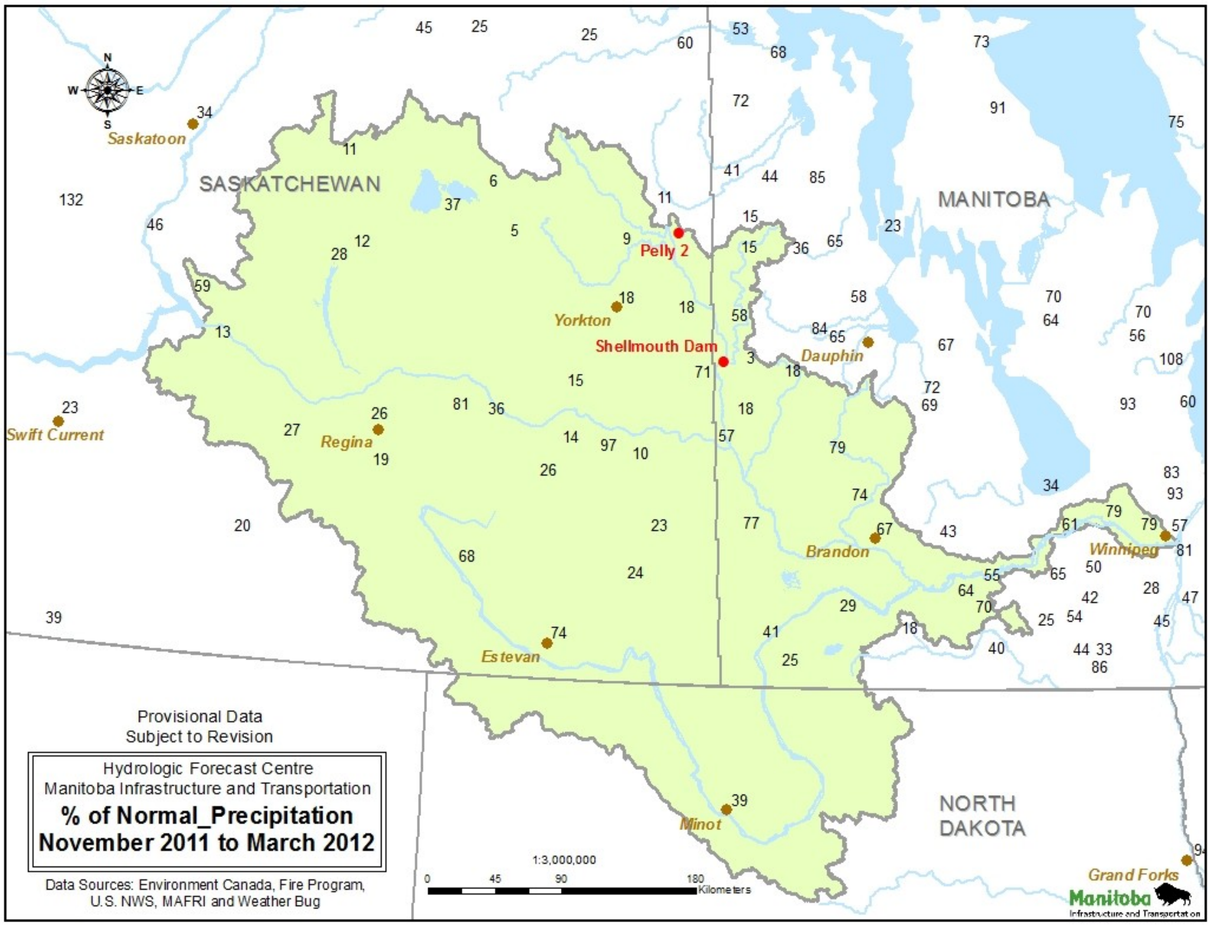

Figure 18: Percent of normal precipitation, November 2011 to March 2012

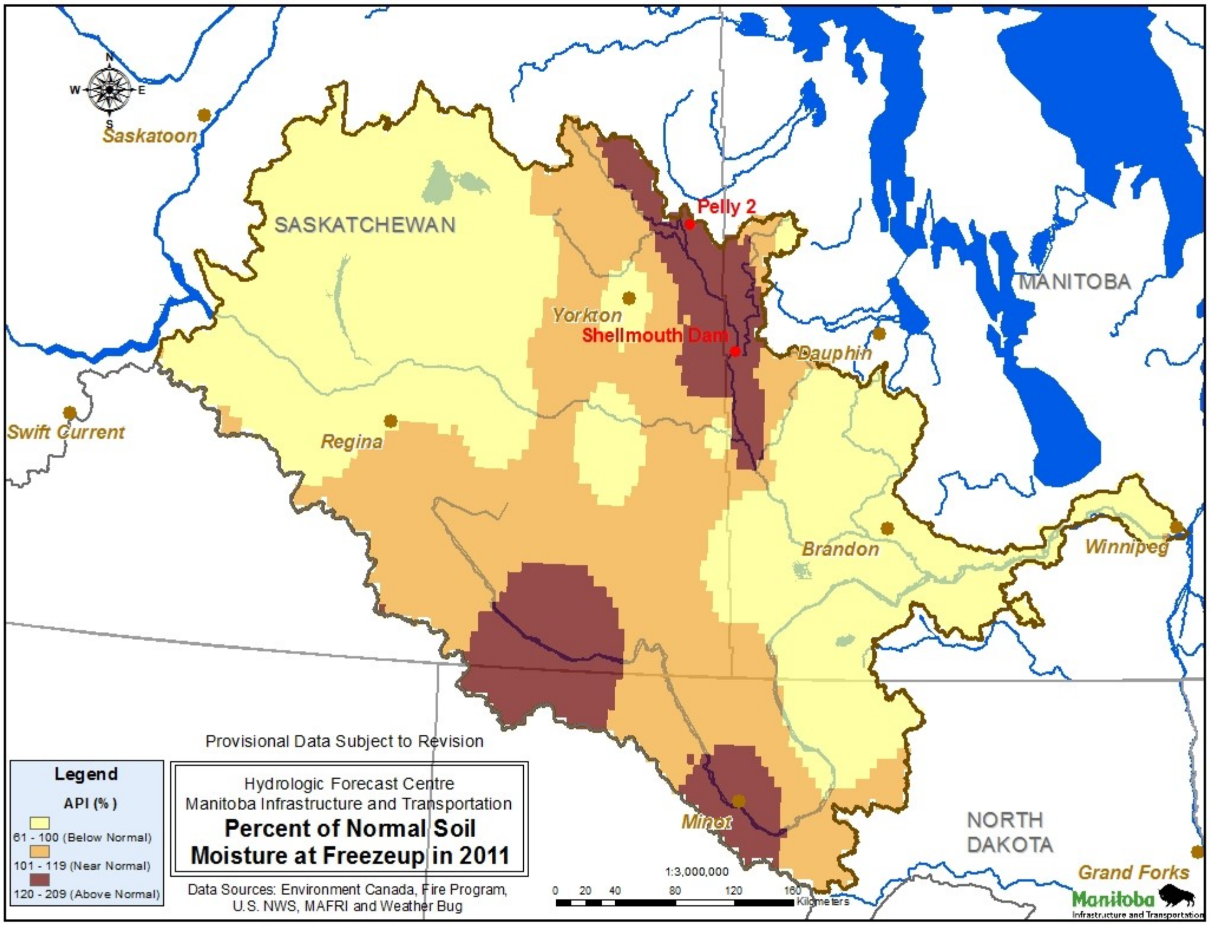

Figure 19: Percent of normal soil moisture at freeze up in 2011

In early March, 2012 the Shellmouth Reservoir level was at 1397.72 ft, nearly five feet below the summer target level. At this time, inflow into the reservoir was only 130 cfs and outflow through the conduit was 200 cfs; thus, reservoir levels were receding even lower. A snow field survey showed a gain of only 10-20 mm of snow water equivalent since February; with so little moisture in the watershed upstream of the reservoir, there was a distinct possibility that the reservoir level might not rise to the summer target level. As well, outflows from reservoirs in North Dakota and Saskatchewan were being reduced and there was a very real possibility that the lower Assiniboine River could experience water deficit conditions. If the dry conditions persisted, storing much of the runoff in the reservoir would be necessary to ensure an adequate water supply to meet demands downstream.

Weather conditions changed very dramatically in April. Precipitation in April, May and June was well above normal in the Assiniboine River watershed. For example, the Pelly-2 climate station (location shown on Figure 18), which is used as an indicator of rainfall conditions upstream of the reservoir, received rain amounts that exceeded the upper decile conditions (i.e. less than a 10% chance of occurring). In April, May and June, the station received 49 mm, 113 mm, and 235 mm of precipitation, respectively. The combined rainfall for the three months set a record at nearly 400 mm; this was approximately 230% of normal (see Figure 20).

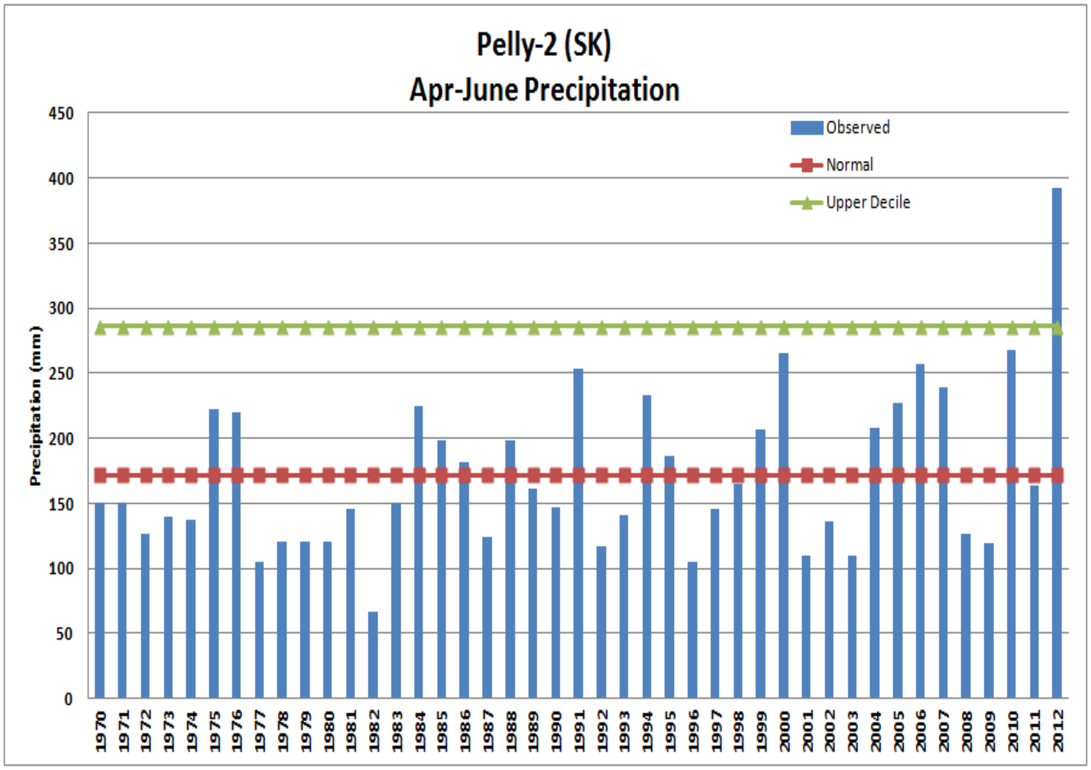

Figure 20: April-June precipitation based on Pelly/Pelly-2 Stations in Saskatchewan

As a consequence of these unusually high rainfalls, flows into the Shellmouth Reservoir increased substantially. An outflow of approximately 1,600 cfs, which is the channel capacity of the river below the dam, was maintained in the conduit from early April 2012 until the reservoir rose high enough for over-spillway flows to begin. As spillway flows increased, the flows through the conduit were reduced to keep total outflows at approximately 1,600 cfs. Once the spillway flow reached 1,600 cfs, the conduit was closed and further increases in outflow were due to increasing spillway flows caused by rising reservoir levels.

Flows through the conduit resumed on August 8, 2012 once the spillway flows fell below 1,600 cfs due to the falling reservoir level. The flows in the conduit were increased periodically as the spillway flows decreased, so that the total outflows were kept at approximately 1,600 cfs. Spillway flows continued until August 26, 2012 when the reservoir fell below 1408.5 ft, which is the elevation of the crest of the spillway. A tabulation of the gate adjustments is contained in Table 5.

Table 4: Shellmouth Reservoir seasonal operation guidelines

Guidelines for Spring	Guidelines for Summer	Guidelines for Winter
• Outflow below 500 cfs if possible until Assiniboine crest has passed Miniota. • Keep outflows from exceeding 1600 cfs but not if this raises reservoir above 1407 feet • Outflows must meet downstream requirements with a minimum of 25 cfs. • If forecast based on observed rain and streamflow indicates reservoir level may rise to 1406.5 feet, keep outflow below 1600 cfs. • If forecast based on observed rain and streamflow indicates reservoir level may rise to spillway, set April outflow as high as required to keep level below 1407 feet. During May or June, if valley crops have been seeded, use peak shaving if necessary to prevent total outflows from exceeding 2000 cfs.	• Summer target range 1400-1404. • Operate to meet downstream needs if possible. Minimum needs are 100 cfs at Brandon and 200 cfs at Headingley. Minimum outflow of 50 cfs and maximum of 1000 cfs while in summer target range. • If serious summer flood develops, adjust outflows up to 1600 cfs to prevent spillway overtopping. If spillway is overtopped anyway, use peak shaving to try to maintain 1600 cfs outflow. • If reservoir level exceeds 1410.5 feet, increase outflows as required to prevent further rises. • On falling limb after spillway overtopped, operate to maintain 1200 cfs until reservoir down to 1406.5. • Operate to prevent decline of more than 0.3 feet per day at bridge downstream of Shellmouth. • When reservoir declines below 1400 feet, set outflow at minimum of 25 cfs. • During severe drought, meet downstream requirements to a level of 1390 feet. At lower levels, outflows to be approved at ministerial level following discussions with stakeholders.	• Minimum drawdown level of 1386 feet. • Target 1404 level after spring runoff. • Try to avoid large fluctuations in outflow. • Be in a position to get down to 1386, without exceeding 1500 cfs outflow, when upper decile forecast indicates a spring level near spillway. • November and December outflows based on lower decile inflow forecast. • January and February outflows based on lower quartile inflow forecast. • March outflow based on upper quartile inflow forecast.

Operating Guidelines

In 2012, the Shellmouth Dam was operated in a manner consistent with most of the approved operating guidelines, which are shown in Table 4. The operations were not consistent with two of the guidelines for summer operation.

First, the fourth summer operating guideline calls for total outflows to be increased once the reservoir level exceeds 1410.5 ft in order to prevent the reservoir from rising higher. In 2012, the reservoir level reached nearly 1413.5 ft, however the total outflows while the reservoir levels were above 1410.5 ft were only those that occurred over the spillway. Conduit outflows were not increased so as to prevent the reservoir level from rising further because increasing the total outflow would have caused more extensive flooding downstream in the Assiniboine River Valley. During a Shellmouth Dam Liaison Committee meeting on June 5, 2012, just prior to the reservoir reaching 1408.5 ft, department staff presented three operating scenarios to the Liaison Committee. The first scenario was to maintain the status quo of 1,550 cfs total outflow; the other two scenarios were to increase the total outflow to 1,900 cfs or 2,100 cfs. Department staff advised the committee that increasing outflows at this point in time would result in lower peak reservoir level and lower regulated peak flows downstream on the Assiniboine River. The additional storage space on the reservoir would have also resulted in a shorter period and decreased extent of artificial flooding. The committee advised that increasing outflows was unacceptable and it was decided to operate in accordance with the wishes of the committee and maintain the outflow at approximately 1,550 cfs. This operation, which was recommended by the committee, reduced the flood protection benefits of the Shellmouth Dam resulting in a higher peak regulated flow and a greater extent and duration of artificial flooding.

Second, after the spillway was overtopped, and while on the recession limb of the hydrograph, the fifth guideline for summer operation states that at this point the Dam should be operated to maintain 1,200 cfs outflow until the reservoir reaches a level of 1406.5 ft. Spillway outflows dropped below 1,200 cfs on August 13, 2012; if the Dam had been operated in accordance with this guideline, the conduit outflows would have been approximately 400 cfs lower than the actual outflows in 2012, in order to maintain total outflows of approximately 1,200 cfs. Instead, the total outflows were maintained at approximately 1,600 cfs, a flow which remained in bank and so did not cause artificial flooding.

There were numerous reasons why the Dam was operated so that the total outflow was maintained at approximately 1,600 cfs on the recession limb of the hydrograph. First, a total outflow of 1,600 cfs helped to bring the reservoir level down to the summer target level (1402.5 ft) more quickly than a 1,200 cfs outflow would have. This created additional storage space in the reservoir more quickly, which lessened the chance that a future storm event would raise reservoir levels above the spillway and thus potentially result in a second period of artificial flooding. It is important to note that there was little crop in the valley during the period of this operation, due to the earlier and larger flood flows; these earlier flows, although higher, were below what would have occurred if the Shellmouth Dam had not been in existence.

In the years 2010, 2011, and 2012, the upper Assiniboine River basin experienced periods of extraordinary wet conditions, which resulted in summertime spillway flows and artificial flooding in each of these three years. In light of this, it may be advisable to review the Shellmouth Dam Operation Guidelines to ensure that they continue to meet the best water management interests of Manitoba.

Table 5: Tabulation of 2012 conduit operations

	Date	Time	Reservoir Level (metres)	Reservoir Level (feet)	Storage Volume (acre feet)	Gate Setting (ft)	Conduit Flow (cfs)	Spillway Flow (cfs)	Total Outflow (cfs)
1	17-Feb-12		426.09	1397.94	242,660	1.08	200	0	200
2	10-Mar-12	13:30	426.02	1397.72	240,020	1.89	349	0	349
3	11-Mar-12	13:30	426.02	1397.69	239,660	2.7	499	0	499
4	15-Mar-12	17:00	425.97	1397.53	237,740	1.09	201	0	201
5	16-Mar-12	12:15	425.99	1397.61	238,700	0.27	50	0	50
6	19-Mar-12	14:00	426.22	1398.36	247,700	0.16	30	0	30
7	28-Mar-12	10:30	427.27	1401.81	290,530	1.01	200	0	200
8	28-Mar-12	13:15	427.27	1401.81	290,530	2.53	500	0	500
9	29-Mar-12	10:50	427.35	1402.05	293,675	3.78	750	0	750
10	29-Mar-12	13:55	427.35	1402.05	293,675	5.05	1,001	0	1,001
11	7-Apr-12	15:45	427.66	1403.10	307,120	6.43	1,300	0	1,300
12	9-Apr-12	18:30	427.71	1403.23	309,720	7.68	1,549	0	1,549
13	2-May-12	14:00	428.38	1405.45	341,600	7.45	1,550	0	1,550
14	23-May-12	13:20	428.90	1407.15	367,825	7.27	1,547	0	1,547
15	6-Jun-12	11:00	429.34	1408.61	389,670	6.92	1,500	50	1,550
16	7-Jun-12	10:25	429.40	1408.78	393,320	6.56	1,425	128	1,553
17	8-Jun-12	12:30	429.50	1409.12	398,980	5.49	1,200	320	1,520
18	9-Jun-12	10:05	429.57	1409.34	401,440	5.03	1,100	474	1,574
19	10-Jun-12	11:10	429.64	1409.56	406,240	4.1	900	650	1,550
20	11-Jun-12	10:40	429.75	1409.91	412,510	3.4	750	988	1,738
21	11-Jun-12	11:45	429.75	1409.91	412,510	2.72	600	1,024	1,624
22	12-Jun-12	10:50	429.79	1410.09	414,860	1.81	400	1,202	1,602
23	13-Jun-12	10:50	429.88	1410.37	419,620	0.9	200	1,597	1,797
24	13-Jun-12	13:20	429.97	1410.66	424,720	0	0	2,037	2,037
25	7-Aug-12	12:01	429.87	1410.33	419,110	0.27	60	1,549	1,608
26	8-Aug-12	11:00	429.85	1410.27	417,920	0.72	159	1,455	1,614
27	10-Aug-12	11:35	429.83	1410.19	416,560	2.75	289	1,339	1,629
28	12-Aug-12	12:30	429.80	1410.11	415,200	1.81	400	1,228	1,628
29	13-Aug-12	10:30	429.76	1409.99	413,170	2.45	540	1,078	1,618
30	14-Aug-12	10:15	429.73	1409.88	411,355	5.49	669	951	1,620
31	16-Aug-12	11:10	429.69	1409.73	408,880	3.78	831	799	1,629
32	17-Aug-12	9:15	429.64	1409.59	406,570	4.33	950	669	1,619
33	18-Aug-12	10:25	429.61	1409.48	404,920	4.7	1,030	581	1,611
34	19-Aug-12	12:15	429.57	1409.35	402,775	5.12	1,120	479	1,599
35	20-Aug-12	10:15	429.53	1409.23	400,795	5.58	1,219	394	1,613
36	22-Aug-12	10:30	429.47	1409.01	397,000	6.24	1,361	251	1,612

37	**23-Aug-12**	11:30	429.43	1408.88	394,920	6.84	1,422	180	1,602
38	**24-Aug-12**	11:25	429.39	1408.74	392,840	6.96	1,505	112	1,617
39	**25-Aug-12**		429.32	1408.53	389,480	7.41	1,605	12	1,616
40	**6-Sep-12**	11:00	428.68	1406.43	357,130	6.74	1,420	0	1,420
41	**6-Sep-12**	1:00	428.69	1406.46	357,130	6.07	1,280	0	1,280
42	**7-Sep-12**	11:15	428.63	1406.27	354,030	7.42	1,560	0	1,560

Note: the reservoir levels in the table are based on a single daily value, reservoir levels may have been affected by wind set-up or set-down