Peace Project Water Use Plan

Monitoring Programs and Physical Works
2010 Annual CWR Report
For Implementation Year: June 2009 to May 2010

Physical Works

- GMSWORKS#1: PCR Aerial Photos
- GMSWORKS#2: PCR Baseline TGP/Temperature
- GMSWORKS#3: PCR Side Channels
- GMSWORKS#4: PCR Hydraulic Habitat
- GMSWORKS#5: PCR Hydraulic Model
- GMSWORKS#6: PCR Mainstem Stage Discharge
- GMSWORKS#7: PCR Riparian Habitat Assessment
- GMSWORKS#8: DNR Demonstration Tributary
- GMSWORKS#9: DNR Tributary Inventory & Feasibility
- GMSWORKS#10: PCR Industry & Taylor Water Quality Assessment
- GMSWORKS#12: PCR & WLL Recreation Access
- GMSWORKS#13: PCR Recreation Access
- GMSWORKS#14: WLL Air Photos & DEM
- GMSWORKS#16: WLL Wetland Inventory
- GMSWORKS#17: WLL Trial Wetlands
- GMSWORKS#18: WLL Debris Field Survey
- GMSWORKS#19: WLL Trial Tributaries
- GMSWORKS#20: WLL Dust Source Survey
- GMSWORKS#21: WLL Dust Control Trial
- GMSWORKS#22: WLL Debris Management
- GMSWORKS#23: WLL Erosion Control Trial
- GMSWORKS#24: WLL Finlay Reach Access
- GMSWORKS#25: WLL Reservoir Bathymetry
- GMSWORKS#26: WLL Communications/Safety
- GMSWORKS#27: WLL Finlay River Access Information Plan
- GMSWORKS#28: Industry Feasibility & Design Study
- GMSWORKS#28A: District of Mackenzie Effluent Discharge Feasibility & Design Study
- GMSWORKS#29: Lynx Creek Boat
- GMSWORKS#30: Peace Island Park
- GMSWORKS#31: Kwadacha

Monitoring Programs

- GMSMON#1: PCR Creel Survey
- GMSMON#2: PCR Fish Index
- GMSMON#3: PCR Fish Stranding
- GMSMON#4: WACB Entrainment
- GMSMON#5: PCR Productivity
- GMSMON#6: PCR Riparian Flooding
- GMSMON#7: PCR Side Channel Fisheries
- GMSMON#8: PCR Side Channel Response
- GMSMON#9: PCR Spill Hydrology
- GMSMON#10: PCR Spill Photos
- GMSMON#11: PCR Spill TGP/Temperature
- GMSMON#12: PCR Wildlife Survey
- GMSMON#13: WLL Fish Index
- GMSMON#14: DNR Tributary Habitat Review
- GMSMON#15: WLL Wetland Habitat
- GMSMON#16: WLL Debris Trends
- GMSMON#17: WLL Tributary Habitat
- GMSMON#18: WLL Dust Control
- GMSMON#19: WLL Erosion Control
- GMSMON#20: WLL Recreation Use
- GMSMON#21A: WLL Archaeological Overview Assessment
- GMSMON#21B: WLL Erosion Monitoring of Archaeological Resources

For Water Licences 123018, 123019, 123020, 123021, 123025

30 June 2010

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BC Hydro Peace Project Water Use Plan
Annual Report: 2010

1 Introduction

This document summarizes the status of Peace Project Water Use Plan (WUP) physical work and monitoring program projects as of 30 June 2010 (financial information is current to 31 May 2010). BC Hydro is required to provide this information to the Comptroller of Water Rights (CWR) pursuant to sections 7, 4, 5, and 4 of Schedules A, B, C, and D, respectively, to the Peace Order made by the CWR under section 88 of the *Water Act* and dated 09 August 2007 (the "Order").

This Annual Report is available to the public.

2 Glossary

The following acronyms, words, or phrases used throughout this document have the meanings given below:

BCH: BC Hydro

Committee Report: The consensus recommendations of the WUP Committee set forth in their report of December 2003. An Executive Summary of those recommendations can be viewed online at:

http://www.bchydro.com/etc/medialib/internet/documents/environment/pdf/wup_peace_river_executive_summary_pdf.Par.0001.File.wup_peace_river_executive_summary.pdf

CWR: The Comptroller of Water Rights for the Province of British Columbia.

DNR: Dinosaur Reservoir, used only in project or management plan names.

GMS: Gordon M. Shrum Generating Station at WAC Bennett Dam.

Order: The order of the CWR, identified as the "Peace Order" and dated 09 August 2007, made pursuant to s. 88 of the *Water Act* of British Columbia and pertaining to implementation of the Peace WUP.

PCN: Peace Canyon Dam.

PCR: Peace River, used only in project or management plan names.

PSP: The Peace Spill Protocol, a group of projects to be implemented in the event of spill releases of water from WAC Bennett Dam or Peace Canyon Dam. The PSP is described in detail in Appendix 3 of the WUP and is ordered pursuant to Schedule D of the Order.

TGP: Total dissolved gas pressure.

ToR: Terms of Reference for WUP projects ordered by the CWR. The ToR can be viewed online at:

http://www.bchydro.com/planning_regulatory/water_use_planning/northern_interior.html

WLL: Williston Reservoir, used only in project or management plan names.

WUP: The Peace Project Water Use Plan accepted by the CWR on 21 August 2007. The WUP can be viewed online at:

http://www.bchydro.com/etc/medialib/internet/documents/environment/pdf/peace_river_water_use_plan.Par.0001.File.peace_river_wup.pdf

WUP Committee: The Peace Water Use Planning Committee as described in the Committee Report.

3 Background

The water use planning process for BC Hydro's Peace River hydroelectric facilities was initiated in February 2001 and completed in December 2003. The conditions proposed in the WUP for the operation of the facilities reflect the December 2003 consensus recommendations (the Committee Report) of the Peace Water Use Planning Committee (the WUP Committee).

Following review by the provincial Cabinet, BC Hydro submitted the WUP to the CWR in June 2006. The CWR accepted the WUP on 21 August 2007.

On 09 August 2007, BC Hydro was ordered to implement the operating conditions proposed in the WUP and to prepare terms of reference (ToR) for specified physical work and monitoring program projects.

GMSWORKS#11 FSJ Water Well, a proposed project relating to the water supply to the community of Fort St. John, was conducted outside the WUP and is not part of this report.

GMSWORKS#15 WLL Digital Elevation Model has been combined with GMSWORKS#14 Airphotos and is described in the section relating to the latter project.

Between 09 February 2008 and present, ToR were submitted to the CWR at various times for approval and leave to commence ordered projects. Leave to commence all projects for which ToR have been submitted has been granted.

ToR for the following two ordered projects have not yet been submitted to the CWR:

- GMSWORKS#23: WLL Erosion Control Trial
- GMSMON#19: WLL Erosion Control

ToR for a portion of GMSWORKS#28: Industry Feasibility & Design Study relating to the community of Mackenzie's sewage outfall have been submitted to the CWR. No

ToR have yet been submitted for those portions of the project relating to the forest products mills in Mackenzie.

The status of those projects is described in Section 5, below.

The WUP includes a number of "management plans", each addressing a key area of concern for the WUP Committee. Many WUP projects are intended to address specific management plans. The management plans and the projects addressing them are:

For Williston Reservoir:

- The Riparian and Wetland Habitat Management Plan, addressed primarily by GMSWORKS#16 and 17, and GMSMON#15.
- The Tributary Habitat Enhancement Management Plan, addressed primarily by GMSWORKS#19 and GMSMON#17.
- The Dust Control Management Plan, addressed primarily by GMSWORKS#20 and 21, and GMSMON#18.
- The Erosion Management Plan, addressed primarily by GMSWORKS#23 and GMSMON#19.
- The Williston Access, Navigation, and Safety Plan, addressed primarily by GMSWORKS#24 and GMSMON#20.
- The Debris Management Plan, addressed primarily by GMSWORKS#18 and 22 and GMSMON#16.
- The Peace/Williston Marine Radio Communications and Improved Signage Plan, addressed primarily by GMSWORKS#26.

For Dinosaur Reservoir, the Dinosaur Reservoir Management Plan, addressed primarily by GMSWORKS# 8, 9, and 12, and by GMSMON#14.

For the Peace River:

- The Peace Side Channel Plan, addressed primarily by GMSWORKS#3 and GMSMON#7.
- The Peace Ramping Plan, addressed primarily by GMSWORKS#3 and GMSMON#7.
- The Peace Flood Pulse Plan, addressed primarily by the Peace Spill Protocol (PSP), a collection of projects to be implemented in the event of a spill from the WAC Bennett or Peace Canyon Dams. The PSP includes GMSWORKS#2 and 7, and GMSMON#3, 4, 6, 7, 8, 9, 10, 11, 12, and 13.

The remainder of the Peace WUP projects either support multiple management plans or do not address a specific management plan.

The Order will be implemented until 2021, when the longest-running projects will end, except for ongoing maintenance on the GMSWORKS#26 marine communications system and any WUP boat ramps constructed.

A review of Williston Reservoir operations is to occur approximately five years after commencement of the WUP. The timing is not yet finalized but will likely be in 2013 because of the staggered start years of projects. During the review, the WUP Committee, as it is then constituted, will:

1. Consider the results of WUP projects and may recommend long-term operating constraints for Williston Reservoir to replace those currently in effect pursuant to the Order;
2. Review the results of all projects and consider what adjustments, if any, are required to scope or methodology; and
3. Make decisions about proceeding with conditional next steps for appropriate projects.

A full review of the WUP will occur approximately ten years after commencement of the WUP. The timing is not yet finalized but the review will likely occur in 2021 or 2022 because of the staggered start years and fixed durations of the WUP projects.

4 Project Timing

Tables 4-1 and 4-2 outline the Peace WUP Physical Works and Monitoring Program projects implementation schedules.

Table 4-1: Schedule of Peace WUP Physical Works Projects Implementation as of June 2010

Project	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021				
GMSWORKS#1: PCR Aerial Photos	✓[7]	✓[7]	u/w[7]									▪[8]	▪					
GMSWORKS#2: PCR Baseline TGP/Temperature	✓	✓	u/w	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪				
GMSWORKS#3: PCR Side Channels	Del	✓	u/w	▪	▪	▪												
GMSWORKS#4: PCR Hydraulic Habitat	Del	✓	u/w	▪[4]														
GMSWORKS#5: PCR Hydraulic Model	Del	✓	u/w	▪	▪	▪[6]												
GMSWORKS#6: PCR Mainstem Stage Discharge	Del	✓	u/w	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]		
GMSWORKS#7: PCR Riparian Habitat Assessment			▪	▪														
GMSWORKS#8: DNR Demonstration Tributary			u/w	▪	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]								
GMSWORKS#9: DNR Tributary Inventory & Feasibility		✓																
GMSWORKS#10: PCR Industry & Taylor Water Quality Assessment	Del	✓	u/w	▪	▪	▪												
GMSWORKS#12: DNR Recreation Access	✓	✓	✓															
GMSWORKS#13: PCR Recreation Access	✓	✓	✓															
GMSWORKS#14: WLL Air Photos & DEM		✓	u/w				▪							▪				
GMSWORKS#16: WLL Wetland Inventory		✓	✓															
GMSWORKS#17: WLL Trial Wetlands			u/w	▪	▪[5]	▪[5]	▪[5]											
GMSWORKS#18: WLL Debris Field Survey		✓	u/w															
GMSWORKS#19: WLL Trial Tributaries	Del	✓	▪	▪	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]									
GMSWORKS#20: WLL Dust Source Survey		✓	u/w															
GMSWORKS#21: WLL Dust Control Trial	✓	✓	u/w	▪														
GMSWORKS#22: WLL Debris Management		✓	u/w	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪[3]				
GMSWORKS#23: WLL Erosion Control Trial	Del[1]	Del[1]	Del[1]															
GMSWORKS#24: WLL Boat Access	Del	✓	✓															
GMSWORKS#25: WLL Bathymetric Mapping			u/w	▪														
GMSWORKS#26: WLL Communications/Safety	Del	✓	u/w	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]	▪[5]	▪[5,9]
GMSWORKS#27: WLL Finlay River Access Information Plan		✓	✓															
GMSWORKS#28: Industry Feasibility & Design Study	Del	Del	Del/u/w[2]	▪[2]														
GMSWORKS#28a: District of Mackenzie Effluent Discharge Feasibility & Design Study			▪	▪	▪[6]													
GMSWORKS#29 Lynx Creek Boat Launch Maintenance			▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
GMSWORKS#30 Peace Island Park Boat Launch Maintenance			▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
GMSWORKS#31 Kwadacha Boat Launch Maintenance			▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
Legend	▪ Program to be undertaken/initiated in identified year u/w Project is under way ✓ Project is completed for the year Del Project is delayed for the year																	

Footnotes:
1. Delayed pending final contract between BC Hydro, the Province of BC, and the Tsay Keh Dene First Nation.
2. The industry portion of this project is delayed pending resolution of the status of the plants in Mackenzie. The community's sewage outfall portion is underway.
3. Final report completion only.
4. Contingent on photos being available from GMSWORKS#1.
5. Work in this year represents maintenance at existing sites.
6. Project wrap up costs, only (i.e. data archiving, report edits, etc.)
7. One of five flows captured in 2008, two additional flows captured in 2009, remaining to be taken in 2010 if possible.
8. Flows not captured in Yr 9 will be taken in Yr 10.
9. Maintenance work will continue in future years.

Table 4-2: Schedule of Peace WUP Monitoring Program Projects Implementation as of June 2010

Project	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021				
GMSMON#1: PCR Creel Survey	✓		Del[3]		▪		▪		▪		▪		▪		▪	▪[2]		
GMSMON#2: PCR Fish Index	✓	✓	u/w	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪[2]				
GMSMON#3: PCR Fish Stranding		✓	▪[4]															
GMSMON#4: WACB Entrainment	✓		▪[4]															
GMSMON#5: PCR Productivity			Del[5]	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪		
GMSMON#6: PCR Riparian Flooding												▪[4]	▪[4]					
GMSMON#7: PCR Side Channel Fisheries			Del[5]	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪[2]	
GMSMON#8: PCR Side Channel Response			▪[4]															
GMSMON#9: PCR Spill Hydrology		✓	▪[4]															
GMSMON#10: PCR Spill Photos			▪[4]															
GMSMON#11: PCR Spill TGP/Temperature			▪[4]															
GMSMON#12: PCR Wildlife Survey		✓	▪[4]															
GMSMON#13: WLR Fish Index	✓	✓																
GMSMON#14: DNR Tributary Habitat			u/w		▪		▪		▪		▪		▪					
GMSMON#15: WLL Wetland Habitat			Del[6]	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪		
GMSMON#16: WLL Debris Trends				▪	▪[2]	▪	▪[2]				▪	▪[2]						
GMSMON#17: WLL Tributary Habitat			Del[6]	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪		
GMSMON#18: WLL Dust Control	✓	✓	u/w	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪[2]					
GMSMON#19: WLL Erosion Control	Del[1]	Del[1]	Del[1]															
GMSMON#20: WLL Recreation Use		✓	u/w	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪[2]				
GMSMON#21A: WLL Archaeological Overview Assessment		✓	✓															
GMSMON#21B: WLL Erosion Monitoring of Archaeological Resources		Del	u/w	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪					
Legend	▪ Program to be undertaken/initiated in identified year u/w Project is under way ✓ Project is completed for the year Del Project is delayed for the year																	

Footnotes:
1. Delayed pending final contract between BC Hydro, the Province of BC, and the Tsay Keh Dene First Nation.
1. Final report completion only.
2. Delayed pending discussions with CWR re suitability of study to meet management objectives.
3. Opportunistic study to be implemented in the event of a spill meeting the criteria of the PSP.
4. Delayed one year due to delay of corresponding WORKS projects.
5. Delayed one year due to loss of resources.

5 Summary of Peace WUP Projects

This section outlines the status of each of the Peace WUP projects as of 30 June 2010 (financial status is covered in Section 6, below). Each subsection describes one project and includes:

- the project objective,
- a description of the project,
- the contractor and the executive summary or equivalent from its latest annual report, and
- the current status of the project.

Physical works are described first, in Section 5.1, followed by monitoring programs in Section 5.2.

5.1 Peace WUP Physical Works Projects

5.1.1 GMSWORKS#1 – Peace River Aerial Photos

Order Clause: Schedule C clause 1

BC Hydro Project Manager: Kim Hawkins

5.1.1.1 Overview

Project Objective: The objectives of this project are to:

- Conduct a mapping inventory to organize a bibliography of all existing maps associated with the Peace River, and
- In Years 1 and 9 of this project, acquire aerial photos of the Peace River between the Peace Canyon Dam and the confluence with the Pine River, at five different flows within normal operating range.

Project Description: The Peace River Aerial Photos project supports physical works and monitoring programs within all of the Peace River management plans. Specifically, this project will provide spatial data to support the PSP and the PCR Flood Pulse, PCR Side Channel, and PCR Ramping Plans.

The project entails capturing photos, at a scale of 1:5000, at flows of approximately 10K cfs, 20K cfs, 70K cfs and 2 additional flow rates between 20K and 70K cfs. At least one set of photos is to be taken when foliage is present to form the basis of vegetation maps. The photos are to be orthorectified and both digital and hard copies of the map files delivered. Completion of any aerial photography not taken in Years 1 and 9 is to be conducted in Years 2 and 10. A status report will be completed after each year of work.

Contractor: The mapping inventory work was conducted by Geomatics and Research. Aerial photography work is being conducted by Selkirk Remote Sensing Ltd., photogrammetrics scanning by Aero Geometrics Ltd. and aerial triangulation by

4DGIS Ltd. All three contractors have conducted similar work for BC Hydro in the past. The BC Hydro Photogrammetry Services Department provided project coordination, supervision and compilation assistance.

ToR Status: In March 2009 the CWR approved a budget increase of $198,625 to reflect updated project implementation costs. The project complies with the revised ToR; no further resubmission is anticipated at this time.

5.1.1.2 Contractor's Report

In 2009 the BCH Photogrammetry Services Department contracted and completed the following work on GMS Works #1:

- On September 13, 2009 acquired 1:5000 scale photography of the Peace River from Peace Canyon Dam to the confluence of the Pine and Peace Rivers. The mission was flown with a constant discharge rate from Peace Canyon Dam at a flow of 10, 733 ft3/s.
- On September 20, 2009 acquired 1:5000 scale photography of the Peace River from Peace Canyon Dam to the confluence of the Pine and Peace Rivers. The mission was flown with a constant discharge rate from Peace Canyon Dam at a flow of 21, 329 ft3/s.
- The aerial photo negatives were processed and then scanned at a pixel size of 14 microns, as per Photogrammetric standards, the resulting scans were adjusted through a computer process of aerial triangulation and controlled by previous aerial triangulation of 2008 Photos.
- After the aerial triangulation process was complete the aerial photographs were set into the Photogrammetric workstations and checked as to quality and completeness of coverage. The Photogrammetric department then imported the previously completed Digital Elevation Model and used this DEM to drape the photography in order to produce a high resolution orthophoto.
- The final products were distributed to various users and archived in the BCH Photogrammetry department.

5.1.1.3 Status

This work was initiated in October 2008 when one set of photos were taken at mid-range flow. In September 2009, two low flow situations were photographed. The remaining high flow photos will be taken between July and August 2010. A second set of photos are to be taken in Yr 9 (2016), and completed in Yr 10 (2017) if necessary.

The bibliography of Peace River maps was completed in April 2009.

5.1.2 GMSWORKS#2 – Peace River Baseline TGP and Temperature

Order Clause: Schedule D clause 1

BC Hydro Project Manager: Kim Hawkins

5.1.2.1 Overview

Project Objective: The objectives of this project are to:

- Determine the temperature regime on the Peace River including the spatial and temporal variation, and
- Maintain total gas pressure (TGP) data loggers and related equipment.

Project Description: The PCR Baseline TGP and Temperature project is a component of the PSP and the PCR Flood Pulse Plan. Baseline temperature data collection will provide information on the temperature regime of the river under normal operating conditions and the influence of reservoir operation on downstream temperature.

The work involves the installation of temperature loggers at various sites around the W.A.C. Bennett Dam, the Peace Canyon Dam and the Peace River to the confluence of the Pine River. Temperature monitoring will occur continuously over the 10-year study period with downloading of temperature data undertaken a minimum of four times per year. Data will be entered into a database and analysis will entail summary statistics describing the temporal and spatial variation in temperature. The level of correlation between forebay temperature at the dams and downstream temperature will also be assessed and an annual report generated.

TGP equipment is to be calibrated and maintained such that it will be ready for installation (for GMSMON#11) in the event of a spill.

Contractor: The temperature loggers were purchased from Hoskin Scientific Ltd. and the TGP equipment from Point Four Systems Inc.; both companies are located in Vancouver, BC.

Temperature gauge installation, monitoring, and TGP equipment maintenance are being conducted by Diversified Environmental Services Ltd. (Diversified) under a five year contract. Diversified is located in Fort St. John and has conducted similar work for BC Hydro in the past.

ToR Status: The project complies with the ToR; no resubmission is anticipated at this time.

5.1.2.2 Contractor's Report

Peace River Baseline TGP/Temperature Year 1 Monitoring Report (April 2010) by Diversified Environmental Consultants - DISCUSSION

Water temperature trends observed during the initial year of the program correspond to predictable temporal and spatial trends for the study area:

- The temperature of water entering the Peace River from the WAC Bennett Dam tailrace shows the lowest daily and annual variation due to the moderating effect of hypolimnetic withdrawal from Williston Reservoir,
- Williston Reservoir exhibits typical thermal stratification with bi -annual mixing occurring in mid-October and late May,

- Due to the relatively high exchange rate of Dinosaur Reservoir, no seasonal thermal stratification appears to develop,
- During Year 1, Peace River water temperatures reached their annual low on approximately January 1, at which time loggers in the vicinity of the Halfway and Pine river reached 0°C; annual seasonal warming began in late March,
- During Year 1, Peace River water temperatures generally reached their annual high during mid-August when temperatures in the downstream portion of the study area reached 17°C; annual seasonal cooling began by late August, Peace River water temperatures increase on a downstream gradient from the WAC Bennett Dam tailrace between late spring and late summer and decrease on a downstream gradient between late fall and late winter,
- Large tributaries such as the Halfway and Pine rivers have the localized effect of warming water temperatures downstream of their confluences with the Peace between spring and early fall,
- The above noted trend is reversed between mid-fall and late winter when large Tributaries have a cooling effect on Peace River temperatures downstream of their confluences,
- The Moberly River has little moderating effect on the Peace River water temperatures during the winter months due to its low winter discharge levels,
- Tributary-influenced sites exhibit wider daily temperature fluctuations than the uninfluenced mainstem sites.

5.1.2.3 Status

Monitoring equipment was purchased in August 2008 and the temperature gauges deployed the following month. Temperature readings are downloaded quarterly.

5.1.3 GMSWORKS#3 – Peace River Side Channels

Order Clause: Schedule C clause 1(a)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.3.1 Overview

Project Objective: The objective of this project is to restore riparian access to side channel habitat that is currently isolated at minimum flows. This will allow BC Hydro to operate the Peace River generation facilities with greater flexibility. A key benefit of successful side channel restoration will be the ability to operate at minimum flows, when electricity market demand is low, without compromising fish and fish habitat.

Project Description:

- Inventory
  - Provide an inventory of side channel complexes in the Peace River between Peace Canyon Dam and the Pine River with prescriptive commentary on each side channel complex

    - Select two or more side channel complexes as demonstration sites for habitat improvement, preferably demonstrating different enhancement techniques and habitat objectives.

- Design
    - Design physical works for selected side channels

- Construct
    - Construct physical works at selected side channels

Contractor: This work is being conducted by Northwest Hydraulic Consultants Ltd. (NHC). NHC has conducted similar work for BC Hydro on other systems.

ToR Status: The ToR for this project is being resubmitted because of a financial variance. The approved costs included in the original ToR did not include either inflation or contingency amounts.

5.1.3.2 Contractor's Report

This study was initiated by BC Hydro to fulfill the recommendations of the Peace Water Use Plan (WUP) Committee to investigate the physical works necessary to maintain habitat productivity in side channels below Peace Canyon Dam (PCN), in lieu of increasing base flows 50 to 100 percent during the summer period. A total of 39 side channel complexes were assessed on the Peace River below PCN to allow for the determination of suitable restoration works to restore or maintain flows and habitat at the minimum flow of 283 m^3/s.

The Peace River has been regulated by W.A.C. Bennett Dam since 1967, and its characteristics are influenced by the operation of this dam and PCN. Flow regulation has altered the annual hydrograph, daily flow patterns, temperature regime, and water quality of the Peace River. The average post-regulation annual maximum daily flow (under the 'normal' operating regime) is 31% of the pre-regulation value at Hudson's Hope and 37% near Taylor. The reduction in peak flows is thought to be the primary cause of a loss of side channel area through sediment infilling and vegetation encroachment.

Side channels in the Peace River have been classified as open, ephemeral or closed. Based on an overview assessment, a range of side channels exist in the study reach, together totalling 87.4 km: 21 open, 8 ephemeral, and 6 closed. The total side channel area is estimated at 506.4 ha, while the mainstem river area is estimated at 3,532.9 ha, thus side channels represent about 12.5% of the total area. Permanent open, ephemeral open and closed side channels comprise of 74.9%, 15.6%, and 9.4% of the total side channel area, respectively.

Potential methods for side channel restoration are reviewed, with a focus on methods that could be directly applied to the Peace River. Most of these methods involve deepening or excavating the channel to remove accumulated sediment and open side channels. Channel inverts and profiles may need to be lowered. Habitat complexing with channel modifications, and wood or boulder placement could be

used to further restore fish habitat. Site access, channel design, habitat complexing and water supply have been identified as key issues.

Conceptual costs are difficult to estimate as the depth and extent of excavations require survey data that is unavailable for the sites. The costs also depend on access and environmental requirements, the scope of work at the selected sites, and available budgets. A notional cost of $20-30 per square meter of full constructed channel has been suggested, and lower values would apply to channels that require partial or limited excavations.

Physical characteristics, and fish and fish habitat attributes were examined through both field and office studies, and interpreted by the authors. Eleven sites (11) sites were short listed, representing predominantly closed side channels that could be excavated into open flowing systems. Simple channel excavations and lowering of critical elevations will primarily provide re-watering under base flow conditions. In side channels above the Halfway River, ongoing sedimentation and ice effects could be minimal and additional habitat complexing and restoration works are suggested. Nine of the eleven sites (all except the lower 2 in the reach) would benefit from cold-clear water fish assemblages including bull trout, rainbow trout and Arctic grayling.

Side Channel 23L and 32L (refers to side channels 23km and 32km from PCN on the left bank) were identified as the sites with the highest overall rating based on the overview assessment carried out under this study. The 23L site was selected due to the fact that it current dry under the regulated flow regime, and restoration of the area would create new back channel habitat. The area is relatively small and accessible. The 32L site was selected due to excellent access, sufficient area available, and good potential to create both open connected side channel habitat and backwater closed side channel habitat within the same area.

Based on the study team recommendations, the 32L site represents the best opportunity of all the sites assessed. Information and data gaps, and implementation issues have been provided in the summary section, which will assist in guiding subsequent steps in the process of developing a restoration plan for Site 32L. This study recommends ongoing coordination with other GMSWORKS projects to better determine other factors that could influence the project or scope.

5.1.3.3 Status

The inventory work associated with this project was initiated in May 2009 and was completed in January 2010. A final report for the inventory stage was completed in May 2010.

The CWR is being asked to render a decision on extending the geographic extents of the project area to include side channels downstream of the Pine River, in order to reduce potential effects that Site C may have on this project. Construction work has been delayed pending that decision.

5.1.4 GMSWORKS#4 – Peace River Hydraulic Habitat

Order Clause: Schedule C clause 1(b)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.4.1 Overview

Project Objective: The objective of this physical work is to estimate hydraulic habitat types as a function of flow. This approach is more cost effective than physical habitat modeling yet produces an effective tool for assessing the utility of management plans and impacts of daily and seasonal flow changes. The model that is developed from these data will allow some interpolation and extrapolation of benefits or impacts of changes in flow to fish habitat.

Project Description:

- Develop a habitat classification scheme and rules for Peace River hydraulic habitat types.
- Delineate the habitat classification on aerial photos for five different flows.
- Digitize habitat types from photos into a GIS-based mapping system (ARC INFO).
- Develop a model of hydraulic habitat as a function of flow.
- Produce a report describing the classification scheme (bias, error, etc.), mapping process, results and discussion of QA.

Contractor: This work is being conducted by Mainstream Aquatics Ltd (Mainstream). Mainstream has previously conducted similar work for BC Hydro on the Peace River.

ToR Status: In January 2010 the CWR approved a resubmission of the GMSWORKS#4 ToR with updated project implementation costs. The project complies with the revised ToR; no further resubmission is anticipated at this time. There is currently a financial variance, a plan is in place to address this variance — see Table 6.1 for details.

5.1.4.2 Contractor's Report

A habitat classification scheme was developed based on predicted physical characteristics of the Peace River. Use of physical characteristics to classify fish habitat was chosen for three reasons. First, fisheries investigations on the Peace River have established quantitative differences in fish abundance and life stage use based on physical characteristics of the river channel and banks (Mainstream and Gazey 2006). Second, physical characteristics are identifiable on large scale colour stereo air photos. Third, physical characteristics of fish habitat are stable over different flow regimes, which allow quantification of fish habitat availability at various water levels.

This system does not incorporate nonphysical attributes of fish habitat because changes to these features are not identifiable on air photos (i.e., water velocity) and/or they can be influenced by factors outside of river discharge (i.e., tributary

input influence on water clarity). The following physical characteristics were incorporated into the habitat classification scheme:

- side channel versus main channel
- open versus closed side channel (regular versus frequent inundation)
- shoals
- channel margin slope
- channel margin roughness (smooth versus irregular banks)
- bed material type
- unique habitats (e.g., man-made features)

5.1.4.3 Status

This work was initiated in May 2009 and is scheduled to be completed by January 2011.

In 2010 three of five target flows were classified for hydraulic habitat. The remaining two flows are expected to be classified during the summer and fall of 2010.

5.1.5 GMSWORKS#5 – Peace River Hydraulic Model

Order Clause: Schedule C clause 1(b)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.5.1 Overview

Project Objective: The objective of this physical work is to support other Peace River projects that are addressing side channel habitat restoration and ramping rate strategies. The model is needed to estimate the degree of side channel inundation as flows increase. Information on water levels at various flows is integral to the design of habitat elements in the side channels project.

Project Description:

- Survey ten new cross-sections between Peace Canyon Dam and the Pine River.
- Produce an interim report on the cross-sections established plus any other cross-sectional data and other survey and hydraulic data that will be beneficial to the modeling effort.
- Develop a working hydraulic model of the Peace River that will provide measures of mainstem and side channel inundation for various discharge regimes.

Contractor: This work is being conducted by Northwest Hydraulic Consultants Ltd. (NHC). NHC has conducted similar work for BC Hydro on other systems.

ToR Status: In January 2010 the CWR approved a resubmission of the GMSWORKS#5 ToR with updated project implementation costs. The project complies with the revised ToR; no further resubmission is anticipated at this time.

5.1.5.2 Contractor's Report

Hydroelectric generation from the Peace River produces nearly a third of British Columbia's electricity through Gordon M. Shrum (GMS) power station at W.A.C Bennett Dam and Peace Canyon Dam (PCN) 14 km downstream. Downstream of PCN, seasonal flows have been normalized with a reduction in spring and summer high flows and an increase in lower autumn and winter flows. Pre-regulation annual maximum daily discharge downstream of PCN ranged from 1,640 to 8,810 m^3/s with an average of 6,165 m^3/s. Post regulation annual maximum discharge averages 1,940 m^3/s. GMS and PCN are power-peaking facilities that fluctuate water levels on an hourly basis.

The variability in flow impacts side channel habitat and fish potentially through mobilization or displacement of fish, fish stranding, channel isolation, or dewatering that can lead to mortality from suffocation, predation, or freezing. Despite obstruction and regulation, there are existing successful fish populations within the Peace River.

Two (2) other studies along the Peace River have concurrently been progressing:

1. GMSWORKS#3 Peace River Side Channel Restoration, where side channel habitat along the Peace River have been identified and prioritized between PCN and Pine River.
2. GMSWORKS#6 Peace River Mainstem Stage Discharge, where an additional sixteen (16) bathymetric cross-sections were surveyed and five (5) pressure transducers installed with 10-point stage discharge relationships developed.

The study presented in the following text (GMSWORKS#5) uses the data collected in the other two (2) projects to develop, calibrate, validate, and apply a Mike11 one-dimensional numerical model for a 98 km long reach of the Peace River; extending from six (6) kilometres downstream of the PCN to just downstream of Pine River. Thus addressing a primary data gap identified in the summary and recommendations of GMSWorks#3; the development of a hydraulic model to estimate water surface elevations where side channel habitat is situated.

The model showed good correlation with the observed data (average R^2 of 0.89 to 0.95) with better correlation for flows greater than 800 m^3/s. Maximum error between modelled and observed water levels on average was 22 cm positive and 32 cm negative. Modelled travel time of peak flows was between 8 and 12% greater than observed over the 100 km long study reach.

From 33 identified side channels, the model results suggest:

1. at a PCN discharge of 283 m^3/s, only 2 side channels are fully wetted and 4 partially wetted.
2. at PCN discharge of 500 m^3/s, 5 side channels are fully wetted and 17 partially wetted.
3. at a discharge of 1,000 m^3/s, 14 side channels are fully wetted and 29 partially wetted.

4. at a PCN discharge of 1,500 m^3/s, 21 side channels are fully wetted and all 33 are partially wetted.
5. at a PCN discharge of 2,000 m^3/s, 26 side channels are fully wetted
6. at a PCN discharge of 3,500 m^3/s, 32 side channels are fully wetted

The model adequately represents the study reach and can be used as a tool to further prioritize side channel habitat improvement work, provide initial estimates for excavation/lowering or development of side channels, and to assess impacts to existing side channel habitat if future flow changes are proposed.

In addition to estimating water levels for various PCN discharges, the model was used to approximate dispersion and transmission of flow peaks; i.e. the reduction in rate of flow change as the peak progresses downstream and the time of transmission often discussed as lag time or kinematic wave celerity.

The methodology used for this study is appropriate to meet the project objectives and could successfully be applied to other reaches along the Peace River or other regulated rivers where an assessment of side channel habitat is required. Using the one-dimensional model as boundary conditions, localized two-dimensional modelling of critical habitat sites could be used to further define site hydraulics and estimate weighted habitat use value.

5.1.5.3 Status

This work was initiated in May 2009 and is scheduled to be completed by January 2013. Work is progressing according to the schedule.

5.1.6 GMSWORKS#6 – Peace River Mainstem Stage Discharge

Order Clause: Schedule C clause 1(b)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.6.1 Overview

Project Objective: The objective of this project is to establish stage discharge relationships at strategic points along the Peace River such that side channel inundation can be inferred from mainstem discharges. This ability will be of particular utility when BC Hydro is ramping discharges down and fish can become stranded in side channels. The project will assist in the fine tuning of ramping sequences, helping to reduce fish stranding and stress mortality tolls on fish.

Project Description:

- Establish transects and install gauges at five sites on the Peace River between Peace Canyon Dam and the Pine River Confluence.
- Develop Stage-Discharge relationships for each site covering flows related to Peace Canyon Dam discharges (283 to 2000 cms).
- Develop a protocol and schedule for maintenance and data quality checks.

Contractor: This work is being conducted by Northwest Hydraulic Consultants Ltd. (NHC). NHC has conducted similar work for BC Hydro on other systems.

ToR Status: In January 2010 the CWR approved a resubmission of the GMSWORKS#6 ToR with updated project implementation costs. The project complies with the revised ToR; no further resubmission is anticipated at this time. There is currently a financial variance, a plan is in place to address this variance — see Table 6.1 for details.

5.1.6.2 Contractor's Report

This study was initiated by BC Hydro to fulfill the recommendations of the Peace River Water Use Plan (WUP) Committee to monitor water levels and develop stage-discharge relations for the Peace River mainstem downstream of the Peace Canyon Dam (PCN) to the Pine River confluence. The purpose of this project is to develop more accurate models of flow attenuation downstream of the dam, and to gather data that will enable side channel inundation levels to be determined during ramping and spill events.

The Peace River has been regulated by W.A.C. Bennett Dam since 1967, and its characteristics are influenced by the operation of this dam and PCN. Flow regulation has altered the annual hydrograph, daily flow patterns, temperature regime, and water quality of the Peace River. The average post-regulation annual maximum daily flow (under the 'normal' operating regime) is 31% of the pre-regulation value at Hudson's Hope and 37% of those values near Taylor, BC.

Hydrometric stations were installed for long term flow monitoring at five locations along the Peace River to assist in the ongoing operation of BC Hydro's G.M. Shrum (GMS) and PCN facilities, and to determine effective flow ramping rates for various project discharges that will reduce the risk of fish stranding in both side channel and mainstem habitats. The hydrometric stations installations and monitoring are in compliance with Grade A standards as set by the BC Ministry of Environment (MOE) Resources Information Standards Committee (RISC) Hydrometric Standards (RISC, 2009).

Discharge measurements for stage-discharge (rating curve) development at each hydrometric site began concurrently with the installation of the hydrometric stations, with VIASAT Data Systems Inc. conducting installation of the satellite linked real-time hydrometric stations, and Northwest Hydraulic Consultants Ltd. (NHC) leading discharge measurements, river cross-section surveys, and data analyses. Rating curves were successfully developed for each hydrometric station, allowing for accurate continuous discharge estimates at the five sites along the river mainstem, and the determination of flow wave attenuation from ramping events at PCN dam. This data is continuously collected by BC Hydro's GOES system.

Rating curve development and analyses meet or exceed RISC (2009) Grade A hydrometric standards. Rating curve analyses have included the computation of confidence limits, cumulative discharge calculations, and gauge comparisons with existing Water Survey of Canada (WSC) gauges on the river. The hydrometric stations were initiated on October 7th, 2009, following the beginning of the reduced

inflow winter period. Consequently, analyses dependant on significant tributary inflow, such as calculations of time series tributary discharge data and a system-wide flow balance model have not yet been conducted. These analyses may be completed following the 2010 freshet, when sufficient data becomes available.

Ramping analysis included the assessment of a down-ramping event from PCN that was representative of a significant reduction in flow that could de-water side channels. 15minute interval stage and discharge data from all hydrometric stations on the Peace River has been presented for this event to illustrate how such an event propagates down the river. Analysis of this event indicates decreasing response times and magnitudes with increasing distance from the dam. Data collected from this project has also been used in the development of a hydraulic model of the Peace River created as part of GMSWORKS #5, which has determined how water levels in critical side channels respond to these ramping events.

Future recommendations for this project include a scheduled yearly and 'as needed' maintenance program for the five new hydrometric stations, with the continued upkeep of accurate rating curves for the estimation of discharge over the ten year duration of this project. For compliance with RISC (2009) hydrometric standards, six discharge measurements are recommended on a yearly basis to be collected over the prescribed range of project flows (283-2000 m_3/s). If a shift of greater than 5% is identified in a rating curve, then an additional 4 discharge measurements should be conducted for the hydrologic year in which the shift occurs, and river cross-sections should also be resurveyed following the occurrence of such an event.

5.1.6.3 Status

This work was initiated in May 2009 and is scheduled to be completed by January 2019. Work is progressing according to the schedule.

5.1.7 GMSWORKS#7 – Peace River Riparian Habitat Assessment

Order Clause: Schedule C clause 1(c)

BC Hydro Project Manager: Kim Hawkins

5.1.7.1 Overview

Project Objective: The objectives of this project are to:

- Determine species composition of vegetation in the riparian zone of the Peace River, and
- Determine spatial distribution of vegetation in the riparian zone of the river.

Project Description: The WUP Committee recommended an assessment of the large-scale temporal and spatial trends of the vegetative community along the Peace River. This study will focus on the current status of riparian habitat and, if a spill occurs during the 10-year management plan study period, this riparian data will be used to assess the impacts.

The project will occur over two years using the air photos taken as part of GMSWORKS#1 to produce vegetation inventory maps in the first year and ground-truthing and surveying sites of key concern, including sites located around the side channel areas that have been selected as part of GMSWORKS#3, in both years. The study area extends from the Peace Canyon Dam to the confluence of the Pine River. A report will be produced each year detailing the progress of the project.

Contractor: This project is scheduled to commence in 2010; the contractor has not yet been selected.

ToR Status: The CWR approved a budget increase of $6,175 in January 2010 to adjust for schedule change, inflation and contingency. No further changes are anticipated at this time.

5.1.7.2 Contractor's Report

The first contractor's report will be filed in 2011.

5.1.7.3 Status

In order to develop the vegetation maps, this project will utilize the aerial photos taken as part of GMSWORKS#1, including at least one set of photos taken when foliage is present. Therefore the project is scheduled to commence in 2010 following the acquisition and development of the air photos in 2008 and 2009.

5.1.8 GMSWORKS#8 – Dinosaur Reservoir Demonstration Tributary

Order Clause: Schedule B clause 1(a)&(b)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.8.1 Overview

Project Objective: The objective of this project is to select up to two of the tributary sites inventoried and described under GMSWORKS#9 and design and construct habitat improvements at these sites. Ideally, each site design would showcase different enhancement techniques.

Project Description:

- Design and construct habitat enhancement for up to two selected tributaries to the Dinosaur Reservoir

Contractor: This work has not yet been awarded pending the completion of GMSWORKS#9.

ToR Status: In January 2010 the CWR approved a resubmission of the GMSWORKS#8 ToR with updated project implementation costs. The project complies with the revised ToR; no further resubmission is anticipated at this time.

5.1.8.2 Contractor's Report

The first contractor's report will be filed in 2011.

5.1.8.3 Status

Design work is scheduled to start in 2010, with construction to start in spring 2011 following the completion of GMSWORKS#9 and a year of "baseline" data collection.

5.1.9 GMSWORKS#9 – Dinosaur Reservoir Tributary Inventory and Feasibility

Order Clause: Schedule B clause 1(a)

BC Hydro Project Manager: Kim Hawkins

5.1.9.1 Overview

Project Objective: The objectives of this project are to:

- Identify the tributaries around the Dinosaur Reservoir that are impacted by the operation of the reservoir and/or by accumulations of debris, and
- Provide a ranking for the tributaries based on biological impact and mitigation potential for success from which one or more sites may be selected for remediation, enhancement, and management of debris.

Project Description: The operation of Dinosaur Reservoir, as well as debris accumulations in tributaries from upstream logging activities, has an impact on the fish access to tributary streams and the utility of these streams as fish habitat. The Committee endorsed a plan to gauge the effectiveness of restoring access to, and fisheries habitat within, these tributaries. The assessment and ranking of the tributaries will be undertaken by reviewing existing studies of the reservoir and conducting a field survey. A final report outlining the results of the assessment will be provided.

Contractor: This work was conducted by Triton Environmental Consultants Ltd. (Triton).

ToR Status: This project was completed in compliance with the ToR.

5.1.9.2 Contractor's Report

<u>Dinosaur Tributary Inventory and Feasibility Report (November 2009) by Triton Environmental Consultants Ltd. – EXECUTIVE SUMMARY</u>

The steep bottom topography and short water retention period within the Dinosaur Reservoir has resulted in low fish productivity. The lack of quality rearing and spawning habitats within the Reservoir make the limited available tributary habitat particularly important for maintaining a naturally sustainable sport fishery.

This Peace Water Use Plan (WUP) project was prompted by concerns about potential fish access restrictions to tributary habitat caused by reservoir operations and woody debris accumulations at tributary confluences.

A pre-field scoping exercise was conducted to identify streams with the highest potential to offer any fish habitat, followed by a field validation component. Field investigations revealed that ten tributaries offer some level of reservoir-accessible habitat, amounting to a combined area of 51,326 m^2 (80% of which is split between Johnson Creek and Gething Creek).

Concerns that woody debris accumulations from upstream logging are restricting fish access to tributaries was not validated during any step of this project (*i.e.* literature review, orthophoto review, and field investigations). In fact, wood within the Reservoir was very sparse and primarily limited to habitat features installed into several bays for rearing habitat enhancement.

A combination of reservoir operations and high bedload movement are causing access restrictions to five tributaries with reservoir-accessible habitat. Dredging to remove aggregated bedload at stream confluences may be viable, but would require an ongoing maintenance commitment. If this concept were pursued, Starfish Creek and unnamed creek (230-804398) are the best two candidates since they have the highest quality habitat with the most available area, and they are located next to each other.

Other enhancement options not related to access restrictions were considered to increase tributary rearing and spawning including: removing barriers; habitat complexing on tributaries; creating new tributary habitat; augmenting flow to existing reservoir-accessible tributaries by diverting non-fish bearing tributaries; habitat complexing within the reservoir; and diverting non-reservoir tributaries into the reservoir.

No viable barrier removal opportunities were identified. The lower end of Johnson Creek is the best candidate location for new side channel creation, but partitioning flows from the existing channel may not result in net gains in productive habitat capacity. No viable opportunities exist for augmenting flows in accessible streams.

Most accessible tributaries are not considered suitable candidates for habitat complexing initiatives due to chronic bedload movement and unstable canyon conditions. Accessible tributary habitats on stable streams are considered functional and provide limited opportunities for habitat complexing enhancements. Converting high value rearing habitat into spawning habitat on Moosebar Creek, and offsetting that alteration by habitat complexing the inlet bay for rearing may achieve an overall net gain to the productive capacity for rainbow trout, but results would have a significant level of uncertainty. This is partly because there is no guarantee relocating an equivalent or greater amount of stream rearing habitat into the reservoir will afford juveniles similar or better success. Although the lower 364 m of Moosebar Creek contains rainbow trout and is considered reservoir-accessible habitat, removing two small falls (1.2 m and 1.4 m) from the lower 60 m should precede any enhancement works upstream to maximize the benefit.

The best tributary-related opportunity for enhancing the productive capacity of the Dinosaur Reservoir fishery is to divert Portage Creek and Bullrun Creek into the Reservoir. Currently both creeks flow into the Peace River just downstream of the Peace Canyon Dam, and have impassable barriers located at their confluences. In total, an estimated 21.5 km of new stream habitat could become accessible to reservoir fish through this initiative. The greatest benefit of this newly accessible habitat would be for rearing, although an effort should also be made to augment spawning habitat within the 1,850 m long new channel section.

Continuing to add woody debris to reservoir bays is another proven strategy to increase rearing habitat quality in a low-risk, economical manner.

5.1.9.3 Status

This project was undertaken by Triton in the second half of 2009 and completed in early 2010.

5.1.10 GMSWORKS#10 – Peace River Industry and Taylor Water Quality Assessment

Order Clause: Schedule C clause 4(e)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.10.1 Overview

Project Objective: The objective of this study is to answer four questions surrounding sedimentation issues at the Spectra surface intakes in the District of Taylor (i.e., What, Where, When, How). The information collected and the recommendations of the study will allow BC Hydro to design specific flow increases from Peace Canyon Dam or to identify a non-operating alternative to address any issues.

Project Description:

- Collect information that would determine the cause of the sedimentation. This would include an estimate of the quantity of deposition under a range of flow conditions.
- Collect information that would determine whether increased flow from BC Hydro's Peace Canyon Dam would affect water temperatures at the intakes during the summer.
- Characterize the Peace/Pine River flow relationship, specifically what Peace channel flow is required to prevent Pine River flows from reaching the north bank.

Contractor: This work is being conducted by Knight Piesold Ltd. Knight Piesold has conducted similar work for other clients in the past.

ToR Status: The project complies with the ToR; no further resubmission is anticipated at this time.

5.1.10.2 Contractor's Report

The following physical changes have been observed and/or inferred in the Peace River since regulation and may be related in an incremental way to the reported water intake problems.

1. Peace River freshet flows have been reduced, while sediment inputs to the river during freshet have been much less affected, meaning that suspended sediment concentrations in the Peace River have likely increased during spring and summer. However, it is unclear at this time which of the Peace or Pine Rivers has higher sediment concentrations overall or how the seasonal variations in concentration compare between the two rivers.

2. Peace River peak flows have been reduced, which has resulted in the river losing its competence to transport formerly mobile bed material. This has caused an increase in fine sediment content on (and possibly within) the bed material, which in turn may have reduced the porosity and hydraulic conductivity of the bed material.

3. The loss of transport competence in the Peace River has affected channel morphology in the vicinity of the Pine River confluence. Bedload sediments delivered by the Pine River are no longer transported downstream as readily by the Peace River, and have been accumulating near the confluence. This has resulted in aggradation of the Peace River bed, bed material accumulation and lateral instability in the lower Pine River, and the progradation of Pine River bed material deposits out into the Peace River channel. The Peace River has been constricted at the confluence, and the approach angle of the Pine River has shifted from 45 to 90 degrees relative to the Peace River above the confluence.

4. The ratio of Pine River freshet flows relative to Peace River freshet flows has increased. Combined with the channel constriction of the Peace River and the change in approach angle of the Pine River, it is possible that the Pine River plume now spreads more widely across the Peace River and mixes more quickly with the Peace River than it used to. Based on the available air photo evidence, however, it is unlikely that the Pine River plume reaches the north bank of the Peace River under normal post-regulation freshet conditions. It should be noted that this has been difficult to assess definitively from the historical air photo record and that further investigation would be required to confirm this conclusion.

5. Summer water temperatures in the Peace River are approximately 3°C to 5°C lower than in the Pine River, presumably due to the cooling effect of deep-level releases from the reservoirs. Temperatures along the north bank of the Peace River are likely influenced primarily by upstream Peace River temperatures rather than Pine River temperatures under most flow conditions. Again, however, it is difficult to state definitively at this time how the mixing of the two river plumes affects summer water temperature at the Spectra intake site.

ALTERNATE HYPOTHESES
Based on these observations and inferences, the following alternate hypotheses are proposed:

1. Sediment deposition at the Spectra intake facility is caused by the general increase in Peace River bed elevation in that reach of the river, and by the sheltered hydraulic conditions at the intake that promote suspended sediment deposition.

2. Suspended sediment concentrations in the Peace and Pine Rivers are not substantially different, so the mixing of the Peace and Pine River sediment plumes does not provide a significant control on sediment concentration in the water extracted at the Spectra intake. Furthermore, the mixing of the Peace and Pine River sediment plumes does not take

place upstream of the Spectra intake facility during freshet flow conditions; the Pine River plume stays attached to the bank opposite the intake.

3. Water temperatures in the Peace and Pine Rivers are substantially different, so the mixing of the Peace and Pine River temperature plumes does provide a significant control on the temperature of water extracted at the Spectra intake. However, the mixing of the temperature plumes rarely occurs upstream of the intake site.

4. Fine sediment deposition on the bar/island complex at the District of Taylor's well site has reduced the porosity and hydraulic conductivity of the alluvium surrounding the wells.

It is likely that some or all of the hypotheses listed above play a combined, incremental role in the reported water intake problems. The goal of the recommended 2010 study program is to collect pertinent observations and data that will test the hypotheses, quantify the incremental effects on the water intake problems, and provide clarification about inter-relationships between hypotheses.

5.1.10.3 Status

This work was initiated in May 2009 and is scheduled to be completed by December 2013.

5.1.11 GMSWORKS#12 – Peace and Williston Recreational Access (Feasibility of Boat Ramps)

Order Clause: Schedule B clause 2(a)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.11.1 Overview

Project Objective: The overall objective of this physical work is to improve boat launch facilities on Dinosaur Reservoir at the day-use park near Hudson's Hope. Improving this facility will enhance the recreation experience on the reservoir and improve safety when accessing the reservoir.

Project Description:

- Feasibility
  - Determine the feasibility and cost of relocating the dock associated with the Dinosaur boat launch as recommended by the WUP Committee.
  - Evaluate the feasibility and cost improvements to the rock berm adjacent to the Dinosaur boat launch.
- Design
  - Design berm improvements.
- Construct
  - Construct berm improvements and relocate the dock.

Note: This project is for feasibility only.

Contractor: This work is being conducted by Moffatt & Nichol Engineers Corporation (M&N). M&N has conducted similar work for BC Hydro on other systems.

ToR Status: In January 2010 the CWR approved a resubmission of the GMSWORKS#12 ToR with updated project implementation costs. The project complies with the revised ToR; no further resubmission is anticipated at this time.

5.1.11.2 Contractor's Report

Dinosaur Reservoir

The site on Dinosaur Lake is at Hudson's Hope Park, on the north side of the lake. This site is heavily used during the summer boating and camping season. There is a good-sized upland parking area. The waterside facilities at the site, described below, include a single-lane cast-in-place concrete boat launch ramp, a floating dock, and a rubblemound breakwater.

The beach appears generally stable, with possible minor erosion to the east (downdrift) of the waterside facilities. There is no evidence of erosion to the west of the waterside facilities. A creek enters the lake on the west side of the picnic area adjacent to the beach. The beach substrate is pea gravel on the middle and upper beach and a mixture of finer sediments on the lower beach. The fact that the floating dock often bottoms out, as described below, suggests that this finer sediment has accreted in recent years.

The concrete boat launch ramp is in good to fair condition. There is some cracking, but it does not appear to be affecting the structural integrity of the ramp. However, repeated freeze-thaw cycles may eventually accelerate deterioration of the concrete in the future. Scour protection rocks, typically 400 to 500 mm diameter, have been displaced by wave activity, however there is no evidence that the ramp is being undermined. The beach at the ramp is of pea gravel and appears stable.

The floating dock is east of the boat launch ramp. The dock components are steel support piles and steel floats, with wooden decking. The water at the dock is too shallow to allow it to float at all water levels, particularly in the early morning[7] when the water level in the lake is relatively low. The dock may also be too short for the number of boats that attempt to tie up during busy periods. Physically, the dock is in good to fair condition: there is some deterioration of the wooden decking but this is minor and does not appear to affect the structural condition or the safety of the dock.

The rubblemound breakwater is west of the boat launch ramp. A number of the rocks originally comprising the breakwater are now scattered over the adjoining beach. Much of the breakwater now consists of a single layer of rock or at most two layers. The rocks range from 300 mm to 1200 mm in diameter. The breakwater is long enough to provide some wave protection to the ramp and the dock, although it would need to be extended as well as repaired if the dock were extended into deeper water.

5.1.11.3 Status

This project is complete.

5.1.12 GMSWORKS#13 – Peace River Recreational Access

Order Clause: Schedule C clause 3(a)&(b)
Schedule A clause 4(a)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.12.1 Overview

Project Objective: The overall objective of this physical work is to create boat launch facilities that allow campers, day visitors, fishers, and other recreational focused users to safely and easily launch boats off trailers through the range of average seasonal water level fluctuations. Having such facilities will enhance the recreation experience on the Peace River and the Peace arm of the Williston Reservoir.

Two boat ramp locations recommended for investigation by the WUP Committee—Taylor and Lynx Creek—were developed outside the WUP.

Project Description:

- Feasibility
  - Determine the feasibility of extending existing or constructing new boat ramps as recommended by the WUP Committee.
  - Evaluate the feasibility of each site in terms of engineering technical feasibility, a cost/benefit analysis, heritage values, and environmental values.
- Design
  - Design boat ramps at feasible locations.
- Construct
  - Construct boat ramps at feasible locations.

Note: This project is for feasibility only.

Contractor: This work is being conducted by Moffatt & Nichol Engineers Corporation (M&N). M&N has conducted similar work for BC Hydro on other systems.

ToR Status: In January 2010 the CWR approved a resubmission of the GMSWORKS#13 ToR with updated project implementation costs. The project complies with the revised ToR; no further resubmission is anticipated at this time.

5.1.12.2 Contractor's Report

Dunlevy Existing Site

The Dunlevy existing site is located on the north side of the Williston Reservoir, Peace Arm, and east of the Dunlevy Inlet in Butler Ridge Provincial Park. The park is accessible through well-maintained gravel roads and has an ample gravel upland parking area. Other facilities at the site include informational signs and pit toilets.

The approach to the boat launch ramp is along a gravel path. The gravel approach to the ramp is in good condition. However, the concrete ramp is in very poor condition as a result of erosion, and has been closed since April 2009 (although it appears that some boaters are still using the ramp).

There is damage at the upper part of the boat launch ramp. A portion of the ramp has been undercut by erosion. Concrete barriers have been placed in the middle of the ramp to keep boaters from straying towards the edge.

At the lower end of the ramp, the bank has slumped and become oversteepened. The concrete planks on the surface of the boat launch ramp in this location have shifted downhill as a result of the oversteepening of the bank.

Relatively rapid erosion is also occurring at the top of the bank.

The substrate at Dunlevy is generally relatively firm, with a good mixture of sand and gravel, as shown in Photo No. 9. There are areas of finer substrate. The areas most subject to slumping, including the area directly below the most eroded upper area have this finer substrate.

M&N staff discussed the erosion issues at the site with three local users.

- Dan Bullian, BC Hydro, Manager of Environmental and Social Issues, visited the Dunlevy site with the project team. He described the erosional problems as being exacerbated by an increase in the operating water levels in the Williston Reservoir. Hydrometric data obtained from the Environment Canada web site indicate that the water level in the Williston Reservoir did not exceed El. 670 m between 1985 and 1994. The peak water level has varied since 1994, but the operating maximum of El. 672.1 m has been approached several times since then, including summer 2007 and 2008.
- Bleu Rowe of BC Hydro, speaking as a boater rather than as a representative of BCH, stated that erosion had been occurring over the past 15 years, and had been getting worse every year.
- Dennis Beattie, an outfitter in Hudson's Hope and President of the Northern Peace local association of the Guide Outfitters Association of British Columbia, stated that a great deal of damage occurred in the past year as a result of wave action generated from strong southeast winds. He also noted that the ramp is not usable low water, and pointed out that the ramp had been constructed without riprap protection.

The boat launch at the Dunlevy site is directly exposed to waves that may be generated by southerly winds in the Peace Arm and within Dunlevy Inlet itself: there is a direct line of sight from the boat launch to the south shoreline of the Peace Arm. This supports the boaters' opinion that wind-generated waves at high water are the likely cause of the erosional problems. However, there may be additional geotechnical issues at the site.

- There is visible ongoing erosion at the toe of the bluff at low water and associated slumping. This is the likely cause of the access problems at low water.

- The bank immediately south of the boat launch ramp is in an area much more protected from south winds, with no direct exposure to the Peace Arm. However, this area appears to be in a very similar condition to the bank at the ramp. If the bank erosion were entirely due to wind-driven waves, it would be expected that the west-facing bank would show much less erosion than the south-facing boat launch.

It is possible that bank erosion mechanism is related to geotechnical issues such as steep slopes, in addition to erosion by wind-generated waves. A review of this site by a licensed geotechnical engineer is recommended before any detailed design work on a new boat launch is performed.

Dunlevy Alternative Sites – East Side of Dunlevy Inlet

The project team investigated potential alternative sites from the waterside (by boat) as well as from the landside. There was a preference for alternative sites on the east side of Dunlevy Inlet, since that area is generally within Butler Ridge Provincial Park and therefore land use was expected to be consistent with a new ramp location. However, as described below, the project team was unable to identify an alternative location on the east side that was clearly preferable to the existing location. A location on the west side of Dunlevy Inlet was identified as possible. The possibility remains of upgrading or moving the boat launch ramp within the context of the existing upland area (i.e., a more minor relocation).

From the waterside, the project team initially sought potential sites on the east side of Dunlevy Inlet that appear to experience significantly less erosion on the upper bank, or that have other features that indicated less erosion. One site south of the existing boat launch ramp was identified as being possibly accretional. However, the sediments at this location were very soft and unsuitable to support a boat launch ramp.

North of the existing boat launch ramp, the shoreline remained fairly consistent and similar to that at the existing boat launch ramp. There was one site that did exhibit less erosion at the upper bank. However, the upland area had much higher relief compared to most of the surrounding area, and also showed evidence of a creek or other runoff. The drawbacks in the upland area at this site made it unsuitable for a boat launch facility.

Near the north (upstream) end of Dunlevy Inlet, the shoreline becomes rocky and unsuitable for construction. Dunlevy Creek is at the head of Dunlevy Inlet, and is accessible by road. The creek itself is shallow and unsuitable for launching boats.

Dunlevy Alternative Site – West Side of Dunlevy Inlet

Given a lack of suitable alternative sites on the east shore of Dunlevy Inlet, the project team investigated the west shore. There is a gravel road along both shores. The road is in good condition (including a new bridge over Dunlevy Creek). Although a sign warns that this road is not maintained past the turnoff to the existing site, it is likely that it will continue to be maintained to allow access to the Torwood Resort.\

One site was identified that is significantly less erosional compared to the majority of Dunlevy Inlet. The site is sheltered from the south by the general alignment of the shoreline and inlet. While there is erosion at the upper bank, this is much less rapid

compared to sites on the west bank of Dunlevy Inlet, as indicated by fact that trees affected by erosion appear to have been dead for some time. The shoreline has a much less steep slope compared to the typical condition on the west bank, which may make low water access easier to achieve. Substrates at the site were generally similar to those at the existing site. The upland area is wooded but appears to have a generally manageable relief.

Users would need to drive approximately 7 km further to reach this site, compared to the existing Dunlevy site.

Land ownership at this site is not certain, although it seems unlikely to be private. The Online Cadastre of British Columbia[5] does not show any ownership or ownership type at the site. In contrast, the Online Cadastre does show the private ownership at the Torwood Resort and other areas on the southeast side of Dunlevy Inlet. The iMapBC GIS system[6] shows that most of the west side of Dunlevy Inlet is subject to licenses of occupation for *Summer Extensive Use* and *Winter Extensive Use* for commercial recreation. This suggests the land tenure would allow for a new boat launch ramp in the vicinity, but this must be verified. The land ownership must be definitively identified if this site is to be considered further.

Elizabeth Creek

The Elizabeth Creek site is located on the south side of the Williston Reservoir, Peace Arm, close to the WAC Bennett Dam. Access to the site is over the dam and down a well-maintained gravel road.

The upland area at the site is limited. The road that provides direct access to the site has been widened to allow parallel parking. A similar parking area is available uphill, on a road parallel to the main access road. Pit toilets are provided at this second parking area. The high relief at this site makes the provision of any further parking area difficult.

The concrete boat launch ramp is in good condition, with only minor spalling in a few locations. A low riprap breakwater protects the ramp over most of its length. There is minor evidence of sedimentation (pea gravel) on the inner side of the breakwater near the bottom of the ramp.

The topography adjacent to the ramp itself is very steep, more so than in the general upland area. The slope immediately adjacent to the ramp is protected by riprap.

Most of the upper slope is rocky, with minor erosion at the top of the bank.
The need for upgrades at the sites was not immediately obvious from the site visit. Later discussions with boat users[3] indicated that the problem was associated with high waves at the site, particularly at low water. This is consistent with the general exposure of the ramp, and the presence of the (rather low-crested) breakwater. It would also be desirable to have a dock at which launched boats could be tied up.

Halfway River Existing Site

The Halfway River existing site features a boat launch area immediately south (downstream) of the Highway 29 bridge over the Halfway River, on the east bank. The site is approximately 40 km from Hudson's Hope and 50 km from Fort St John,

directly between the two locations. Access to the site from Highway 29 is via a short gravel road, which connects directly to a turnaround and to the launch ramp access.

The water level at the site was unusually high (approximately 433 metres relative to geodetic datum at the 97th percentile) at the time of the site visit. The water was also unusually turbid. Consequently, the physical condition of the boat launch ramp could not be investigated as part of the reconnaissance survey. Information was obtained from BC Hydro staff, boat users, and the underwater contours from the hydrographic survey.

The launch ramp is located adjacent to the riprap protection for the Highway 29 Bridge over Halfway River. According to BC Hydro staff, it is often necessary to clear riprap that has fallen onto the ramp during the winter. The river is often frozen during winter.

There is a sandbar that lies generally shore-parallel, starting at the central bridge pier and connecting to the logjam south of the boat launch.

Generally, it is preferable for ramps to be oriented such that vessels are launched in the downstream direction rather than the upstream direction. At this site, the water depth in the downstream direction is too shallow to make this feasible without dredging. According to Mr. David Woinarski of Landsong Heritage Consulting, the water level can be lower in the afternoon than in the morning. Boaters unfamiliar with the site are sometimes caught on this sandbar on their return.

Parking at the site is limited to the turnaround area and the approach to the old Highway 29 Bridge. According to Mr. Woinarski, the parking and turnaround area are occasionally backed up with traffic; more parking would be needed if the boat launch were improved. One boater encountered by the Project Team in Hudson's Hope commented that she would use the boat launch more often if the approach were not as steep.

An additional amenity offered by the site is a gravely beach, suitable for picnicking, located south of the boat launch.

Advantages of the site are:

- Very easy access from Highway 29;
- The existing access road is in good condition, although the approach to the ramp is very steep (up to 18 percent);
- The site is protected from the highest currents by the bridge pier; and,
- The site is protected from winds by the topography.

Disadvantages of the site are:

- Dredging will be necessary to provide sufficient water depth for year-round launch, although dredge quantity would be minimal and it seems likely the maintenance of the dredged area could also be minimal;
- The upland area is relatively high relief, and there is limited level area available for additional parking; and,
- Halfway River is often blocked by ice during the winter.

Halfway River West Bank Site

The Halfway River West Bank site is located directly across from the existing site. Access from Highway 29 is available along a good-quality gravel road, a distance of approximately 270 metres.

With the exception of this road, and the remains of the approach to the old Highway 29 bridge, this site is essentially undeveloped.

Based on the online cadastral map obtained from the BC Ministry of Agriculture and Lands web site, the area south of Highway 29 is designated Crown Lands.

The shoreline at and immediately south of the bridge is a steep, riprap-protected bank.

Moving further south, a low, soft bluff is present. Starting approximately 50 m south of the bridge, a flat sandy beach is present; this beach was not visible during the initial site visit because of the high water level). The area near the sandy beach is not suitable for a boat launch ramp, since the water remains shallow for a long distance from shore, and the physical works required to overcome this would affect the valuable shoreline habitat downstream.

However, a new launch ramp could be constructed at the southern boundary of the riprap. This ramp would be similar to the existing ramp, except that it would be aligned more directly into the flow of the river.

In contrast to the existing site, there is no readily accessible beach and picnic area. The sandy beach is relatively low and accessed over a low bluff (typically 1.5 to 2 metres high).

Advantages of the site are:

- Easy access from Highway 29;
- The existing access road is in good condition;
- There is a large area available for parking and other upland development; and,
- The site is protected from winds by the topography.

Disadvantages of the site are:

- Dredging would be necessary to provide sufficient water depth for year-round launch, would be more extensive than at the existing site, and could be difficult to maintain;
- Halfway River is often blocked by ice during the winter; and,
- Picnic or other public areas would not provide easy access to the water without additional physical works, and a wide beach area is not available.

If it is desired to develop this site, it would be necessary to carefully examine the potential for adverse effects on the downstream habitat. It may also be necessary to provide additional shore protection armouring, or to set the parking and turnaround areas back from the river to provide stable bank.

Peace River Site near Confluence with Halfway River

The Peace River site is located approximately 1 km upstream of the confluence with Halfway River. Access to the Peace River site is along an unimproved, single-lane

track and the cost associated with improving this track to provide adequate boat launch access is likely to be the main barrier for developing this site. Based on the online cadastral map obtained from the BC Ministry of Agriculture and Lands web site, the area between the proposed site and Highway 29 is designated Crown Lands.

The shoreline at the site is characterized by a soft, low bluff (typically 2 to 3 m tall) fronted by a narrow, mixed sand and gravel beach. The upland wooded area has a relatively high relief. A low lying marsh area is located on the west side of this channel. These areas have high habitat value and are at too low an elevation to be feasible for upland infrastructure such as parking: consequently, the proposed boat launch ramp and associated works would be confined to the area east of the blind channel.

The upland areas are heavily wooded and have relatively high relief.

Advantages of the site are:

- There is sufficient water depth for year-round boat launches;
- There is a large area available for upland parking and other development;
- Water level fluctuations and currents associated with rainfall run-off are less dramatic compared to the Halfway River sites;
- The boat launch ramp will rarely be blocked by ice during the winter; and,
- There are significant interpretive opportunities associated with the adjacent wetland area and blind channel.

Disadvantages of the site are:

- Additional shore protection armouring may be required upstream and downstream of the potential boat launch ramp location to maintain stable bank. It is recommended that a hydraulic model and analysis should be done at the design stage to ensure bank stability;
- The site is more exposed to winds compared to the Halfway River site; and,
- Significant expense would be associated with the construction and maintenance of an access road to the site, and other new infrastructure.

Blackfoot Park Site

The existing boat launch ramp at Blackfoot Regional Park is located close to the Alberta border, and is immediately downstream (east) of the Clayhurst Road Bridge.

The water level at the site was unusually high at the time of the site visit on August 14, 2008 (approximately 384.5 metres relative to geodetic datum and 93rd percentile). As a result, it was not possible to assess the condition of the boat launch ramp during the reconnaissance survey. The upper portions of the boat launch ramp appeared to be in good condition, little scour was evident in the exposed portion of the ramp.

The park infrastructure is extensive and includes camping and picnic areas in addition to the concrete boat launch ramp. Access to the boat launch ramp is over a well-maintained gravel road, while the turnaround and parking area at the ramp has a sandy surface.

The riprap slope protecting the bridge abutment has lost several rocks, although the remainder of sections of the slope and the exposed geotextile are in good condition.

Signs posted at the site indicate that the boat launch is currently closed. Discussions with Joan Dickinson, a relatively regular visitor to the site, indicated that the boat launch is closed because of concrete debris on the ramp. More generally, she and her family have indicated that the concrete ramp is in poor condition. Ripples in the water over the ramp support the presence of debris over the ramp.

A sandy track runs east from the boat launch site. During the site visit, this track terminated in the water. However, during more normal water levels it appears that the track reconnects to the main park road forming a loop. Mrs. Dickinson indicated that the logjam, visible in varies in extent according to recent flows but often extends most of the way to the bridge.

Based on the headway made by the survey vessel, the current in the river was estimated at approximately 2.5 m/sec (4.9 kts) during the site visit.

Due to the flat topography and shallow water east of the site in the area no suitable boat launch areas were found in the park downstream of the site.

Additionally, the logjam would form a barrier to boat access when it is in a relatively large configuration. Similarly, no suitable areas were observed upstream, and it would be undesirable for park users to be required to cross over Clayhurst Road to use the ramp.

Consequently, no alternative sites were investigated in detail.

The existing site has many advantages:

- Easy access from Clayhurst Road;
- The existing access road is in good condition;
- There is sufficient water depth for year-round launch;
- There is good upland infrastructure in Blackfoot Regional Park; and,
- If desired, there is ample space to increase parking at the boat launch ramp.

The main disadvantage of the site appears to be occasional high currents, which have damaged the riprap slope. The concrete boat launch ramp may have suffered direct damage from falling and tumbling riprap or other debris; it may also have suffered indirect damage from scour caused by the high currents. However, both of these problems can be overcome through appropriate engineering of the riprap, ramp, and scour protection.

5.1.12.3 Status

This project is complete.

5.1.13 GMSWORKS#14 – Williston Air Photos and DEM

Order clause: Schedule A 3(d)

BC Hydro Project Manager: Karen Skibo

5.1.13.1 Overview

Project Objective: The objective of this project is to (1) conduct a mapping inventory to compile a bibliography of all existing maps of Williston Reservoir, (2) acquire aerial photos of Williston Reservoir at low pool in 2009 and develop a bare earth digital elevation model, and (3) acquire aerial photos of the Williston Reservoir in 2013 and 2018 and re-compile the DEM based on new data.

This project is designed to support the Williston Reservoir management plans. Specifically, this project will provide spatial data and information to support projects within the Riparian and Wetland Habitat, Tributary Access, Dust Control, Erosion Control, and Access, Navigation and Safety Management Plans.

Project Description: In 2009/10, a bibliography of existing maps was developed and aerial photos will be acquired at 1:5000 and 1:20,000 for the entire reservoir. A digital elevation model (DEM) will also be developed based on LiDAR. In 2013 and 2018, new air photos will be acquired at targeted WUP sites at a scale of 1:5000 and of the entire reservoir at 1:20000. The DEM will also be updated at that time.

Contractor: This work is being conducted by Groupe Alta.

ToR Status: No changes.

5.1.13.2 Contractor's Report

The contractor's report for 2010 is outstanding.

5.1.13.3 Status

The first stage of work was initiated in April 2009 and completed in December 2010. A final report for this stage is expected. The second set of air photos occurs in 2013 and the third set in 2018.

5.1.14 GMSWORKS#16 – Williston Wetland Inventory

Order Clause: Schedule A clause 2(a)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.14.1 Overview

Project Objective: The objective of this physical work is to inventory wetland habitats in areas that may be dewatered for long periods in order to later improve reservoir habitat and increase the utility of the drawdown zone for some wildlife and fish species. Wetlands are often considered one of the most productive habitats types in the temperate region and are one of the habitat types that are significantly impacted when reservoirs, such as Williston, are created by flooding large valleys. This project is for the feasibility / inventory work only.

Project Description:

- Compile a list of candidate sites, adjacent to the Williston Reservoir, which would be useful for the creation of permanent or ephemeral wetland habitats following some physical works modification.

- Describe the biophysical characteristics (including a map) of each site such that they can be suitably ranked on the basis of:
  - Area of inundation potential,
  - Wildlife and fisheries benefits,
  - Overview environmental and archaeological assessments of the sites,
  - Accessibility,
  - Capital cost of the physical works required,
  - Projected maintenance costs (debris management, erosion control), and
  - Ancillary benefits for all stakeholders and First Nations
  - Rank the candidate sites.

Contractor: This work is being conducted by Golder and Associates Ltd. Golder has conducted similar work for BC Hydro on other systems.

ToR Status: In January 2010 the CWR approved a resubmission of the GMSWORKS#16 ToR with updated project implementation costs. The project complies with the revised ToR; no further resubmission is anticipated at this time.

5.1.14.2 Contractor's Report

Golder Associates Ltd. (Golder) was retained by the British Columbia Hydro and Power Authority (BC Hydro) in May of 2009 to conduct a survey of wetlands within Parsnip Reach of the Williston Reservoir (GMSWORKS 16).

The purpose of this project is to identify options for creation of perched wetlands as identified by PWUP 2003. In creating such perched wetlands, it is anticipated that enhancement of habitat will occur to improve fisheries and wildlife resources while also improving riparian habitat along the foreshore of Williston Reservoir. An ancillary benefit of creation of wetlands would be one of dust control as is presently being studied through ongoing work in the Finlay Reach.

Ultimately, the results from the present study and this associated report are to identify potential Demonstration Projects which BC Hydro can consider for trial construction of wetlands in the Parsnip Reach of Williston Reservoir. In addressing this goal, 42 potential candidate sites were surveyed in mid June throughout Parsnip Reach by a Golder team consisting of a biologist, archaeologist and geotechnical engineer. Part of the background in selecting sites included a review of available orthophoto data for the Parsnip Reach and interviewing individuals with experience working in the reservoir. This desk top overview included a brief literature review of pertinent reports and documentation from the Peace/Williston Fish and Wildlife

Compensation Program (PWFWCP), Ducks Unlimited Canada (DUC), and BC Hydro.

Regulatory requirements necessary to consider in the construction of wetlands are also identified in this report. These requirements include those for the *Federal Fisheries Act*, the *Navigable Waters Protection Act* and the *Species at Risk Act* as well as provincial regulations such as the *Water Act* and the *Wildlife Act*. Results from the surveys of sites are discussed relevant to biological, geotechnical and archaeological considerations, and summarized in a Site Catalogue. The Site Catalogue documents information required when considering constructing a wetland, and includes photographs for each of the surveyed sites. Additionally, an analysis of historical reservoir levels was completed identifying the average number of days the Williston Reservoir exceeds elevations (in 1 m increments) on a monthly and annual basis. This task was included since it is pertinent to issues of functionality of constructed wetlands prior to inundation by the reservoir.

The historical water level analysis is also relevant to issues of durability of prescribed treatments due to scour from wave action, as well as from rafted debris and ice which may come into contact with prescribed treatments.

Part of the process of recommending candidate sites for Demonstration Projects required a prioritization of those surveyed. This process involved summarizing the results of the surveys in the Site Catalogue into tabular form.

Key data pertaining to access and exposure of surveyed sites, and the anticipated costs to complete proposed treatments at these sites were summarized into a table and then sorted based upon a point system assigned to these key data. Through this process, five candidate sites were selected for consideration as Demonstration Projects. These sites include Site 6-2 (Airport Lagoon), Sites 15 and 16 (Unnamed sites), Site 34 (Beaver Pond) and Site 37 (Tony Creek).

These five sites represent a diversity of treatment options and locations as described in specific descriptions for each site. The prescription for Site 6-2 recommends raising a culvert to maintain minimum water levels in a large lagoon. Site 15, 16 and 34 indentify embayments where small dikes could be constructed to impound water to create permanent wetlands. Site 37 identifies an opportunity to elevate land as a means of providing a platform for growing, stabilizing and proliferating riparian vegetation.

Site descriptions for each candidate site proposed as a Demonstration Project(s) include identification of the location and attributes of the site. These site descriptions also summarize the following additional information:

- proposed treatment(s) and objectives;
- rationale for selection;
- targeted benefits to wildlife and habitat;
- likelihood of success, risks, potential impacts and maintenance issues;
- requirements for additional work;
- estimated costs; and
- regulatory requirements.

Treatment options are further discussed relevant to the type of structures being prescribed, including concepts for stabilization through incorporating vegetation and bioengineering into the structure as well as by engineered design of the structure. Recommendations for sites relying on traditional dikes to impound water include structures with low slopes (4H:1V or greater), incorporation of woody debris to act as revetments and/or break waters and capping the structure with gravel/cobble sized materials. The option of using a geotextile product called a MacTube™ is also discussed as another technique to build a dike.

Finally, a number of additional recommendations are made that suggest a step wise process towards construction of the Demonstration Projects. These include the need to consider adaptive management as a tool to measure the success of proposed treatments. Also, co-ordination of the goals and objectives of GMSWORKS 16 with other work BC Hydro is presently completing in the Williston Reservoir and information from similar work in other BC Hydro reservoirs will contribute to the success of trial demonstrations of wetland initiatives in Williston Reservoir.

5.1.14.3 Status

This project is complete.

5.1.15 GMSWORKS#17 – Williston Trial Wetlands

Order Clause: Schedule A clause 2(a)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.15.1 Overview

Project Objective: The objective of this physical work is to create wetland habitats in areas that may be dewatered for long periods in order to improve reservoir habitat and increase the utility of the drawdown zone for some wildlife and fish species. Wetlands are often considered one of the most productive habitat types in the temperate region and are one of the habitat types that is significantly impacted when reservoirs, such as Williston, are created by flooding large valleys.

Project Description:

- Design
  - Develop a preliminary engineering design for candidate wetland sites selected in GMSWORKS #16.
  - Develop a final engineering design for each candidate wetland site selected in GMSWORKS #16.
- Construction
  - Implement the engineering design.
  - Develop an annual maintenance schedule, as-built drawings, site map, landscape scheme, and vegetation list for each constructed site.

Contractor: This work has not started and has not been awarded.

ToR Status: In January 2010 the CWR approved a resubmission of the GMSWORKS#17 ToR with updated project implementation costs. The project complies with the revised ToR; no further resubmission is anticipated at this time.

5.1.15.2 Status

This work has not started. It is currently planned to begin in 2011.

5.1.16 GMSWORKS#18 – Williston Debris Field Survey

Order clause: Schedule A 3(c)

BC Hydro Project Manager: Karen Skibo/Stuart McGregor

5.1.16.1 Overview

Project Objective: The objectives of the Williston Debris Field Survey are to collect baseline information on volume of debris within the reservoir and recruitment of debris to the reservoir, as well as to develop a management strategy for debris. The volume and recruitment data will be used together with the data collected as part of the Williston Debris Trends monitoring program (GMSMON#16) to assess the effectiveness of the Williston Targeted Debris Management Project (GMSWORKS#22) at removing debris. The debris management study will provide an overall strategy for debris management on Williston Reservoir for the next 10 years.

Project Description: The debris field survey entails map and air photo review and ground-truthing to develop an estimate of the (i) debris volume, (ii) sources of recruitment, (iii) rate of recruitment to the reservoir from known sources, and (iii) potential wood value categories of the debris. The debris management study will assess the cost effectiveness and feasibility of alternative means of debris control/management methods, develop an inventory of suitable sites for handling debris, and recommend a strategy and schedule of operations based on study findings and management priorities.

Contractor: This work is being conducted by AECOM Canada Ltd.

ToR Status: In January 2010 the CWR approved a resubmission of the GMSWORKS#18 ToR with updated project implementation costs. The project complies with the revised ToR; no further resubmission is anticipated at this time. There is currently a financial variance, a plan is in place to address this variance — see Table 6.1 for details.

5.1.16.2 Contractor's Report

Williston Reservoir is located in north-eastern British Columbia within the Mackenzie River Basin. Large volumes of woody debris within the reservoir create ongoing challenges for operation of the reservoir and for recreational and community users.

Little is known about the sources of debris, how much there is, and what it could be used for. This report constitutes the first step at addressing these issues; it contains three main sections:

- estimation of existing debris volume within the reservoir;
- identification of the various sources of debris and their relative contribution to the total debris volume; and
- recommendations on what the debris could be used for.

The current accumulation of woody debris within the reservoir is significant. Debris covers approximately 5,760 ha (about 4 % of the surface area) of the reservoir. The total volume of wood debris in the reservoir is approximately 1.3 million m^3. In June 2009, the vast majority of wood debris (88 %) was stacked up in ribbons and piles along the high water mark. At that time, the reservoir was approximately 10 m under the high water mark.

The distribution of debris is detailed below.

Total volume of woody debris on Williston Reservoir in June, 2009

Reservoir Sector	Debris Categories					Total (m^3)
	Ribbons and piles (m^3)	Floating (m^3)	Scattered (m^3)	Log boom loses (m^3)	Timber not cleared prior to flooding (m^3)	
Peace Arm	**54,425**	**--**	**60**	**400**	**1,190**	**56,075**
North	27,985	--	45	400	680	29,110
South	26,440	--	15	--	510	26,965
Finlay Arm	**714,100**	**10,830**	**6,730**	**3,900**	**68,765**	**804,325**
East	384,140	1,410	4,250	900	30,040	420,740
West	329,960	9,420	2,480	3,000	38,725	383,585
Parsnip Arm	**367,965**	**13,230**	**4,070**	**5,600**	**35,305**	**426,170**
East	120,710	13,050	390	2,500	10,340	146,990
West	247,255	180	3,680	3,100	24,965	279,180
Total	**1,136,490**	**24,060**	**10,860**	**9,900**	**105,260**	**1,286,570**

Potential Sources of Debris and Recruitment Rate

In the future, several potential sources of debris may contribute to increasing woody debris in the Williston Reservoir and all have been examined. Several of these sources including blow down, windfalls, lost log from log storage or boom transport , slope slippage, land slippage on over steepened slopes, slides in forested terrain all are insignificant contributors to the volume of woody debris in the reservoir at present. We have also concluded that while there are numerous stands of submerged trees in the reservoir these are now likely less buoyant and will decay and lay down on the reservoir floor below the low water line and thus do not contribute to exposed debris volumes or result in navigational issues. This study has concluded that these are not likely to be the main source of debris in the future.

In the future two main sources of wood debris that are likely to continue to contribute woody debris to the reservoir are:

- Shoreline erosion - Shoreline erosion is very active in the Williston Reservoir. Eroded banks border approximately 60 % of the reservoir (1,320 km/^{2},148 km). The annual shoreline retreat was established at 1.0 m, which represents an area of 132 ha. A mean volume of 100 m^3/ha was used to establish the volume of debris. Based on this hypothesis, the annual recruitment rate of debris is established at 13,200 m^3. It is important to note that at any given location, the variation can be extreme.

- Tributary streams - About 50 tributaries has been identified as a potential source of debris. Woody debris present in these streams result mainly from the erosion of the stream banks in the immediate vicinity of the mouth of the crick where the banks consists of erodible material. The annual recruitment rate of debris is established at 2 000 m^3.

The "recruitment rate" for the various sources of woody debris in terms of volume/annum is small in comparison to the volume of woody debris that has accumulated in the reservoir over the past 50 years. How long the wood debris stays mobilized in the reservoir has not been answered by this study and it may make little difference from a management standpoint, we do understand from the debris condition that it is many years. It is clear that to reduce the volume of woody debris in the reservoir it must be stabilized in place or removed before a noticeable decrease will be observed.

Physical Wood Quality

Despite the relatively large volumes of debris in the reservoir, the opportunities for recovery are limited and the choice of recovery strategies must be the result of operational, technical and financial analysis. That will be a focus of the management plan in the next phase of this study.

Within the framework of sampling work done in the field, a number of parameters were measured and/or assessed on the logs to determine the commercial potential of woody debris in the reservoir. The result was that the diameter and length of the debris logs is extremely variable. The absence of bark and branches and large cracks on the majority of the logs studied indicate that this debris has been subjected to deposition and floatation for several years and, therefore, the physical and chemical characteristics of these logs may have been modified. The presence of roots and stumps at the ends of approximately 25 to 30 % of the logs indicates that many will require cutting before transport.

Potential uses for this quality of wood include control of erosion, habitat creation for fish and wildlife and energy production.

5.1.16.3 Status

This work was initiated in April 2009 and is scheduled to be completed by December 2010. A report for the debris field survey has been received and a report for the debris management study is expected in December 2010.

5.1.17 GMSWORKS#19 – Williston Reservoir Trial Tributaries

Order Clause: Schedule A clause 2(b)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.17.1 Overview

Project Objective: The overall objective of this physical work is to improve or restore the access to rivers that are tributary to Williston Reservoir. A build-up of debris or seasonal water level fluctuations may compromise access at the mouth of the tributary. The first phase of this project will inventory tributaries impacted by reservoir operations and/or debris fields.

Project Description:

- Inventory
  - Develop an inventory of tributaries impacted by reservoir operations and/or debris fields.
  - Rank these tributaries based on biological impact, mitigation costs and application to other programs.
  - Develop a plan for the removal, on site disposal, or management of any debris accumulations that are limiting tributary access.
  - Create an annual debris management plan and maintain tributary access for five years.
- Implementation
  - Produce a pre-construction report that outlines potential construction techniques.
  - Remediate of access at two Tributary sites.
  - Produce an end-of-project report.

Note: This project is for feasibility only.

Contractor: This work is being conducted by Synergy Applied Ecology Ltd. (SAE). SAE has conducted similar work for other clients in the past.

ToR Status: In January 2010 the CWR approved a resubmission of the GMSWORKS#19 ToR with updated project implementation costs. The project complies with the revised ToR; no further resubmission is anticipated at this time.

5.1.17.2 Contractor's Report

Acting on the recommendations of public consultation, the Planning Committee for the Peace Project Water Use Plan (WUP) recommended a number of operational and non-operational initiatives focused on increasing access and use of water resources throughout the Williston Reservoir watershed while still allowing for the

normal operation of existing hydroelectric facilities on the Peace River, northern British Columbia (B.C.) (BC Hydro 2008a). One of these initiatives is focused on facilitating improved fish access into direct tributaries of the Williston Reservoir affected by seasonal water level fluctuations.

Large woody debris (LWD) introduced from reservoir development and active shoreline erosion is mobilized at high water levels and deposited on shore during drawdown. In natural systems, LWD is an important functional component of fish habitat. Although the potential for LWD to result in a physical barrier that is impermeable to fish is likely low, LWD in reservoirs can have a scouring effect on shoreline substrates that increases sedimentation, limits vegetation growth, and erodes stream channels in reservoir drawdown zones. Normal reservoir operations also have the potential to effectively disconnect the tributary from the reservoir during the low water drawdown period, when stream flow into the reservoir may become shallow and braided across the exposed reservoir floodplain. Additional hindrances to fish passage are the lack of cover and habitat complexity in drawdown areas, rendering migrating fish susceptible to predation from piscivorous fishes and avian predators. These factors are exacerbated when reservoir water levels are lowest.

Large rivers with high discharge rates and typically wide, deep channels are much less affected by reservoir water level fluctuations due to the scouring power of high volumes of flowing water allowing them to sufficiently erode through the floodplain and maintain the predictable channel characteristics of natural, upstream reaches. The power of these systems also renders them less susceptible to LWD accumulation by forcibly transporting woody debris or scouring underneath or around the obstruction. However, reservoir drawdown and LWD aggregation may have significant impacts to small to mid-size streams that lack the discharge-dependent power to overcome the resistance to move in-stream objects and maintain channel structure across the drawdown zone.

Fishes evolve behaviour and life history characteristics that maximize fitness by ensuring they will be in the best habitat to fulfill requisite life cycle objectives. If the physical environment changes, it may cease to provide favourable conditions or resources required. Effective management strategies recognize that species depend not only on a matrix of suitable habitat, but on the availability of certain habitats in the right place at the right time (Naiman and Latterell 2005). Reservoir drawdown may impact mature, adfluvial early-spring spawning fish, such as grayling and burbot, that encounter barriers as they migrate to natal streams due to low discharge and water depth before the onset of spring freshet. Further, young of the year fall spawning fish, such as bull trout and kokanee, may suffer the same physical barrier during emigration to reservoir rearing habitats in late-winter, low-flow periods.

Many of the rivers and streams draining into Williston Lake are under-populated with fish species. Fish distribution and demographic trends since initial impoundment in the early 1970's have shown an increase in the proportion of fishes adapted to lacustrine habitat while riverine adapted fishes have declined (Langston and Blackman 1993). Regionally significant fish species such as Arctic grayling (*Thymallus arcticus pop.1*), bull trout (*Salvelinus confluentus*) and kokanee (*Oncorhynchus nerka*) have responded differently to habitat alteration. Bull trout, blue-listed in B.C. (MoE 2009), are reported to have shifted habitat preference and are successfully utilizing the Williston Reservoir for forage where they feed primarily

on lake whitefish (*Coregonus clupeaformis*) and kokanee (Blackman *et al.* 1990; Stewart *et al.* 2007). Grayling, and mountain whitefish (*Prosopium williamsoni*), have suffered drastic population declines since the early 1980's when stocks were reported healthy in the reservoir and its tributaries (Northcote 2000; Blackman 2001). Grayling now appear to be restricted to a small number of watersheds above the W.A.C. Bennett and Peace Canyon Dams and are estimated to be less than 1% of their original population (McPhail 2007). As a result, the grayling (population 1) is red-listed in BC (B.C. Minist. of Environ. Victoria 2009) and requires considerable attention to support recovery of the population. Arctic grayling depend on the lower reaches of larger mainstem rivers or the reservoir embayments that these watercourses empty into for adult rearing habitat (Clarke *et al.* 2007; McPhail 2007).

The Peace/Williston Fish and Wildlife Compensation Program (PWFWCP) has collected a large body of data relevant to the perceived tributary access impacts to native fishes linked to reservoir development since the program inception in 1988 and a significant amount of resources have been expended to develop potential compensation solutions since the creation of the reservoir, but as of yet little work has been done implementing previously proposed mitigation recommendations (Langston 1992; Fielden *et al.* 1993; Langston and Blackman 1993; Morgan 1995; Aquatic Resources Limited 2002).

This report attempts to reconcile previous recommendations with a practical and thoughtful approach to designing an experimental trial using proven mitigation and restoration techniques to improve fish access to affected tributary systems. Although we are not aware of any previous examples of similar remediation projects implemented in reservoirs elsewhere, the designs we recommend have been successfully implemented in many stream mitigation and restoration projects and follow recognized hydrologic design principles (Newbury and Gaboury 1993).

Specifically, our objectives are to improve or restore fish access to fluvial habitats isolated by LWD accrual and /or drawdown effects resultant from normal reservoir operation, with a focus on increasing access to available habitat of listed and regionally significant fish. This report discusses:

- Inventory and ranking of candidate tributary sites
- Biophysical description of 2 sites recommended for trial mitigation
- Conceptual design recommendations for mitigation works to restore access and improve fish habitat at tributary mouths by rehabilitating channel characteristics at elevations between the low and high water levels:
- Management / maintenance plan for physical works
- Cost estimate for proposed physical works

5.1.17.3 Status

This project is complete.

5.1.18 GMSWORKS#20 – Williston Dust Mapping

Order clause: Schedule A 3(a)

BC Hydro Project Manager: Aaron Flett

5.1.18.1 Overview

Project Objective: This is a feasibility study to assess the practicality of using satellite technology to predict dust emission potential based on soil characteristics of Williston beaches. The outcome, if the study is successful, is a reliable management tool for predicting in near real-time which beaches are likely to erode and allow fast response and treatment of those areas to minimize dust emissions. The four principal objectives of the study are:

1. Assess the ability of satellite technology to predict near surface soil moisture and surface roughness, which critically control the wind erosion threshold, at appropriate spatial and temporal scales on a representative beach;

2. Assess the ability of satellite technology to differentiate the textural characteristics of the surface sediments;

3. Characterize the wind erosion threshold and dust emission potential of selected beach surfaces and evaluate the relationship between those measurements and the satellite signals for soil moisture, roughness, and texture; and

4. Develop a preliminary near real-time algorithm to predict potential dust emission for typical wind speeds at Williston Reservoir based on weekly satellite scenes.

Project Description: The project entails (i) conducting a field soil survey on a select beach in Finlay arm, (ii) estimating the threshold velocity required to entrain sediment and PM_{10} concentrations at the sampling locations, (iii) acquisition of at least four satellite images and evaluation of available models to determine the most promising technique for assessing surface texture, roughness and moisture, and (iv) incorporating the data into a wind erosion model that will detect areas of potential high erosion.

Contractor: This work is being conducted by Dr. William Nickling of the University of Guelph and Dr. Jack Gillies of the University of Nevada.

ToR Status: A ToR resubmission was approved in March 2009, and again on April 22 2010 with respect to required changes to scope and budget. Presently, scope, schedule, and budget are in compliance.

5.1.18.2 Contractor's Report

Controlling dust emissions of particulate matter ≤10 µm (aerodynamic diameter, i.e., PM10) from beaches that are exposed around the Williston Reservoir after the annual draw down of water is an engineering challenge. Part of that challenge is to identify which beaches or areas of specific beaches should be targeted for control based on their susceptibility to wind erosion due to environmental factors (e.g., weather, drying conditions, etc.) as well as the potential strength of the dust

emissions. The strength of the dust emissions will be a function of the availability and amount of PM10 in the beach sediments (a function of sediment texture) and the strength of the wind. Having the ability to identify, in advance, areas that should be prioritized for treatment could result in significant cost savings for mitigation to reduce the contributions of PM10 from these beaches that affects local and regional air quality.

This project was undertaken to assess the feasibility of developing a model system that would identify the emission potential of beaches around the Williston Reservoir, which could lead, in the future, to a system capable of providing information on the emission potential of the beaches through time and as a function of environmental conditions. Such a modeling system could form the basis for strategizing when and where to apply dust control measures to maximize the investment on reducing the PM10 concentrations that impact the local and regional environment, while saving costs related to mitigation efforts.

The primary objectives of the study were to:

1. assess the ability of remotely-sensed data from RADARSAT-2 to predict near surface soil moisture and surface roughness, which critically control wind erosion threshold, at appropriate spatial and temporal scales on a representative beach that has a range of surface and textural characteristics,
2. assess the ability of RADARSAT-2 and/or LandSAT to differentiate the textural characteristics of the surface sediments, which will affect wind erosion threshold and dust emission potential,
3. using a recently developed instrument (PI-SWERL), characterize the wind erosion threshold and dust emission potential of selected beach surfaces and evaluate the relationship between these measurements and the remotely sensed signals for soil moisture, roughness, and texture,
4. further develop an available wind erosion model to enable it to characterize erosion and dust emission potential using the RADARSAT-2 and LandSat-derived data, as well as the measured surface threshold and emission relationships obtained with the PISWERL for typical wind speeds at the Williston Reservoir.

This project successfully addressed the above listed objectives and produced a working dust emission model that could, with some further development, serve as the basis of a predictive system to identify beach areas at Williston Reservoir that could be prioritized to receive dust emission controls. The modeled high emission days correspond to dates where dust storms occurred as measured at the on-site meteorological tower and dust monitoring station (recorded by the Tillage Trials project), demonstrating that the model can effectively reproduce an emission event. The model uses relatively few parameters and the methodology developed to obtain these input parameters using GIS and remote sensing techniques along with a stochastic approach for assessing threshold shear velocity can be applied not only to this location in the future but to other locations as well. Model results indicate that there is a spatial distribution to dust emissions on the reservoir beaches that change as a function of the state of the input parameters. With foreknowledge of the critical input parameters the model could be run in a forecasting mode to provide a map of dust emission potential as a function of location and strength.

In addition to this accomplishment several other significant results can be identified. For regions with dated or missing surface soil data sets the Grain Size Index (GSI) approach based on use of the LandSAT data has proven to be useful to assign surface soil textual characteristics to areas.

The derivation of surface soil moisture and roughness from remote sensing is an area of ongoing research and it was demonstrated that of the three available algorithms used to estimate soil moisture from RADARSAT-2 data the method of Dubois et al. (1995) is best suited for this region.

This study also demonstrated that the PI-SWERL can be used to measure both threshold shear velocity for the onset of wind erosion and dust emission and develop the relationship between shear velocity and dust flux for sites with great economy of labour and logistics, as compared with more traditional methods such as tower-based or large portable wind tunnel measurements.

This project has demonstrated that it is feasible to operationalize a PM10 emission prediction system for the Williston Reservoir beaches, which could be used as a management tool to guide the dust control measures that will reduce the impacts of these emissions on the local and regional air quality.

5.1.18.3 Status

This work was initiated in May 2009. Additional work was needed to refine the model in summer 2010. A final report is expected for December 2010.

5.1.19 GMSWORKS#21 – Williston Dust Control Trials

Order clause: Schedule A 3(a)

BC Hydro Project Manager: Aaron Flett

5.1.19.1 Overview

Project Objective: Since the creation of Williston Reservoir, winds have picked up fine particles of silts and clays (“dust”) from the exposed drawdown zone of the Finlay arm of the reservoir. This aerial movement of particulates is of concern to residents and users of the area, particularly the Tsay Keh Dene and Kwadacha First Nations. This project will assess and validate mitigation techniques for controlling aeolian dust erosion on Williston Reservoir. The specific objectives are to:

- assess the effectiveness of tilling the beaches;
- test the feasibility of using an irrigation system;
- assess the feasibility of re-establishing vegetation in the drawdown zone;
- test different barriers for the protection of vegetation;

- investigate the optimum nutrient conditions for biostimulating the growth of native plants; and

- develop a composting process for debris.

Project Description: Strategies for reducing aeolian erosion are being assessed via the following trials:

- tillage trial sites testing response of aeolian dust concentration to different treatments of beach surface roughness;

- irrigation trial system testing response of aeolian dust concentration to an increase in beach surface moisture;

- vegetation protection trial sites that use physical barriers to prevent destruction of existing vegetation in a wetland area; and

- vegetation enhancement trials testing plant response to (i) different nutrient treatments, (2) transplant to non-vegetated areas, and (3) native grass seed dispersal in non-vegetated areas.

Contractor: This work is being led by Dr. William Nickling of the University of Guelph, Dr. William Schillinger of the University of Washington, Dr. William Fryrear, Dr. Manivalde Vaartnou and Associates, Dr. Sietan Chieng of the University of British Columbia, and Dr. Abimbola Abiola of Olds Agricultural College.

ToR Status: A ToR resubmission was approved in March 2009, and again on April 22 2010 with respect to required changes to scope and budget. Presently, scope, schedule, and budget are in compliance. An additional amendment is expected to trial more vegetation work in future years and to try other works suggested by the scientists involved.

5.1.19.2 Contractor's Report

Each year the draw down of the Williston Reservoir for the production of hydro electric power results in the exposure of approximately 10,000 hectares of wide flat beaches with surfaces comprised predominantly of fine-grained sediments. On exposure in the spring, these sediments are prone to deflation by wind, resulting in large dust storms. There is need to design, test, and implement a dust mitigation program to decrease atmospheric dust concentrations to acceptable levels. The authors of this report proposed that tillage to roughen the beach by lifting silt and clay from below the soil surface would likely provide effective dust mitigation by trapping saltating soil particles.

In May 2008, a field trial was initiated on Omineca Flats beach on the Williston Reservoir to assess the most effective tillage technique to reduce dust emissions and sand transport on exposed beaches. A replicated experiment was designed to test two tillage implements, the twisted-point chisel and lister plow, to determine their effectiveness in providing durable roughness on Williston beaches. Omineca Flats Beach was selected as the site for the 2008 tillage experiment due its elevation and

accessibility by road. As a relatively "high" beach, Omineca opens earlier and stays open longer than some other beaches, thus extending the length of the dust season.

Upon arrival at Omineca beach on May 13, we found the site to be unsuitable due to numerous exposed tree stumps that prevented establish a statistically valid field experiment due to lack of adequate space. With no other alternative, we modified the experiment by eliminating the required "buffer strips" between treatments.

Visual observation of tillage plots indicated that both the twisted-point chisel and lister plow were effective in trapping soil sediment. Neither implement was effective in deep sand pockets where silt and clay could not be brought to the surface. The twisted-point chisel proved to be the more durable of the two implements for Williston conditions because it has two flex points whereas the lister plow is of ridged design. Although statistically valid field data were not obtained from the tillage experiment in 2008, we did gain confidence that tillage is an effective method to control blowing dust from beaches.

The authors and BC Hydro personnel visited several Williston beaches by helicopter and crew boat in June 2008. Davis Flats North beach was selected for the 2009 tillage experiments. Only the twisted-point chisel will be used in the main tillage experiment in 2009. An additional experiment will be established in 2009 to determine whether the entire beach area needs to be tilled to control blowing dust or whether tilled and non-tilled alternating strips will be adequate. The new study is hereafter called the "spacing experiment". Both the twisted-point chisel and lister plow will be used in the spacing experiment.

5.1.19.3 Status

This is a three-year feasibility study. Work was initiated in April 2008 and is scheduled to be completed by February 2011. Annual reports are expected in February of each year.

5.1.20 GMSWORKS#22 – Williston Targeted Debris Management

Order clause: Schedule A 3(c) and 5(a)

BC Hydro Project Manager: Stuart McGregor

5.1.20.1 Overview

Project Objective: Woody debris on Williston Reservoir has impacts on humans, fish, and wildlife. The objective of this project is to support the implementation of other WUP projects by (i) minimizing damage to sites associated with other projects, (ii) improving boat safety, (iii) improving fish access to tributaries, and (iv) reducing shoreline erosion and destruction of riparian vegetation.

Project Description: The project entails conducting an annual aerial debris reconnaissance survey, collecting debris (on land or water) at selected sites, and managing it to prevent negative impacts to WUP projects, navigational safety, fisheries, and shorelines. Management strategies could range from removing the woody debris from the reservoir (e.g., piling above high water line) or using it in the

reservoir to create positive impacts (e.g., secured physical barriers to reduce destruction to vegetation)

Contractor: The first year of work was conducted by Chu-Cho Enterprises Ltd., a local First Nations company.

ToR Status: Presently, scope, schedule, and budget are in compliance.

5.1.20.2 Contractor's Report

The 2009 Debris Management season had a two part approach –a land based portion and a water based portion of debris management.

The land based portion of the program lasted approximately 25 days. The first portion of this was spent at Raspberry Beach. The second portion was on the Tsay Key Beach. A backup plan of Collins / Laferty Beach was used in case of unforeseen prohibitive circumstances at the priority 1 and 2 beaches.

The water based portion was of similar length in time and focused on the 'Finley Plug' which is a floating log mass historically in the North end of the reservoir. The Isola Log Dump was used as a place to dewater and store the timber for future use.

Pile size was 75 m3 per pile, or two highway logging truck loads. Production varied based on amount of debris and skid distances where required to move debris. Production reached 3 piles/day/machine, totalling 9 piles (675 m3 = 540 T) per day.

TSAY KEY BEACH PILING

Considerable skidding of logs and debris was required at Tsay Key Beach as the debris is only road accessible at one area in front of the village. The skidder brought debris to the excavators for piling. The program will consider a Forwarder for next year's operation, depending on the amount of material that needs to be moved.

COLLINS / LAFERTY BEACH PILING - ALTERNATIVE

This beach area will be an alternative in case of problems in the first two areas noted. The debris flight noted debris was abundant on these beaches and there is good road access to the beach area.

LAND BASED OPERATIONS

Timber was removed from the reservoir to be sorted and piled outside of areas that will be at risk of logs floating back into the reservoir. No burning of piled wooden debris occurred this season. Finding a use for the timber is difficult due to the fact that no sawmills or pulp mills are being operated at the current time in Mackenzie BC due to poor market conditions. Ideas for use of the debris are varied, with a clean burning electric generator being the most promising. Any additional removal of debris will not be in this plan (for example the GMS generating facility removal of floating wooden debris for safety).

Equipment: Archaeology Crew, Environmental Crew, 2 Excavators with brush rake and thumb, 1 Heel Boom loader , 1 Skidder

Start Date: May 22, 2009

RASPBERRY BEACH PILING

Millennia Research conducted a cursory review over ground to be piled. LGL worked with Millennia crews to provide an environmental assessment for each area. The intent was to avoid areas of particular environmental sensitivity, such as streams and watercourses.

Once the piling occurred, another walk of the areas affected was conducted.

Raspberry Beach area has existing road access and a former logging cutblock road parallels the reservoir in several areas. This is beneficial for future removal of piled timber by logging truck. During the flight, many piles were still on the beach area from piling years ago. These piles get wetted by the rising of the reservoir each year but have not moved. Skidding of logs to areas outside the reservoir occurred at this beach. All areas skidded were archaeologically and environmentally assessed. It is accepted that the piles will be wetted from the rising reservoir, but the debris will not return to the reservoir based on the presence of old piles that have not.

Piles were focused at or close to the existing road networks near the beach. Piles were sorted based on two categories

WATER BASED OPERATIONS

Chu-Cho employed a Tug Boat and Sidewinder to boom debris for towing to a log dump. Once the debris was at the log dump, the boom was secured and excavators removed debris from the lake to pile at site for future scaling and use.

Equipment: 2 Excavators with brush rake and thumb, 1 Heel Boom loader , 1 Skidder

Start Date: June 19, 2009

Duration: 25 days

Supervisor: Mark Dahl

FINLEY PLUG FLOATING DEBRIS

The Finley Plug was trapped in the northern end of the reservoir with a long boom of logs. This allowed the operation to continue without chasing the plug.

From the Plug, smaller booms of logs were removed to Isola Log Dump in the Ingenika Arm of the reservoir. Three Excavators were utilized to remove debris from the reservoir and pile within the log dump area. A Skidder was needed to move logs away from the Excavators and pile within the dump area. The booms were secured in the Ingenika Arm to ensure that debris remaining would be piled the following year.

The Tug operation towed much more debris than could be piled this season. The Log Dump has a scale site and area to pile debris.

Production was to be similar to ground based operations at 3 piles /day /excavator.

ISOLA LOG DUMP

Steve Rooke from the Ministry of Forests was in agreement that the Tsay Key Dene Band will be able to utilize this area with minimal permit requirements as the original owner of the dump is no longer using the area. The dump has road access and can be used as a loading area to haul debris in the future.

5.1.20.3 Status

This is a 10-year project. Work was initiated in May 2009 and is scheduled to be completed by January 2019. Annual reports are expected in January of each year.

5.1.21 GMSWORKS#23 Williston Erosion Control Trial

Order Clause: Schedule A clause 3(b)

BC Hydro Project Manager: Jay Joyner

5.1.21.1 Overview

Project Objective: This project will investigate the feasibility of erosion controls at the Tsay Keh village site and implement any chosen solution on a trial basis.

Project Description: This project has not been designed.

Contractor: This project has not been awarded.

ToR Compliance: The submission of ToR for this project is on hold pending creation of a Reserve for the Tsay Keh Dene First Nation (TKD) pursuant to an agreement between BC Hydro, the TKD, and the Province of British Columbia.

5.1.21.2 Contractor's Report

This project has not yet begun.

5.1.21.3 Status

BC Hydro, the Province of British Columbia, and the TKD have signed an agreement with respect to certain grievances of the TKD. The final agreement impacts certain changes to Indian Reserve status in the area that may impact this project. This project is on hold pending resolution of Reserve creation.

5.1.22 GMSWORKS#24 – Finlay Reach Access

Order Clause: Schedule A clause 4(b)&(c)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.22.1 Overview

Project Objective: The objective of these physical works on Williston Reservoir is to enhance recreational opportunities on the reservoir. Increasing the number of facilities and disbursing them throughout the reservoir will enhancing recreational opportunities for campers, day visitors, fishers and other recreation-focused users, allowing them to safely and easily launch boats off trailers through the range of average seasonal water level fluctuations.

One boat ramp location recommended for investigation by the Water Use Plan Committee – "Fort Ware access at the Finlay River backwaters" – was completed outside the Water Use Plan.

Project Description:

- Feasibility
  - Determine the feasibility of extending or constructing the Ingenika boat ramp and Tsay Keh Village barge landing.
  - Determine the feasibility of extending or constructing the Parsnip Reach boat ramps.
  - Evaluate the feasibility of each site in terms of engineering technical feasibility, a cost/benefit analysis, heritage values, and environmental values.
- Design
  - Design boat ramps at feasible locations.
- Construct
  - Construct boat ramps at feasible locations.

Note: This project is for feasibility only.

Contractor: This work is being conducted by Moffatt & Nichol Engineers Corporation (M&N). M&N has conducted similar work for BC Hydro on other systems.

ToR Status: In January 2010 the CWR approved a resubmission of the GMSWORKS#24 ToR with updated project implementation costs. The project complies with the revised ToR; no further resubmission is anticipated at this time.

5.1.22.2 Contractor's Report

Russell Trail Site

The Russell Trail site, also known as the Boat Landing, is an informal boat launch ramp on the Finlay River. The advantage of this site, as described by band members, is that it is accessible at low water.

The main disadvantage of this site is the poor road access. To reach the site, a user must turn off the existing Finlay-Russell Forest Service Road and travel

approximately 4.5 km along a single-lane gravel path that is not maintained. The stretch in which a high bank to the left and a drop to the right of the road would make it difficult to expand the existing one-way road to a two-way road.

Because of the state of the road, the project team walked the last 500 metres along the footpath to the site.

The site itself is relatively small. The informal ramp has a sandy bottom and has been cut into the bank. The shoreline immediately upstream and downstream of the ramp is gravelly and appears reasonably stable.

This site was rejected because of the poor access as well as the relatively small area available for upland turnaround and parking. Additionally, it is relatively far up the Finlay River, and as such does not adequately meet the WUP goals of allowing access to the Finlay Reach of the Williston Reservoir. Therefore, the engineering feasibility of this site was not investigated further.

Deserter's Dump Site

The Deserters' Dump site is located about 10 km north of the Tsay Keh Village on the Finlay River. Access to the site is along a well-maintained forest road. There is a sizeable upland area that would be available for parking and turnaround. The site has often been used as an informal boat launch in the past.

The iMapBC GIS system shows that a Special Use Permit (SUP), with a Special Use Description of Dryland Sort, was previously in force at the site: however, it was retired as of January 2006. Since there is no active SUP at the site, it appears feasible that BC Hydro could obtain a permit to locate a recreational facility there.

The lower beach is made up of fine material, with a large number of relic tree stumps. The fact that the tree stumps are still in place as cut, and that they have not been covered up or lost due to erosion at the roots, suggests that the beach is reasonably stable at this location. The substrate, although fine, is reasonably compact with a fair to good bearing capacity. The middle and upper beach are similar, except that there is an increasing admixture of coarse gravel and smaller cobbles higher on the beach.

At the far downstream end of the site is a second area that has been used as an informal boat launch ramp in the past. This area appears less well-suited to improvement, however. The substrate is much softer, and the area is accreting fine sediment. This would create both construction problems (over excavating to obtain a good foundation for a formal ramp) and maintenance problems (cleaning silt from the ramp).

A recent Terms of Reference published by BC Hydro notes that sedimentation in Deserters' Canyon is causing problems with access to the river, according to the Kwadacha and Tsay Keh Dene First Nations.

Discussions with locals indicate that the water level does not drop much below that observed during the site visit on May 25, 2009. Based on this observation, there would be adequate water depth to launch at low water.

The river current was reasonably fast but not enough to rule out the site. The currents apparently do not increase much above that observed during the site visit. Although the spring runoff does not start until June, the water level in the reservoir increases as the quantity of runoff increases. The trade-off between the increased inflow to the river and the increased backwater effect from the reservoir is such that very high currents are not common. The currents were lower at the far downstream end of the site: however, this does not overcome the other drawbacks of this area.

To summarize, physically and in terms of land use this appears a good site for a boat launch ramp serving the Finlay River. The drawback of this location is that launching into the Finlay River does not allow access to the Williston Reservoir at high water levels. The predominant winds in the Williston Reservoir are from the south. A large fraction of the woody debris in the Williston Reservoir, whether it is new debris from ongoing logging activities, natural wood wastage, or from trees drowned when the reservoir was formed, is driven by the winds and waves to the mouth of the Finlay River. This debris completely blocks access from the Finlay River to the reservoir.

Therefore, this location may not satisfy the requirements of the Water Use Plan. It may, however, improve general recreational boating access in the area. The views of members of the Tsay Keh Dene band about the usefulness of an improved boat launch in this area were mixed. The same comments would also apply to the Russell Trail site.

Strandberg Dump Site

The Strandberg Dump Site is located at the north end of the Parsnip Reach of the Williston Reservoir, on the Omenica Arm. The dump site is reached by driving approximately 6 km along a well-maintained gravel track from the Finlay Forest Service Road.

There are potential land use issues associated with this site. Canadian Forest Products holds an active Special Use Permit for Dryland Sort at the site[1]. However, it does not appear that the site itself has been used for some time; the scale bridge on the approach to the site is derelict and there is no other evidence of recent operation. It is possible that the permit could be retired. Between 0.5 km and 1 km west of the Strandberg site is an area where the special use permit has been retired. However, while the shoreline in this area is visually similar to that at the dump site, the beach is very soft and unsuitable for construction of a boat launch ramp.

There is no existing boat launch ramp at the site, nor any evidence of its use for informal launch. According to Vincent Chingee, the First Nations representative from the McLeod Lake band, the site is often used for launch at high water.

There is a broad gravel track along the upland side of the site, and generally there is ample upland area for vehicle and trailer parking. The shoreline adjacent to the dump site is relatively steep, and contains a significant amount of woody debris. Further east, there is a flat spit with a significant density of tree stumps. This area to the east is too flat to be suitable for a boat launch ramp: the ramp would be several hundreds of metres long as well as away from existing roads.

The upper beach is firm, with a mixture of coarse and fine gravel with some sand. There is a great deal of woody debris on areas of the beach. The middle beach is at

rather a steep slope, and exhibits a range of different substrate types. In most cases, the middle beach is also firm. The exception is a stretch of the beach with a significant admixture of wood chips. The wood chips create a relatively soft surface: even if they did not, this would not be a good long-term option for a boat ramp foundation. This stretch of beach has been avoided in the conceptual design.

The lower beach contains a higher sand fraction, but is otherwise similar to the middle beach. The shoreline continues to drop off at a steep angle below the waterline.

The main question regarding this site, other than the land use issues, is the wave climate.

There are constructability issues with the very steep slopes at the shoreline, and the coarse substrate suggests a very energetic wave climate at this location.

Finlay Bay Site

The Finlay Bay boat launch is adjacent to the Finlay Bay Forest Service Campsite. The campsite and boat launch ramp are reached via 75 km of the gravel (and rough in places) West Parsnip Forest Service Road.

Finlay Bay is similar to Cut Thumb Bay, in that there is no formal or even fixed boat launch ramp – rather, there is a broad beach with vehicle tracks indicating the most commonly used and preferred launch locations. The beach substrate is very variable. Near low water, the substrate is muddy, with localised patches of gravel from the rocky backshore. Further up the ramp, the substrate is a mixture of sand and gravel. Despite the mud, the substrate generally is reasonably firm.

The boat launch ramp is reached along a gravel track that passes through a relatively wide, open area. There is an outhouse as well as picnic tables on the upland grassy area, but there are otherwise no significant facilities there. The access road is a reasonably good gravel track.

The main drawback with the Finlay Bay site is the lack of access at low water. It was possible to launch a small boat from this site during the site investigations (this site was used by the survey team, Atek Hydrographic Surveys). However, the water was more than 5 metres above the lowest operational water level at this time.

The deepest water at the site is located between two natural tombolo formations, where two rocks in the water have Anchored the shoreline. These tomobolos in turn appear to be acting as groynes, creating a natural pool between them. The backshore at this location is shale and is the source of the anchoring rocks.

Manson Dump Site

The Manson Dump Site is located on the west shore of the Black Water Arm, near its connection to the Parsnip Arm of the Williston Reservoir. As with the Strandberg site, Canadian Forest Products holds an active Special Use Permit for Dryland Sort at the site.

The active permit only covers the upland area and not the shoreline: however, the upland area would be needed for access, turnaround, and parking if a new boat launch ramp were constructed at the site.

There is no evidence of existing use of the site as a boat launch.

The beach at the site is sandy and very soft in the less sheltered parts, towards the north of the site. These areas are extremely erosional and completely unsuitable for construction of a boat launch ramp.

The upland area is large and flat, with generally a good gravel surface. There is runoff-induced erosion in some locations along the edge of the upland area: this could be ameliorated through a combination of vegetation and stormwater management. Interestingly, there is a small stormwater outfall on the beach, the drainage area for this outfall was not identified during the visit.

There are two tracks from the upland area down to the beach. The track on the northern side is extremely soft, similar to the beach on that side, and is not shown here. The track on the southern side is less soft, although still readily erodible. The substrate in this area is a mixture of sand with a small amount of gravel.

The most stable portion of the beach is in a sheltered bay on the south side of the site.

The main question regarding this site, other than the land use issues, is the softness of the substrate on the beach. This may make it infeasible to construct a boat launch ramp without a significant amount of over excavation and other foundation work.

Black Water Dump Site

The Black Water Dump Site is located approximately 1.5 km south of the Manson Dump Site, also on the west side of the Black Water Arm. The Black Water Dump site is covered by the same Special Use Permit as the Manson Dump Site. There is a log roller in good condition on the shoreline near the south end of the site, which indicates that the site may have been in use recently.

Similar to the Manson Dump Site, there are two access roads – one on the north and one on the south side of the site. Both are in reasonably good condition. In contrast to the Manson Dump Site, the flat area between the two access roads is below the high water level. This would make it less suitable for use as a parking or upland area, unless it were filled.

There is rather little upland space above high water on the south side of the site. In contrast, the north side has a relatively large cleared area, which would be suitable for parking and a high water turnaround. A little-used gravel roadway extends some distance from this area towards the shoreline.

Much of the substrate at the north side of the site is gravel and cobbles. The flat area between the two access roads is largely coarse gravel and small cobbles. The slope from the north access road to this area is sandier: the slope from the north access road directly towards the water is rather steep and again contains a larger fraction of

coarse gravel. A drainage channel cuts across the beach a short distance south of the north access road.

Physically, this site appears much more suitable for construction of a boat launch ramp compared to the nearby Manson Dump Site, which has a soft sandy beach. The land use issues are the same for the two sites – Canadian Forest Products holds a single Special Use Permit that covers both sites.

Six Mile Bay
The water at the gravel boat launch at Six Mile Bay is protected, but is too shallow to allow boats to launch at the lowest water levels. The lower part of the boat launch is a gravel ramp cut into the side of the bank; the ramp turns the corner around this bank and is then oriented directly inland for its upper part. Near the lower end of the ramp, the substrate becomes muddy and apparently is soft when wet, but generally the ramp substrate is firm packed gravel and fines.

There is a gravel turnaround at the top of the ramp, which can be used at high water. However, the access road does not provide any room for parking at high water. The access road appears in good condition and joins to the West Parsnip Forest Service Road.

The forest immediately adjacent to and inland of the access road is flat, and it would be feasible to construct parking spaces for use at high water in this location.

On the east side of the upper part of the ramp is a wetland area and creek, which argues against expanding the facilities into this area. On the other side of the ramp is a wide, flat area, slightly below high water, which would be available for facilities such as a turnaround for use at lower water.

Cut Thumb Bay
Cut Thumb Bay is a largely unimproved but heavily used boat launch site, accessed from the Parsnip West Forest Service Road. This is the best site for launches into the Williston Reservoir at low water, and was used as the launch point for all of the site investigations described herein, with the exception of MacKenzie Landing.

The gravel track to the launching area is subject to blockage by driftwood, which is apparently cleared by users. There is a large area available for parking and turnaround. While there is a visible gravel track to the best launching spots, the entire area of the bay provides a driveable gravel surface.

The specific area with deepest water and the best grade for launching at low water is clearly visible from track marks as well as the presence of trailers.

One suggestion from the TOR was that it might be possible to relocate the launch site to the nearby Cut Thumb Bay Forest Service Campsite. The shoreline at this campsite is very different from the shoreline at the boat launch: it is relatively narrow and sandy rather than
gravely. The sand on the beach is very soft and is not suitable to support a boat launch ramp. In addition, there is little upland space within the campsite itself to support a ramp: there is some erosion near the roadway at the upper part of the

beach, and any new boat launch ramp would be cut into this upper area rather than extended onto fill placed on the beach.

Based on these considerations, the possibility of constructing a boat launch ramp at the campsite was rejected. The possibility remains of constructing a boat launch ramp closer to the campsite that would be usable during the summer high water period, when the campsite is most heavily used. This new ramp would be accessed from the campsite along the existing gravel road that runs along the top of the beach between the campsites and the shore. While this track is in generally good condition, there are problems associated with woody debris.

Mackenzie Landing

Alexander Mackenzie's Landing is located 8 km from Mackenzie on the West Parsnip Forest Service Road. There are extensive facilities at the site, including campsites and an event seating area. Access to the boat launch ramp is close to the entrance to the entrance area and adjacent to a picnicking area. There is a turnaround and parking at the top of the ramp.

The upper part of the boat launch ramp is constructed of precast concrete panels placed on the beach. The beach is firm and gravely. There is no scour protection: however, the extent of scour and associated damage is extremely minor.

The intermediate part of the boat launch ramp is a cast-in-place ramp in the middle beach.

This lower concrete portion is also in good condition, with little cracking or scour. This concrete portion of the ramp is only used at higher water levels. A gravel access ramp nearly 200 m long branches off from the concrete boat launch ramp, across a level mudflat, towards the low water portion of the ramp. The low water ramp is also of gravel; there is no obvious demarcation between the access ramp and the low water boat launch ramp.

The upper part of the gravel ramp is in good condition, although on the date of the site inspection it was partially blocked by a log boom. The gravel ramp is underlain by corduroy (logs) over much or all of its length. This corduroy has become exposed in places towards the lower end of the ramp.

Apart from these localised areas, the gravel ramp surface was generally firm down to the lower end. The substrate consisted of packed gravel and sand, in contrast to the muddy substrate covering the flats on the lower and middle beach.

While the physical condition of the ramp is good (concrete portion) to fair (gravel portion), there are a number of functional issues. These are particularly associated with the lower, gravel portion of the ramp. According to boat users at the site, portions of the ramp are washed away every winter. The ramp is not usable at very low water levels (below approximately El. 657.0 m). Finally, there are no turnarounds adjacent to the lower ramp.

5.1.22.3 Status

This project is complete.

5.1.23 GMSWORKS#25 – Williston Reservoir Bathymetry

Order Clause: Schedule A clause 3(d)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.23.1 Overview

Project Objective: A bathymetric map of the Williston Reservoir is an integral part of the integrated approach to the many diverse water management issues in the basin. Using this type of data, the amount and location of exposed reservoir bed can be identified. This information will allow more proactive and detailed planning for many of the WUP projects including: debris, dust, erosion, wetlands and tributaries. These bathymetric data can also be used to develop hydrographic charts of the shallower near-shore areas of the Williston Reservoir.

Project Description:

- Conduct a spring LiDAR survey, at annual low pool, of the shoreline around Williston Reservoir to elevation 678.3 m (~2225 ft.) including the dewatered near-shore reservoir bottomlands.
- Conduct a late summer Multi-beam Echo Sounding survey of the near-shore area, with an appropriate overlap of the LiDAR coverage, to an elevation of 652 m (2140 ft.).
- Develop hydrographic charts, bathymetric contour maps, 3-D projections, and bathymetric profiles of Williston Reservoir.

Contractor: This work is being conducted by Terrasond Limited (Terrasond). Terrasond has conducted similar work for other clients.

ToR Status: In January 2010 the CWR approved a resubmission of the GMSWORKS#24 ToR with updated project implementation costs. The project complies with the revised ToR; no further resubmission is anticipated at this time.

5.1.23.2 Contractor's Report

The first contractor annual report will be submitted in 2011.

5.1.23.3 Status

This work was initiated in April 2010 and is scheduled to be completed by January 2012. An annual report is due in April 2011.

5.1.24 GMSWORKS#26 – Williston Communication and Safety

Order Clause: Schedule A clause 5(b)&(c)
Schedule B clause 2(b)
Schedule C clause 3(a)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.24.1 Overview

Project Objective: This package of work includes two "broad" projects that focus on safety: radio communication and signage, with the objective of improving the overall safe use of the two reservoirs and the Peace River. The WUP Committee concluded that marine radio communication and improved signage was required in order to improve the quality and safety of the recreation experience in the Peace system. The radio channel would provide a valuable safety net for boaters. Improved signage would provide information about the location of access facilities, hazards associated with the hydroelectric facilities, and the marine channel.

Project Description:

- Conduct a study that details current radio communication resources covering the Williston and Dinosaur reservoirs and the Peace River (from Peace Canyon Dam to Taylor) including private repeaters and public access frequencies.
- Recommend a plan for a radio communication network that will provide public access coverage to the reservoirs and the river.
- Develop a radio network for the Williston and Dinosaur reservoirs and the Peace River between Peace Canyon Dam and Fort St. John.
- Install information signage at all boat launch facilities on the two reservoirs and the Peace River.
- Install electronic signage at Hudson's Hope Park to display current reservoir levels and daily forecasts.
- Develop an annual maintenance plan and budget for the repeater stations and the signage.

Contractor: This work is being conducted by HN Telecom Ltd. (HN). HN has conducted similar work for other clients.

ToR Status: In January 2010 the CWR approved a resubmission of the GMSWORKS#26 ToR with updated project implementation costs. The project complies with the revised ToR; no further resubmission is anticipated at this time.

5.1.24.2 Contractor's Report

BC Hydro, as part of their water licensing agreement with the BC Provincial Government, has been requested to design and implement a "VHF Marine Distress System" covering Williston Lake, the Dinosaur Reservoir, and downstream on the Peace River to the confluence with the Pine River, near Taylor, BC. This report defines the VHF radio system functional requirements, identifies issues with respect to operating such a system, offers a number of technical alternatives, proposes a recommended system arrangement, outlines a proposed operational plan and identifies the immediate implementation issues.

Requirements

The initial requirement implied a mobile radio system to be available to boaters only, and only for emergency calling. However, further to discussions with BC Hydro and potential users in the area, and recognizing that a system such as this needs to be

used on a regular basis to ensure it is functional, the proposal is that the user group be expanded to include all recreational and incidental users, including BC Hydro and their contractors, the Portage Mountain Yacht Club, aircraft operators, travelers in the area, etc. Furthermore, the system should be open to limited general information communications traffic. In summary, a public access mobile radio system is desired covering a linear distance of nearly 500 km, most of which (over 400 km) is in a remote lightly populated mountainous region.

A future requirement may be the addition of a telephone interconnects, to be restricted for BC Hydro use and limited to brief messages to minimize the impact on system traffic and solar power plant requirements.

Technical and Operational Issues

The technical issues related to implementing the required system and addressed in this report include:

- Selecting the most appropriate frequency band;
- Locating fixed sites to provide the desired coverage;
- Arranging trunk facilities to link between the fixed sites and to a monitoring station.

The concerns with the operation of such a system have also been identified, and include:

- System operation involving multiple user groups;
- System monitoring arrangements for emergency calling;
- Consideration of the operational complexity of the system and the need for education on system use;
- System maintenance.

All of these operational concerns involve the system users and need to be addressed, not just on system start-up, but also in the long term. Consequently, it is recommended that a user group organization be formed to deal with these issues. Further, it is recommended that an educational pamphlet be produced and made available free of charge outlining the system configuration and method of operation. Signage at boat ramps and on the roads alone is not considered adequate. These operational concerns should be addressed, at least to the planning stage, before the repeater network system is implemented.

As the proposed Williston marine communications network is intended for both public safety and limited general communications, there is a concern the system will become overloaded with non-safety related traffic. Hence, there will be a need to monitor the system on a regular basis to ensure one user group does not monopolize the network, limiting use by others. Poor user discipline may also result in excessive repeater usage and could lead to power failure at the solar powered repeater sites.

Given the above, it is recommended that BC Hydro retain an Operations Manager living within the service area. This manager should monitor the network on a daily basis, interface with the various user groups, manage required maintenance activities and generally police the network usage to ensure the network is functioning as intended.

Network Configuration

It is proposed that the VHF marine band frequencies be used for this system, and an agreement in principle for the use of this band has been received from Industry Canada. The benefit of the VHF marine band is that mobile and portable radios that operate on a standard channel numbering plan are readily available. The disadvantage is that the marine channels are not equipped with continuous tone coded squelch (CTCSS), and are thus subject to interference from other systems. In addition, repeater talk-around channels are not available, thus requiring a radio with the ability to scan two or more channels, if the repeater channel is to be monitored when working mobile-to-mobile direct.

To achieve the coverage desired over this large area, which for analysis purposes has been divided into sectors as shown on the area map on the following page, a total of nine potential VHF repeater sites were evaluated:

- Three existing BC Hydro, mountain top, solar powered, repeater sites:
  - Deception Cone
  - Wolverine
  - Carbon Creek

- Two existing BC Hydro microwave/telecommunications sites:
  - Morfee
  - Bullhead

- Two existing mountain top, solar powered, repeater sites:
  - Bevel Mountain (Site developed by Canfor)
  - Rochfort (Site developed by Vic Romaszewski for the Portage Mountain Yacht Club)

- One new mountain top, solar powered, repeater site:
  - Portage Mountain

- One existing telecommunications site:
  - Bear Flat (Petron site – Penn West Petroleum)

5.1.24.3 Status

This work was initiated in January 2009. BC Hydro Telecom reviewed the contractor's report and developed an alternative configuration. BC Hydro Telecom will be designing and implementing the project. The system will use 6 sites to provide coverage: Deception Cone, Wolverine, Carbon Creek, Morfee, Bullhead and Portage Mountain. Two marine VHF channels will be employed. The construction portion of the project is scheduled to be completed by the fall of 2010 with the maintenance portion of the project continuing through 2029.

5.1.25 GMSWORKS#27 – Finlay River Access Information Plan

Order Clause: Schedule A clause 6(a)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.25.1 Overview

Project Objective: Investigate the cause of sediment build-up in the Finlay River upstream of its confluence with the Williston Reservoir.

Project Description: This work will accept or reject the hypothesis that Williston Reservoir is contributing to sediment deposition in Deserter's Canyon and thereby affecting boating access to the Finlay River. If a positive relationship is shown to exist, both operating and non-operating alternatives could be considered in a future Peace Water Use Plan review.

Contractor: This work is being conducted by Knight Piesold Ltd. Knight Piesold has conducted similar work for other clients in the past.

ToR Status: In January 2010 the CWR approved a resubmission of the GMSWORKS#27 ToR with updated project implementation costs. The project complies with the revised ToR; no further resubmission is anticipated at this time.

5.1.25.2 Contractor's Report

The Finlay River flows southeast ward into the Williston Reservoir in north-central British Columbia. The reservoir is impounded by the WAC Bennett Dam on the Peace River, which was commissioned by BC Hydro in 1967. The First Nations inhabitants of the Finlay River valley upstream of the reservoir have reported that sediment accumulation in the river is limiting river navigability and access to resource harvest sites. The problem occurs near the river / reservoir confluence during periods of low river flow and low reservoir level in the early spring. The particular site of concern is located immediately upstream of Deserters Canyon. In response to these concerns, the Consultative Committee of the Peace Project Water Use Plan has initiated the Finlay River Access Information Plan (GMSWORKS #27).

The assessment carried out under GMSWORKS #27 has concluded that the navigation problems upstream of Deserters Canyon have been caused or exacerbated by reservoir impoundment and backwater effects, and by the manner in which the reservoir is operated, based on the following lines of reasoning. Evidence supporting the statements below is developed and presented within this report.

1. Reservoir inundation and backwater effects extend approximately 2 km upstream of the Deserters Canyon bridge during normal summer reservoir conditions, and 8 km upstream of the bridge under full pool conditions.

2. The Finlay River transports most of its bedload during the month of June when river flows are the greatest. This material is deposited in a deltaic topset bed starting at the site of transition from riverine to lacustrine flow conditions at the time of maximum sediment transport. The location and spatial distribution of topset bed deposition varies from year to year due to variability in reservoir levels during the period of highest river flows.

3. The deposition of topset beds in variable locations has caused or exacerbated widespread channel instability and consequent navigation problems upstream of the bridge. The river channel is difficult to navigate during low flow periods due to the increased channel width and reduced channel depth, and due to the frequently shifting alignment of the main flow pathways.

Delta development is an inevitable result of reservoir impoundment. If the average reservoir level were higher or lower, the location of the delta would simply be transferred to a different site. The variability of June reservoir levels likely distributes the instability and navigation problems over a wider area. If the reservoir levels were managed more consistently, the topset bed deposition and lateral channel erosion would be more concentrated at a single site along the channel, but the local intensity of those processes would be increased.

It is unlikely that changes in river hydrology or sediment supply have contributed appreciably to the sediment deposition and navigation problems in the Finlay River. A trend toward earlier annual occurrence of maximum daily discharge in the river, due to regional climatic patterns, does not translate directly to different reservoir levels at the time of maximum discharge. The Finlay River has an effectively unlimited sediment supply in the form of alluvial and glaciofluvial deposits, so sediment transport in the river is largely dependent on river flow. Annual flow volume and peak flow rates have not changed significantly over time. The creation and operation of the reservoir appear to be the primary causes of altered sediment deposition patterns in the Finlay River.

A site visit in early spring of 2010 is recommended to facilitate confirmation and refinement of the above assessment, based on an inspection of exposed deltaic deposits and river navigability at low river flow and reservoir level conditions.

5.1.25.3 Status

This project is complete.

5.1.26 GMSWORKS#28 Industry Feasibility & Design Study

Order Clause: Schedule A clause 1

BC Hydro Project Manager: Alan Chan-McLeod

5.1.26.1 Overview

Project Objective: This project was intended to be an engineering feasibility and design study to determine practical and cost-effective solutions to the following issues associated with lower reservoir levels at Mackenzie:

- water supply at the Abitibi newsprint and Pope & Talbot pulp mills;
- effluent disposal at Abitibi's newsprint mill, Pope & Talbot pulp mill, and District of Mackenzie; and
- log supply for Canfor and Abitibi sawmills.

Project Description: See section 5.1.27 for a description of the component of this project relating to effluent disposal at the District of Mackenzie. The components of this project relating to the Mackenzie mills have not been designed.

Contractor: See section 5.1.27 for a description of the component of this project relating to effluent disposal at the District of Mackenzie. The components of this project relating to the Mackenzie mills have not been awarded.

ToR Status: See section 5.1.27 for a description of the ToR for the component of this project relating to effluent disposal at the District of Mackenzie. The submission of ToR for the components of this project relating to the Mackenzie mills is on hold pending resolution of the status of those mills.

5.1.26.2 Contractor's Report

See section 5.1.27 for a description of the component of this project relating to effluent disposal at the District of Mackenzie. No contractor's report is currently planned for the components of this project relating to the Mackenzie mills.

5.1.26.3 Status

See section 5.1.27 for a description of the component of this project relating to effluent disposal at the District of Mackenzie. The components of this project relating to the Mackenzie mills are on hold pending resolution of the status of those mills.

5.1.27 GMSWORKS#28a District of Mackenzie Effluent Discharge Feasibility & Design Study

Order Clause: Schedule A clause 1

BC Hydro Project Manager: Alan Chan-McLeod

5.1.27.1 Overview

Project Objective: This project was intended to be an engineering feasibility and design study to determine practical and cost-effective solutions to the issues associated with lower reservoir levels at Mackenzie and effluent disposal at the District of Mackenzie.

Project Description: This project consists of five phases:

1. Project initiation: development of ToR and awarding the contract.

2. Feasibility study: the consultant will study options to be reviewed by agencies and the District, culminating in a final report with recommendations.

3. Preliminary design of the preferred management options will be prepared.

4. A recommendation to Government will be made respecting implementation of a practical, cost-effective approach to be submitted to the WUP Committee.

5. Government and WUP Committee review and approval.

Contractor: This project will be awarded later in 2010.

ToR Status: A ToR for this component of the project was granted leave to commence by the CWR on 11 January 2010.

5.1.27.2 Contractor's Report

The first annual contractor's report will be filed in 2011.

5.1.27.3 Status

The RFP for this project has closed. A contract award will be made later in 2010, with work starting in 2010.

5.1.28 GMSWORKS#29 Lynx Creek Boat

Order Clause: Schedule C clause 2 (c)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.28.1 Overview

Project Objective: This project was intended to conduct ongoing maintenance at the Lynx Creek boat ramp, and may include:

- Replacement of pre-cast concrete planks;
- Replacement, or repair, of the rock groyne; and
- Maintenance on the parking lot.

Project Description: This project will keep the Lynx Creek ramp in usable condition.

Contractor: This project has not been awarded.

ToR Status: Currently, scope, schedule, and budget are expected to be met.

5.1.28.2 Contractor's Report

This project has not yet begun.

5.1.28.3 Status

This project has not yet begun.

5.1.29 GMSWORKS#30 Peace Island Park

Order Clause: Schedule C clause 2 (a)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.29.1 Overview

Project Objective: This project was intended to conduct ongoing maintenance at the Peace Island Park boat ramp, and may include:

- Construction of a loc-block® groyne;
- Placement of rip-rap to prevent further scour action; and
- Maintenance on the scour protection and surface of the ramp .

Project Description: This project will keep the Peace Island Park ramp in usable condition.

Contractor: This project has not been awarded.

ToR Status: Currently, scope, schedule, and budget are expected to be met.

5.1.29.2 Contractor's Report

This project has not yet begun.

5.1.29.3 Status

This project has not yet begun.

5.1.30 GMSWORKS#31 Kwadacha

Order Clause: Schedule A clause 4 (b)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.30.1 Overview

Project Objective: This project was intended to conduct ongoing maintenance at the Kwadacha boat ramp, and may include:

- Replacement, realignment of pre-cast concrete planks;
- Replacement, realignment, or repair, of the rock groyne; and
- Ongoing general maintenance of the ramp.

Project Description: This project will keep the Kwadacha ramp in usable condition.

Contractor: This project has not been awarded.

ToR Status: Currently, scope, schedule, and budget are expected to be met.

5.1.30.2 Contractor's Report

This project has not yet begun.

5.1.30.3 Status

This project has not yet begun.

5.2 Peace WUP Monitoring Program Projects

5.2.1 GMSMON#1 – Peace River Creel Survey

Order Clause: Schedule C clause 4(a)

BC Hydro Project Manager: Kim Hawkins

5.2.1.1 Overview

Project Objective: The objective of this project is to assess catch and effort of sport fishing over time and to determine if it is a confounding variable for stock assessment of fish populations in the Peace River. It is not the intention of the monitoring program to assess recreational or tourism-related issues such as angler satisfaction.

Project Description: The results of the PCR Creel Survey monitoring program are designed to complement the PCR Side Channels, PCR Ramping, and PCR Flood Pulse Plans. The Creel Survey is scheduled to take place every second year between May and September over a 10-year period. Data will be collected on all fish species by interviewing both shoreline and boat anglers on the Peace River between the Peace Canyon Dam and the confluence with the Pine River. Data analyses and reports will be completed for the years the survey is undertaken and a final study report will be produced at the conclusion of the monitoring program.

Contractor: LGL Ltd. was contracted by the BC Hydro Site C Project Team in 2008 to conduct a PCR Angling and Recreational-Use Creel Survey. The study undertaken by LGL Ltd. was designed to determine how the potential construction and operation of the Site C dam would change the pattern of river use. The parameters of that study fulfilled the requirements of the first year of GMSMON#1 and the results of the LGL study could be added to the data acquired during the implementation period of this WUP monitoring program.

The contractor for GMSMON#1 has not yet been selected.

ToR Status: The CWR approved a budget increase of $4,551 in January 2010 to adjust for inflation and contingency.

5.2.1.2 Contractor's Report

There is no contractor report for 2010.

5.2.1.3 Status

GMSMON#1 was scheduled to commence in 2010, however, the project is currently deferred pending discussions with regards to the suitability of the project scope and design to achieve the stated objectives.

5.2.2 GMSMON#2 – Peace River Fish Index

Order Clause: Schedule C clause 4(b)

BC Hydro Project Manager: Kim Hawkins

5.2.2.1 Overview

Project Objective: This project addresses the question: "What is the population response of fish in the Peace River following the addition/modification of in-stream physical works or the implementation of an alternative minimum discharge regime?"

In addition to addressing the management question, the objectives of this project are to:

- Collect a time series of data on the abundance, spatial distribution, and biological characteristics of nearshore and shallow-water fish populations in the Peace River that will build upon previously collected data by Peace River fish community indexing programs;
- Build upon earlier investigations for further refinement of the sampling strategy, sampling methodology, and analytical procedures required to establish a long-term monitoring program for fish populations; and
- Identify gaps in understanding or data in current knowledge about fish populations and in procedures for sampling them.

Project Description: By monitoring target fish populations to assess population abundance, distribution and growth, the PCR Fish Index project will evaluate the effectiveness of PCR management plans designed to improve fish habitat and productivity. Largely following the design and protocol that has been refined during the years of the Peace River fish community indexing program, a mark-recapture study will be employed using a boat electrofisher. The study area is the stretch of the river from the Peace Canyon Dam to the confluence with the Pine River. Monitoring is scheduled to occur annually, in late summer, over 10 years. A report will be prepared each year following the field work and data analysis. After the 10th year of monitoring a final completion report will be prepared.

The project contractor is also required to attend the BC Hydro annual Large Rivers Workshop to present and discuss the results of the field season and overall trends of the monitoring program.

Data Interpretation: The initial goal of the project was to establish fish monitoring protocols that can reliably provide an index of target fish populations. The findings of the 2009 Peace River Fish Index indicated that the monitoring protocols will meet the goal, particularly for mountain whitefish. Additionally, as in-stream physical works projects intended to improve fish habitat and productivity have not yet commenced,

the 2009 fish indexing program information was integrated into that from previous years to increase the baseline data for future analysis. Recommendations from the 2009 field season included maintaining the current study design and sampling protocols but addressing a number of data gaps that are inherent in the current design of the project.

Contractor: Mainstream Aquatics Ltd. has conducted the Peace River fish indexing program since its inception in 2001 and continued to undertake the work in 2009/2010, in association with W.J. Gazey Research.

ToR Status: The project complies with the ToR; no resubmission is anticipated at this time.

5.2.2.2 Contractor's Report

Peace River Fish Index Project 2009 Studies (May 2010) by Mainstream Aquatics Ltd. - EXECUTIVE SUMMARY

In 2001, BC Hydro initiated the Large River Fish Community Indexing Program to help define the effects of dam and reservoir operations on fish populations in flow regulated watersheds and to ensure operations are both environmentally and economically sustainable. The program has occurred annually from 2001 to the present. During that period the goal of the program was to establish cost-effective monitoring protocols to provide reliable indices of fish population characteristics. In 2008, the Large River Fish Community Indexing Program for the Peace River, subsequently referred to as the Peace River Fish Index Project, was implemented under the Peace Water Use Plan (WUP). The WUP includes management plans to enhance fish habitat and fish productivity in the Peace River system. As such the goal of the Fish Index Project has shifted from evaluating monitoring protocols to monitoring target fish populations to assist in the evaluation of the effectiveness of Peace River management plans and associated physical works projects implemented under the WUP.

The 2009 Peace River Fish Index Project study area encompassed a 92 km portion of the Peace River from just downstream of the Peace Canyon Dam to downstream of the Moberly River confluence. Repeated sampling (six sessions) in three sections (1, 3, and 5) occurred from 18 August to 19 September, 2009 using a boat electrofisher in near-shore habitats. Field sampling conditions (i.e., discharge, water clarity, and water temperature) were considered good and were within the range recorded since 2001.

General fish community characteristics in 2009 were similar to results of previous investigations. Fourteen large-fish species were recorded and mountain whitefish was numerically dominant. The other two target species, Arctic grayling and bull trout, were not abundant.

Arctic grayling
No Arctic grayling were captured in Section 1 in 2009. As has been recorded during previous studies, Arctic grayling sampled from Sections 3 and 5 exhibited similar biological characteristics. Samples were dominated by Age 1 and Age 2 fish and there were no measurable differences between the two sections in terms of length-

at-age, body condition-at-age, growth, and apparent annual mortality. The results were generally consistent with previous studies. There continues to be annual shifts in length and age distributions of the Arctic grayling sample populations, which are related to strong age classes in a particular year. Several parameters (i.e., growth curves, anabolic constants, length-at-age, body condition-at-age) all indicated general stability in Arctic grayling population health over time. The results for 2009 were consistent with results of previous index studies.

Arctic grayling catch rates were low and fish abundance was similar among Sections 3 and 5 in 2009. Catch rates in both sections continued to decline after the peaks recorded in 2007. The biological data did not show any large shift in population structure or health that could explain the decline in abundance. As such, the decline may reflect natural variation in Arctic grayling abundance.

Recruitment of Age 1 Arctic grayling has been zero in Section 1 for the duration of the program. In Sections 3 and 5, Age 1 Arctic grayling were recorded during all sample years, but recruitment varied annually. Recruitment also appears to differ between sections, suggesting different recruitment sources.

Bull trout

Bull trout were recorded in all three sections. Length and age distributions of bull trout were similar among sections. Fish younger than Age 4 dominated and bull trout older than Age 6 were not well represented. As has been found during previous studies, Age 1 fish were scarce. Bull trout growth and body condition was similar among sections. Fish grow very quickly and exhibit good body condition. Age and length distributions of the combined sample remained stable across years. During all sample years, age distributions were dominated by subadults, while young fish and adult fish were poorly represented. The absence of adult fish from the index sections was likely caused by use of tributaries for spawning during the study period. As such, it is unlikely that the results accurately reflect the age structure of the Peace River bull trout population.

Bull trout catch rates were low in all sections and there were no strong section differences. There has been no large change in bull trout abundance for the duration of the program. Age 3 bull trout were recruited in each section during all years of the study. Recruitment varies annually, but has been consistent among sections since 2004.

Mountain whitefish

In 2009, mountain whitefish were abundant in all three sections and the results were consistent with previous index studies. There were spatial differences in length and age distributions of mountain whitefish. Fish in Section 1 exhibited truncated age and length distributions caused by the dominance of Age 3 to Age 6 fish. Younger fish (Age 1) and older fish (> Age 6) were largely absent. In contrast, mountain whitefish in Sections 3 and 5 exhibited multi-modal length distributions that represented a wide range of ages. There also were spatial differences in mountain whitefish length-at-age, body condition, and annual mortality between Section 1 and Sections 3 and 5. There continues to be annual differences in mountain whitefish age and length distributions based on numerical strengths of younger age classes; however, the spatial differences remain consistent among years. In terms of population health, some parameters (i.e., growth curves, anabolic constants, and body condition-at-

age) indicated no temporal change in population health. However, starting in 2003, annual mean length-at-age estimates of some age classes declined in all three sections. An examination of annual growth rate of the affected age classes indicated that the cause likely was related to growth during the early period of life rather than a decline in growth rate of older age classes.

Mountain whitefish continue to be abundant in Sections 1, 3, and 5. As found by previous index studies, catch rates differed by habitat. Mountain whitefish were more abundant in habitats containing minimal physical cover (SFN habitat) compared to habitats containing an abundance of physical cover (SFC habitat). Annual differences in abundance were identified. After a downward trend in abundance recorded in Section 1 between 2004 and 2007, mountain whitefish abundance has remained stable. Mountain whitefish in Section 3 and Section 5 continue to exhibit a cyclic pattern of abundance.

During most years of study mountain whitefish recruitment indices were lower in Section 1 compared to Section 3 and Section 5. Mountain whitefish recruitment indices were similar in Section 3 and Section 5.

Population Estimates

Overall, the program was highly successful (in terms of the number of marks applied and recaptured) for mountain whitefish, but less so for Arctic grayling and bull trout. Estimates for Arctic grayling were not available in Sections 1 and 5, and bull trout estimates were not available in Section 1, because no marks were recovered,

Bayes sequential model population estimates for mountain whitefish were 17,253 (CV = 8.3%) fish in Section 1, 10,918 (CV = 6.4%) fish in Section 3, and 10,991 (CV = 7.6%) fish in Section 5. Population estimates for mountain whitefish were very similar regardless of model (constant capture probability, time varying capture probability, constant catchability, or time varying catchability) or estimation program (MARK or ADMB).

The population estimate of Arctic grayling in Section 3 was 3,554 (CV = 102.7%) fish. Because of sparse recoveries, the posterior distribution is highly skewed and mean estimate is unreliable. There is a 0.95 probability that the population size is at least 285 Arctic grayling in Section 3. For bull trout, estimates were 345 (CV = 35.8%) in Section 3 and 126 (CV = 48.6%) fish in Section 5.

Catchability

The catchability estimate for mountain whitefish remained robust despite a range of conditions encountered among sample years and sections. As such, catch rate can be used as an index of absolute abundance. Twenty one data points are now available to quantify the relationship.

Recommendations

The initial goal of the program was to establish fish monitoring protocols that can be used reliably to provide an index of target fish populations. The findings of the 2009 Peace River Fish Index Project indicated that the monitoring protocols are suitable to meet this goal, particularly for mountain whitefish. Based on these findings we recommend the following:

1. Repeat the standard program to extend the time series data. Sample Sections 1, 3, and 5 to extend the sampling history.
2. Maintain the current study design and sampling protocols.

As the WUP management plans are implemented the goal of the Peace River Fish Index Project will focus on monitoring target fish populations in order to evaluate the effectiveness of those plans. In order to achieve this goal, consideration should be given to addressing a number of data gaps that are inherent to the current design of the program. As recommended during previous studies, consideration should be given to adjusting the scope of the Peace River Fish Index Project or developing separate sampling programs, in order to address these issues.

5.2.2.3 Status

Field work was successfully completed in 2009 and the annual report received in May 2010.

5.2.3 GMSMON#3 – Peace River Fish Stranding

Order Clause: Schedule D clause 3(a)

BC Hydro Project Manager: Kim Hawkins

5.2.3.1 Overview

Project Objective: The objective of this project is to address the following key management questions:

- What is the magnitude of entrapment/stranding along the Peace River after a spill?
- Which species and life stages are affected by stranding and is the level of stranding biologically significant to fish populations in the Peace River?
- What areas of the Peace River have the highest risk of stranding?

Project Description: The PCR Fish Stranding monitoring program will address the PSP and the PCR Flood Pulse Plan. This project will be conducted opportunistically as no spill release is proposed at this time. If a spill event occurs that meets the criteria of the program, the survey will be undertaken immediately after the spill when total discharge has returned to within the normal operating range and will be completed within one day. The study area is the stretch of the Peace River from the Peace Canyon Dam to the confluence of the Pine River.

Prior to the completion of the spill, a study review and aerial survey will be used to plan the survey design of the assessment. Fish stranding will be assessed at pre-selected sites. Any captured fish from isolated pools will be transferred to the main channel. Following completion of the survey a summary report will be prepared.

Contractor: The contract was awarded for a period of 5 years (2009-2013) to Cooper Beauchesne and Associates Ltd.

ToR Status: In November 2008 the CWR approved a budget increase of $39,731 to reflect updated project implementation costs. The project complies with the revised ToR; no resubmission is anticipated at this time.

5.2.3.2 Contractor's Report

As there has not been a spill to date, there is no associated report. However, the contractor has summarized activities undertaken to date:

The report includes a brief overview of the project and progress towards addressing the management questions identified in the project Terms of Reference (BC Hydro 2008). Also included is a summary of issues that arose during the first year of the contract and the actions taken to resolve these issues in regards to the Peace River Fish Stranding (GMSMON 3).

Introduction

Fish stranding has been acknowledged by BC Hydro as an expected outcome of a spill event on the Peace River but the magnitude of stranding is uncertain. As a result, the monitoring of fish stranding following a spill event was recommended during the water use planning process and is one of the monitoring programs associated with the Peace Spill Protocol. The intent of this monitoring program is to quantify the impact of spills on the abundance of the over 28 fish species found in the Peace River (BC Hydro 2003). Previous stranding studies on regulated rivers identified fish stranding to primarily occur as entrapment within an isolated pool and as bar stranding on gravel, cobble, and boulder bars (e.g., Higgins and Bradford 1996). A previous stranding assessment on the Peace River found that the highest risk areas for stranding were those areas with shallow slope and gravel bar areas associated with braided channels (BC Hydro 1997).

To address the unknown extent of fish stranding from spill events and the potential impacts on fish populations the management questions to be addressed by this monitoring program are:

1. What is the magnitude of entrapment/stranding along the Peace River after a spill?
2. Which species and life stages are affected by stranding and is the level of stranding biologically significant to fish populations in the Peace River?
3. What areas of the Peace River have the highest risk of stranding?

To address these management questions, the following hypotheses will be tested by the monitoring program:

H_{01}: Fish are not isolated in pools after dam operations return to normal operating levels after a spill event.

H_{02}: Fish are not stranded interstitially in gravel and on bars (e.g., gravel, cobble bars) once dam operations return to normal operating levels after a spill event.

H_{03}: The magnitude of stranding is not biologically significant to the population abundance of a given fish species.

Water use decisions that will potentially be affected by the results of this monitoring program are future spill strategies and the use of pulses of water to maintain side-

channel habitat for fish downstream of the Peace Canyon dam. The basic question is whether or not spills and/or flood pulses result in benefits to fish overall by maintaining and creating habitat or are detrimental and cause significant population impacts through stranding.

Methods

The general approach of this study is to develop a stranding survey methodology to address the management questions and hypotheses identified above. The stranding survey will only be completed if a spill occurs that meets the defined criteria. The stranding survey sites will be identified from a combination of map review and aerial site reconnaissance. The study area covers the Peace River from the Peace Canyon Dam downstream to the confluence of the Pine River. A previous stranding assessment stratified this area into three segments based on river length to be covered, number of high risk stranding sites suspected from aerial observations and map review, and professional expertise (BC Hydro 1997):

- Peace Canyon to Lynx Creek 14 km
- Lynx Creek to Halfway River 31 km
- Halfway River to Pine River (Taylor) 57 km

As defined in the Peace Spill Protocol, a fish stranding assessment will occur following each spill event where the discharge from the Peace Canyon Dam is >70,629 cfs (2000 cms) for two days or longer (BC Hydro 2003). The stranding survey will be completed immediately after the spill when the total discharge has returned to within the normal operating range.

Fish stranding will be assessed at pre-selected index sites. Index sites will have some physical features that are indicative of potential stranding. The study area may be stratified to improve estimates. A previous stranding assessment stratified the area (Table 3-1) based on river length to be covered, number of high risk stranding sites suspected from aerial observations and map review, and professional expertise (BC Hydro 1997), and this scheme will likely be used in this study.

Work Completed in Year 1

After submission of an updated fisheries study team and structure to BC Hydro, a project kick-off meeting was held via teleconference on July 21, 2009. Key topics discussed during the meeting included:

1. The data and information requirements for the design phase of the project. Specific requests were made for data and reports that were not available on BC Hydro's website. Some of the requested information would not be available until a confidentiality agreement was signed.

2. It was stated that all contact with First Nations and land access is to be coordinated through BC Hydro.

3. It was stated that full pool was unlikely to be reached in 2009 and therefore a spill was not expected.

The first data sets received were the orthophotos and digital elevation model (DEM) for the study area. The DEM was used to generate 50 cm contours from the base elevation to approximately 5 m above the main channel from the Peace Canyon Dam to the Pine River confluence. Once the contours were generated a set of air photo mosaics were created for the three river segments identified above. The photo mosaics were used as the basis of the map review for the preliminary identification of potential stranding survey sites.

A copy of the report from the 1996 spill was received on March 2, 2010. The locations of stranding transects used in the 1996 survey were digitized to assist in the identification of potential stranding survey sites. Since no UTM coordinates were included in the 1996 spill report, these locations were used as a guideline only.

A draft safety plan for the field component of the project was submitted to BC Hydro for review in September 2009. An updated version of the safety plan will be submitted prior to the initiation of any field work under the monitoring program. As noted in CBA's proposal, all key fisheries personnel were confirmed to have valid Swiftwater Rescue Technician training or subsequently completed the course if updating was required.

Issues Identified in Year 1

The primary issue in Year 1 was obtaining copies of relevant reports that were not available on BC Hydro's website. The most important of these was the report and associated mapping from the 1996 spill. This and a few associated reports were received in early March 2010. This key information was required for development of the fish stranding assessment methodology. It was also not possible to complete the initial site reconnaissance in the fall of 2009 without this information; the site reconnaissance was therefore planned for spring 2010.

There are no outstanding issues in relation to continuation of work on GMSMON 3 as of March 31, 2010. Additional information that would be helpful in finalizing the study methods and planning for the site reconnaissance would be a copy of any reports prepared following the 2002 spill and flow mapping of the maximum operational discharge (70,000 cfs). Flow mapping could take the form of either map data or aerial photography completed at this discharge.

Work to be Completed in Year 2

Work planned for completion in Year 2 of the contract (April 1, 2010 – March 31, 2011) includes submission of an updated safety plan prior to the beginning of any fieldwork, finalization of the study methodology, and completion of a site reconnaissance to finalize stranding index sites. A complete stranding assessment will be undertaken if a spill occurs.

5.2.3.3 Status

Opportunistic study to be implemented in the event of a spill. There has not been a spill event to date. Pre-spill work will continue to be undertaken in 2010.

5.2.4 GMSMON#4 – WAC Bennett Dam Entrainment

Order Clause: Schedule D clause 3(b)

BC Hydro Project Manager: Kim Hawkins

5.2.4.1 Overview

Project Objective: The objectives of the monitoring program are to:

- Estimate the number of fish, size of fish, and species of fish entrained through the spillway into Dinosaur Reservoir;
- Determine the relationship between spill discharge rate and number of fish entrained through the spillway during spill releases at WAC Bennett Dam;
- Determine the level of correlation between diel/spatial variables (i.e., time of day, fish depth in water column) and number of fish entrained through the spillway during spill releases at WAC Bennett Dam, and
- Estimate the rate of acute mortality in fish entrained through the spillway.

Project Description: The WAC Bennett Dam Entrainment monitoring program will address the PSP and the PCR Flood Pulse Plan. Implementation of this study is conditional on the opportunistic occurrence of a spill event where spill discharge exceeding 7240 cfs (205 cms) at WAC Bennett Dam occurs for two days or longer. The study will be implemented for each spill event that meets this criterion.

Monitoring of fish entrainment, using a fixed-station hydroacoustic system, will occur at the spillway of the WAC Bennett Dam during the entire period of a spill, or some statistically representative period of time should there be time constraints. The rate of fish mortality will be estimated using a pilot study in the first spill event. In the event of a second spill within the 10-year study period, the pilot study will be expanded or modified accordingly based on the initial results. The study could be broadened to examine factors influencing mortality rate such as variation in spill discharge and fish species. Following completion of the survey a summary report will be prepared.

Contractor: BC Hydro contracted BioSonics Inc. (BioSonics) to undertake the hydroacoustic portion of the study should a spill occur. In the summer of 2008, as the spill risk at the Bennett Dam increased, BioSonics mobilized and, when the spill did not occur, conducted an onsite trial installation of the remote hydroacoustic fish monitoring system. BC Hydro will issue a Request for Proposals for the fish mortality portion of the program in the near future and the contract will be awarded for a period of 5 years.

ToR Status: In January 2010 the CWR approved a budget increase of $107,866 to reflect updated project implementation and management costs. The project complies with the revised ToR; no resubmission is anticipated at this time.

5.2.4.2 Contractor's Report

Opportunistic study to be implemented in the event of a spill. There has not been a spill event to date and so no annual report to date.

5.2.4.3 Status

Opportunistic study to be implemented in the event of a spill. There has not been a spill event to date.

5.2.5 GMSMON#5 – Peace River Productivity

Order Clause: Schedule C clause 4(c)

BC Hydro Project Manager: Kim Hawkins

5.2.5.1 Overview

Project Objective: The objective of this project is to address the following key management questions:

- What is the composition of the invertebrate and periphyton community in the side channels of the Peace River?
- Does increased water flow to side channels as a result of side channel enhancement or change in the minimum base flow regime alter the biomass/composition of the periphyton and invertebrate community?
- After side channel enhancement or implementation of an alternative minimum base flow regime, does the resulting periphyton and invertebrate community increase the food availability (i.e., increased abundance of invertebrate prey) to fish populations?

Project Description: The PCR Productivity monitoring program will assess the effectiveness of the PCR Side Channels and the PCR Ramping Plans, and address a data gap in the ecological knowledge of periphyton and invertebrate communities in Peace River side channel habitat.

Annual monitoring will occur during the growing season when monthly flows from Peace Canyon Dam are near or at their minimum (May-July). One year of pre-enhancement data will be collected to provide a baseline. The study area will include the section of the Peace River from the Peace Canyon Dam to the confluence with the Pine River. Within the study area, study sites will include two trial side channels (selected as part of GMSWORKS#3) as well as control side channels. If possible, the control side channels will be the same as those selected under the PCR Side Channel Fisheries project (GMSMON#7).

Project reporting will consist of a series of annual data reports and a single final report at the conclusion of the program.

Contractor: This project is scheduled to commence in 2011; the contractor has not yet been selected.

ToR Status: In January 2010 the CWR approved a budget increase of $19,694 to adjust for inflation and contingency.

5.2.5.2 Contractor's Report

This project has not yet started.

5.2.5.3 Status

Implementation of this project is dependant on sites being chosen as part of GMSWORKS#3, the design and construction components of which are currently deferred, pending a decision by the CWR. The CWR is being asked to render a decision on extending the geographic extents of the project area to include side channels downstream of the Pine River, in order to reduce potential effects that Site C may have on this project.

5.2.6 GMSMON#6 – Peace River Riparian Flooding

Order Clause: Schedule D clause 3(c)

BC Hydro Project Manager: Kim Hawkins

5.2.6.1 Overview

Project Objective: The objectives of this study are to:

- Determine species composition of vegetation in the riparian zone of the Peace River;
- Determine spatial distribution of vegetation in the riparian zone of the Peace River, and
- Assess changes over time in species and spatial composition in the riparian zone of the river.

Project Description: This riparian habitat assessment will examine the impact of a spill event on large-scale temporal and spatial trends of the vegetative community along the Peace River. The monitoring program primarily addresses the PSP and PCR Flood Pulse Plan, and secondarily the PCR Ramping Plan.

The study area includes the riparian area of the Peace River from Peace Canyon Dam to the confluence with the Pine River. Vegetation maps for the study area will be developed and a riparian vegetation assessment will occur on the ground. Vegetation maps will be created for the riparian area at normal flows and of the river channel elevation during a 120,000 cfs discharge event. Six sites, at a minimum, will undergo a detailed riparian vegetation assessment on the ground. Air photos will be interpreted in 2020 and riparian assessment of study sites will occur in 2019 and 2020 if a spill occurs prior to those years. The information will be used to assess trends in the community over time as well as response to changes in flow regimes.

An annual report will describe the methods, status of the study, and results-to-date. In the final year, the report will include a complete description of methodologies, results and statistical analyses used to assess changes in vegetation over time.

Contractor: This project is scheduled to be undertaken in 2017 and 2018 if a spill occurs prior to those dates; the contractor has not yet been selected.

ToR Status: The project complies with the ToR; no resubmission is anticipated at this time.

5.2.6.2 Contractor's Report

This project has not yet started.

5.2.6.3 Status

Opportunistic study to be implemented in 2017 and 2018 in the event of a spill release prior to 2017. There has not been a spill event to date.

5.2.7 GMSMON#7 – Peace River Side Channel Fisheries

Order Clause: Schedule C clause 4(d)

BC Hydro Project Manager: Kim Hawkins

5.2.7.1 Overview

Project Objective: This PCR Side Channel Fisheries program will monitor side channels enhanced through physical works to assess their effectiveness at improving fish habitat. Specifically, the objectives of this monitoring program are to:

- Monitor stage and flow in Peace River side channels;
- Assess degradation/aggradation in side channels;
- Assess bed-texture changes (infilling/armouring) in side channels; and
- Determine abundance and distribution of small fish within side channels.

The objectives are designed to develop a baseline of information from which spill-induced and habitat manipulation changes can be measured.

Project Description: Changes in the Peace River morphology due to reduced peak flows are suspected of creating loss and degradation of fish habitat in side channels. The PCR Side Channel Fisheries project will assess the effectiveness of the PCR Side Channels Plan and the PSP, and will include monitoring of hydrological and physical properties of side channels, as well as fish utilization, during normal operations.

This monitoring program will characterize the side channels of the Peace River in terms of flow, physical state, and fish use/presence under normal dam operations. The small-fish survey will target juveniles and other small fish in the side channels as little is known about their presence or use of this habitat. The fish survey component

will also complement the PCR Fish Index monitoring program, which focuses on the mainstem of the river, by providing a more complete picture of the Peace River fish community.

The study area is the Peace River from Peace Canyon Dam to the confluence with the Pine River. Study sites to be monitored over the 10-year period will include the trial (habitat manipulation) side channels selected in GMSWORKS#3 PCR Side Channels project and two control side channels.

Contractor: This project is scheduled to commence in 2011; the contractor has not yet been selected.

ToR Status: In January 2010 the CWR approved a budget increase of $13,586 to adjust for inflation and contingency. The project complies with the revised ToR; no resubmission is anticipated at this time.

5.2.7.2 Contractor's Report

This project has not yet started.

5.2.7.3 Status

Implementation of this project is dependant on sites being chosen as part of GMSWORKS#3, the design and construction components of which are currently deferred, pending a decision by the CWR. The CWR is being asked to render a decision on extending the geographic extents of the project area to include side channels downstream of the Pine River, in order to reduce potential effects that Site C may have on this project.

5.2.8 GMSMON#8 – Peace River Side Channel Response

Order Clause: Schedule D clause 3(d)

BC Hydro Project Manager: Kim Hawkins

5.2.8.1 Overview

Project Objective: The objective of this monitoring program is to assess the impact of high flow rates (i.e., a spill event) in side channels on:

- Channel morphology and the physical dimensions of the side channels;
- Textural changes to the bed;
- Abundance and distribution of fish species, and the relative importance of fish species life stage use within side channels; and
- Changes relative to pre-spill conditions in the side channels.

Project Description: Changes in the Peace River morphology due to reduced peak flows are suspected of creating loss and degradation of fish habitat in side channels. Spill events are a means of changing fish habitat by scouring new channels and modifying the riverbanks. The PCR Side Channel Response monitoring program will

include monitoring of hydrology, physical properties, and fish utilization of the side channels immediately (within a month) following a spill event.

This monitoring program will characterize the side channels of the Peace River in terms of morphology and fish presence and distribution following a spill event, and will assist in measuring the effectiveness of the PSP and the PCR Ramping Plan. Changes to the side channels will be quantified by comparing the data to baseline data collected as part of the GMSMON#7 PCR Side Channel Fisheries monitoring program.

The study area includes the Peace River from Peace Canyon Dam to the confluence with the Pine River. Study sites will be the same (two trial habitat manipulation side channels and two control side channels) as those monitored in the PCR Side Channel Fisheries project. Implementation of this monitoring project is conditional on a spill event occurring where total discharge from the Peace Canyon Dam exceeds 88287 cfs (2500 cms) for two or more days. It will be implemented following each spill that meets this criterion during the 10-year study period.

Contractor: BC Hydro will issue a RFP in the near future and the contract will be awarded for a period of 5 years.

ToR Status: The project complies with the ToR; no resubmission is anticipated at this time.

5.2.8.2 Contractor's Report

There is no contractor's report for 2009 as there was no spill.

5.2.8.3 Status

Opportunistic study, to be implemented in the event of a spill. There has not been a spill event to date. The sites to be monitored will be based on the site selection process imbedded in GMSWORKS#3.

5.2.9 GMSMON#9 – Peace River Spill Hydrology

Order Clause: Schedule D clause 3(e)

BC Hydro Project Manager: Kim Hawkins

5.2.9.1 Overview

Project Objective: The objective of this monitoring project is to compile and analyze the hydrology data that will be useful for investigating the effects of spill events on the aquatic systems downstream of the GMS and Peace Canyon generating stations. Without a proper understanding of the hydrology of the spill in the context of pre- and post-spill conditions, it will be difficult to understand the responses observed in the aquatic ecosystem during and after the spill.

Project Description: Much of the hydrology data that would be useful to analyze a spill event is already collected by BC Hydro and Water Survey Canada. Additional

gauging may be required on some tributaries to increase data resolution or make the data more accessible. As well, other Peace WUP projects, such as the Mainstem Stage Discharge project or the PCR Hydraulic Model project may provide important spill hydrology data (e.g. cross sections, water level gauges).

The first stage in the PCR Spill Hydrology project is to assess data that is being routinely collected and to identify any additional data requirements. If a gap exists between needs and availability, an assessment will have to be made on whether or not there is value in closing that data gap. The current budget for this project includes assessment of data collection requirements, development of the framework and the analysis of the spill event. If additional data collection platforms are deemed to be necessary in order to improve the coverage of a spill event, additional funds would be required to purchase and install the instrumentation.

A data collection framework will be constructed to describe the kinds of data to be collected, how the data will be reported, and the end use of that data. This framework would essentially be an outline of the report analyzing the spill event and will be completed by November 2010.

In the event of a spill meeting the PSP criteria, the entire cycle of the spill event (pre-spill, spill, and post-spill) will be captured for analysis. The spill event will be analyzed and a report compiled once the spill event has passed and all the data has been collected. The analysis will include a review of the data and a discussion of the relevance of data and will identify additional data needs that can be addressed during the next spill event.

Contractor: This work is being conducted by Northwest Hydraulic Consultants Ltd. in conjunction with work they are undertaking for GMSWORKS#5 and #6.

ToR Status: The project complies with the ToR; no resubmission is anticipated at this time.

5.2.9.2 Contractor's Report

There is no contractor's report for 2009 as there has been no spill.

5.2.9.3 Status

Opportunistic PSP study with a pre-spill research component that commenced in June 2009. There has not been a spill event to date.

5.2.10 GMSMON#10 – Peace River Spill Photos

Order Clause: Schedule D clause 3(g)

BC Hydro Project Manager: Kim Hawkins

5.2.10.1 Overview

Project Objective: The objective of the monitoring program is to collect aerial photos of the Peace River during and immediately after a spill event.

Project Description: The PCR Spill Photos project supports the PSP and the PCR Flood Pulse Plan management plans. The program has a secondary application for the PCR Side Channel and PCR Ramping Plans.

Photos will be taken for each spill event with total discharge exceeding 70,629 cfs (2000 cms) for at least two days. Aerial photographs will be acquired of the Peace River during spill events at a scale of 1:5000 from the Peace Canyon Dam to the confluence with the Pine River. Photos will be captured at (i) three different flows that are at 10,000 cfs intervals above 70,000 cfs (2000 cms) and (ii) immediately following the spill event when flows are less than 70,000 cfs (2000 cms). Aerial photos will undergo orthorectification. A summary report will be prepared describing the work conducted and the mapping and analytical methods used for a given spill event. The consultant will provide BC Hydro with final copies both digital and hard copy of the map files.

Contractor: In the event of a spill, aerial photography work will be conducted by Selkirk Remote Sensing Ltd. BC Hydro's Photogrammetry Services Department will provide project coordination, supervision and compilation assistance.

ToR Status: In March 2009 the CWR approved a budget increase of $99,253 to reflect updated project implementation costs. The project complies with the revised ToR; no resubmission is anticipated at this time.

5.2.10.2 Contractor's Report

There is no report for 2009 as there was no spill.

5.2.10.3 Status

Opportunistic study to be implemented in the event of a spill. There has not been a spill event to date.

5.2.11 GMSMON#11 – Peace River Spill TGP and Temperature

Order Clause: Schedule D clause 3(f)

BC Hydro Project Manager: Kim Hawkins

5.2.11.1 Overview

Project Objective: The objectives of this monitoring program are to:

- Measure TGP for the duration of a spill and immediately after, and
- Assess TGP levels in terms of impact on fish populations in the Dinosaur Reservoir and the Peace River downstream of the Peace Canyon Dam.

Project Description: Spill releases at GMS may affect the quality of downstream waters. Specifically, supersaturation of dissolved gases during a spill may occur as water plunges from the dam into the receiving waters, entraining air into the flow. The result is partial pressures of atmospheric gases in solution that are greater than in the atmosphere. TGP is a measure of dissolved gas supersaturation. At high TGP

levels, lethal and sub-lethal effects in fish have been documented. Water quality guidelines for fish populations in BC specify that TGP should not exceed levels of approximately 110% and 103% for water depths greater and less than one metre, respectively. Prolonged exposure to TGP levels exceeding 115% may result in acute physiological effects on fish. This project will monitor TGP levels to assess dissolved gas supersaturation downstream of a spill event.

The PCR Spill TGP and Temperature monitoring project addresses two Peace WUP management plans; the PSP and the PCR Flood Pulse Plan.

This monitoring is conditional on the occurrence of a spill event. TGP monitoring will begin immediately prior to a spill and will be measured continuously throughout the spill and for 2 weeks after spill completion. If possible, equipment will be installed 1-2 weeks before the spill to collect data on pre-spill conditions.

TGP meters will be installed at stations within the forebay of the dams, tailraces, and in the Peace River downstream of the Peace Canyon Dam at various locations to the confluence with the Pine River. Data will be analyzed to determine the relationship between dam discharge and TGP, and assess the extent of fish exposure to deleterious levels of gases. A report detailing the findings will be produced following the spill.

Contractor: This work will be conducted by Diversified Environmental Services Ltd., the company that also has the contract to maintain the TGP meters and conduct temperature monitoring under GMSWORKS#2.

ToR Status: In January 2010 the CWR approved a budget increase of $14,795 to reflect updated project implementation and management costs. The project complies with the revised ToR; no resubmission is anticipated at this time.

5.2.11.2 Contractor's Report

There is no contractor's report for 2009 as there was no spill.

5.2.11.3 Status

Opportunistic study to be implemented in the event of a spill. There has not been a spill event to date.

5.2.12 GMSMON#12 – Peace River Wildlife Stranding Survey

Order Clause: Schedule D clause 3(h)

BC Hydro Project Manager: Kim Hawkins

5.2.12.1 Overview

Project Objective: The objective of this project is to address the following key management questions:

- What are the impacts of a spill event on ungulates and their habitat?

- What are the impacts of a spill event on beavers and their habitat?
- What are the impacts of a spill event on riparian birds and their habitat?
- What are the impacts of a spill event on the western toad and their habitat?

Project Description: Wildlife may be impacted when a spill event occurs at Peace Canyon Dam. This project will assess these impacts and address two Peace WUP management plans: the PSP and the PCR Flood Pulse Plan.

The study area is the floodplain of the Peace River from the Peace Canyon Dam to the confluence with the Pine River. Aerial and boat surveys will be conducted to determine the number of ungulates on islands and beavers along the river. An assessment of bird and toad populations will be based on (i) a literature/expert review to determine the bird species of greatest concern based on the timing of the spill and size of spill expected, (ii) index sites selected using existing terrestrial ecosystem mapping and flow mapping, and (iii) a survey of western toad and targeted bird species to assess mortality or risk of mortality. A final report will be prepared at the end of the monitoring program.

Contractor: The contract was awarded for a period of 5 years (2009-2013) to Cooper Beauchesne and Associates Ltd.

ToR Compliance: In November 2008 the CWR approved a budget increase of $63,380 to reflect updated project implementation costs. The project complies with the revised ToR; no resubmission is anticipated at this time.

5.2.12.2 Contractor's Report

As there has not been a spill to date, there is no associated report. However, the contractor has summarized activities undertaken to date:

Introduction

In 1996 a controlled release of water from the WAC Bennett and Peace Canyon Dams raised concerns about downstream impacts to wildlife (BC Hydro 1997). As a result of the 1996 spill event, monitoring measures were recommended to assess impact on a variety of resources for future spill events. BC Hydro is also required to conduct surveys at different spill volume threshold to assess impacts on wildlife as part of its water licensing (BC Hydro 2007). Controlled releases of water or spill events are known or suspected to impact 4 groups of wildlife downstream from the dam: ungulates, beaver (*Castor canadensis*), riparian birds, and western toad (*Bufo boreas*).

Since 1996, several wildlife surveys have been conducted that provide information on the vulnerability to floodplain-dwelling wildlife to spill events. In 1996, Diversified Environmental Services conducted an assessment of ungulate use of islands with the Peace River. Two years later, Wiacek (1998) prepared a summary of the wildlife resources in the area and the potential impacts of fluctuating water levels on them.

Robertson et al. (1999) conducted aerial surveys for aquatic birds (focus on shorebirds and waterfowl) in 1996 and again in 1999. Fraker and Hawkes (2000)

conducted wildlife surveys in 1999 on the floodplain of the Peace River from the Peace Canyon Dam to the Alberta border that focused on water-associated birds, amphibians and reptiles, and aquatic mammals. In 2005 and 2006, Keystone (2006) completed baseline wildlife surveys in the Peace River corridor to update previous baseline work that had been completed in the early 1990s (Simpson 1991, 1993).

To address the impact of spill events on selected wildlife the management questions to be addressed by this monitoring program are:

1. What are the impacts on ungulates and their habitat as a result of a spill event?

2. What are the impacts on beavers and their habitat as a result of a spill event?

3. What are the impacts on riparian birds and their habitat as a result of a spill event?

4. What are the impacts on the western toad and their habitat as a result of a spill event?

To address these management questions, the following hypotheses will be tested by the monitoring program:

H_{01}: Ungulate mortality/habitat loss resulting from a spill significantly impacts the ungulate population in the Peace River floodplain downstream of Peace Canyon Dam.

H_{02}: Beaver mortality/habitat loss resulting from a spill significantly impacts the beaver population in the Peace River floodplain downstream of Peace Canyon Dam.

H_{03}: Riparian bird mortality/habitat loss resulting from a spill significantly impacts the riparian bird population in the Peace River floodplain downstream of Peace Canyon Dam.

H_{04}: Western toad mortality/habitat loss resulting from a spill does not significantly impact the western toad population in the Peace River floodplain downstream of Peace Canyon Dam.

Work Completed in Year 1

As no spill happened in Year 1 and the contract award occurred near the end of the timing window for focal taxa surveys, no field work was completed in Year 1. Planning for Year 2 field work composed the majority of the completed tasks, including:

- Start-up meeting and project management. A start-up meeting was conducted on the 21st of July 2009 with BC Hydro and CBA Ltd. personnel to identify GIS

data and literature requirements. Subsequent communication focused on data acquisition.

- Data acquisition and organization. Some GIS data was provided in Year 1, including elevation and terrestrial ecosystem mapping data. This was used to construct a digital elevation model to identify areas of both low elevation and gradient where flooding was likely to occur at peak spill levels. Terrestrial ecosystem data provided by BC Hydro was also used to identify riparian and wetland habitat for bird and amphibian survey sites.

- Literature review. A review of all pertinent literature available was completed to identify focal riparian bird species, suggest preliminary index site locations, and inform methodology development for pre- and post-spill fieldwork.

A draft safety plan for the field component of the project was submitted to BC Hydro for review in September 2009. An updated version of the safety plan will be submitted prior to the initiation of any field work under the monitoring program.

Issues Identified in Year 1

The primary issue in Year 1 was obtaining copies of relevant reports that were not available on BC Hydro's website. This included the report and associated mapping from the 1996 spill, ungulate point counts, TEM data, and land ownership data. Most of this information was received in early March 2010. A site reconnaissance was then planned for spring 2010 using this key information.

There are no outstanding issues in relation to continuation of work on GMSMON 12 as of March 31, 2010. Additional information that would be helpful in finalizing the study methods and planning for the site reconnaissance would be a copy of any reports prepared following the 2002 spill and flow mapping of the maximum operational discharge (70,000 cfs). Flow mapping could take the form of either map data or aerial photography completed at this discharge. This information will assist in refining survey site selection.

Work to be Completed in Year 2

Work planned for completion in Year 2 of the contract (April 1, 2010 – March 31, 2011) includes submission of an updated safety plan prior to the beginning of any fieldwork, finalization of the survey methods, completion of a site reconnaissance to assist in identifying stranding survey sites, and completion of pre-spill surveys at selected index sites. The peak- (if deemed necessary) and post-spill surveys wildlife stranding surveys will be completed if a spill occurs in 2010.

5.2.12.3 Status

Opportunistic study to be implemented in the event of a spill. There has not been a spill event to date.

5.2.13 GMSMON#13 – WLL Fish Index

Order clause: Schedule D 3(i)

BC Hydro Project Manager: Karen Skibo

5.2.13.1 Overview

Project Objective: The objective of the project is to collect one year of baseline information on the fish populations in the Peace arm of Williston Reservoir under normal operating conditions at the dam. The impact of a spill at WAC Bennett Dam on reservoir fish may then be assessed based on the results of this study in combination with GMSMON#4, which estimates the number of fish entrained through the spillway.

Project Description: Fish sampling (gillnetting) and hydroacoustic surveying occurred in July/August 2008. Data was collected relating to fish spatial distribution, size, and abundance.

Data Interpretation: The total number of pelagic fish in the Peace arm was estimated at 3.2 million. In comparison to a previous (non-WUP) study in 2000, the abundance of fish was greater in 2008 but individual fish were smaller overall in size. Kokanee and lake whitefish may be more susceptible to entrainment than other fish species captured due to their vertical distribution in the water column and their behavioural patterns. However, limited inference can be made on fish vulnerability to entrainment at other times of the year from this one-year study alone. Changes in fish vulnerability to entrainment over the course of a year are uncertain as fish behavioural patterns will change with reservoir conditions (e.g., mixed water column).

Contractor: This work was conducted by Peace-Williston Fish Wildlife Compensation Program and Ministry of Environment.

ToR Status: This project was completed in compliance with the ToR.

5.2.13.2 Contractor's Report

The Williston Reservoir Fish Index (2008) study focused on determining the composition, distribution and abundance of fish in the pelagic area of the Peace Arm of Williston Reservoir using data obtained from gillnetting and a hydroacoustic survey. Data from this study can be used to guide future decision making related to spill risk strategies and mitigation of impacts on reservoir fish populations. We estimated the species composition, abundance and biomass of pelagic-dwelling fish in the Peace Arm. The spatial distribution, size and age of the primary species were also determined.

The total abundance of Peace Arm pelagic fish was estimated at 3.2 million, or nearly double the estimate in 2000. The total biomass estimate (all species and sizes combined) of 3.7 kg/h for 2008 remained approximately the same as the estimate from the 2000 survey. The highest numbers of fish, particularly peamouth chub, were caught at the forebay sampling station. Despite these numbers, the forebay area is the least productive site along the length of the Peace Arm owing to higher levels of turbidity and less light penetration, which may also account for our finding that

Fulton's condition factor of fish at the forebay site was significantly less than the other sites.

The data show that kokanee are the dominant species within the pelagic area and may comprise up to 90% of the total pelagic fish numbers, of which the large majority are age 0+ fish. The next most abundant pelagic species are lake whitefish. Kokanee have taken over as the dominant pelagic species from lake whitefish, which has been shown to be dominant throughout Williston Reservoir (including Peace Arm) in previous studies. Numerically, kokanee have increased in the order of four times while lake whitefish have declined by at least 50% since the 2000 study. The increase in kokanee abundance suggested by this study is consistent with an estimated fourfold increase in the basin-wide estimates for kokanee spawners since the early 2000s. We were unable to determine the significance of peamouth in overall pelagic fish production due to highly variable catches. We assumed that their total abundance is lower than what the gillnet catch data suggests (i.e. lower than 23% of total pelagic fish) as they frequent the surface waters (particularly near the dam) where they are more vulnerable than other species to catch in surface gillnets. Gillnetting also suggested far fewer numbers of opportunistic predators (i.e., rainbow trout, lake trout and bull trout) compared with the main forage fish species (i.e., kokanee and lake whitefish).

We consider peamouth chub, kokanee, and lake whitefish to be most vulnerable to entrainment due to their extensive use of the pelagic habitat in the Peace Arm. Peamouth, although not as abundant as gillnet catches might indicate, are known to utilize pelagic habitat near the surface which would make them vulnerable to entrainment. Kokanee and lake whitefish may also be more susceptible to entrainment than other species based on their abundance and habitat preferences. Their vertical distribution and behavioral patterns during crepuscular periods into epilimnetic waters for feeding make these species particularly vulnerable during the summer when the reservoir is thermally stratified. When the reservoir is not stratified and fish distributions are more dispersed during spring, fall and winter, it is unclear how susceptible the pelagic species are to entrainment or whether some species may be more vulnerable than others.

Recommendations have been made for future sampling to refine the baseline fish index through a repeat of the 2000 sampling with some additional surface and mid-water gillnet sampling to address questions on species composition. Some additional sampling techniques (eg. sidescan sonar and near-surface trawling in the vicinity of the forebay) have been proposed as possible ways to further determine which species are most vulnerable to entrainment in the event of a spill.

5.2.13.3 Status

This project is complete.

5.2.14 GMSMON#14 – Dinosaur Reservoir Tributary Habitat

Order Clause: Schedule B clause 3(a)

BC Hydro Project Manager: Kim Hawkins

5.2.14.1 Overview

Project Objective: The objective of this project is to address the following key management questions:

- Is the tributary enhancement work pursuant to GMSWORKS#8 effective at increasing usable habitat?
- Is the area and quality of fish habitat created by the tributary enhancement work sufficient to noticeably increase spawning and rearing opportunities in the reservoir?
- Is the area and quality of fish habitat created by the tributary enhancement maintained over time?

Project Description: The productive capacity of fish populations in Dinosaur Reservoir is constrained by habitat conditions. Within tributaries, quantity of habitat is limited by fish barriers such as waterfalls, and habitat quality is affected by debris flows and silt loads from upland areas. Consequently, rearing and spawning habitat in and around the reservoir is poor. These factors, as well as increased fishing pressure, have resulted in low sportfish recruitment in the reservoir.

Fish access to tributaries and fish habitat quality within the tributaries is impacted by dam operations and by debris from upstream logging. This project is a trial attempt to improve access and/or enhance fish habitat in a selected tributary. Other tributaries may be selected for enhancement if the Dinosaur Tributary Enhancement management plan proves to be effective over its first five years.

Monitoring will include collection of at least one year of pre-enhancement data and up to four years of data from the enhanced tributary. Monitoring will occur every second year over the 10-year study period, beginning the same year as, but prior to, the enhancement work. Data collection, data analyses, and a report will be completed each study year and a final study report will be produced in Year 10.

Contractor: This project was awarded to Triton Environmental Consultants Ltd.

ToR Status: The project complies with the ToR; no resubmission is anticipated at this time.

5.2.14.2 Contractor's Report

The first contractor's annual report will be due in 2011.

5.2.14.3 Status

This monitoring project commenced in June 2010.

5.2.15 GMSMON#15 – Williston Wetland Habitat

Order clause: Schedule A 6(b)

BC Hydro Project Manager: Karen Skibo

5.2.15.1 Overview

Project Objective: The objective of the monitoring project is to assess the effectiveness of a wetland enhancement trial (GMSWORKS#17 Wetland Trials) to improve foreshore habitat for fisheries, wildlife, and riparian areas as well as maintain the enhancement over the life of the project.

Project Description: The current plan is to monitor fish, vegetation, waterfowl, and amphibian response to the enhancement. This plan is dependent on the outcome of GMSWORKS#16 Wetland Inventory, which determines the wetland site and design.

Contractor: The contractor has not yet been selected as the project is scheduled to begin in 2011.

ToR Status: This project has been delayed one year due to lack of resources. A ToR amendment will be filed with the CWR to adjust schedule and budget to reflect this delay. See also the summary of GMSWORKS#17, above.

5.2.15.2 Contractor's Report

This project has not yet begun.

5.2.15.3 Status

This work is scheduled to begin in May 2011 and to be completed by November 2020. Annual reports are expected in November of each year.

5.2.16 GMSMON#16 – Williston Debris Trends

Order clause: Schedule A 6(g)

BC Hydro Project Manager: Karen Skibo

5.2.16.1 Overview

Project Objective: The objective of the monitoring project is to assess the effectiveness of GMSWORKS#22 WLL Targeted Debris Management in reducing debris-related navigational hazards, minimizing debris-related destruction to WUP project sites, and decreasing overall volume of debris fields.

Project Description: Volume of woody debris and its recruitment to the reservoir will be assessed using field measurements and air photos. Data will be compared to the baseline survey (GMSWORKS#18 Williston Debris Field Survey) conducted in 2009 to determine if the volume of wood is decreasing over time.

Contractor: The contractor is AECOM Canada Ltd., which is also conducting GMSWORKS#18 Williston Debris Field Survey.

ToR Status: Scope and schedule for the project are presently in compliance. Direct management costs are forecast to run under budget; however, the project has yet to

begin so any resubmission to adjust the approved budget will be deferred until a later time.

5.2.16.2 Contractor's Report

This project has not yet begun.

5.2.16.3 Status

This project is scheduled to begin March 2011 and run through January 2012, with a second project year from April 2013 to January 2014, and the third year from April 2018 to January 2019. Final reports are expected in January of each project year.

5.2.17 GMSMON#17 – Tributary Habitat Review

Order clause: Schedule A 6(c)

BC Hydro Project Manager: Karen Skibo

5.2.17.1 Overview

Project Objective: The Tributary Habitat Review monitoring project will assess the effectiveness of tributary enhancement under GMSWORKS#19 Williston Trial Tributaries in improving fish and wildlife habitat. The tributary enhancement trial is expected to remove obstructions that may be blocking fish access and debris that may be eroding the shoreline.

Project Description: The current plan is to monitor fish, vegetation, songbird, and amphibian response to the tributary enhancement. This plan, however, is dependent on the outcome of inventory and design components of the GMSWORKS#19 Trial Tributaries, which identifies the project site and design.

Contractor: The contractor has not yet been selected as the project is scheduled to begin in 2011.

ToR Status: This project has been delayed one year due to lack of resources. A ToR amendment will be filed with the CWR to adjust schedule and budget to reflect this delay. See also the summary of GMSWORKS#19, above.

5.2.17.2 Contractor's Report

This project has not yet begun.

5.2.17.3 Status

This work is scheduled to begin in May 2011 and to be completed by December 2020. Annual reports are expected in December of each year.

5.2.18 GMSMON#18 – Williston Dust Control

Order clause: Schedule A 6(d)

BC Hydro Project Manager: Aaron Flett

5.2.18.1 Overview

Project Objective: The objective of the monitoring project is to provide long-term data on airborne particulate matter concentrations in the upper Finlay arm airshed and to evaluate the effectiveness of dust mitigation treatments in the drawdown zone of Finlay arm.

Project Description: Air quality monitors and meteorological instruments are installed each spring at select sites in Finlay arm. Instrumentation measures wind speed and direction, particulate matter sized10 µm (PM_{10})and 2.5 µm ($PM_{2.5}$), rainfall, temperature, and relative humidity. Data is collected from approximately early May to late June of each year.

Data Interpretation: In general, both PM_{10} and $PM_{2.5}$ concentrations were very low in 2008 but varied considerably from one site to another over the study period due to exposure, wind speed and direction as well as local sediment sources and surface moisture content. It is likely that only one dust event at one monitoring location would have exceeded the proposed Canada Wide Standard for PM_{10}. Low $PM_{2.5}$ concentrations can likely be attributed to the relatively low concentration of very fine particulates in the local beach sediments. Data results are consistent with an earlier non-WLR study that found low PM_{10} and $PM_{2.5}$ concentrations at Tsay Keh village.

Contractor: This work is being conducted by Dr. William Nickling of the University of Guelph.

ToR Status: Currently, scope, schedule, and budget are expected to be met.

5.2.18.2 Contractor's Report

Monitoring of regional air quality around Williston Reservoir was conducted at six locations during the 2008 dust season using Partisol Dichotomous Aerosol Air Samplers. The locations of the monitors were Omineca, Pet Toy, Tsey Keh, High Point, Middle Creek North, and Lafferty. Five of the sites were on exposed beaches and one site (High Point) was located in a forest clearing well above the Reservoir. PM10 and PM 2.5 concentrations were measured at all sites.

In general, PM 10 and PM 2.5 concentrations were very low. In only two one-hour periods did the PM 2.5 exceed 25 ug/m3. Most sites had several one-hour average PM10 concentrations above 50 mg/m3. It is likely that only one dust event at one monitoring location would have exceeded the proposed Canada Wide Standard for PM10 if the hourly data were averaged over 24 hours. Regional air quality will continue to be monitored at the same locations in 2009, except that the Omineca site will be moved to Davis Flats North.

5.2.18.3 Status

This work was initiated in April 2008 and is scheduled to be completed by March 2017. Annual final reports are expected in February of each year.

5.2.19 GMSMON#19 – Williston Erosion Control

Order clause: Schedule A 6(e)

BC Hydro Project Manager: Jay Joyner

5.2.19.1 Overview

Project Objective: This project will monitor the effectiveness of any constructed erosion works under GMSWORKS#23 WLL Erosion Control Trial.

Project Description: This project has not been designed, pending completion of GMSWORKS#23.

Data Interpretation: This project has not yet started.

Contractor: This project has not yet been awarded.

ToR Compliance: The submission of ToR for this project is on hold pending creation of a Reserve for the Tsay Keh Dene First Nation (TKD) pursuant to an agreement between BC Hydro, the TKD, and the Province of British Columbia.

5.2.19.2 Contractor's Report

This project has not yet begun.

5.2.19.3 Status

BC Hydro, the Province of British Columbia, and the TKD have signed an agreement with respect to certain grievances of the TKD. The final agreement impacts certain changes to Indian Reserve status in the area that may impact this project. This project is on hold pending resolution of Reserve creation.

5.2.20 GMSMON#20 – Reservoir Recreation Use

Order clause: Schedule A 6(f)

BC Hydro Project Manager: Karen Skibo

5.2.20.1 Overview

Project Objective: The objective of the monitoring project is to assess boat ramp usage on Williston Reservoir. If new boat ramps are constructed or improvements made to existing ramps as part of GMSWORKS#24 Williston Boat Access, the Reservoir Recreation Use project is designed to determine the frequency of use of

newly constructed boat ramps and measure the change in use of boat access following physical improvements.

Project Description: Vehicle traffic counters and cameras will be used to assess boat ramp usage between May and October of each year. Monitoring is taking place at existing boat ramps where site enhancements are expected based on the scope of GMSWORKS#24. The number of monitoring sites will increase in the event that new boat ramps are constructed as part of GMSWORKS#24.

Data Interpretation: Results from counter data ranged from 61 visits at Strandberg to 947 visits at Dunlevy between June 1 and October 31 2009. Cut Thumb, Finlay Bay and Dunlevy had more site users in August than in June. The proportion of photo-validated vehicles bringing boats to the recreation sites varied between 31% and 42%.

There was significantly greater boat ramp use in high water months and low water month (p<0.05) at Cut Thumb, Finlay Bay, Dunlevy. This result was expected for Finlay Bay and Dunlevy as their launch sites are only suitable for high water conditions.

The Year 1 data will be supplemented by F11/Year 2 data prior to construction of the boat launch improvement, meaning there will be 2 years of baseline data.

Contractor: This work was conducted by Synergy Applied Ecology in Year 1 and they have been renewed to continue the work in Year 2.

ToR Status: Minor adjustments to project scope and schedule were adopted in year one, including:

- Camera and counter locations were moved from boat launches to the primary access road.

- Rec use monitoring at Blackwater/Manson Dump site was replaced with Standberg.

The Year 2 contractor costs are forecast to increase from $12,814.00 to $17,000.00, due to the above-listed adjustments in Year 1 and the Year 2 changes described below.

Scope changes for Year 2 are:

- Conduct manual counts on key dates to validate data from counters and camera at select sites. This will provide greater assurance on the validity of existing and future data and may replace camera's in future years as a means of distinguishing between total vehicles vs. vehicles with boats.

- Update camera housing to deter theft and reduce data losses in Year 2. Camera data provide added value to the counter data and reducing losses will improve the effectiveness of this Monitor. The use of cameras was not a condition of the

ToR, but instead a suggestion of the contractor hence the need to provide greater theft protection was not anticipated in the ToR.

These scope, schedule, and budget changes do not impact the overall project scope, schedule, and budget.

5.2.20.2 Contractor's Report

BC Hydro is planning new boat launches and improvements to existing boat launches at several recreation sites along the Williston Reservoir. A 10-year reservoir recreation use monitoring program was initiated to assess use of the boat launch sites before and after improvements. Vehicle counters and remote cameras were used to monitor six sites in Year 1 (2009) of the monitoring program, including Elizabeth Creek and Dunlevy in the Peace Reach, and Finlay Bay (76 Mile), Six Mile Bay, Cut Thumb Bay (38 Mile), and Strandberg in the Parsnip Reach. Monitoring equipment was placed on the access road leading into each site (5 sites), or directly adjacent to the boat launch (1 site). No camera data was collected at Elizabeth Creek boat launch. Total use by site estimated from counter data varied from 61 visits at Strandberg to 947 visits at Dunlevy between June 1 and October 31 2009. Cut Thumb, Finlay Bay and Dunlevy had more site users in August than in June. The proportion of photo-validated vehicles bringing boats to the recreation sites varied between 31% and 42%. The vehicle counters are a very cost effective and reliable monitoring tool but can only provide an index of site use that may or may not reflect site use by boaters. Remote cameras function less reliably, and are more labour intensive to set-up and maintain, but the data they provide can answer the specific questions that this monitoring program is intended to address

5.2.20.3 Status

This work was initiated in May 2009 and is scheduled to be completed by February 2019. Annual final reports are expected in February of each year.

5.2.21 GMSMON#21a – Heritage and Culture Information Plan: Archaeological Overview Assessment

Order clause: 7 (a)

BC Hydro Project Manager: Karen Skibo

5.2.21.1 Overview

Project Objective: The objective of the study is to collect information on the heritage resource potential or sensitivity within portions of the drawdown zones on the Williston and Dinosaur reservoirs and along the banks of the Peace River, and, based on this research, identify heritage site locations suitable for long-term erosion monitoring.

Project Description: The project entails a review of existing documentation (e.g., maps, reports) and undocumented information (i.e., available from local First Nations) to develop a landscape-based analysis that will identify sites with

archaeological potential. Preliminary field reconnaissance work will confirm the archaeological resource potential of the identified sites.

Contractor: The work was conducted by Millennia Research Ltd.

ToR Status: In January 2010 the CWR approved a budget increase of $1,911 to adjust for inflation and contingency. The project was completed in compliance with the revised ToR.

5.2.21.2 Contractor's Report

Archaeological Overview Assessment 2009 Preliminary Report (October 31, 2009) by Millennia Research Limited – MANAGEMENT SUMMARY

An Archaeological Overview Assessment (AOA) was conducted as part of the Peace Water Use Plan project GMSMON #21A - Heritage and Cultural Information Plan, in order to begin work on formally assessing the impact of reservoir operations on archaeological sites, and recommend steps for further study. A principal outcome of the study is the identification of a short list of archaeological sites where long-term erosion studies can be carried out under GMSMON #21B.

The study area comprising a vast portion of northeastern British Columbia (BC) was divided into two principal areas, (1) Williston Reservoir and (2) Dinosaur Reservoir and the Peace River from the Dinosaur Reservoir to the Alces River near the BC/Alberta border. Each area was investigated by separate consultant; Millennia Research Limited (Millennia) for Williston Reservoir, and ARCHER CRM Partnership (ARCHER) for the downstream areas. A minimum of three sites on Williston Reservoir, one on Dinosaur Reservoir and two downstream on the Peace will be selected for a long-term study of erosion impacts from the short list provided here. One recommendation presented here is that the Dinosaur Reservoir representative, for which no archaeological site could be found, be transferred to the Williston Reservoir to better represent the great number of archaeological sites and diversity of erosional settings found there.

The surficial geological mapping by Rutter (1974) of the Williston Reservoir was found to be an excellent basis on which to identify landforms with archaeological potential in that portion of the study area. The hundreds of previously recorded archaeological sites in the Williston Reservoir were overlain on georeferenced images of the maps and the landform types correlated. These sites, and the survey that produced the inventory, are not drawn from a representative sample of landforms in the entire area. Rather, they mainly represent large plains that produce dust through saltation and which were subject to an Archaeological Impact Assessment prior to dust abatement treatment. Smaller landforms with archaeological potential, and large areas such as low elevation flats which are not suitable for dust abatement treatment, are underrepresented. However, sites in areas not surveyed by the Dust Abatement Program were found both in previous archaeological surveys, some dating to pre-inundation, and in 2009 work directed to examining such areas.

Both Rutter's classifications and field observations make it clear that archaeological potential is principally controlled by slope. Steep areas have low (but not nil) archaeological potential; flatter areas often have high potential. Most of the

archaeological sites recorded to date are located on landforms of glacial origin, principally glacial lake beds and terraces associated with deglaciation. Some sites are associated with relatively old post-glacial intermediate terraces; and a few are associated with recent post-glacial alluvial terraces, fans, and floodplain.

Eleven sites comprise the short-list for Williston Reservoir candidates for the required three long-term erosion study sites. Seven are on Finlay Reach and four are on Parsnip Reach. Specific areas for LiDAR (**Li**ght **D**etection **A**nd **R**anging) scanning are presented in the main body of the report below.

Prior to the inception of this project, the nature of erosion events and impacts on archaeological remains along the shores of the Dinosaur Reservoir and downstream along the banks of the Peace River had not been investigated in any meaningful matter. Anecdotal observations suggested that water level fluctuations along the Peace River were likely impacting archaeological remains, whether it be the controlled release of water from the Williston and Dinosaur Reservoirs or natural inflow from major tributaries of the Peace River such as the Halfway, Beatton, Pine, or Moberly Rivers. Using orthophoto imagery, 12 areas were short-listed for inspection and observation to find candidates for the three long-term erosion study sites. Three were on the Dinosaur Reservoir, and nine along the Peace River.

ARCHER's field work on selected areas of the Peace River valley and the Dinosaur Reservoir shoreline revealed that, as expected, the dynamics and extent of erosion are substantially different than what is found in the Williston Reservoir. With regards to Dinosaur Reservoir, nearly all of the shoreline displays active erosion. However, no 'flats' like those found on Williston Reservoir are present. Instead, steep, tall erosion scarps are eroding the toe of steep hillsides at most locations, and where relict fluvial and lacustrine terraces are being eroded, they are eroding into 5-7 m of water within 5 m of the shoreline. No previously, or newly, recorded archaeological sites were determined to be affected, although our ability to identify new sites was constrained to visual surveys.

Erosion along the Peace River does not appear to be directly caused by the flow of water into the Peace River (i.e., water undercutting banks until they fail). Rather, it appears that the flow of the Peace River prevents the stabilization of banks by removing previously eroded materials from the toe of slopes, preventing shoreline 'armouring' in the form of clasts and vegetation from accumulating and stabilizing the slopes above. Anecdotal evidence collected from local land owners along the Peace River in the course of our field work appears to agree with our observations that construction of the Williston and Dinosaur Reservoir dams may have altered and reduced the erosional capacity of the Peace River. At present, the largest contributor to the erosion of banks along the Peace River appears to be surface water runoff, and not the Peace River itself. Bank erosion due to surface water runoff appears to be greatest where cultivated lands border the river.

There were no suitable candidate sites for erosion monitoring studies identified in the Dinosaur Reservoir.

5.2.21.3 Status

This project is complete.

5.2.22 GMSMON#21B – Peace River Erosion Monitoring – Archaeological Resources

Order Clause: 7(b)

BC Hydro Project Manager: Kim Hawkins

5.2.22.1 Overview

Project Objective: The objective of this monitoring study is to collect quantitative measures of the magnitude, severity, rate of change and estimated duration of erosion effects caused by reservoir operations on selected heritage sites.

Project Description: This project will involve research and analysis, as a well as an in-field component for establishing monitoring stations and subsequent annual data collection. Erosion monitoring stations will be established at a minimum of six locations within the study area, divided between the Williston and Dinosaur Reservoir draw down areas and along the banks of the Peace River from the Peace Canyon Dam to the confluence with the Alces River near the BC/Alberta.

Archaeological sites identified from GMSMON#21A will be selected according to their suitability for long-term monitoring based upon their location in areas affected by reservoir operations, the presence of cultural materials on the surface, accessibility, and community preference. Non-intrusive methods of monitoring will be employed. As this study is not being carried out under a Provincial Heritage Inspection Permit, no artifacts or other cultural materials will be collected from the monitoring stations and no subsurface testing will be conducted.

Both archaeological and geospatial data collection will take place in each of the nine years of this study. Baseline LIDAR scans will be established in Year 1, with successive LIDAR scans (epochs) in each of years 2-9, inclusive. A draft interim report that summarizes the methods employed and study findings will be prepared shortly after the conclusion of the data collection each year. A final report for the study will also be provided.

Contractor: This project commenced in 2010; Millennia Research Ltd. was awarded the Year 1 (of 9) work.

ToR Status: In January 2010 the CWR approved a budget increase of $11,484 to adjust for inflation and contingency. The project complies with the revised ToR; no resubmission is anticipated at this time.

5.2.22.2 Contractor's Report

The first contractor's annual report will be due in 2011.

5.2.22.3 Status

This monitoring project commenced in the spring of 2010.

6 Peace WUP Project Costs

Table 6-1 summarizes the financial status of all Peace WUP projects as of 31 May 2010.

Table 6-1: Peace Project WUP Monitoring Programs and Physical Works Costs

Monitoring Programs and Physical Works	Activity	Costs Approved by CWR	Total Forecast (Life to Date Actuals and Forecast)	Variance Total to Approved	Explanation	Corrective Action
GMSWLR ANNUAL REPORT		$164,803	$164,803			Annual report costs for the entire WLR program are being revisited with the CWR later this year.
Peace River and Dinosaur Reservoir Monitoring Program Projects						
GMSMON#1 PCR CREEL SURVEY		$292,981	$279,083	$13,898		
	Direct Management	$60,879	$45,783	$15,096		
	Implementation	$232,102	$233,300	($1,198)		
GMSMON#2 PCR FISH INDEX		$2,285,174	$2,220,225	$64,949		
	Direct Management	$112,133	$104,205	$7,928		
	Implementation	$2,173,041	$2,116,020	$57,021		
GMSMON#3 PCR FISH STRANDING		$165,449	$16,082	$149,368		
	Direct Management	$17,079	$12,961	$4,118		
	Implementation	$148,370	$3,121	$145,249		
GMSMON#4 WACB ENTRAINMENT		$362,544	$351,408	$11,136		
	Direct Management	$35,945	$17,296	$18,649		
	Implementation	$326,599	$334,112	($7,513)		
GMSMON#5 PCR PRODUCTIVITY		$1,133,979	$1,068,965	$65,014		
	Direct Management	$129,576	$82,165	$47,411		
	Implementation	$1,004,403	$986,800	$17,603		
GMSMON#6 PCR RIPARIAN FLOODING		$226,273	$216,149	$10,124		
	Direct Management	$31,213	$21,049	$10,164		
	Implementation	$195,060	$195,100	($40)		
GMSMON#7 PCR SIDE CHANNEL FISHERIES		$841,652	$771,182	$70,470		
	Direct Management	$148,761	$92,182	$56,579		
	Implementation	$692,891	$679,000	$13,891		
GMSMON#8 PCR SIDE CHANNEL RESPONSE		$69,846	$60,735	$9,111		
	Direct Management	$16,812	$7,835	$8,977		
	Implementation	$53,034	$52,900	$134		
GMSMON#9 PCR SPILL HYDROLOGY		$68,979	$51,397	$17,582		
	Direct Management	$18,979	$12,999	$5,980		
	Implementation	$50,000	$38,398	$11,602		

GMSMON#10 PCR SPILL PHOTOS		$297,996	$297,996			
	Direct Management	$10,951	$10,951	($0)		
	Implementation	$287,045	$287,045			
GMSMON#11 PCR SPILL TGP/TEMP		$57,127	$42,085	$15,042		
	Direct Management	$21,546	$9,832	$11,714		
	Implementation	$35,581	$32,253	$3,328		
GMSMON#12 PCR WILDLIFE SURVEY		$205,448	$12,906	$192,542		
	Direct Management	$20,214	$8,415	$11,799		
	Implementation	$185,234	$4,491	$180,743		
GMSMON#13 WLL FISH INDEX		$124,909	$73,816	$51,093		
	Direct Management	$14,296	$12,796	$1,500		
	Implementation	$110,613	$61,020	$49,593		
GMSMON#14 DNR TRIBUTARY HABITAT		$150,364	$134,127	$16,237		
	Direct Management	$57,080	$40,627	$16,453		
	Implementation	$93,284	$93,500	($216)		
Peace River and Dinosaur Reservoir Physical Works Projects						
GMSWORKS#1 PCR AERIAL PHOTOS		$709,994	$392,829	$317,165		
	Direct Management	$15,317	$13,501	$1,816		
	Implementation	$694,677	$379,328	$315,349		
GMSWORKS#2 PCR BASELINE TGP/TEMP		$254,554	$214,771	$39,783		
	Direct Management	$77,340	$67,265	$10,075		
	Implementation	$177,214	$147,506	$29,708		
GMSWORKS#3 PCR TRIAL SIDE CHANNELS		$548,139	$448,427	$99,712		
	Direct Management	$128,339	$37,790	$90,549		
	Implementation	$419,800	$410,637	$9,163		
GMSWORKS#4 PCR HYDRAULIC HABITAT		$134,816	$143,823	($9,007)	Flows did not materialize for all conditions. Increased costs reflect conversion from one year to two year program.	Re submit ToR to account for extended delivery schedule
	Direct Management	$17,728	$24,331	($6,603)		
	Implementation	$117,088	$119,492	($2,404)		
GMSWORKS#5 PCR HYDRAULIC MODEL		$270,648	$245,639	$25,009		
	Direct Management	$31,742	$33,257	($1,515)		
	Implementation	$238,906	$212,382	$26,524		

GMSWORKS#6 PCR MAINSTEM STAGE DISCHARGE		$306,437	$309,345	($2,908)	Additional resources required during installation of gauges.	Staff costs to be reduced during remainder of project to deliver this project on budget.
	Direct Management	$37,664	$83,365	($45,701)		
	Implementation	$268,773	$225,980	$42,793		
GMSWORKS#7 PCR RIPARIAN HABITAT ASSESSMENT		$181,857	$102,869	$78,988		
	Direct Management	$22,854	$9,459	$13,395		
	Implementation	$159,003	$93,410	$65,593		
GMSWORKS#8 DNR RIPARIAN HABITAT ASSESSMENT		$247,265	$248,740	($1,475)	Direct Management underestimated in initial planning	Staff costs to be reduced during remainder of project to deliver this project on budget.
	Direct Management	$63,222	$98,340	($35,118)		
	Implementation	$184,043	$150,400	$33,643		
GMSWORKS#9 DNR TRIBUTARY INVENTORY & FEASIBILITY		$41,013	$30,720	$10,293		
	Direct Management	$16,031	$7,595	$8,436		
	Implementation	$25,000	$23,125	$1,875		
GMSWORKS#10 PCR INDUSTRY & TAYLOR WATER QUALITY ASSESSMENT		$220,253	$204,886	$15,367		
	Direct Management	$69,761	$64,550	$5,211		
	Implementation	$150,492	$140,336	$10,156		
GMSWORKS#12 DNR RECREATION ACCESS		$118,729	$71,750	$46,979		
	Direct Management	$60,765	$15,796	$44,969		
	Implementation	$57,964	$55,954	$2,010		
GMSWORKS#13 PCR RECREATION ACCESS		$326,409	$128,062	$198,347		
	Direct Management	$96,825	$13,548	$83,277		
	Implementation	$229,584	$114,514	$115,070		
Williston Reservoir Monitoring Program Projects						
GMSMON#15 WLL WETLAND HABITAT		$981,420	$950,417	$31,003		
	Direct Management	$157,922	$126,917	$31,005		
	Implementation	$823,498	$823,500	($2)		
GMSMON#16 WLL DEBRIS TRENDS		$215,563	$208,533	$7,030		
	Direct Management	$46,859	$39,833	$7,026		
	Implementation	$168,704	$168,700	$4		
GMSMON#17 WLL TRIBUTARY HABITAT		$1,467,158	$1,451,460	$15,698		
	Direct Management	$133,598	$117,760	$15,838		
	Implementation	$1,333,560	$1,333,700	($140)		

GMSMON#18 WLL DUST CONTROL		$3,595,427	$3,594,063	$1,364		
	Direct Management	$250,306	$249,507	$799		
	Implementation	$3,345,121	$3,344,556	$565		
GMSMON#19 WLL EROSION CONTROL					This project is on hold. See the project description, above.	
	Direct Management		$2,527	($2,527)		
	Implementation		$4,752,500	($4,752,500)		
GMSMON#20 WLL RECREATION USE		$268,906	$256,917	$11,989		
	Direct Management	$115,060	$103,194	$11,866		
	Implementation	$153,846	$153,723	$123		
GMSMON#21A WLL ARCHAEOLOGICAL OVERVIEW ASSESSMENT		$113,614	$111,301	$2,313		
	Direct Management	$16,186	$17,902	($1,716)		
	Implementation	$97,428	$93,399	$4,029		
GMSMON#21B WLL EROSION MONITORING OF ARCHAEOLOGICAL RESOURCES		$705,659	$654,262	$51,397		
	Direct Management	$119,954	$77,670	$42,284		
	Implementation	$585,705	$576,592	$9,113		
Williston Reservoir Physical Works Projects						
GMSWORKS#14 WLL AIR PHOTOS & DEM		$2,804,180	$2,302,684	$501,496		
	Direct Management	$30,295	$45,250	($14,955)		
	Implementation	$2,773,885	$2,257,434	$516,451		
GMSWORKS#16 WLL WETLAND INVENTORY		$143,076	$128,857	$14,219		
	Direct Management	$12,656	$14,820	($2,164)		
	Implementation	$130,420	$114,037	$16,383		
GMSWORKS#17 WLL TRIAL WETLANDS		$479,630	$464,177	$15,453		
	Direct Management	$78,264	$62,747	$15,517		
	Implementation	$401,366	$401,430	($64)		
GMSWORKS#18 WLL DEBRIS FIELD SURVEY		$258,412	$267,203	($8,791)	Additional resources required to implement environmental standards.	None. Costs expected to balance out over life of program.
	Direct Management	$20,735	$20,753	($18)		
	Implementation	$237,677	$246,450	($8,773)		
GMSWORKS#19 WLL TRIAL TRIBUTARY(S)		$536,522	$484,969	$51,553		
	Direct Management	$135,156	$83,136	$52,020		
	Implementation	$401,366	$401,833	($467)		

GMSWORKS#20 WLL DUST SOIL MAPPING		$351,569.00	$351,158	$411		
	Direct Management	$16,111.00	$16,000	$111		
	Implementation	$335,458.00	$335,158	$300		
GMSWORKS#21 WLL DUST CONTROL TRIAL		$1,444,279	$1,443,003	$1,276		
	Direct Management	$46,373	$46,300	$73		
	Implementation	$1,397,906	$1,396,703	$1,203		
GMSWorks#22 WLL DEBRIS REMOVAL		$10,940,198	$10,798,481	$141,717		
	Direct Management	$151,838	$185,738	($33,900)		
	Implementation	$10,788,360	$10,612,743	$175,617		
GMSWORKS#23 WLL EROSION CONTROL TRIAL					This project is on hold. See the project description, above.	
	Direct Management		$106	($106)		
	Implementation		$33,200	($33,200)		
GMSWORKS#24 WLL BOAT ACCESS		$891,306	$359,362	$531,944		
	Direct Management	$427,592	$200,892	$226,700		
	Implementation	$463,714	$158,470	$305,244		
GMSWORKS#25 WLL BATHYMETRIC MAPPING		$1,219,603	$1,192,576	$27,027		
	Direct Management	$48,957	$22,036	$26,921		
	Implementation	$1,170,646	$1,170,540	$106		
GMSWORKS#26 WLL COMMUNICATIONS/SAFETY		$1,610,081	$1,284,348	$325,733		
	Direct Management	$425,173	$219,027	$206,146		
	Implementation	$1,184,908	$1,065,322	$119,586		
GMSWORKS#27 WLL FINLAY RIVER ACCESS INFORMATION PLAN		$82,146	$59,928	$22,218		
	Direct Management	$21,284	$12,198	$9,086		
	Implementation	$60,862	$47,730	$13,132		
Williston Reservoir Industry Feasibility and Design Study						
GMSWORKS#28 INDUSTRY FEASIBILITY AND DESIGN STUDY		$354,134	$2,732,250	($2,378,116)	Forecast includes all component of study (feasibility, design, construction and maintenance). CWR Approval is ONLY for feasibility.	Expectation is that this project will be delivered on budget once additional components of the program hove received Leave to Commence
	Direct Management	$21,134	$46,950	($25,816)		
	Implementation	$333,000	$2,685,300	($2,352,300)		

BOATRAMPS						
GMSWORKS# 29 Lynx Creek		$279,674.26	$279,674.26			
	Direct Management	$91,007.26	$91,007.26			
	Implementation	$188,667.00	$188,667.00			
GMSWORKS#30 Taylor Ramp		$405,452.26	$405,452.26			
	Direct Management	$91,007.26	$91,007.26			
	Implementation	$314,445.00	$314,445.00			
GMSWORKS#31 Kwadacha		$353,433.94	$353,433.94			
	Direct Management	$164,766.94	$164,766.94			
	Implementation	$188,667.00	$188,667.00			

* Red values in parentheses denote overage.