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May 30, 2011

Project no. 0978-001

Warren Bell
WA:TER – Wetland Alliance: The Ecological Response
Box 3458
Salmon Arm, BC, V1E 4S2

Dear Mr. Bell:

**RE: Salmon River and Delta: Information Review - FINAL**

BGC is pleased to provide you this final letter report on Salmon River and Delta: Information Review. Please contact the undersigned if you have any questions or comments.

Yours sincerely,

**BGC ENGINEERING INC.**
**per:**

ORIGINAL SIGNED BY

Matthias Jakob, Ph.D., P.Geo.
Senior Geoscientist

Att.

MJ

# LIMITATIONS

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# 1.0 INTRODUCTION

## 1.1. Background

The non-profit organization Wetland Alliance: The Ecological Response (WA:TER) retained BGC to review existing data and reports regarding Salmon River and its delta at Shuswap Lake. The objective of this preliminary study was to review existing information and identify data gaps with the ultimate objective of conducting an integrated assessment of flood risk that also entails ecological values. This letter report summarizes the data and information that have been reviewed and points towards data and analytical gaps that would allow an assessment of flood and associated risks, which can be accomplished within the framework of a quantitative flood risk assessment (QFRA).

BGC has not critically reviewed any of the documents listed with respect to correctness of their content, methods or analytical techniques. This review solely reports and summarizes conclusions gathered by others, with the exceptions of preliminary flood frequency analyses for Salmon River and Shuswap Lake performed by BGC.

## 1.2. Historical Perspective

The earliest significant development in the study area was the Canadian Pacific Railway (CPR) line that was completed in 1885 at the toe of the delta over a length of approximately 2 km. Two bridges under the railway were constructed across Salmon River and Hobbs Creek which constrain the distributary channels in the proximal delta area. Agricultural development in the lower Salmon River watershed began in the early 1900s, but intensified in the early 1950s which has led to a notable increase in bank erosion rates (Miles, 1995). Riprap placement and ploughing has reduced the number of back channels and wetland areas. In recent years, local dikes have been constructed and fill has been placed along properties in the immediate vicinity of the Trans-Canada Highway (TCH) Bridge over Salmon River (C. VanBuskirk, pers. comm., 2011).

The TCH Bridge was built in 1946 and design flows are unknown at this time. According to local Ministry of Transportation and Infrastructure personnel, maintenance staff monitor and remove trapped debris from under the bridge during the Salmon River spring freshet, while the lower bridge stringers (support beams) are regularly submerged (C. VanBuskirk, pers. comm., 2011).

The three greatest Salmon River freshets on record, recorded at Water Survey of Canada (WSC) hydrometric station 08LE021 near the TCH Bridge at Salmon Arm, occurred in 1997, 1996 and 2008 at peak instantaneous discharges of 61.4 $m^3/s$, 60.0 $m^3/s$ and 50.9 $m^3/s$, respectively. The 08LE021 period of record for peak instantaneous flow data is 1974 to present (36 years), and for daily maximum data is 1911-1912, 1963 to1966, and 1969 to present (46 years). It is likely that Salmon River has experienced considerably larger events than those on record.

## 2.0 REVIEWED DOCUMENTS

The following reports were given to BGC by WA:TER to review (Table 2-1). Various other data, graphs, images, aerial and ground photographs, and correspondence were also provided.

**Table 2-1: List of Reports Reviewed by BGC**

| Author | Date | Title |
|---|---|---|
| Ecoscape Environmental Consultants, Ltd. | Jul-2010 | Spring Inventory Results along the Salmon River, Salmon Arm, BC |
| Stantech Consulting Ltd. | May-2010 | Addendum to Riparian Regulations Assessment Reports #1257 and #1310 2571-2971 10th Avenue SW, Salmon Arm, British Columbia |
| Geoterrain Consultants | Mar-2010 | Geologic Development of the Salmon River Delta, BC |
| Ecoscape Environmental Consultants, Ltd. | Nov-2009 | Environmental Assessment and Biophysical Review |
| R.J.P. Holdings Ltd. | Apr-2009 | Windthrow and Danger Tree Assessment - Lots 1 & 2 - Plan 2174: Supplementary Attachment |
| Nature Conservacy of Canada | Apr-2009 | Okanagan Ecoregional Assessment Summary |
| G.E. Roseberg and Associates | Sep-2008 | An Assessment of the Development Proposed by SmartCentre Located at 10th Ave. SW and 30th Street, Salmon Arm |
| Jacques Whitford AXYS, Ltd. | Jun-2007 | Preliminary Geotechnical Investigation: Proposed Salmon Arm Commercial Development |
| Dobson Engineering Ltd. | Mar-2007 | Review of Public Road Crossing Capacities on the Mainstem of the Salmon River and Potential Impacts of Increased Runoff due to the Loss of Forest Cover by the Mountain Pine Beetle |
| British Columbia Ministry of Environment | Mar-2007 | Water Quality Assessment of the Salmon River at Salmon Arm 1985-2004 |
| Regency Consultants Ltd. | Jul-2004 | A Report Concerning the Agricultural Impacts of the Removal of [the proposed development area] from the Agricultural Land Reserve |
| Future Legacy Consulting Group | Feb-2004 | Habitat Conservation Strategy for Salmon Arm Bay, Discussion Paper |
| Forsite Consultants Ltd. | Mar-1998 | Salmon River Sediment Source Survey |

| Author | Date | Title |
|---|---|---|
| Forsite Consultants Ltd. | Mar-1998 | The Stability of Stream Channels within the Salmon River Watershed |
| Crippen Consultants | Dec-1990 | Floodplain Mapping Program: Salmon River Shuswap Lake to Spa Creek |
| Department of Environment; E. Gordon Le Breton | Apr-1976 | Groundwater Return Flow from Irrigation at a Test Study Site in the Salmon River Valley, Shuswap Lake Basin |
| Mike Miles and Associates | Mar-1995 | Salmon River Channel Stability Analysis |
| Dawson, A.B, and C.C. Kelley | May-1965 | Soil Survey of the Shuswap Lakes Area |
| Kamloops Museum? | 1974? | The Great Flood |

# 3.0 FLOOD HAZARD

## 3.1. Previous Work

Peak flows on the Salmon River have been investigated by a number of consulting companies using discharge data from WSC station 08LE021. Crippen (1990) used 27 years of record (1912 and 1963 to 1990[1]) to determine the 200-year peak flow ($Q_{200}$) for the river. Using three different extreme value (EV) distributions, Generalized Extreme Value (GEV), Three-parameter Lognormal (LN3) and Log Pearson Type III (LP3), Crippen estimated that the 200-year maximum daily discharge at Shuswap Lake as 59.3 $m^3$/s, while the peak instantaneous flow was 61.7 $m^3$/s. Further flood frequency estimates were made by Miles (1995) and Dobson (2007), and are summarized in Table 3-1. The 2011 BGC estimate is discussed in the next section.

**Table 3-1: Summary Statistics for Flood Frequency Analysis from Different Studies**

| | **Crippen, 1990** | **Miles, 1995** | **Dobson, 2007** | **BGC, 2011** |
|---|---|---|---|---|
| **200-yr Estimate ($m^3$/s)** | 59.3 | 62.8 | 75 | 77.3 |
| **Data Type** | daily maximum | peak instantaneous | peak instantaneous | peak instantaneous |
| **Years of Record** | 27 | 20 | 33 | 36 |

Using cross-section survey data and peak flow estimates, Crippen (1990) produced floodplain maps (flood inundation extents and flood construction levels) for the Lower Salmon River using the 1D hydraulic model HEC2. The analysis was based on their $Q_{200}$ estimate of 59.3 $m^3$/s for a Shuswap Lake high water level of 350.09 m. This lake level was directed by the Invitation for Proposal for the work that Crippen was awarded and was based on a design brief by Hay & Company Consultants Inc. (1990), which was not available to BGC for review. Crippen (1990) then conducted sensitivity analyses for discharge and Manning's *n*-values to determine differences in flood levels.

Dobson (2007) noted that the TCH Bridge over Salmon River does not meet the current 200-year flood flow conveyance based on their peak flow estimate and would likely be overtopped in a 200-year flood event. Dobson further noted that an additional 6 out of 19 bridge crossings between Salmon Arm and Falkland have insufficient capacity for the 200-year flood.

[1] The 1990 value was considered preliminary at the time of analysis and was later finalized as a different value

### 3.2. BGC Flood Frequency Analysis

BGC conducted preliminary analyses of Salmon River flood frequency and Shuswap Lake water levels based on the available peak instantaneous flow data from 1974 to 2009 (WSC station 08LE021) and daily maximum water level data from 1951 to 1985 (WSC station 08LE070) and from 1986 to 2009 (WSC station 08LE109). BGC used four different extreme value statistical distributions to estimate peak instantaneous flows for return periods of 2 to 500 years: Generalized Extreme Value (GEV), Log Normal 3 (LN3), Log Pearson Type III (LP3) and the Pearson Type III (P3) distributions. These are the same distributions used in the Crippen (1990) analysis, with the addition of the P3 distribution. As a check, BGC also repeated the Crippen flood frequency analysis with the same period of record and computed the same results. Results from the BGC flood frequency analysis are summarized in Table 3-2.

**Table 3-2: Peak Instantaneous Flow Estimates for WSC Station #08LE021 (1974 to 2009)**

| Return Period | **EV Distribution Type** | | | | Average |
|---|---|---|---|---|---|
| | GEV | LN3 | LP3 | P3 | |
| [years] | [m$^3$/s] | | | | |
| 2 | 32.0 | 31.0 | 32.3 | 32.0 | 31.8 |
| 5 | 43.8 | 43.3 | 43.5 | 43.4 | 43.5 |
| 10 | 51.1 | 51.6 | 50.0 | 50.3 | 50.7 |
| 20 | 57.6 | 59.9 | 55.6 | 56.5 | 57.4 |
| 50 | 65.5 | 70.8 | 62.0 | 64.0 | 65.6 |
| 100 | 71.0 | 79.2 | 66.4 | 69.4 | 71.5 |
| 200 | 76.2 | 87.8 | 70.4 | 74.6 | 77.3 |
| 500 | 82.6 | 99.5 | 75.2 | 81.2 | 84.7 |

BGC's analysis demonstrates that the average value for the 200-year peak instantaneous flow (which does not account for goodness of fit) is 77.3 m$^3$/s. The best fit line corresponds to the P3 distribution which is 74.6 m$^3$/s. This average is approximately 30% higher than that used by Crippen (1990) for hydraulic modeling and could result in increased water levels of 0.5 m and up to 25% more area inundated compared to the current floodplain mapping in the vicinity of the TCH bridge (Crippen, 1990 in their sensitivity analysis). The increase from the Crippen estimate (daily maximum) to BGC's estimate (peak instantaneous) is associated with large freshets in 1996, 1997 and 2008. This observed increase in the design event suggests that the 1990 floodplain maps should be updated.

BGC's lake level frequency analysis (with 59 years of maximum daily levels) resulted in an estimated 200-year lake level of 349.66 m which is 0.43 m lower than that cited by Crippen (1990) in their design brief. Results from the BGC lake level frequency analysis are summarized in Table 3-3.

**Table 3-3: Peak Lake Level Estimates for Shuswap Lake, WSC Station #08LE070 and #08LE109 (1951 to 2009)**

| Return Period | EV Distribution Type | | | | Average (LN3, LP3, P3) |
|---|---|---|---|---|---|
| | GEV | LN3 | LP3 | P3 | |
| [years] | [m³/s] | | | | |
| 2 | 348.29 | 348.19 | 348.44 | 348.18 | 348.27 |
| 5 | 351.49 | 348.81 | 348.71 | 348.81 | 348.78 |
| 10 | 353.02 | 349.13 | 348.76 | 349.13 | 349.01 |
| 20 | 354.17 | 349.40 | 348.78 | 349.40 | 349.19 |
| 50 | 355.28 | 349.71 | 348.78 | 349.71 | 349.40 |
| 100 | 355.92 | 349.91 | 348.78 | 349.91 | 349.53 |
| 200 | 356.41 | 350.09 | 348.79 | 350.09 | 349.66 |
| 500 | 356.91 | 350.32 | 348.81 | 350.32 | 349.82 |

## 3.3. Discussion

Experience over the last two decades has shown that the $Q_{200}$ estimate for Salmon River has progressively increased as the data record increases in length. This result is not surprising because the increased record length increases the likelihood of capturing extreme floods. The analyses conducted herein are, to some degree, rudimentary because they do not account for the following caveats:

- The extrapolation of a 36 year record to a 200-year return period flow is associated with error. In general, caution is advised when extrapolating to return periods that are more than twice the period of record.
- The analyses have been conducted under the assumption of data stationarity (no changes in the long-term means), which may be violated given that a small increase in the trend of the peak daily flows were observed through trend analyses (Table 3-1). Possible long-term effects of climate change, insect infestations, logging, forest fires, or other impacts have not been considered in the analyses.
- The analyses above treat all data as homogenous, which may not be the case. Different hydroclimatic events may result in distinctly different data populations (i.e. snowmelt only versus rain-on-snow), which may necessitate separate analyses.

- The probability that the lake level peak coincides with the peak flood is very low and has never occurred in the past 48 years with a 30-day average lag between the two. Without analyzing the probability of the lake and river hydrographs at least overlapping, the assumptions made for generating floodplain maps will need to be tested.
- The 200-year lake level has been estimated previously at 350.06 m, whereas BGC's preliminary analysis resulted in an estimate of 349.66 m. The effects of this difference on hydraulic modelling are unknown at this time but should be investigated in a future analysis.

# 4.0 FLUVIAL GEOMORPHOLOGY AND HILLSLOPE PROCESSES

The fluvial geomorphology of the river has been examined by Miles and Associates (1995), and the adjacent hillslope processes have been studied by Forsite (1998a). The principal conclusions can be summarized as follows:

## 4.1. Fluvial Geomorphology

- Considerable bank erosion has occurred along Salmon River and is attributed to loss of riparian vegetation, which destabilizes banks through loss of root cohesion. This has led to a wider active channel (a doubling of active channel width at three observed locations between 1951 and 1990) and thus shallower water (Miles, 1995). This, in turn, has increased stream temperatures, damaged aquatic habitat, deteriorated water quality, and led to higher turbidity since 1954 (Burt and Wallis, 1997).
- Miles (1995) estimates that the 2-year (bankfull) flood can mobilize 1 mm-sized sand at the TCH bridge, though continuous small-scale sand movement was observed at much lower discharge during a field visit by BGC in March of 2011.
- The low channel gradient in the lower river (0.27% based on the Crippen (1990) longitudinal profile) leads to extensive overbank flooding with fine sediment (silt and sand-sized) deposition, which in turn explains the fertility of the adjacent floodplain.
- Survey profiles obtained by Ecoscape in 2009 demonstrate that natural levees exist along the right bank of Salmon River within the delta.
- Sediment has accumulated on the upstream side of the CP Railway embankment leading to an elevated floodplain (Ecoscape, 2009).
- The historical delta evolution has been qualitatively evaluated by Geoterrain (2010).

## 4.2. Hillslope Processes and Forestry

- Forsite (1998a) determined that 38% of all landslides in the Salmon River watershed occur in gullies and may be the result of stream undercutting.
- Abandoned and unmaintained roads account for 60% of the landslides (Forsite, 1998b).
- The B.C. Ministry of Environment projected that 80% of mature lodgepole pine in the BC Interior will be destroyed by mountain pine beetle by 2013 (Dobson, 2007).

## 4.3. Discussion

To date, the fluvial geomorphology of Salmon River has not been analyzed with hillslope processes even though a coupling of those is virtually certain. Miles' (1995) work is now outdated and would need to be repeated to include the last 16 years of data on channel changes. Chronosequential maps of channel changes would be helpful in identifying current trends and predicting future bank erosion patterns. A quantification of sediment movement rates would be very helpful but could only be achieved through repeat cross-section measurements. A stage change analysis would at least provide an idea as to bed changes at the relevant WSC gauges which may indicate trends or randomness in bed elevations.

## 5.0 FLOODPLAIN ECOLOGY

Several studies have focused on various aspects of floodplain ecology including fish habitat, bird habitat, vegetation, and water quality. Key points from the reviewed reports are outlined in the following sections.

### 5.1. Fish Habitat

- Fisheries and Oceans Canada (DFO) has identified Salmon River as an important escapement river for Sockeye, Chinook, Coho, Kokanee and Pink salmon, rainbow trout, Dolly Varden, Mountain whitefish and suckers (Stantec, 2010).
- The cyclic nature of the Salmon River sockeye return has plummeted over time and a return of over 300 fish hasn't been witnessed in over a decade (Ecoscape, 2009).
- Salmon River used to be an important fishing ground for First Nations. However, salmon counts have collapsed drastically since the early 1990s. This collapse is valid for the entire Fraser River watershed and may be associated with an outbreak of a novel cancer-causing viral disease (Salmon Leukemia Virus) (Miller et al. 2008).

### 5.2. Bird Habitat

- Over 230 different species of birds have been observed on the Salmon Arm Bay foreshore (Future Legacy, 2004).
- The delta is suitable habitat for at least 3 red listed species, including Western Screech-owl which has been documented in the delta cottonwood communities (Ecoscape, 2009).
- A spring 2010 two-day terrestrial and bird species inventory on the delta identified two blue-listed bird species: Great Blue Heron and Western Painted Turtle (Ecoscape, 2010).

### 5.3. Vegetation

- The delta's vegetation has been characterized by Ecoscape (2010), who describe the biodiversity of the area as rich and the habitat as rare and critical.
- There is potential habitat in the wetland for a rare plant species, Mexican mosquito fern (*Azolla Mexicana*), which has been observed in the Shuswap Lake area, including the Salmon River mouth (Ecoscape, 2009).
- Forested areas have been lost north of the delta distributaries which have reset vegetative succession in the area, and allowed establishment of canary grass (Future Legacy, 2004).

## 5.4. Water Quality

Salmon River is a water source for domestic, irrigation and livestock supplies. Therefore, water quality (WQ) is an important aspect of the overall floodplain ecosystem. The review of available information resulted in the following principal observations:

- Contaminants are largely non-point source and arise from forestry, agriculture and urban development. The principal contaminants of concern are ammonia, phosphorous, nitrogen, metals and fecal coliform in addition to general turbidity (BC MoE, 2007).
- WQ analyses have shown that dissolved oxygen levels often exceed water quality objectives, while several metals (e.g. cadmium), colour values, fecal coliforms and Escherichia Coli often exceed guidelines and are correlated to turbidity. In addition, arsenic levels may be increasing, and lithium and extractable silicon is decreasing (BC MoE, 2007).
- Grazing and cattle access to the river have increased nutrient loadings and water extraction has led to extreme low flows with salmonid and indigenous fish mortality (Aquametrix, 1994).

## 5.5. General Ecologic Value

Most riverine deltas are of high or exceptional ecologic value and count amongst the most valuable ecosystems to support biodiversity and provide goods and services to society. The Salmon River Delta does not appear to be an exception. Wetlands provide water purification and nutrient retention, recreational values and pleasing aesthetics. Water level fluctuations are critical for maintaining wetland species diversity and abundance, and low water is also important for seed establishment (Keddy, 2010). Developed nations are increasingly valuing wetlands and increasingly focusing on wetland preservation or re-generation. The following information was obtained from the review of accessible information:

- An environmental assessment has been completed that described the delta area vegetation communities, evaluated fish and wildlife values, assessed rare and endangered species potential, and identified environmentally sensitive areas and traditional uses of the area (Ecoscape, 2009).
- The corridor that connects the shoreline and Shuswap Lake with upstream habitats is one of the few remaining such corridors in the area and is critical for wildlife migration (Ecoscape, 2009).
- The delta includes one Terrestrial Priority Conservation area and two Freshwater Priority Conservation areas. Both are rated with the highest conservation and vulnerability values in the Okanagan Ecoregion (Nature Conservancy of Canada, 2009).

- Loss of riparian vegetation and delta channel complexity can lead to high water temperatures during the summer months, loss of refugia, loss of nutrient transport from organic matter and other effects (Keddy, 2010).

## 6.0 CONCLUSIONS AND RECOMMENDATIONS

This preliminary information review was completed to identify data and analysis gaps that would allow an assessment of flood and associated risks, which can be accomplished within the framework of a quantitative flood risk assessment (QFRA).

The principal objective of a QFRA is to gain a thorough understanding of the consequences of various flood scenarios. This provides the tools for decision makers tasked with managing urban and industrial development and associated infrastructure to weigh the various risks with the benefits gained through future developments. In absence of this understanding, development decisions cannot be footed on sound science, and may therefore not be in the best interest of society at large.

The currently used floodplain maps suggest that a long section of the TCH will be inundated in the 200-year flood together with land adjacent to the highway. Any development will thus need to take flood hazard into account in the design of buildings and their access. BGC's review has identified a large number of data and analytical gaps that should be filled to aid decision makers in the permitting process for development. Based on this review, BGC recommends undertaking the studies in the following sections, which could be united under the umbrella of a comprehensive flood risk assessment.

### 6.1. Flood Frequency

Flood frequency should be assessed in light of forcing mechanisms that may lead or have led to a non-stationarity or non-homogenous data series which would violate the assumptions underlying standard flood frequency analysis. This should include:

- Splitting the data record in snowmelt versus rain-on-snow events and repeating the analyses for the different data populations;
- running a peak-over-threshold analysis on the dataset to focus on the highest flow irrespective if this includes several flows in any given year;
- determining the prediction intervals for the best fit distributions to illustrate the range of possible flood discharge;
- providing a thorough review of the current understanding of the influence of climate change on the regional hydrology and model changes to obtain a sense of at least the general trend in changes in peak flow over time; and
- conducting a probabilistic assessment of the interaction of high lake levels and high flood levels to provide realistic flood elevations and areas inundated for the 20-year, 200-year and 500-year return period floods.

### 6.2. Hydraulic Modelling

Hydraulic modelling will determine flood levels (stages), areas inundated, and flow velocities (2-dimensional modelling). Flood hydrology is linked with fluvial geomorphology because the latter process is capable of changing a river channel's geometry. As a minimum requirement to better understand and characterize the lower channel and delta hydrology BGC, recommends the following tasks:

- Simulate floods with a 2-D hydraulic model at different return periods (20-yr, 200-yr, 500-yr) in combination with the analyses listed in 6.1 to determine the area inundated, flood velocities and flood levels, which are variables that will feed into the flood risk assessment. This model should be based on regional LiDAR data gathered in 2010. Use of these topographic data will allow a realistic assessment of the hydraulic effects of all pertinent flow obstacles to the flood model including the highway, railway embankment, industrial buildings and fills.
- Model flood scenarios whereby the TCH bridge is blocked either by flow exceeding the conveyance or by a large organic debris jam.
- Conduct sensitivity analyses with existing or future development to investigate any issues of flood risk transfer.

### 6.3. Fluvial Geomorphology and Hillslope Processes

As stated in 6.2, fluvial geomorphology is inseparately linked to flood hydrology. It also affects the river and delta ecology since geomorphic processes such as bank erosion, levee formation; meandering and sedimentation are responsible to some degree for habitat creation. BGC recommends the following tasks to gain a better and updated understanding of the river's and delta's fluvial geomorphology:

- Quantify channel changes for the lower Salmon River and delta by providing and plotting bank erosion rates over time using the entire set of available air photographs at appropriate scales.
- Resurvey cross-sections to determine changes in cross-section area.
- Assess changes in bed elevations at Salmon River gauges.
- Quantify delta advance rates through detailed mapping from air photographs.
- Quantitatively assess the impact of the CP railway embankment on delta evolution and progression.
- Link Salmon River sediment flux with delta progression rates.
- Determine the long-term effect of a lengthening channel on changes in channel gradient, sediment movement rates and channel bed aggradation.
- Attempt to predict future delta changes.
- Attempt to isolate natural sediment flux from artificially increased sedimentation rates.
- Attempt to quantify the sediment input from hillslope processes with direct connectivity to the river channel (mostly by debris flows and debris floods) and assess their effect on changes in the channel planform.

- Attempt to predict long-term changes in the fluvial geomorphology that could affect flood risk along the river and on the delta.

### 6.4. Delta Ecology

The review of existing reports on the ecology of Salmon River Delta has resulted in the following recommendations for further study:

- Re-inventory the existing flora and document floral succession including endangered species;
- interaction assessment between vegetation and terrestrial habitat;
- bird wintering habitat and bird migration studies;
- quantification of ecological values; and
- quantification of available fish habitat at various flows and lake levels.
-

### 6.5. Flood Risk Assessment

- For each hazard scenario considered, determine the potential losses in terms of economic losses (damaged homes and industries, content/replacement costs, business interruption loss, reconstruction values, infrastructure interruption-related losses), loss of life (given warning scenarios and mortality functions), ecologic losses (short and long-term impacts to valuable terrestrial or aquatic habitat), environmental losses (contamination through hazardous materials, manure, decomposing drowned animals) as well as a qualitative assessment of human suffering or loss of archeological or culturally valuable sites.
- Depending on the timing of when and if such flood risk assessment is conducted, use the Professional Practice Guidelines for Legislated Flood Hazard and Risk Assessments in a Changing Climate in B.C. that are currently being prepared under the auspices of APEGBC and which will be published in the fall of 2011.
- Define tolerable flood risk levels in collaboration with various stakeholders.
- Determine how unacceptable flood risk can be reduced for the maximum benefit of stakeholders and society at large while perhaps even creating recreational space and enhancing habitat.
- Plan and budget for risk reduction measures.

The study proposed above would close the salient data gaps and would likely benefit the following stakeholders:

- *The City of Salmon Arm* in planning for future expansions, subdivisions and industrial development, near or on the delta and river floodplain;
- *First Nations (Switzmalt Indian Band)* in understanding flood risk and expected losses during floods as well as assess potential risk transfer issues that may arise from development on the delta or the upstream floodplain;
- the *Citizens of Salmon Arm* in comprehending the physical processes that shape the lands around them and create awareness and resiliency of flood hazards;
- owners of industrial development on the delta and upstream floodplain in planning and mitigation against floods;
- private land owners on the delta and the upstream floodplain in planning for future subdivisions, buildings;
- insurance companies in determining expected losses;
- *the Provincial Emergency Program* in predicting expected losses for different flood scenarios;
- *Canadian Pacific Railway* in planning for floods and anticipating flood-related business interruptions;
- the *Ministry of Transportation and Infrastructure* in planning for any possible highway twinning and bridge re-design across the delta and floodplain;
- *Fisheries and Oceans Canada* in understanding current challenges faced by fish and how to counter those challenges to improve fish habitat; and
- non-governmental organizations in evaluating the flood and ecological risks, allowing them to focus on preservation of environmentally sensitive areas.

BGC realizes that each of the above stakeholders have different and in some cases incongruent interests. However, extreme flooding may affect all of these parties and an integrated approach in reducing flood risk is required to avoid issues of risk transfer and to receive maximum benefits of any future flood risk reduction strategies. Such stakeholder process has been successfully conducted for the District of Chilliwack in 2008 and the Lower Kootenay Indian Band (ongoing). Given the various interest groups, a comprehensive flood risk assessment should also be co-funded by a variety of stakeholders and the financial burden fairly distributed.

## 7.0 CLOSURE

We trust the above satisfies your requirements at this time. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

**BGC ENGINEERING INC.**
**per:**

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