Shuswap Project Water Use Plan

Flooding Risks in the Middle Shuswap River

Implementation Year 1

Reference: SHUMON-3

Final Report


Summit Environmental Consultants Inc.
Suite 200, 2800 29 Street
Vernon, B.C. V1T 9P9

May 18, 2012
May 18, 2012
File: 2008-8510.010

Natural Resource Specialist
Water License Requirements
BC Hydro
6911 Southland Drive, 11th Floor
Burnaby, B.C.
V3N 4X8

Re: FINAL REPORT - SHUMON-3: FLOODING RISKS IN THE MIDDLE SHUSWAP RIVER

Dear Mr. McArthur:

Summit Environmental Consultants Inc. is pleased to submit this final report that presents the results of our hydrological assessment of flooding risks in the Middle Shuswap River.

Please contact either of us if you have any questions.

Yours truly,

Drew Leibak, M.Sc.
Hydrologist

Reviewed by:

Brian T. Guy, Ph.D., P.Geo., P.H.
Senior Geoscientist
Executive Summary

In 2006, BC Hydro developed a terms of reference (TOR) for effectiveness monitoring programs, which were aimed at providing BC Hydro with information upon which to base future operating decisions. The TOR outlined a monitoring program “SHUMON-3 Flooding Risks in Middle Shuswap River” for the completion of a one-year study to determine if a flood performance measure of 232 m$^3$/s at Wilsey Dam was appropriate for identifying flooding risks in the Middle Shuswap River.

A field monitoring program was implemented in 2008 to provide an assessment of flood conditions within the Middle Shuswap River at three (3) sites to test the hypothesis that overbank flooding occurred when discharge at Wilsey Dam reached 232 m$^3$/s. The three sites were identified as Site 1 – Huwer Property, Site 2 – Huwer Bridge, and Site 3 – Procter Property. At each site, staff plates, benchmarks, and photopoints were installed and topographic surveys were completed in 2008. However, the required flow (232 m$^3$/s) did not occur until June 2011.

The flood monitoring sites were visited six (6) times from 2008 to 2011, which included field examination of flood extents in May 2008 and June 2011, in addition to a helicopter survey of the entire Middle Shuswap River completed by BC Hydro in 2006. During the helicopter survey and field reviews, overbank flooding was observed at all three flood monitoring sites. The extent of flooding at Site 2 – Huwer Bridge had been reduced after 2006, due to bank stabilization work and the installation of a rock dyke by Fisheries and Oceans Canada. Overbank flooding at Site 1 – Huwer Property and Site 3 – Procter Property was observed to occur along the channel at numerous locations, which resulted in the ponding of water in the fields adjacent to the channel and the reactivation of an abandoned channel at Site 3 – Procter Property. Pothole flooding was also present at the monitoring sites, a result of an increase in the water table elevation.

The extent of overbank flooding was similar during the 2006 helicopter survey and the 2011 field review due to the similar discharges measured at Wilsey Dam (approximately 237 to 240 m$^3$/s). Flooding was just beginning during the 2008 field review, when the discharge at Wilsey Dam was approximately 200 m$^3$/s, which suggested that the hypothesis that overbank flooding occurs at a discharge of 232 m$^3$/s at Wilsey Dam (identified in the TOR) was incorrect.

Unregulated streamflows entering the Middle Shuswap River downstream of Wilsey Dam and above the three sites are also relevant for flood management within the Middle Shuswap River. The largest contribution of streamflow to the Middle Shuswap River below Wilsey Dam is from Bessette Creek. In 2008, the estimated discharge in the Middle Shuswap River the point that overbank flooding began was 234 - 239 m$^3$/s, comprised of 200 m$^3$/s at Wilsey Dam, 29 m$^3$/s at Bessette Creek, and an estimated 5 – 11 m$^3$/s from other non-monitored tributaries.
Based on the results of this investigation, it is recommended that in order to limit flooding adjacent to the Middle Shuswap River, the outflows from Sugar Lake should be managed to meet a target of 229 m$^3$/s within the Middle Shuswap River based on the combination of discharge at Wilsey Dam and on Bessette Creek. It is also recommended to upgrade the Bessette Creek station to provide real-time flow and water level data; and to confirm the assumption of a one-day lag time between Sugar Lake and Wilsey Dam.

The benefit of following the recommendations contained herein may be greater than using the 232 m$^3$/s target originally suggested by BC Hydro (2002), as the target of 229 m$^3$/s (from the combination of discharge at Wilsey Dam and Bessette Creek) indicated an additional 35 days (i.e. approximately 1.3 days per year on average) when flooding likely occurred adjacent to the Middle Shuswap River as compared to that originally estimated over 1974-2000.
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1 Introduction

1.1 PROJECT BACKGROUND

Flooding and bank erosion along the Middle Shuswap River downstream of Wilsey Dam has been identified as an area of concern by the Consultative Committee for the Shuswap River Water Use Plan (WUP) (BC Hydro 2005). Downstream of Wilsey Dam, private individuals own property within the Middle Shuswap River floodplain. Therefore, the Consultative Committee identified the need to develop a better understanding between the magnitude of flooding and discharge from Sugar Lake Dam. BC Hydro has previously estimated that flooding starts within the Middle Shuswap River when flows past Wilsey Dam reach 232 m$^{3}$/s, as above this flow, the Shuswap River has been observed to over-top channel banks at a farm near Cherry Creek, B.C. (BC Hydro 2006). Previous studies have been completed to investigate Sugar Lake Dam operation alternatives to help store more water during the spring freshet; however, these studies did not investigate downstream flooding effects. Therefore, a large uncertainty exists in regards to the hypothesis that flooding begins within the Middle Shuswap River at a discharge of 232 m$^{3}$/s at Wilsey Dam.

In 2006, BC Hydro developed a Terms of Reference (TOR) for effectiveness monitoring programs, which were aimed at providing BC Hydro with information upon which to base future operating decisions. The TOR outlined a monitoring program “SHUMON-3 Flooding Risks in Middle Shuswap River” for the completion of a one-year study to determine if the WUP’s flood performance measure of 232 m$^{3}$/s at Wilsey Dam is appropriate for identifying flooding risks in the Middle Shuswap River (BC Hydro 2006). The ultimate goal of SHUMON-3 is to help determine whether operating alternatives at Sugar Lake Dam can reduce flooding risks within the Middle Shuswap River and improve the ability to predict flood timing to provide land-owners time to take actions to minimize damage.

This report presents the results of the SHUMON-3 investigation.

1.2 PROJECT OBJECTIVES

The objectives of this assessment were outlined in the proposal “Flooding Risks in Middle Shuswap River; Study 3 – Shuswap River Water Use Plan Monitoring Program” submitted by Summit Environmental Consultants Inc. (Summit), in conjunction with the Splats’in First Nation, to BC Hydro on March 20, 2008:

1. Identify the key areas where flooding is a concern along the Middle Shuswap River;
2. Determine the discharge at which flooding begins in the Middle Shuswap River;
3. During a single flood event, determine the relation between discharge from Sugar Lake Dam, discharge at Wilsey Dam, and the extent of flooding; and
4. Examine the hypothesis that flooding in the Middle Shuswap River begins when flows downstream of Wilsey Dam reach 232 m$^{3}$/s (measured at Water Survey of Canada hydrometric station No. 08LC003).
1.3 STUDY METHODS

As outlined in the TOR, six main tasks were required to complete the study:

1. Information collection, review and summary, including existing flood information and video footage, relevant hydrologic, topographic, and geologic reports, as well as aerial photographs;
2. Site selection and survey, including the identification of three (3) sites considered to be at risk of flooding. Each monitoring site included a permanent benchmark, photopoint, staff gauge, and site topographic survey;
3. Completion of high flow surveys of each monitoring site when flows at Wilsey Dam were 232 m$^3$/s, including photo documentation and recording of stage elevations (i.e. water levels);
4. Collection, organization, and reduction of hydrometric data obtained from a network of hydrometric stations along the Middle Shuswap River and Bessette Creek;
5. Development of a Microsoft Access database for all collected information and data, including all discharge and stage information, results of the site surveys, and photographs; and
6. Production of a final report.
2

Middle Shuswap River

2.1 GENERAL CHARACTERISTICS

The Middle Shuswap River is located between Sugar Lake and Mabel Lake (Figure 2-1). The specific portion of the river that is the subject of this report (the Middle Shuswap River Project Area) is highlighted in Figure 2-1. The Shuswap River is a tributary of the South Thompson River. The Middle Shuswap River Basin lies in the Shuswap Highland and Monashee Mountains physiographic regions (Holland 1976) and is bounded on the east by the Columbia River Basin, on the west by the Okanagan River Basin, and on the south by the Kettle River Basin. The drainage area of the Shuswap River at the head of Mabel Lake is 3,098 km$^2$.

The Middle Shuswap River Basin is affected by both continental and modified maritime conditions (BC Hydro 2003; 2005). Total precipitation at Lumby (Environment Canada Climate Station: Lumby Sigalet Rd.; No. 1164730; Elevation 559.5 m; 1971 – 2000 normals) averages 628.3 mm, of which 164.9 mm (water equivalent) falls as snow (between the months of October and April). Mean daily temperatures at Lumby range from a high of 17.9 °C in July to a low of -4.9 °C in January.

BC Hydro operates a 6 MW hydroelectric facility on the Middle Shuswap River at Shuswap Falls, referred to as the Shuswap Generating Facility at Wilsey Dam (Figure 2-1). The Shuswap Generating Facility is a run-of-the-river project that has been in operation since 1929 (BC Hydro 2005).

2.2 HYDROLOGIC REGIME

According to Obedkoff (1998; 2003), the Shuswap River is located within the Northern Columbia Mountains Hydrologic Zone (#14), subzone ‘f’. The Shuswap River is generally characterized by a snowmelt dominated peak rising in April and peaking sometime between mid-May and mid-June. Late fall rainstorms are common, recharging soil moisture heading into winter and producing short-duration high flows. Low flows occur generally from the end of November to early March, and in hot summer months, with the lowest flows commonly occurring in January or February.

The Middle Shuswap River is regulated by both Sugar Lake and Wilsey Dam. Sugar Lake is used to provide storage for hydroelectric generation 31 km downstream at Wilsey Dam. Normally, the level of Sugar Lake is lowest in mid-April prior to spring freshet, and once full pool is reached it is maintained until late fall. Water is then released during the fall and winter for power generation and to maintain fisheries flows. Downstream of Wilsey Dam, tributaries (e.g. Bessette Creek and Ireland Creek) contribute to the flow of the Middle Shuswap River.
WSC Hydrometric Stations:

Shuswap River at Sugar Lake Outlet (08LC018)
Shuswap River near Lumby (08LC003)
Bessette Creek above Beaverjack Creek (08LC039)
The Water Survey of Canada (WSC) operates two hydrometric stations on the Middle Shuswap River: Shuswap River at Sugar Lake Outlet (WSC Station No. 08LC018) and Shuswap River near Lumby (WSC Station No. 08LC003); and one on Bessette Creek (WSC Station No. 08LC039; “Bessette Creek above Beaverjack Creek”) (Figure 2-1). The records for the station “Shuswap River near Lumby”, which is just downstream of Wilsey Dam, extend from 1913-2010.

Figure 2-2  Mean Daily Discharge of Shuswap River near Lumby (WSC Station No. 08LC003), 1913-2010.

2.3 STREAMFLOW MANAGEMENT

Streamflows within the Middle Shuswap River are largely controlled by flow releases from Sugar Lake and the management of the Shuswap Generating Facility at Wilsey Dam. The operations of Sugar Lake and Wilsey Dam are outlined by BC Hydro (2005) and summarized below.

2.3.1 Sugar Lake

Sugar Lake is located north of Highway 6 near Cherryville, B.C. It is approximately 10 km long and has a storage capacity of approximately 133,700 ML. The drainage area of Sugar Lake is 1,130 km².
Sugar Lake is operated following the conditions outlined within the “Sugar Lake Dam: Operation, Maintenance, and Surveillance Manual (OMS) for Dam Safety” (BC Hydro undated). The operating conditions include flow augmentation for fish from the fall to spring, in addition to providing continued recreation opportunities on Sugar Lake and downstream on the Middle Shuswap River. The Sugar Lake operating levels are chosen to benefit fish and aquatic productivity in the reservoir.

Normal operating elevations of Sugar Lake range between 589.64 m and 601.72 m. The actual water levels do not often go below 594.70 m due to a natural barrier between the reservoir and dam release facilities.

Water levels in Sugar Lake depend on snowpack, weather conditions during freshet, and rainfall, all of which vary. Water is stored when inflows exceed the releases, but BC Hydro attempts to release at least $15 \, m^3/s$ at all times (BC Hydro 2003). The volume of water stored up to late fall is released slowly during the winter. During freshet, the Sugar Lake Dam discharge is maximized by opening all four gates until the peak has passed. Once the freshet has passed, the summer operations (June – August) attempt to bring the lake elevations close to full pool for recreation purposes and storage for fishery requirements in the fall and winter. During fall (September – December) and winter (January – March) operations, water is released from Sugar Lake based on minimum flow requirements downstream for fisheries and Wilsey Dam. In addition, during this period of operation, BC Hydro attempts to draw the lake down to allow for maximum available storage directly prior to freshet (i.e. May 1) in order to reduce the risk of flooding in the Middle Shuswap River.

### 2.3.2 Wilsey Dam

The Shuswap Generating Facility at Wilsey Dam is operated following the conditions outlined within the “Wilsey Dam: Operation, Maintenance, and Surveillance Manual (OMS) for Dam Safety” (BC Hydro undated). The operating conditions include minimum flow releases of $13 \, m^3/s$ (January 1 to August 14) and $16 \, m^3/s$ (August 15 to December 31) (measured at WSC Station No. 08LC003; Shuswap River near Lumby) for power generation purposes and to maintain important spawning and rearing habitat (BC Hydro 2005).

Flows at Wilsey Dam are determined by flow releases from Sugar Lake, as well as local inflows provided by Cherry and Ferry Creeks. The active storage in the headpond at Wilsey Dam is approximately 110 ML. The spillway crest can be manually adjusted, and it is normally raised in the fall to raise the headpond elevation and reduce the risk of ice buildup. The crest elevation is returned to normal before freshet.

### 2.4 FLOODING CONCERNS

Flooding and stream bank erosion downstream of Wilsey Dam on the Middle Shuswap River has affected landowners with floodplain properties. The Consultative Committee has discussed methods to enhance flood control through changes to the dams and the operational plans. However, the Consultative
Committee indicated that performance measures for flooding risks were difficult to prepare because the relationship between discharge from Sugar Lake Dam and the magnitude of flooding was poorly understood (BC Hydro 2005).

On May 26, 2006, in order to begin to understand the extent of flooding of lands adjacent to the Middle Shuswap River, a helicopter survey was conducted by BC Hydro at a discharge at Wilsey Dam between 240 and 245 m$^3$/s. The survey was conducted from Wilsey Dam to the head of Mabel Lake and identified areas of significant overbank flooding. Upon review of the survey (i.e. the film footage) and observations of overbank flooding of a farm near Cherryville, the Consultative Committee estimated that flooding begins when discharge past Wilsey Dam reaches 232 m$^3$/s.

A discharge of 232 m$^3$/s at Wilsey Dam represents a peak flow event with approximately a 1-in-2.5 year return period$^1$ and a mean daily discharge exceedance probability of 1.0 % based on the available period of record from the nearby WSC station (Figure 2-3). A summary of the Middle Shuswap River’s maximum mean daily discharge for the available period of record and the number of days the mean daily discharge was above 232 m$^3$/s is provided in Table 2-1. From the available records, discharge above 232 m$^3$/s at Wilsey Dam has been observed to last between 1 to 21 days during the freshet period.

$^1$ The return period was estimated using the B.C. Ministry of Environment, Lands, and Parks (MELP) Flood Frequency Analysis Program (version 1.1), which fits the data to four frequency distributions: Pearson Type III, Log Pearson Type III, Log Normal, and Gumbel. The general procedure for estimating the return period from the MELP program involves visually inspecting and assessing the goodness-of-fit for each distribution, with poor fits excluded. Reviews of each distribution concluded that all distribution types fitted the data reasonably well; therefore, the results from all four distributions were used in calculating the average value.
Figure 2-3    Middle Shuswap River mean daily discharge exceedance probabilities (measured at WSC Station “Shuswap River near Lumby”), 1913-2010.
Table 2-1  Middle Shuswap River high water summary, 1913-2010.

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</tr>
<tr>
<td>1969</td>
<td>225</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>1970</td>
<td>173</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>1971</td>
<td>241</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>1972</td>
<td>385</td>
<td>-</td>
<td>21</td>
</tr>
<tr>
<td>1973</td>
<td>202</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>1984</td>
<td>279</td>
<td>286</td>
<td>6</td>
</tr>
</tbody>
</table>

Note:  
1. Coloured boxes represent periods when the Middle Shuswap River’s mean daily discharge at Wilsey Dam was greater than 232 m³/s;  
2. Max Daily Q = maximum daily average discharge recorded during the year;  
3. Max Inst. Q = maximum instantaneous discharge recorded during the year; and  
4. # of Days > 232 m³/s = number of days the daily average discharge exceeded 232 m³/s.
Flood Monitoring Program

Consistent with the TOR for this investigation, a field monitoring program was implemented in 2008 to provide an assessment of flood conditions at three (3) at risk sites along the river, and to test the hypothesis that overbank flooding occurred when discharge at Wilsey Dam reached 232 m$^3$/s. The field monitoring program is summarized in this section.

3.1 SITE SELECTION

All relevant hydrologic, geologic, and topographic information for the Middle Shuswap River was reviewed, including the May 2006 BC Hydro helicopter survey footage. Based on the review, three (3) sites along the Middle Shuswap River downstream of Wilsey Dam were selected as having the highest risk of flooding. The sites are identified in Figure 3-1 and include:

- Site #1 – Huwer Property;
- Site #2 – Huwer Bridge; and
- Site #3 – Procter Property.

Prior to installation of equipment at the monitoring sites, property owners were contacted and discussions confirmed that flooding had occurred at, or near the selected locations. The following text provides a brief description of the extent of flooding at each property, based on discussions with the property owners and review of available information.

Site #1 – Huwer Property

Overbank flooding occurs over the majority of the property adjacent to the river, with the largest extent occurring at the northern end of the property. Fields on the northeast and east of the property become inundated during high water due to direct overbank flooding and increases in the water table elevation above the ground surface in low lying areas. According to the property owner, Mr. Bill Huwer, channel banks were enhanced in 2008 by Fisheries and Oceans Canada (DFO). The enhancement included the installation of root wads, planting of riparian vegetation, and some bank stabilization work. These enhancements were done to improve fish habitat as well as provide some flood control.

Site #2 – Huwer Bridge

Overbank flooding occurs along the length of the property adjacent to the Middle Shuswap River, with the largest extent occurring on the southeastern and eastern sections of the property. Flooding in this location results from a combination of overbank flooding by the river, increases in the water table elevation above the ground surface in low lying areas, and overbank flooding of the Huwer Channel (Figure 3-1). The Huwer Channel is a small flood channel that becomes active during high water conditions (Minor 2006). According to the property owner, Mr. Joe Huwer, enhancement of the channel banks and flood control work along the Middle Shuswap River was completed in 2008. This work included stabilizing some banks with riprap and the construction of a small rock dyke along a portion of the property. Root wads were also
installed along the Middle Shuswap River banks in 2008 by DFO to improve fish habitat and provide some flood control.

**Site #3 – Procter Property**
Overbank flooding occurs over the portions of the property adjacent to the Middle Shuswap River, with the largest extent occurring at the western edge of the property. During high water conditions, a relic channel (an oxbow) becomes active and overbank flooding can occur along the channel banks. In addition, at certain flood levels, the Procter Channel\(^2\) can overflow its banks (Leroy Procter, property owner, pers. comm. 2008). According to Mr. Procter, channel banks along the Middle Shuswap River were enhanced in 2008 by DFO to improve fish habitat.

### 3.2 SITE INSTALLATION AND TOPOGRAPHIC SURVEY

After approval was obtained from the property owners, monitoring equipment was installed at each of the three flood monitoring sites in April 2008 by Drew Lejbak, M.Sc. of Summit and Ryan Felix of the Splats’in First Nation. The discharge of the Middle Shuswap River at Wilsey Dam at the time of installation was 21.7 m\(^3\)/s.

A staff plate was installed at each site such that the water level could be observed and measured during high (flood) flows. For Sites 1 – Huwer Property and Site 3 – Procter Property, the staff plates were installed along the channel bank, while at Site 2 – Huwer Bridge, the staff plate was installed on a bridge pier (Photographs 1 to 3 of Figure 3-2). Permanent benchmarks were installed in the vicinity of the staff plate locations and at other points-of-interest and were used to assign a datum to each location through standard surveying techniques (Photograph 4 of Figure 3-2). Finally, photopoints were established at each site to provide locations for consistent photo documentation during high (flood) flows (Photographs 5 and 6 of Figure 3-2). The location of each staff plate, benchmark, and photopoint is provided in Figure 3-1.

A total station topographic survey was also completed at each of the selected flooding sites. Survey points at each site included channel banks, top of channel bank, general flood plain area, and other points-of-interest (e.g. benchmarks). The topographic survey was completed in the Geologic Survey of Canada (GSC) datum using a Trimble GPS to provide the reference datum and was conducted on April 28, 2009. Figure 3-1 provides a summary of the survey points collected during the topographic survey and all of the survey points are included in a Microsoft Access database in Attachment 1.

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\(^2\) The Procter Channel is a small natural off channel of the Shuswap River that was enhanced in 2003 to improve rearing habitat for coho salmon (Minor 2003).
Figure 3-1: Selected Middle Shuswap River flood monitoring sites.

Legend:
- Survey Point
- Benchmark
- Staff plate
- Photo point
- River/Stream
- Surveyed contour (0.2 m interval)

Site 1 - Huwer Property
Site 2 - Huwer Bridge
Site 3 - Procter Property
Figure 3-2: Selected Photos of Flood Monitoring Sites

Photo 1: View of staff plate located at Site 1 - Huwer Property (from Photopoint 1a).

Photo 2: View of staff plate located at Site 3 - Procter Property.

Photo 3: View of staff plate located at Site #2 - Huwer Bridge.

Photo 4: Benchmark installed at Site 1 - Huwer Property.

Photo 5: Photopoint 2a (flagged wooden stake) at Site 2 - Huwer Bridge.

Photo 6: View upstream from Photopoint 1b at Site 1 - Huwer Property.
3.3 FIELD REVIEW AND SITE VISITS

After the site installations were complete, flows were monitored in the river to identify when the discharge at Wilsey Dam was approximately 232 m$^3$/s. The flows were monitored by tracking real time water levels transmitted from the WSC station “Shuswap River near Lumby”. According to the WSC, a discharge of 232 m$^3$/s occurs at a water level between 5.372 m and 5.376 m (Lynn Campo, pers. comm., 2008 and 2011), so these water levels were targeted.

The required flows did not occur in 2008, 2009, or 2010. Nonetheless, in these years, site visits were conducted to check the equipment and survey the sites (Table 3-1). The required flow did occur in June 2011.

### Table 3-1 Summary of site visits to the Middle Shuswap River flood monitoring sites, 2006-2011.

<table>
<thead>
<tr>
<th>Date</th>
<th>Mean Daily Discharge at Wilsey Dam (m$^3$/s)</th>
<th>Summary of Site Visit</th>
</tr>
</thead>
</table>
| May 26, 2006 | 237                                         | • BC Hydro helicopter survey
• Significant overbank flooding observed throughout the Middle Shuswap River |
| April 24, 2008 | 21.7                                        | • Site installation and photo documentation                                           |
| May 21, 2008  | 201                                         | • Site review and photo documentation
• Overbank flooding observed at Sites 1, 2, and 3                                     |
| July 24, 2008 | 29.0                                        | • Site review after high water period to ensure monitoring sites were still in place
• Photo documentation                                                                |
| April 28, 2009 | 46.1                                        | • Topographic survey of monitoring sites
• Site review and photo documentation                                                  |
| April 22, 2010 | 54.3                                        | • General maintenance of monitoring sites and survey of staff plates
• Site review and photo documentation                                                  |
| June 12, 2011  | 238                                         | • Discharge of >232 m$^3$/s observed at Wilsey Dam
• Site review and photo documentation
• Overbank flooding observed at Sites 1, 2, and 3                                     |

During each visit, a water level on the staff plate was recorded and 360-degree photo documentation at each of the established photopoints was completed, and photographs were taken at other points-of-interest. During the high water reviews in May 2008 and June 2011, overbank flooding was observed at each of the flood monitoring sites and field sketches of the flooding extent at each site were completed.

BC Hydro (helicopter survey) and Summit completed flood monitoring reviews of the Middle Shuswap River in 2006 and at the monitoring sites in 2008 and 2011, respectively. The following is a summary of the flooding extent that was observed during each review. All photograph references in this section are for figures that are located in Appendix A and a collection of all photographs obtained during this investigation are provided in the database in Attachment 1.

4.1 SITE 1 – HUWER PROPERTY

4.1.1 2006 Helicopter Survey

On the day of the survey, the mean daily discharge at Wilsey Dam was 237 m$^3$/s. Significant overbank flooding occurred over the majority of the property adjacent to the Middle Shuswap River, with the largest extent occurring at the northern end of the property. Fields on the northeast and east of the property became inundated during high water due to direct overbank flooding and water table increases above the ground surface in low lying areas. The flood waters were observed to approach Mabel Lake Road at the eastern edge of the property and inundate a shed located on the property. An approximation of the flood extent observed in 2006 is provided in Figure 4-1a.

4.1.2 2008 Field Review

At the time of the field review, the instantaneous discharge at Wilsey Dam was 199 m$^3$/s. Key field observations included:

- The water level on the staff plate was 381.265 m GSC;
- Water levels of the Middle Shuswap River were to the top of bank (Photograph 1 of Figure A-1);
- Initial stages of overbank flooding (at five (5) locations) were observed at the northern end of the property, with small streams flowing along the bank into the fields (Photographs 2 to 4 of Figure A-1). The approximate depth of the small streams was 0.05–0.10 m;
- Some pothole pooling of water was occurring within the fields due to the high water table elevation (Photograph 5 of Figure A-1); and
- Significant overbank flooding occurred along one section of the northern edge of the property (Photograph 6 of Figure A-1). This is a result of the channel bank being approximately 0.5-1.0 m lower in this area.

Using the measured water level at the time of the visit and the topographic survey of Site 1, the flood extent and overbank flooding locations are provided in Figure 4-1b. The flood extent was confirmed using photographs and a field sketch completed during the field review.
4.1.3 2011 Field Review

At the time of the field review, the instantaneous discharge at Wilsey Dam was 242 m$^3$/s. Key field observations included:

- The water level on the staff plate was 381.513 m GSC;
- Water levels of the Middle Shuswap River were to the top of bank (Photograph 1 of Figure A-2);
- Standing water was observed along the channel banks and within fields, with depths ranging from 0.10-1.0 m (Photograph 2 of Figure A-2);
- Some pothole pooling of water was occurring within the fields due to the high water table elevation. This increase in water table elevation was also observed in the yard of the private residence on the east side of Mabel Lake Road (Photograph 3 of Figure A-2);
- Overbank flooding was present along the right bank, approximately 100-150 m downstream from the staff plate location (Photographs 4 of Figure A-2). The velocity of the overflow was generally slow due to vegetation on the banks;
- Significant overbank flooding was observed at one location where the Middle Shuswap River had overtopped the bank and was flowing directly into the field (Photograph 5 of Figure A-2). At this location, the overbank flooding was approximately 10 m wide and 0.25-0.30 m deep;
- Similar to 2008, overbank flooding also occurred again at the section of low channel bank at the northern edge of the property (Photograph 6 of Figure 4-2). At this location, a significant amount of wood debris from the river was caught on the barbed wire fence; and
- The bank stabilization work completed by DFO in 2008 likely helped reduce some overbank flooding, as flooding was not observed at locations that had had mounding of soil or placement of rip rap.

Using the measured water level at the time of the visit, the topographic survey, photographs, and field sketches, the flood extent and overbank flooding locations are provided in Figure 4-1c.

4.2 SITE 2 – HUWER BRIDGE

4.2.1 2006 Helicopter Survey

On the day of the survey, the mean daily discharge at Wilsey Dam was 237 m$^3$/s. Significant overbank flooding occurred along the length of the property adjacent to the Middle Shuswap River, with the largest extent occurring on the southeastern and eastern sections of the property. Flooding in this location resulted from a combination of overbank flooding by the Middle Shuswap River, water table increases above the ground surface in low lying areas, and overbank flooding of the Huwer Channel. An approximation of the flood extent observed in 2006 is provided in Figure 4-2a.
Figure 4-2: Approximation of flood extent in 2006, 2008, and 2011 at Site 2 - Huwer Bridge

2006 Helicopter Survey
Discharge at Wilsey Dam = 237 m³/s

2008 Field Review
Discharge at Wilsey Dam = 201 m³/s

2011 Field Review
Discharge at Wilsey Dam = 240 m³/s

Legend
- Benchmark
- Staff plate
- Photopoint

Approximate area of flooding

Meters

0 25 50 75 100

Photo source: Virtual Earth
### 4.2.2 2008 Field Review

At the time of the field review, the instantaneous discharge at Wilsey Dam was 201 m$^3$/s. Key field observations included:

- The water level on the staff plate was 388.902 m GSC;
- Water levels of the Middle Shuswap River were at, or close to the top of bank (Photograph 1 of Figure A-3);
- The water was very close to overflowing the banks along the entire property adjacent to the river. Overbank flooding at this site would have been more substantial if not for the presence of the rock dyke installed by DFO (Photograph 2 of Figure A-3);
- Some pothole pooling of water was occurring within the fields due to the high water table elevation (Photograph 3 of Figure A-3);
- The Huwer Channel was active with flood waters spilling into it. For the majority of the channel, flood waters were at, or close to the top of bank (Photograph 4 of Figure A-3). However, at one location, the channel had begun spilling into the fields adjacent to it (Photograph 5 of Figure A-3); and
- The property owner indicated that this flood stage was the highest that he felt comfortable with for his property (Joe Huwer, pers. comm. 2008).

Using the measured water level at the time of the visit, the topographic survey, photographs, and field sketches, the flood extent and overbank flooding locations are provided in Figure 4-2b.

### 4.2.3 2011 Field Review

At the time of the field review, the instantaneous discharge at Wilsey Dam was 239 m$^3$/s. Key field observations included:

- The water level on the staff plate was 389.034 m GSC (Photograph 1 of Figure A-4);
- Water levels of the Middle Shuswap River were to the top of bank (Photograph 2 and 3 of Figure A-4);
- Some pothole pooling within fields due to the water table elevation increasing, with depths ranging from 0.10-0.20 m (Photograph 4 of Figure A-4);
- The Huwer Channel was active with flood waters spilling into it. For the majority of the channel, flood waters were at, or close to the top of bank (Photograph 5 of Figure A-3).
- Standing water was located within fields adjacent to Huwer Channel due to minor overbank flooding and high water table elevation (Photograph 6 of Figure A-3). The depth of the standing water was approximately 0.10 m;
- The bank stabilization work and rock dyke installation by DFO helped to reduce the amount of overbank flooding at this site; and
- The field review at this site was difficult due to the amount of vegetation present.
Using the measured water level at the time of the visit, the topographic survey, photographs, and field sketches, the flood extent and overbank flooding locations are provided in Figure 4-2c.

4.3 SITE 3 – PROCTER PROPERTY

4.3.1 2006 Helicopter Survey

On the day of the survey, the mean daily discharge at Wilsey Dam was 237 m³/s. Overbank flooding occurring over the portions of the property adjacent to the Middle Shuswap River, with the largest extent was occurring at the western edge of the property. A relic channel (an oxbow) was also active. An approximation of the flood extent observed in 2006 is provided in Figure 4-3a.

4.3.2 2008 Field Review

At the time of the field review, the instantaneous discharge at Wilsey Dam was 200 m³/s. Key field observations included:

- The water level on the staff plate was 384.822 m GSC (Photograph 1 of Figure A-5);
- Water levels of the Middle Shuswap River were to the top of bank (Photograph 2 of Figure A-5);
- Initial stages of overbank flooding were observed along the western edge of the property, with small streams flowing along the bank into the adjacent land (Photographs 3 and 4 of Figure A-5). The depth of water overtopping the bank was approximately 0.10 m;
- An abandoned side channel adjacent to the Middle Shuswap River was active (Photograph 5 of Figure A-5); and
- The relic channel was active, with water levels to the top of bank (Photograph 6 of Figure A-5).

Using the measured water level at the time of the visit, the topographic survey, photographs, and field sketches, the flood extent and overbank flooding locations are provided in Figure 4-3b.

4.3.3 2011 Field Review

At the time of the field review, the instantaneous discharge at Wilsey Dam was 240 m³/s. Key field observations included:

- The water level on the staff plate was 385.105 m GSC;
- Water levels of the Middle Shuswap River were to the top of bank (Photograph 1 Figure A-6);
- Overbank flooding was present along the right bank, approximately 200-300 m upstream from the staff plate location (Photographs 2 and 3 of Figure A-6). The depth of water overflowing at the top of the bank was 0.20-0.30 m;
- Significant overbank flooding was observed at one location where the Middle Shuswap River had overtopped the bank (Photograph 4 of Figure A-6). At this location, the overbank flooding was approximately 8 m wide and 0.20-0.30 m deep;
The abandoned side channel adjacent to the Middle Shuswap River was active with water depths >1.0 m in some locations (Photographs 5 of Figure A-6). Water within the abandoned channel was being directed downstream;

Due to the overbank flooding, standing water was present at various locations between the property fence line and the Middle Shuswap River (Photograph 6 of Figure A-6); and

The relic channel was active, with water levels to the top of bank.

Using the measured water level at the time of the visit, the topographic survey, photographs, and field sketches, the flood extent and overbank flooding locations are provided in Figure 4-3c.

4.4 SUMMARY

Overbank flooding was observed at all three monitoring sites in 2006, 2008, and 2011. The extent of flooding at Site 1 – Huwer Property and Site 2 – Huwer Bridge had been reduced after 2006, due to the bank stabilization work by DFO. Overbank flooding at Site 1 – Huwer Property, was observed to occur along the channel at numerous locations, which resulted in the ponding of water in the fields adjacent to the channel. Pothole flooding was also present at Site 1, due to an increase in the water table elevation. Finally, at Site 3 – Procter Property, overbank flooding was observed to occur along the channel at numerous locations, which resulted in an abandoned channel becoming reactivated and standing water collecting in various locations. In addition, at Site 3, a relic channel was reactivated.

Due to the similar discharges at Wilsey Dam (approximately 237 to 240 m$^3$/s) during the 2006 helicopter survey and the 2011 field review, the observed flood extents were similar, except at Site 2 – Huwer Bridge due to the bank stabilization work and the rock dyke installed by DFO after 2006. Flooding was also identified during the 2008 field review, but the flood extents were smaller. The 2008 field review was conducted when the discharge at Wilsey Dam was approximately 200 m$^3$/s, which suggests that the hypothesis that overbank flooding begins at a discharge of 232 m$^3$/s at Wilsey Dam is incorrect.
A) 2006 Helicopter Survey
Discharge at Wilsey Dam = 237 m³/s

B) 2008 Field Review
Discharge at Wilsey Dam = 200 m³/s

C) 2011 Field Review
Discharge at Wilsey Dam = 240 m³/s

Legend

- Benchmark
- Staff plate
- Photopoint

Approximate area of flooding

Meters

0 25 50 75 100

Photo source: Virtual Earth

SHUMON-3:
FLOODING RISKS IN THE MIDDLE
SHUSWAP RIVER

PROJECT:

PREPARED FOR:
BC Hydro

FILE: figured_3.mxd

DATE: May 2012
DRAWN BY: Bdj - Procter Property

PROJECT NO.: 2008-8510.000
Figure 4-3: Approximation of flood extent in 2006, 2008, and 2011 at Site 3

May 2012
Flood Management

Management of flows within the Middle Shuswap River during the spring freshet is challenging due to storage constraints within Sugar Lake, as well as the fact that unregulated flows downstream of Wilsey Dam (e.g. Bessette Creek and Ireland Creek) add to the flow of the river. The results of the flood monitoring program from 2008-2011 suggest that flooding within the Middle Shuswap River can begin at a discharge at Wilsey Dam lower than 232 m$^3$/s.

5.1 MIDDLE SHUSWAP RIVER FLOODING

Based on the results of the 2008-2011 flood monitoring program, overbank flooding was observed to occur at a discharge lower than the hypothesized 232 m$^3$/s at Wilsey Dam. The unregulated inflows downstream of Wilsey Dam are also relevant for flood management within the Middle Shuswap River. The largest contribution of streamflow to the Middle Shuswap River below Wilsey Dam is from Bessette Creek (Figure 2-1), which is actively monitored by the WSC (Station No. 08LC039: Bessette Creek above Beaverjack Creek). No other tributaries to the Middle Shuswap River are monitored. Since the 2008 observations indicated that overbank flooding began at a discharge of approximately 200 m$^3$/s at Wilsey Dam (Section 4.4), a review of the downstream contribution of streamflows to the Middle Shuswap River was conducted to refine the estimated discharge required to initiate overbank flooding.

Table 5-1 provides estimates of the Middle Shuswap River discharge at the flood monitoring sites at the time of field review. These estimates include an estimated 5 – 10 m$^3$/s contributed by minor tributaries such as Ireland Creek and Beaverjack Creek.

Table 5-1 Estimate of discharge within the Middle Shuswap River at the flood monitoring sites.

<table>
<thead>
<tr>
<th>Date</th>
<th>Instantaneous Discharge at Wilsey Dam (m$^3$/s)</th>
<th>Instantaneous Discharge of Bessette Creek (m$^3$/s)</th>
<th>Discharge at Wilsey Dam plus Bessette Creek (m$^3$/s)</th>
<th>Estimate of Middle Shuswap River Discharge at Flood Monitoring Sites$^2$ (m$^3$/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 26, 2006$^1$</td>
<td>237</td>
<td>30.5</td>
<td>268</td>
<td>273 – 278</td>
</tr>
<tr>
<td>May 21, 2008</td>
<td>200</td>
<td>28.9</td>
<td>229</td>
<td>234 – 239</td>
</tr>
<tr>
<td>June 12, 2011</td>
<td>240</td>
<td>24.0</td>
<td>264</td>
<td>269 - 274</td>
</tr>
</tbody>
</table>

Note:
1. For 2006, the data represents mean daily discharge, not instantaneous discharge; and
2. This includes minor streamflow contributions downstream of the WSC station on Bessette Creek.
Overbank flooding was just beginning to occur during the 2008 field review; and the discharge within the Middle Shuswap River at that time was estimated to be 229 m$^3$/s (plus a small flow contribution from minor tributaries). Due to the addition of other minor tributaries downstream of Wilsey Dam and Bessette Creek, it is probable that overbank flooding begins at a discharge of 234 – 239 m$^3$/s adjacent to the three monitoring sites. This implies that BC Hydro’s original determination that flooding begins at 232 m$^3$/s is approximately correct, but that that value is the flow adjacent to the three monitoring sites, not the flow at Wilsey Dam. This further implies that flood management requires consideration of flows in both the Middle Shuswap River and Bessette Creek. Flows in the other tributaries can’t be used for flow management because they aren’t monitored at this time.

5.2 MIDDLE SHUSWAP RIVER FLOW MANAGEMENT

As discussed earlier (Section 2.3), flow releases from Sugar Lake largely control flows within the Middle Shuswap River. However, due to the natural contribution of inflows to the Middle Shuswap River and the lag time between Sugar Lake and Wilsey Dam, changes in flow releases from Sugar Lake do not immediately correspond to flow changes within the Middle Shuswap River. Assuming that a change in flow imposed at Sugar Lake has an associated lag time of one day under all flow conditions, the relationship of mean daily discharge between Sugar Lake outflows (WSC Station No. 08LC018; Shuswap River at Sugar Lake Outlet) and the Middle Shuswap River at Wilsey Dam (WSC Station No. 08LC003; Shuswap River near Lumby) observed from 1990 to 2010$^3$ is provided in Figure 5-1. The line drawn on Figure 5-1 represents the least squares regression line through the data. The equation for the regression line (Eq. 1) can be used as an approximation of the discharge at Wilsey Dam (if Sugar Lake outflows are known), as follows:

$$
\log(Q_{\text{Wilsey Dam}}) = 1.027(\log(Q_{\text{Sugar Lake Outlet}})) + 0.066
$$

Eq.1

where:

- $Q_{\text{Wilsey Dam}}$ = the mean daily discharge (m$^3$/s) at the WSC hydrometric station “Shuswap River near Lumby” (Station No. 08LC003); and
- $Q_{\text{Sugar Lake Outlet}}$ = the mean daily discharge (m$^3$/s) at the WSC hydrometric station “Shuswap River at Sugar Lake Outlet” (Station No. 08LC018).

---

$^3$ This period was selected as it represents the most continuous period of overlapping record between the two hydrometric stations.
Figure 5-1  Comparison of mean daily discharge between Sugar Lake Outflows and Wilsey Dam, 1990-2010.

Therefore, the discharge of the Middle Shuswap River adjacent to the three monitoring sites can be first approximated by using Eq.1 to estimate the discharge of the river at Wilsey Dam, and adding the flow of Bessette Creek:

\[
Q_{\text{Middle Shuswap River}} = Q_{\text{Wilsey Dam}} + Q_{\text{Bessette Creek}}
\]  

where:

- \(Q_{\text{Middle Shuswap River}}\) = the discharge of the Middle Shuswap River adjacent to the three flood monitoring sites;
- \(Q_{\text{Wilsey Dam}}\) = the discharge (m\(^3\)/s) at the WSC hydrometric station “Shuswap River near Lumby” estimated using Eq.1; and
- \(Q_{\text{Bessette Creek}}\) = the discharge (m\(^3\)/s) at the WSC hydrometric station “Bessette Creek above Beaverjack Creek”.

By taking this approach, the difference in spring runoff patterns and timing between Bessette Creek and the headwaters of Sugar Lake are taken into consideration, which helps provide additional management flexibility (e.g. if Bessette Creek’s discharge is low, increased releases from Sugar Lake could occur). Based on the results of this investigation, it is recommended that to limit flooding adjacent to the Middle Shuswap River, the outflows from Sugar Lake should be managed to meet a target of 229 m\(^3\)/s (i.e.
Q_{MiddleShuswapRiver} = 229 \text{ m}^3/\text{s} \) based on the combination of discharge at Wilsey Dam and Bessette Creek (WSC 08LC039). In summary, the recommended management approach is as follows:

1. Monitor Bessette Creek flows; and
2. Manage Sugar Lake to achieve a combined Bessette Creek plus Wilsey Dam flow of 229 m$^3$/s.

BC Hydro (2002) reported that for a standard period from 1974-2000, the flooding hypothesis of 232 m$^3$/s measured at Wilsey Dam resulted in approximately 65 days (over the 27-year period) when flows were >232 m$^3$/s. Assuming the same standard period, but considering flows in both the Middle Shuswap River and Bessette Creek with a flooding hypothesis of 229 m$^3$/s instead, the results suggest that an additional 35 days of flooding occurred than originally estimated (i.e. an additional 1.3 days per year on average over the 27-year period). In other words, the benefit of following the recommendations contained herein may be higher (i.e. reducing the number of flooding days from 100 to near zero, vs reducing from 65 to near zero over the 27-year period) than it would be using the assumptions contained within BC Hydro (2002).

4 The number of days ≤229 m$^3$/s was calculated using available mean daily discharge records from Bessette Creek (WSC Station No. 08LC039; Bessette Creek above Beaverjack Creek) and a synthetic dataset of mean daily discharge below Wilsey Dam provided by BC Hydro (Michael McArthur, pers. comm., 2012). The synthetic dataset was developed by BC Hydro using their ShuWup model under the Alt SQ scenario. Actual discharge records at Wilsey Dam were not used for this analysis due to a lack of continuous records from 1974-2000 in the Middle Shuswap River at Wilsey Dam (WSC Station No. 08LC003; Shuswap River near Lumby), as well as to ensure consistency with BC Hydro (2002). Note that the total number of days ≤229 m$^3$/s from the combination of Bessette Creek and the Middle Shuswap River is 9736 days, while the total number of days ≤232 m$^3$/s in the Middle Shuswap River alone (Alt SQ synthetic dataset) is 9771 days. The discrepancy between the number of days ≤232 m$^3$/s calculated here and reported by BC Hydro (2002) is not known; therefore, the 35 day difference between the calculated values was assumed correct.
6

Summary and Recommendations

6.1 SUMMARY

In 2006, BC Hydro developed a TOR for a monitoring program “SHUMON-3 Flooding Risks in Middle Shuswap River” to complete a study to determine if the WUP’s flood performance measure of 232 m$^3$/s at Wilsey Dam is appropriate for identifying flooding risks in the Middle Shuswap River (BC Hydro 2006). The ultimate goal of SHUMON-3 is to help determine whether operating alternatives at Sugar Lake Dam can reduce flooding risks within the Middle Shuswap River and improve the ability to predict flood timing to provide land-owners time to take actions to minimize damage. The key management questions and results for the SHUMON-3 are:

1. **What are the key areas where flooding is a concern along the Middle Shuswap River?**

A field monitoring program was implemented in 2008 to provide an assessment of flood conditions within the Middle Shuswap River at three sites where flooding had occurred in 2006 to test the hypothesis that overbank flooding occurred when discharge at Wilsey Dam reached 232 m$^3$/s. The three sites were Site 1 – Huwer Property, Site 2 – Huwer Bridge, and Site 3 – Procter Property. The required flow did not occur until June 2011.

The flood monitoring sites were visited six (6) times from 2008 to 2011, which included field reviews during high water periods in May 2008 and June 2011. In addition, a helicopter survey of the entire Middle Shuswap River was completed by BC Hydro in 2006. During the helicopter survey and high water field reviews, overbank flooding was observed at all three flood monitoring sites. The extent of overbank flooding was similar in 2006 and 2011 due to the similar discharges measured at Wilsey Dam (approximately 237 to 240 m$^3$/s), except at Site 2 – Huwer Property due to bank stabilization work and the installation of a rock dyke by DFO after 2006. In 2008, flooding was just beginning during the field review.

2. **At what discharge does flooding begin in the Middle Shuswap River?**

Bessette Creek and other smaller tributaries contribute flow to the river between Wilsey Dam and the three monitoring sites. Of these, only Bessette Creek is monitored. A 2008 field review was conducted when the discharge at Wilsey Dam was approximately 200 m$^3$/s, which indicated that the hypothesis that overbank flooding occurs at a discharge of 232 m$^3$/s at Wilsey Dam was incorrect. The estimated discharge within the Middle Shuswap River at the initiation of flooding during the 2008 field program was 234 – 239 m$^3$/s; comprised of 200 m$^3$/s at Wilsey Dam, 29 m$^3$/s from Bessette Creek, and 5 – 10 m$^3$/s from other non-monitored tributaries. As a result, it was estimated that overbank flooding begins at a discharge of 229 m$^3$/s, which includes the combination of discharge at Wilsey Dam and Bessette Creek (WSC 08LC039).
3. **During a single flood event, what is the relation between discharge from Sugar Lake, discharge at Wilsey Dam, and the extent of flooding?**

Based on the results of this investigation, it is recommended that to limit the flooding adjacent to the Middle Shuswap River, the outflows from Sugar Lake should be managed to meet a target of 229 m$^3$/s, where 229 m$^3$/s represents the sum of discharge at Wilsey Dam and discharge of Bessette Creek (WSC 08LC039).

The target of 229 m$^3$/s (from the combination of discharge at Wilsey Dam and Bessette Creek) indicated an additional 35 days (i.e. an additional 1.3 days per year on average) when flooding likely occurred adjacent to the Middle Shuswap River as compared to that originally estimated by BC Hydro (2002) over 1974-2000. This suggests that the benefit of following the recommendations contained herein may be greater than originally suggested with the assumptions contained in BC Hydro (2002).

### 6.2 RECOMMENDATIONS

The following additional recommendations are provided for improved flood management within the Middle Shuswap River:

1. Due to the addition of streamflows downstream of Wilsey Dam, these streamflows are relevant for flood management within the Middle Shuswap River. The largest contribution of streamflow to the Middle Shuswap River below Wilsey Dam is from Bessette Creek, which is actively monitored by the WSC (Station No. 08LC039; Bessette Creek above Beaverjack Creek). It is recommended that BC Hydro consider discussing with the WSC the opportunity of turning the Bessette Creek hydrometric station into a real time transmitting station. This would allow BC Hydro to better understand streamflows downstream of Wilsey Dam, which could improve management opportunities; and
2. The relationship established between Sugar Lake outflows and the discharge at Wilsey Dam in this report is an approximation based on an assumption that the lag time between Sugar Lake and Wilsey Dam is one day. To improve the relationship, it is recommended that a more detailed investigation of the lag time be completed.
Literature Cited


Appendix A - Selected Flood Monitoring Site Photographs
FIGURE A-1:
2008 Selected Photos of Site 1 - Huwer Property

Photo 1: Middle Shuswap River at top of bank looking downstream from Photopoint 1a.

Photo 2: Initial stages of overank flooding at Site 1 - Huwer Property.

Photo 3: Overbank flooding and ponding of water in fields at Site 1 - Huwer Property.

Photo 4: Overbank flooding at Site 1 - Huwer Property.

Photo 5: Pothole flooding at Site 1 - Huwer Property.

Photo 6: Location of significant overbank flooding at Site 1 - Huwer Property.
Figure A-2: 2011 Selected Photos of Site 1 - Huwer Property

**Photo 1:** Middle Shuswap River at top of bank.

**Photo 2:** Standing water within the fields adjacent to the Middle Shuswap River.

**Photo 3:** Standing water located in the yard of a private residence (east of Mabel Lake Road).

**Photo 4:** Overbank flooding observed at Site 1 - Huwer Property.

**Photo 5:** Overbank flooding observed at Site 1 - Huwer Property.

**Photo 6:** Location of significant overbank flooding at Site 1 - Huwer Property.
Photo 1: Middle Shuswap River at top of bank looking upstream from Photopoint 2a.

Photo 2: Rock dyke installed along the channel bank at Site 2 - Huwer Bridge looking upstream from Photopoint 2b.

Photo 3: Pothole flooding observed at Site 2 - Huwer Bridge.

Photo 4: Observation of the Huwer Channel at bankfull discharge.

Photo 5: Overbank flooding from the Huwer channel on to adjacent fields.
Figure A-4:
2011 Selected Photos of Site 2 - Huwer Bridge

1. Staff plate located at Site 2 - Huwer Bridge.
2. Middle Shuswap River upstream from Photopoint 2a.
3. Middle Shuswap River upstream from Photopoint 2b.
4. Pothole flooding observed at Site 2 - Huwer Bridge looking north from Photopoint 2b.
5. Observation of the Huwer Channel at bankfull discharge looking downstream from Photopoint 2d.
6. Overbank flooding from the Huwer Channel.

Field Photos:
- May 2012
- June 12, 2011

Project:
SHUMON-3:
FLOODING RISKS IN THE MIDDLE SHUSWAP RIVER

Prepared for:
BC HYDRO

Drawing No.: Figure A-4
File: Figure A-4.cdr
Photo 1: Staff plate at Site 3 - Procter Property.

Photo 2: Middle Shuswap River looking upstream from Photopoint 3a.

Photo 3: Observation of overbank flooding looking west from Photopoint 3c.

Photo 4: Observation of overbank flooding and ponding of water at Photopoint 3c.

Photo 5: Reactivation of abandoned channel adjacent to the Middle Shuswap River.

Photo 5: Oxbow channel at Site 3 - Procter Property southeast from Photopoint 3b.

Figure A-5: 2008 Selected Photos of Site 3 - Procter Property

PROJECT: SHUMON-3: FLOODING RISKS IN THE MIDDLE SHUSWAP RIVER

PREPARED FOR: BC HYDRO

DATE: May 2012
DRAWN BY: DL
DATA SOURCE(S): Field Photos: May 26, 2008

PROJECT NO.: 2008-8510.010
DRAWING NO.: 1 of 1
FILE: Figure A-5.cdr
Figure A-6:
2011 Selected Photos of Site 3 - Procter Property

Photo 1: Middle Shuswap River looking upstream from Photopoint 3a.

Photo 2: Observation of overbank flooding at Site 3 - Procter Property.

Photo 3: Observation of overbank flooding at Site 3 - Procter Property.

Photo 4: Location of significant overbank flooding at Site 3 - Procter Property.

Photo 5: Standing water located within the reactivated abandoned channel at Site 3 - Procter Property.

Photo 6: Ponding of water at Site 3 - Procter Property looking south from Photopoint 3c.