

Peace Project Water Use Plan Monitoring Programs and Physical Works Annual Report: 2011 For Implementation Year: June 2010 to May 2011 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

June 30, 2011

Monitoring Programs

- GMSMON-1: PCR Creel Survey
- **GMSMON-2: PCR Fish Index**
- GMSMON-3: PCR Fish Stranding
- GMSMON-4: WACB Entrainment
- <u>GMSMON-5: PCR Productivity</u>
- 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

Table of Contents

1	Introdu	ction	4						
2	Glossary4								
3	Background5								
4	Project Timing7								
5	Summa	ry of Peace WUP Projects	.11						
5.	1 Pe	ace WUP Physical Works Projects	. 11						
	5.1.1	GMSWORKS-1 – Peace River Aerial Photos	.11						
	5.1.2	GMSWORKS-2 – Peace River Baseline TGP and Temperature	. 12						
	5.1.3	GMSWORKS-3 – Peace River Side Channels	. 14						
	5.1.4	GMSWORKS-4 – Peace River Hydraulic Habitat	. 16						
	5.1.5	GMSWORKS-5 – Peace River Hydraulic Model	. 17						
	5.1.6	GMSWORKS-6 – Peace River Mainstem Stage Discharge	. 18						
	5.1.7	GMSWORKS-7 – Peace River Riparian Habitat Assessment	. 19						
	5.1.8	GMSWORKS-8 – Dinosaur Reservoir Demonstration Tributary	.21						
	5.1.9	GMSWORKS-9 – Dinosaur Reservoir Tributary Inventory and Feasibility	. 23						
	5.1.10	GMSWORKS-10 – Peace River Industry and Taylor Water Quality							
		Assessment	.24						
	5.1.11	GMSWORKS-12 – Peace and Williston Recreational Access (Feasibility of Boat Ramps)	.25						
	5.1.12	GMSWORKS-13 – Peace River Recreational Access	.26						
	5.1.13	GMSWORKS-14 – Williston Air Photos and DEM	.26						
	5.1.14	GMSWORKS-16 – Williston Wetland Inventory	.28						
	5.1.15	GMSWORKS-17 – Williston Trial Wetlands	.29						
	5.1.16	GMSWORKS-18 – Williston Debris Field Survey	. 30						
	5.1.17	GMSWORKS-19 – Williston Reservoir Trial Tributaries	. 31						
	5.1.18	GMSWORKS-20 – Williston Dust Mapping	. 32						
	5.1.19	GMSWORKS-21 – Williston Dust Control Trials	. 34						
	5.1.20	GMSWORKS-22 – Williston Targeted Debris Management	.43						
	5.1.21	GMSWORKS-23 – Williston Erosion Control Trial	.44						
	5.1.22	GMSWORKS-24 – Finlay Reach Access	.44						
	5.1.23	GMSWORKS-25 – Williston Reservoir Bathymetry	.45						
	5.1.24	GMSWORKS-26 – Williston Communication and Safety	.46						
	5.1.25	GMSWORKS-27 – Finlay River Access Information Plan	.48						
	5.1.26	GMSWORKS-28 – Industry Feasibility & Design Study	.48						
	5.1.27	GMSWORKS-28A District of Mackenzie Effluent Discharge Feasibility &							
		Design Study	.49						
	5.1.28	GMSWORKS-29 Lynx Creek Boat	.50						
	5.1.29	GMSWORKS-30 Peace Island Park	.50						
	5.1.30	GNSWORKS-31 Kwadacha	.51						
	5.1.31	GIVISWORKS-33 BOAT Ramp Design Ingenika	.52						
	5.1.32	GIVISWORKS-34 BOAT Ramp Design Finlay Bay	. 52						
	5.1.33	GIVIS WORKS-35 BOAT Ramp Design 6 Mile Bay	.53						
	5.1.34	GINSWORKS-36 Boat Ramp Design Cut Thumb Bay	. 54						

	5.1.35	GMSWORKS-37 Boat Ramp Design Mackenzie Landing	54
	5.1.36	GMSWORKS-40 Boat Ramp Design Blackfoot Park	55
	5.1.37	GMSWORKS-41 Boat Ramp Design Halfway River	56
	5.1.38	GMSWORKS-53 Boat Ramp Design Hudson's Hope	57
	5.1.39	GMSWORKS-54 Boat Ramp Design Dunlevy	57
5.	2 Pe	eace WUP Monitoring Program Projects	58
	5.2.1	GMSMON-1 – Peace River Creel Survey	58
	5.2.2	GMSMON-2 – Peace River Fish Index	59
	5.2.3	GMSMON-3 – Peace River Fish Stranding	64
	5.2.4	GMSMON-4 – WAC Bennett Dam Entrainment	67
	5.2.5	GMSMON-5 – Peace River Productivity	68
	5.2.6	GMSMON-6 – Peace River Riparian Flooding	70
	5.2.7	GMSMON-7 – Peace River Side Channel Fisheries	71
	5.2.8	GMSMON-8 – Peace River Side Channel Response	72
	5.2.9	GMSMON-9 – Peace River Spill Hydrology	74
	5.2.10	GMSMON-10 – Peace River Spill Photos	75
	5.2.11	GMSMON-11 – Peace River Spill TGP and Temperature	76
	5.2.12	GMSMON-12 – Peace River Wildlife Stranding Survey	77
	5.2.13	GMSMON-13 – WLL Fish Index	80
	5.2.14	GMSMON-14 – Dinosaur Reservoir Tributary Habitat	81
	5.2.15	GMSMON-15 – Williston Wetland Habitat	84
	5.2.16	GMSMON-16 – Williston Debris Trends	85
	5.2.17	GMSMON-17 – Tributary Habitat Review	86
	5.2.18	GMSMON-18 – Williston Dust Control	87
	5.2.19	GMSMON-19 – Williston Erosion Control	91
	5.2.20	GMSMON-20 – Reservoir Recreation Use	92
	5.2.21	GMSMON-21A – Heritage and Culture Information Plan: Archaeological Overview Assessment	93
	5.2.22	GMSMON-21B – Peace River Erosion Monitoring – Archaeological	
	_	Resources	94
6	Peace	WUP Project Costs	96
		•	

BC Hydro Peace Project Water Use Plan Annual Report: 2011

1 Introduction

This document summarizes the status of Peace Project Water Use Plan (WUP) physical work and monitoring program projects as of 31 May 2011 (financial information is current to 31 May 2011). 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_riv er_executive_summary.pdf

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

DNR: Dinosaur Reservoir.

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.

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, also known as Williston Lake.

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 9 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 9 February 2008 and present, ToR were submitted to the CWR at various times for approval and leave to commence ordered projects. In addition, addendums to various ToR have been submitted to the CWR at various times for approval. Leave to commence all projects for which ToR or addendums 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, and accepted by, the CWR. No ToR have yet been submitted for those portions of the project relating to the forest products mills in Mackenzie, but submission is expected in 2011.

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 2014 because of the staggered start years of projects. During the review, the WUP Committee, as it is then constituted, will:

- Consider the results of certain 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 certain 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 2011

Project		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
GMSWORKS-1: PCR Aerial Photos	√7	$\sqrt{7}$	\checkmark^7	u/w ⁷					• ⁸	•				
GMSWORKS-2: PCR Baseline TGP/Temperature	✓	✓	√	u/w	•	•	•	•	•	•	•			
GMSWORKS-3: PCR Side Channels	Del	✓	√		•	•								
GMSWORKS-4: PCR Hydraulic Habitat	Del	\checkmark	✓	u/w										
GMSWORKS-5: PCR Hydraulic Model	Del	✓	√	u/w	•	- ⁶								
GMSWORKS-6: PCR Mainstem Stage Discharge	Del	✓	✓	u/w⁵	- ⁵	- ⁵	• ⁵	• ⁵	- ⁵	- ⁵	- ⁵	• ⁵		
GMSWORKS-7: PCR Riparian Habitat Assessment			√	•										
GMSWORKS-8: DNR Demonstration Tributary			√		- ⁵	•5	• ⁵	• ⁵	- ⁵					
GMSWORKS-9: DNR Tributary Inventory & Feasibility		✓												
GMSWORKS-10: PCR Industry & Taylor Water Quality	Del	.(_	_								
Assessment	Dei	v	v	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 ⁴										
GMSWORKS-19: WLL Trial Tributaries	Del	✓			- ⁵	• ⁵	• ⁵	• ⁵	- ⁵					
GMSWORKS-20: WLL Dust Source Survey		\checkmark	✓	u/w	•									
GMSWORKS-21: WLL Dust Control Trial	✓	\checkmark	✓	u/w										
GMSWORKS-22: WLL Debris Management		\checkmark	√	•	•	•	•	•	•	•	•	_ ³		
GMSWORKS-23: WLL Erosion Control Trial	Del ¹	Del1	Del1	Del1										
GMSWORKS-24: WLL Boat Access	Del	✓	√											
GMSWORKS-25: WLL Bathymetric Mapping			√	•										
GMSWORKS-26: WLL Communications/Safety	Del	✓	Del	∎ ⁵	• ⁵	■ ⁵	∎ ⁵	∎ ⁵	5	- ⁵	• ⁵	5	5	■ ^{5,9}
GMSWORKS-27: WLL Finlay River Access Information		.(./											
Plan		v	v											
GMSWORKS-28: Industry Feasibility & Design Study		Del	\checkmark^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			v	•	•	•	•	•	•	•	•	•	•	•
GMSWORKS-31 Kwadacha Boat Launch Maintenance			~	•	•	•	•	•	•	•	•	•	•	•
GMSWORKS-33 Boat Ramp Design Ingenika			✓											
GMSWORKS-34 Boat Ramp Design Finlay Bay			√											
GMSWORKS-35 Boat Ramp Design 6 Mile Bay			✓											
GMSWORKS-36 Boat Ramp Design Cut Thumb bay			✓											
GMSWORKS-37 Boat Ramp Design Mackenzie Landing			✓											
GMSWORKS-40 Boat Ramp Design Blackfoot Park			√											
GMSWORKS-41 Boat Ramp Design Haitway River			√											
GMSWORKS-53 Boat Ramp Design Hudson's Hope			√											
GIVISVVUKKS-54 BOAT RAMP Design Dunievy	- D-	agram to he	v	/initiated :-	a idoatifi -	dvoer								
	Pro Pro	ogram to be	undertaken.	miliated II		u year								
Legend		U/W Project is under way												
		oject is delay	ed for the v	rear										

Footnotes: 1. Delayed pending completion of outstanding commitments under contract between BC Hydro, the Province of BC, and the Tsay Keh Dene First Nation.

Peace Project Water Use Plan Annual Report: 2011

- 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. Final report completion.
- 5. Work in this year represents maintenance at existing sites.
- Project wrap up costs, only (i.e. data archiving, report edits, etc.)
 One of five flows captured in 2008, two additional flows captured in 2009, none in 2010, remaining to be taken in 2011 if possible.
- Flows not captured in Year 9 will be taken in Year 10.
 Maintenance work will continue in future years.

Table 4-2: Schedule of Peace WUP Monitoring Program Projects Implementation as of June 2011

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			Del⁵	•	•	•	•	•	•	•	•	•	•	
GMSMON-6: PCR Riparian Flooding										- ⁴	- ⁴			
GMSMON-7: PCR Side Channel Fisheries			Del⁵	•	•	•	•	•	•	•	•	•	•	• ²
GMSMON-8: PCR Side Channel Response				• ⁴										
GMSMON-9: PCR Spill Hydrology		\checkmark	\checkmark	- ⁴										
GMSMON-10: PCR Spill Photos				• ⁴										
GMSMON-11: PCR Spill TGP/Temperature				• ⁴										
GMSMON-12: PCR Wildlife Survey		\checkmark	\checkmark	• ⁴										
GMSMON-13: WLR Fish Index	\checkmark	\checkmark												
GMSMON-14: DNR Tributary Habitat			\checkmark		•		•		•		•			
GMSMON-15: WLL Wetland Habitat			Del ⁶	u/w	•	•	•	•	•	•	•	•	•	
GMSMON-16: WLL Debris Trends				•	• ²	•	• ²				•	• ²		
GMSMON-17: WLL Tributary Habitat			Del ⁶	u/w	•	•	•	•	•	•	•	•	•	
GMSMON-18: WLL Dust Control	\checkmark	\checkmark	\checkmark	u/w	•	•	-	•	•	•	• ²			
GMSMON-19: WLL Erosion Control	Del ¹	Del ¹	Del ¹	Del ¹										
GMSMON-20: WLL Recreation Use		\checkmark	\checkmark	u/w	•	•	•	•	•	•	•	• ²		
GMSMON-21A: WLL Archaeological Overview Assessment		\checkmark	\checkmark											
GMSMON-21B: WLL Erosion Monitoring of Archaeological		Del	1	11/14/							I.			
Resources		Dei		u/w	-	-		-	-	-	-			
Legend	egend → 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 completion of outstanding commitments under contract between BC Hydro, the Province of BC, and the Tsay Keh Dene First Nation.

2. Final report completion only.

3. Delayed pending discussions with CWR re suitability of study to meet management objectives.

4. Opportunistic study to be implemented in the event of a spill meeting the criteria of the PSP.

5. Delayed one year due to delay of corresponding WORKS projects.

6. 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 31 May 2011 (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 the contractor's 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 two 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

There is no contractor's report for 2010 as no work was undertaken (see 5.1.1.3 Status, below).

5.1.1.3 Status

This work was initiated in October 2008 when one set of photos were taken at midrange flow. The bibliography of Peace River maps was completed in April 2009. The bibliography of Peace River maps was completed in April 2009. In September 2009, two low flow situations were photographed.

Effort was made in 2010 to capture the two remaining flow photographs, however conditions were not favourable to create the required flows during the period when it was feasible to take the photographs (i.e. between May and Oct. when ground and water is ice/snow free and the sun angle is appropriate for the photos to be taken). Near record low reservoir levels in Williston combined with energy market demands resulted in a postponement of the photos until later in the summer when market conditions were expected to improve. Then on September 16, 2010 Peace Canyon transformer T2 was forced out of service limiting plant discharge to only half the normal capacity. It didn't come back online until Oct 27, 2011, too late to get the air photos done due to the low sun angle.

BCHydro will attempt to capture the remaining high flow photos between July and August 2011. As the previous contractor has recently gone out of business an RFP will be issued shortly to identify a new contractor capable of taking the aerial photography. A second set of photos are to be taken in Year 9 (2016), and completed in Year 10 (2017) if necessary.

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

Annual Report – Executive Summary

Long-term monitoring of baseline water temperature and total dissolved gas pressure (TDGP) in the vicinity of the WAC Bennett and Peace Canyon dams is an essential component of the Peace Spill Protocol and the Peace River Flood Pulse Plan as set out by the Peace Water Use Plan Committee and the Peace Water Use Plan (WUP; BC Hydro 2010). Data collected through the monitoring of these parameters will be used to help assess and quantify the environmental effects of spills, as well as provide information on the temperature regime of the Peace River under normal operating conditions and the influence of reservoir operations on downstream temperature. Long-term baseline temperature data will also be available for use in other projects and monitoring programs within and outside of the Peace WUP. This report summarizes data collection and maintenance activities conducted at 18 monitoring sites located between the WAC Bennett Dam forebay (Williston Reservoir) and a point approximately 7 km downstream of the confluence of the Pine and Peace rivers during Year 2 (Dec 2009 - Dec 2010).

In situ reference temperatures were recorded at the time of each field download event using a certified laboratory-grade mercury thermometer calibrated in

increments of 0.1°C, for comparison to the corresponding hourly logger readings. With the exception of 2 sites (pineDN1 and replacement logger halfUP2), mean calibration errors for all temperature loggers were ≤ 0.2 °C.

Results of Year 2 water temperature monitoring over the 132 km length of the study area indicate a moderating effect of hypolimnetic withdrawal from Williston Reservoir and seasonal impacts associated with ambient air temperature. Minimum winter temperatures decrease and maximum summer temperatures increase with distance downstream.

Long term sampling protocols were refined in Year 2. Low flow conditions prevalent in the Peace River mainstem throughout the summer and fall of 2010 resulted in stranding of loggers at or above the waterline during some extreme low flow periods, which saw levels much lower than those observed in Year 1. Adjustments were made to ensure data loggers remained submerged at all flow conditions. Potential loss of data from logger stranding, tampering, or battery failure could be reduced by decreasing the interval between downloads.

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. NHC has completed the Inventory and site selection phase. We will be posting and RFP for the permitting, construction design, and construction in June 2011.

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%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 m³/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 two in the reach) would benefit from cold-clear water fish assemblages including bull trout, rainbow trout and Arctic grayling.

Side Channel complexes 32L and 102.5R were identified as the sites with the highest overall rating based on the overview assessment carried out under this study. The 102.5R 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.

We are requesting that the CWR extend the geographic extents of the project area to include the 102.5 R sidechannel, downstream of the Peace River/Pine River confluence, 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 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. The remaining two flows have not been yet classified and are expected to be classified in summer and fall 2011.

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 crosssectional 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 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. Addendum Update letter submitted to CWR on March 18 2011: The WUP prescribed a budget of \$50,000 to deliver this project over a 10 year period. However, after the installation of the equipment, it is clear that the WUP budget estimate does not reflect the effort and costs required to obtain data sufficient to reach the objective that drives the project. Specifically, the budget will not support the envisioned methodology of maintaining 5 stations to RISC (2009) Grade A standards over a 10 year period. The RISC standards were developed by the BC Ministry of Environment to define uniform guidelines for field procedures, calculations, validations, and documentation of hydrometric information from nonintegrated (non-Water Survey of Canada, WSC) hydrometric stations. Grade A standard is applied to the highest level of data quality. The consultant has proposed an alternative maintenance program of regularly scheduled annual work for a period of five (5) years at the RISC (2009) Grade A standard. The consultant advises that this will address the objective. The cost for the revised program is \$108,757.00 with contingency for the full five years.

5.1.6.2 Status

This work was initiated in May 2009 and is scheduled to be completed by January 2015. Work will progress after the decision is made by the CWR.

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 was awarded to Cooper Beauchesne and Associates Ltd. and work on Year 1 of 2 commenced in July 2010.

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

Annual Report - Executive Summary

Changes in the hydrograph of the Peace River downstream of the Peace Canyon Dam are considered to have altered the dynamics and succession in riparian vegetation communities. It is assumed that the Peace River riparian communities have not yet reached a state of equilibrium under the regulated flow regime following construction of the W.A.C. Bennett and Peace Canyon dams.

The focus of this project, GMSWORKS 7 – Peace River Riparian Habitat Assessment, is to assess the current state of riparian habitats along the Peace River from the Peace Canyon Dam downstream to the confluence of the Pine River. The riparian zone was defined as the area between flows of 10,000 cfs (283 m³/s) and 120,000 cfs (3398 m³/s). This report presents the results from Year 1 (2010) of the Peace River Riparian Habitat Assessment project. The focus of this report is on the results of the photo interpretation and the ground-truthing completed to date.

During photo interpretation, a total of 32 habitat types were created to classify riparian habitats in the study area. Riparian habitat types identified through the photo interpretation component of the project included non-vegetated, herbaceous and shrub, forested, wetlands, standing water and anthropogenic disturbance. A total of 1232 polygons were created to classify the more than 6255 ha of riparian habitats in the study area.

In Year 1, ground sampling was completed in 16 of the 32 riparian habitat types identified through photo interpretation. The minimum number of two full plots was only completed in half of the riparian habitats sampled to date. However, based on the ground-truthing completed to date, it appears that the habitat typing from the photo interpretation was generally accurate. The one exception was habitat class 14, where paper birch (*Betula papyrifera*) was mis-typed as trembling aspen (*Populus tremuloides*). It was also noted that some height classes were also outside of the range assigned during photo interpretation. Additional ground truthing data will be required to address both of these issues.

The focus of Year 2 will be on completing the ground truthing of the riparian habitats identified through photo interpretation and refining the mapping based on the ground-truthing results.

5.1.7.3 Status

Year 1 work was completed in 2010/2011 and the second and final year of the project will be undertaken in 2011/2012.

5.1.8 GMSWORKS-8 – Dinosaur Reservoir Demonstration Tributary

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

BC Hydro Project Manager: Kim Hawkins

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: Triton Environmental Consultants Ltd. was contracted to undertake Environmental Impact Assessment related activities.

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

Annual Report - Executive Summary

The Dinosaur Reservoir is a run-of-the-river design that has 15 sport and non-sport fish species documented (Langston and Murphy 2008). Pattenden and Ash (1993) identified reservoir food supply, fish entrainment over the Peace Canyon Dam, and rearing and spawning habitat as the primary factors limiting fish productivity within the Dinosaur Reservoir. This is largely due to the small littoral area associated with the Reservoir's steep bottom topography, and the short water retention period of only three days (Pattenden and Ash 1993). As such, the rearing and spawning habitat opportunities available in tributaries is critical for supporting a viable sport fishery in the Reservoir.

An assessment completed in association with GMSWORKS-9 determined the best tributary-related opportunity for enhancing the productive capacity of the Dinosaur Reservoir fishery is to realign Portage Creek and Bullrun Creek such that they drain into the Reservoir (Triton 2009). Currently both creeks flow into the Peace River just downstream of the Peace Canyon Dam, and have impassable barriers located at their confluences.

The Project is located on Crown land and is expected to result in over 22 km of new habitat becoming accessible to Dinosaur Reservoir fish including: 2.4 km of mainstem habitat in Bullrun Creek, 18.3 km of mainstem habitat in Portage Creek, and 1.9 km of new mainstem channel alignment. It is estimated this would represent the most accessible habitat area of any Reservoir tributary; currently Johnson Creek and Gething Creek offer the most habitat area with 21,320 m² and 20,250 m² respectively (Triton 2009). However, the Portage/Bullrun system would not necessarily be more valuable to the productive fish capacity of the Reservoir than the

contributions made by Johnson and Gething, because those are large tributaries with high value spawning habitat.

The design and implementation components of the proposed works will be addressed through Peace Water Use Plan (WUP) project GMSWORKS-8 – Dinosaur Reservoir Demonstration Tributary, which provides for three main elements including an engineering technical feasibility report, an Environmental Impact Assessment (EIA), and an Archaeological Overview Assessment. The EIA task within that project is the focus of the present document. As laid out in GMSMON-14, the success of the proposed project will be evaluated through a five year monitoring program that will be implemented over a ten year period, including one year of baseline data collection and four years of data collection once the enhancement is completed. Year 1 of that initiative was completed in 2010 by Triton, and fish and fish habitat elements of that report are heavily referenced in this document.

Aquatic and terrestrial ecosystem components within and adjacent to the proposed project area were evaluated, and valued ecosystem components (VECs) were identified to assess impacts. The characterization of aquatic ecosystems included several elements of management concern including: fish and fish habitat and water quality. Terrestrial components of management concern that were characterized included: forested and non-forested ecosystems (including rare or endangered ecosystems and plant species), wildlife habitats, and wildlife species (including rare or endangered or endangered species).

A net gain in productive fisheries capacity for the Dinosaur Reservoir is anticipated since Portage Creek is currently a 'closed system' that may only be utilized as a recreational fishery by a few landowners, if any, whose property is bisected by this watercourse. As such, converting it into a system that contributes to a much broader fishery base clearly seems favourable. Since the potential effects of the Project on water quality (*e.g.* turbidity during construction) can be mitigated by following standard BMPs, no negative impacts to that VEC are anticipated.

To allow the ponds associated with Reach 1.2 in Portage Creek to persist for as long as possible for potential utilization by various wildlife species (*e.g.*, mammals that live in and near water such as beavers, waterfowl, and amphibians such as the western toad), it is recommended they not be drained by breaching the beaver dams for the purpose of fish salvaging. This increases the risk that not all fish will be salvaged from the pond once flows are diverted, however, the ponded areas are expected to retain much of their water until such time as the dams naturally fail. Any stranded fish should continue to survive for a period of time and will likely serve as a food source for wildlife species such as otters and mink.

Loss of up to 4.8 ha of riparian vegetation adjacent to the old stream alignments may eventually result from the Project, however, this would occur by way of a slow transition into upland forest habitat over time. As such, there will actually be a shortterm increase in riparian habitat with the creation of the new channel section. Also, riparian vegetation adjacent to the beaver ponded Reach 1.2 in Portage Creek should continue to persist for an extended time if the dams are left intact, which would conserve 1.2 ha of riparian habitat. As such, the severity of the residual effect is expected to be low and the effects will be localized. Since they are rare on the landscape, it is unlikely that any of the four plant species of potential concern (*i.e.* rusty wood-rush, western Jacob's-ladder, meadow willow and autumn willow) will be encountered within the Project area. However, if encountered they should be avoided if possible, and in the event that avoidance is not possible an effort should be made to transplant them into a suitable nearby location. With this mitigation strategy in place, no significant residual impacts are anticipated.

Wildlife species with potential to be affected by the Project include western toads and breeding birds. To protect these VECs it is recommended that any clearing or draining of ponds not commence until on or after August 1st as per the *Region 7 Omineca – Reduced Risk Timing Windows for Fish and Wildlife* to allow bird chicks to fledge their nests. By delaying construction until August, it is also likely that any tadpoles that might be present in Reach 1.2 of Bullrun Creek will have transitioned into the less sensitive toadlet life stage. However, a qualified EM should be onsite and prepared to salvage western toad tadpoles and/or toadlets if necessary, which will require a valid *Wildlife Act of British Columbia* permit. If construction starts earlier than the August 1st to April 30th window, an intensive nest survey should be completed by a qualified professional who will flag off an appropriate buffer area to be avoided. If these mitigation measures are followed, no adverse residual affects should result.

A review of VECs in the Project area suggest that effects of the Project can either be mitigated fully (if strategies are implemented as envisioned), or residual effects that might result would be localized, with no or low significance at the landscape level.

5.1.8.3 Status

Design work is scheduled to start in 2011, with construction to start in spring 2012 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 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 Status

This work was initiated in May 2009 and is scheduled to be completed by December 2011. Based on the results of Years 1 and 2 a limited additional work program is recommended for Year 3. There appears to be little justification for continuing with Years 4 and 5 of the original five-year study program as recommended in the 2010 report. A decision was made to follow the recommendations of the consultant and complete this project in Year 3.

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 Moffattt & 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 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 Moffattt & 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 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 (DEM), 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 acquired at 1:5000 and 1:20,000 for the entire reservoir. A digital elevation model (DEM) was developed based on LiDAR. Two additional sets of air photos will be acquired over a 10-year period 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 those times.

Contractor: This work was conducted by Groupe Alta/AeroPhoto and BC Hydro.

ToR Status: No changes.

5.1.13.2 Contractor's Report

This report describes the first of three sets of air photo acquisition and related photogrammetry work. The project in 2009/2010 consisted of three components:

- 1) Bibliography of a photo/maps for the Williston Reservoir area
- 2) Aerial photos at a 1:5000 and 1:20000 scale (or digital equivalent)
- 3) LIDAR and a bare earth digital elevation model

A comprehensive bibliography was created for all of BC Hydro's maps and photos of the Williston Reservoir. The bibliography includes a list of 630 maps and 64 rolls of film. The BC Hydro Photogrammetry Services maintains and stores the bibliography.

Data capture of the Williston Reservoir by GroupeAlta occurred between May 21, 2009 and June 4, 2009 and resulted in the following:

- High level (1:20000) digital photos: 1125 from 3 days of capture
- Low level (1:5000) film photos: 7940 from 22 rolls in 9 days of capture.

Delivery of the photo data occurred in a staged process. An orthophoto data set was created from the aerial photography and used the LiDAR data as control of the orthophoto, providing a very high resolution and comprehensive data set.

GroupeAlta captured the LiDAR during the same time frame as the air photos. The outcome was 2620 tiles of data for a total of 71.5 gigabytes of LiDAR data or approximately 1.5 billion points. LiDAR files were delivered in December 2009. BC Hydro Photogrammetry Services conducted quality assurance on the LiDAR files by viewing sample data in 3D Photogrammetric workstations. Groupe Alta provided vector data of man-made and natural features (all visible roads, all visible water features including marshes, swamps, ponds, rivers, etc.) from the water line to 200 m horizontal distance from full pool. The vector data was used along with the LiDAR data to create the contours for the final mapping product. BC Hydro Photogrammetry Services created 475 maps at a scale of 1:2500 and includes an orthophoto background to provide a comprehensive set of maps for the Williston Reservoir.

5.1.13.3 Status

The first stage of work was initiated in April 2009 and completed in December 2010. The second set of air photos was scheduled to be acquired in 2013, but those photos were taken in Spring of 2011 to take advantage of the very low reservoir level, thus assisting several Peace projects including dust mitigation, wetlands and tributaries, and bathymetry. Advancing those photos did not negatively affect the project budget. The third set of photos is scheduled to be acquired 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 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 2013.

5.1.16 GMSWORKS-18 – Williston Debris Field Survey

Order clause: Schedule A 3(c) BC Hydro Project Manager: Alan Chan-McLeod

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 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. The inventory report is currently in the review process and should be finalised by July 2011.

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.

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5.1.17.2 Status

This project is complete. Construction to occur in 2014.

5.1.18 GMSWORKS-20 – Williston Dust Mapping

Order clause: Schedule A 3(a)

BC Hydro Project Manager: Aaron Flett/Karen Skibo

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:

- 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;
- 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 Nickling Environmental Ltd.

ToR Status: A ToR resubmission was approved in June 2009, April 2010, and June 2011 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 $\leq 10 \ \mu m$ (aerodynamic diameter, i.e., PM_{10}) from exposed beaches around the Williston Reservoir after the annual draw down of water is an engineering challenge. An important issue for reducing dust emissions 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 and surficial conditions (e.g., sediment texture, antecedent moisture, wind speed, and air temperature) as well as the potential strength of the dust emissions. The

strength of the dust emissions is a function of the availability and amount of PM_{10} in the beach sediments (a function of sediment texture and the suspended sediment content in the Reservoir waters) 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 PM_{10} from these beaches that affects local and regional air quality.

A project was initiated in the spring of 2009 to assess the feasibility of developing a model to identify the emission potential of beaches around the Williston Reservoir in relation to textural, surficial and meteorological conditions. A model of this nature could form the basis of an operational plan that evaluates 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 2009 study were to: 1) assess the utility of remotely-sensed data obtained from satellites 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) use a recently-developed instrument (PI-SWERL) to 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, and 4) further develop an available wind erosion model to enable it to characterize erosion and dust emission potential using LandSat-derived data and the measured surface threshold and emission relationships obtained with the PI-SWERL for typical wind speeds at the Williston Reservoir. During the early phases of the investigation it was found that RADARSAT-2 imagery was not a cost effective approach and required too much data manipulation at present to be used successfully in an operational model. Although RADARSAT-2 is a superior platform in that it removes the difficult problem of cloud cover common in this region in predicting surface conditions, it use is not logistically feasible at this time.

The overall goal of the 2010 field study was to extend the range and general applicability of the dust prediction model that was developed as part of the study by Nickling et al. (2010) and to enhance the data set of 2009 by characterizing a greater spatial extent of Williston beach environments, examining temporal variability of the threshold wind speed at which dust emissions begin, and the strength of those emissions as a function of wind speed. To achieve this goal, two major objectives were developed for the 2010 field study: 1) quantify the range of potential dust emissions at beaches throughout the reservoir to the best of our ability to meet the challenges of weather, travel restrictions, and other logistical constraints, and 2) identify the locations, textural characteristics, associated threshold wind speed and potential emissions from "hot spots" where a large percentage of the total atmospheric dust loading may originate.

During the 2010 field season 321 PI-SWERL test were carried out at 16 sites around the reservoir to asses the spatial and temporal variability of dust emissions. These data were subsequently used in the further refinement and development of the DUST_EM model.

Based on the 2010 input data the revised model was successful in predicting days of high emissions that corresponded to the dates where dust storms occurred in the valley as measured by dust sampling instrumentation deployed as part of the Tillage Trials and Regional Air Monitoring programs. In addition, the model was effectively able to predict near surface wind speed at the beaches where wind sensors were available. Results clearly demonstrate 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.

The 2010 study further confirms the efficacy of the PI-SWEL as a cost effective instrument for the measurement of 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. It is clear that to fully operationalize the model more detailed testing on the beaches using PI-SWEL is necessary to constrain the temporal and spatial variability of potential emissions from the Williston Beaches.

In addition to these accomplishments several other significant results can be identified. For regions with dated or missing surface soil data sets the Grain Size Index (GSI) approach that uses LandSAT data has proven to be useful to assign surface soil textual characteristics to different areas. However, LandSAT imagery remains problematic due to its relatively infrequent flyovers and the presence of cloud cover that interferes with surface observations. In future alternative platforms other than RADARSAT and LandSAT need to be investigated as alternative sources for collecting key environmental parameters that influence dust emissions and are also logistically feasible and cost effective.

Overall the 2010 study 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. An additional three years of data are required to refine the model. A final project report is expected for February 2013.

5.1.19 GMSWORKS-21 – Williston Dust Control Trials

Order clause: Schedule A 3(a)

BC Hydro Project Manager: Aaron Flett/Karen Skibo

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 [completed];
- irrigation trial system testing response of aeolian dust concentration to an increase in beach surface moisture [completed];
- vegetation protection trial sites that use physical barriers to prevent destruction of existing vegetation in a wetland area;
- vegetation enhancement trials testing plant response to (1) different nutrient treatments, (2) transplant to non-vegetated areas, and (3) native grass seed dispersal in non-vegetated areas; and
- beginning in 2011, the feasibility of soil binding agents.

Contractor:

- Tillage trials were led by Dr. William Nickling of the University of Guelph, Dr. William Schillinger of the University of Washington, and Dr. William Fryrear. Those trials are complete.
- Irrigation trials were led by Dr. Sietan Chieng of the University of British Columbia. Those trials are complete.
- Vegetation protection trials and vegetation enhancement trials are being led by Dr. Abimbola Abiola of Olds Agricultural College, Symbios Research and Restoration, and, for the early trials, Dr. Manivalde Vaartnou and Associates.

ToR Status: Because of the adaptive approach to these cutting-edge trials, project plans have changed annually as new data, information, and learnings are incorporated. Accordingly, BC Hydro has submitted annual ToR addenda to update the scope, schedule, and budget of the project. ToR resubmissions were approved in March 2009, April 2010, and May 2011. Presently, scope, schedule, and budget are in compliance with the latest amendments.

5.1.19.2 Contractor's Report

<u>Tillage</u>

During the 2009 and 2010 field seasons North Davis Flats Beach was used to conduct both the main tillage and tillage spacing experiments. Eight windstorms occurred at Davis Beach between May 12 and June 2, 2010. Two of the storms were back-to-back; therefore, data sets were obtained from six wind events. Two major tillage experiments were conducted: (i) the main tillage experiment and (ii) the tillage spacing experiment. In addition to the BSNE and E-Sampler data sediment fill in area in the main tillage experiment was measured by GPS mapping after each windstorm. Data were also collected on soil particle size distribution, erodible fraction and soil surface roughness. The objective of the tillage spacing experiment was to determine if suitable erosion control was possible by tilling in strips. In the tillage spacing study, sediment fill in by GPS mapping, soil roughness, and BSNE dust samples were obtained after each windstorm. Soil aggregate size distribution, soil textural classification, and the percentage of clay particles less than 10 µm in diameter were determined from samples collected from the ridges after the initial tillage as well as from non-tilled areas between tillage strips. The soil texture should not change during the erosion season, but the erodible fraction may change with additional rainfall

In the main tillage experiment, GPS depositional data provided a good expression of the quantity of material being trapped by the tillage furrows. Each measurement area covered 15,000 m². In 2009 fill in on Block F was 71%, Block A was 16%, B 38%, C 25%, D 35%, and Block E 28%. In 2010 the fill in was 85% on Block F, 68% on Block E, 100% on Block D, 54% on Block C, 15% on Block B, and 16% on Block A. The wind erosion period in 2010 was much longer than in 2009. The beach soil surface was drier in 2010 compared to 2009 and winds more intense and frequent. The measured capacity of the chisel furrow is 0.002 m³/ m². The total volume of eroded soil collected by the furrows in Block F in 2009 was 21.2 m³ and in 2010 was 25.6 m³. The chain readings of soil roughness indicate that a tilled soil surface will potentially reduce soil movement by 99%. However, when there are erodible soils upwind, dust will be picked up and carried over the tilled surface. The tilled surface will not remove all the dust from the wind stream, but will prevent additional dust from entering the wind stream. Essentially, there will be no erosion of the tilled area unless eroded material upwind of the tilled area moves onto the tilled area filling the furrows, or deep sandy soils are not covered with stable clods and ridges. As the furrows fill in the surface becomes smoother and less effective in trapping sand sediment.

Tillage must be perpendicular to dominant wind direction to be most effective. The 100 m wide tilled strips in the main tillage experiment reduced the mass of soil being transported by 46 to 67%. E-samplers at the upwind and downwind edges of both the tillage and check plots measure PM_{10} concentrations at a height of 2 m above the surface. The E-samplers show an overall average reduction in PM_{10} concentrations of 7.8% across the tilled Blocks while the check areas averaged 14.9% increase in PM_{10} concentration. Conditions were much different in 2010 but the numbers are similar. The check had a 7.2% increase while the tilled had a 9.9% decrease in PM_{10} across the tilled area. The first two storms in 2010 were from a NNW direction and the PM_{10} concentrations on Block A and B were high with a steady decrease in PM_{10} at the downwind E-sampler of Block F indicating that dust was coming from upwind
beaches and there was a gradual increase in PM_{10} concentrations going across the blocks. Once the PM_{10} material gets into the wind, there is no method of getting it out of the wind stream. To minimize PM_{10} emissions, soils must not be allowed to erode.

The tillage spacing experiment indicates that soil texture was very important in identifying areas where strip tillage will be effective. If there is silt and clay within 30 cm of the soil surface, tillage will produce a rough and stable soil surface. The twisted chisel had an average furrow fill in of 29% and the lister 17%. Because of the variability between blocks there was no significant difference in fill area among the 1x, 2x, and 3x spacing treatments. The reduction on perpendicular roughness in the tillage strips from the beginning to the end of the spacing experiment was 30% for the chisel and 20% for the lister. There was no difference in erodible fraction or random roughness for the two tillage implements. Scientists have been working for over 70 years to develop tillage methods for croplands that will effectively control wind erosion. There are other soil roughening methods that may be effective at Williston, but additional experimentation would be required. We doubt that any one tillage implement will be equally effective for all soil conditions. We do know from our experiences in Williston that, to maximize erosion control, as much beach area as feasible should be tilled. Any non-tilled areas will serve as source areas of blowing dust.

Monitoring of regional air quality during the 2010 dust season was carried out around the Williston Reservoir using Partisol Dichotomous Samplers at six locations and E Samplers at four locations. Results of the regional monitoring study clearly indicated that the spring and summer of 2010 was far dustier than that of 2009, resulting in a large number of occurrences at most sites where the 24-hr average PM_{10} concentrations greatly exceed the 50 µg/m³ threshold mandated by the Canada Wide PM_{10} Standard prior to 2010. This large increase in the number of very dusty days was particularly prevalent at Tsay Keh, Davis and Pete Toy monitoring sites. The frequency and magnitude of exceedances in 2010was most likely due to the very low pool of 2010 that kept large areas of beach exposed for extended periods.

In contrast to the PM_{10} levels, relatively low levels of were found at all sites. $PM_{2.5}$ levels were typically well below 20 μ g/m³ and well within the Canada Wide Standard (CWS) for airborne particulates of 30 μ g/m³ $PM_{2.5}$ (24 hour averaging time) based on the 98th percentile of annual measurements, averaged over 3 consecutive years.

In response to concerns expressed by Tsay Keh band members and others regarding possible health effects associated with high organic carbon levels, MinVol samplers were deployed at Tsay Keh Beach and Ivor Creek (High Point) during the summer months of 2010 to measure carbon levels associated with $PM_{2.5}$. Results indicate that elemental carbon values are very low (typically >1 µg/m³) with organic carbon values being somewhat reaching maximum values of high as 9 µg/m³ at Tsay Keh and 6.8 µg/m³ at Ivor Creek/High Point. These levels are not particularly high and typical of what would be expected in forested environments with organic debris in the soils and on the beaches. As a comparison Gu et. Al (2010) found organic carbon levels associated with $PM_{2.5}$ in Tianjin, China in excess of 100 µg/m³, due primarily to the burning of coal for electrical power.

Our major recommendations to combat blowing dust on Williston Reservoir beaches in the future are:

- Develop and implement a detailed Management Plan for the implementation of dust control measures at Williston. This should be viewed as a living document that should be updated regularly as new knowledge from experiment and empirical evidence becomes available.
- Determine the major dust-emitting areas for each beach on Williston Reservoir. This information can be most readily obtained by helicopter during major wind storms. The dust-emitting areas can easily be mapped using GPS from the helicopter.
- 3) Determine soil texture to a depth of 40 cm in 50-meter-wide grids on all Williston beach areas that are potentially suitable for tillage (i.e., areas free of tree stumps). This can be accomplished by mounting a hydraulic soil probe on a Ranger off-road vehicle. The depth of sand covering the silt and clay layers can be determined by hand analysis. This information, along with the GPS coordinates from where each sample was obtained, would be entered into a hand-held data logger. Four such samples would be required for each hectare. Following completion of this grid soil textural sampling, a map can be generated for all Williston beaches to show where tillage will likely be effective and where Hydro and Tsay Keh should focus their tillage efforts. Such soil textural sampling is especially important for the dust emitting "hot spots" identified through GPS mapping by helicopter in Recommendation #2 (above). In addition to, and to compliment soil mapping, we recommend that a VERIS electrical conductivity cart be employed to provide soil textural data from the surface 40 cm of soil. Such a cart could be pulled by an ATV and map by GPS at least 50 hectares per day. The soil textural maps would be a huge benefit in determining exactly what beach areas are suitable for tillage or other control measures.
- 4) Explore different tillage implements that have the potential to lift stable silt and clay clods from fairly deep soil depths (e.g., 40 cm). These implements will need to be rugged. Spinning disc and/or coulter blades will be more expensive and wear out more quickly in the abrading sand than shanks.
- 5) Seek solutions to reduce blowing dust from deep sands where tillage is not effective. Consider small-scale research on polymer-based soil stabilizers that can to pass Canadian environmental standards when used a low rates (as they have in some other countries). Only relatively low rates of stabilizer product combined with low volumes of water carrier should be evaluated, otherwise the cost of the stabilizer product will be prohibitive and the logistics of water application over large areas unrealistic. Pulverized wood chips may be spread on deep sand areas to control dust emissions.

Vegetation

In previous years BC Hydro attempted to seed commercially available, introduced, alien, agronomic grasses to the beaches at the Williston Reservoir. This was a useful endeavor; but not successful. Consequently, the vegetation program discussed herein was initiated in 2008 to ascertain if some other techniques in vegetation establishment could provide some long-term dust mitigation on the beaches of the Williston reservoir. The program has not been underway for a sufficient period of time

to provide definite conclusions, but progress has been made in the last three years to optimize the success of future endeavors.

Native grasses of northern provenance may succeed where the agronomic grasses failed. Thus, a demonstration trial was established to ascertain the seed viability of my inventory of northern grasses. These nine species, plus three west coast grasses, all twelve of which were last harvested in 2005, were included in a demonstration trial in 2008 to determine the viability of the seeds. The trial was established at the former Abitibi log sort near Tsay Keh Dene village in 2008, and was fully evaluated August, 2009 and August, 2010. A second trial with native grasses was established on Davis North beach in 2009, and was fully evaluated in August, 2010. No signs of winter injury were apparent at either site. The plants were fully evaluated at both sites for canopy cover, plant numbers and plant height. Some species were not successful and have been eliminated from future consideration. Results indicate that seven species; violet wheatgrass (Agropyron violaceum), slender wheatgrass (Agropyron pauciflorum), bearded wheatgrass (Agropyron subsecundum), glaucous bluegrass (Poa glauca), alpine bluegrass (Poa alpina), fowl bluegrass (Poa palustris) and rocky mountain fescue (Festuca saximontana) merit consideration for future Williston reservoir seed mixtures. If BC Hydro wishes to initiate revegetation in 2013 it is necessary to start seed multiplication in 2011, and spring/fall seeding trials should be established at Collins Bay and Lafferty beach.

Other revegetation techniques have also been assessed. Graminoids such as sedges can be grown in a greenhouse environment and willow cuttings can be rooted in greenhouses. However both are expensive programs which have logistical difficulties. Thus, two small trials were established on Tsay Keh beach in 2009 to see if sedges could be grown directly on the beach, and to see if willows could be directly rooted onto the beach. Neither trial was successful, and further efforts with sedges and willows will need long-term programs at southern nurseries.

The final trial was an attempt to promote the growth of 'goosegrass' on the Williston beaches by moving roots and rhizomes of this five species complex from an area where there was extensive 'goosegrass' to an area void of 'goosegrass' in May, 2009. Initially this was very successful as numerous small plants emerged within three weeks by mid-June, 2009. However, these plants did not survive; probably because they died of drought-stress later in the very dry summer of 2009. This trial should be repeated; but the plots should be located further from the forest edge to allow for more moisture in the summer for any small plants which emerge from the roots and rhizomes.

Detailed recommendations regarding these four aspects of revegetation, and other aspects of dust control which should be considered are provided near the end of this report.

Vegetation Enhancement and Protection Trials

As part of Williston Dust Control Trials, vegetation enhancement and protection trials were carried out in 2009 to assess the use of vegetation as a means of dust mitigation on Williston Reservoir. There were no new additions of compost and fertilizers in 2010. The residual effects of 2009 NPK and compost enhancements

were monitored; hence 2010 data are compared with results obtained in 2009 which was the baseline year. The trials in 2010 included:

- Year 2 of an experiment that is testing NPK fertilizers and compost as soil amendment and soil conditioners, respectively, at Davis Flats North beach
- Year 2 of an assessment of the effectiveness of debris piles to act as berms to protect vegetated sites at Collins Bay beach
- Greenhouse trials using reservoir woody debris-based compost to grow a local native plant
- A series of small-scale informal pilot study type trials

The following is a summary of the 2010 results:

- a) The addition of NPK increased vegetation cover, plant height and above ground biomass of many plant species on Davis Flat North beach.
- b) Plant biomass and plant height showed significant correlation (R²=0.79, p=0.001).
- c) The plant growth correlated with levels of nitrogen in the soil in 2009, but not in 2010, as the nitrogen, especially nitrate-nitrogen was limiting in the soil and might have been depleted during the 2009 growth season. This is due to the fact that phosphorus is not as mobile as nitrogen and yearly addition of phosphorus may not be required.
- d) Biomass produced in 2010 was more than double that of 2009 due to both the residual effect of nutrients from 2009 and a drier than normal year with longer growing season in 2010, as well as the fact that the plots were not rotor-tilled in 2010.
- e) The levels of heavy metals in the soils of Davis Flats North were non-detectable for Sb, As, Be, Se, Sn, Th and V and insignificant for Mo for both 2009 and 2010. High levels of these trace elements are phytotoxic.
- f) The growth response of native plants, principally *Equisetum sp*, in terms of total biomass and plant height showed significant positive correlations to organic matter (R²=0.2292, p=0.05), total C, Na, SAR, Cu, Pb, Ni and K, but negative correlations to ash, Ba, Cd, Mn, Ca, CEC (cation exchange capacity) and nitrate in 2010.
- g) Significant variations were found in soil quality from location to location in the vegetation enhancement site in terms of most of the analytical parameters. An example is the levels of organic matter in the soil which were higher in plots in blocks (treatments) 3, 4 and 5 than in 1 and 2, with in without the addition of compost. These variations were responsible for the differences in the vegetation types at the site since the plots were not seeded with specific plant varieties.

- h) There are significant differences in soil characteristics between blocks (replicates) and between the top (0-15 cm) of the soil and the bottom (15-30 cm) in soils in the research plot area.
- i) Grass plugs of bentgrass from greenhouse trials that were planted on Davis were effectively established and provided complete cover within 6 weeks.
- j) There was no significant difference in the mean annual hourly soil temperatures irrespective of soil treatment, but soils with high organic matter soils and soils amended with compost were warmer than soils with low organic matter in winter and cooler in summer. This temperature inversion is observed in the soil temperature profiles.
- k) Wood debris from Williston Reservoir can be composted to produce high quality compost that meets the CCME compost quality guidelines, which can be used as soil amendment and conditioner even at concentrations as low as 5%. The addition of nitrogen fertilizer to the recipe shortened the duration of composting to less than three months. The recommended recipe for debris compost is the T2 recipe. T2 compost meets all the CCME guidelines for compost quality and maturity within 3 months. Though the earlier part of this work was done in 2009, the greenhouse and field uses of the compost were in 2010.
- I) Broadcasting of NPK fertilizer on existing growth of calamari grass (*Calamagrostis canadiences*) improved plant growth.
- m) A gene bank of reed canary grass that is native to the Tsay Keh region was collected from Rat Lake, and is currently being maintained at Olds College greenhouses. This could be used for future re-vegetation of Williston beaches.
- n) Plugs of field-ready Reed Canary grass (*Phalaris arundinacea*) can be produced under greenhouse condition within 4-5 weeks at 10 seeds per plug using pro-mix greenhouse media.

Irrigation

Two kinds of field tests for windblown dust control were proposed to be carried out during the 2010 dust season:

- 1) surface irrigation, and
- 2) debris-log (beaver) berm

Surface irrigation was carried out at Tsay Keh Beach and the debris-log berm test was proposed to be carried out at Shovel Creek. The latter was not implemented as planned due to the reasons explained below.

Surface water at Hydro Creek was the source of water used for the irrigation test. The intake point was located at the upstream end of a culvert underneath the road. This location is about 400 feet, upstream, from the mouth of the creek. About one meter operating head at the end of the irrigation main line was found. The findings confirmed that surface water at Hydro Creek has sufficient hydraulic head to allow successful delivery of water from the creek to Tsay Keh Beach for the operation of surface irrigation.

Flexible plastic tubing (normally used in subsurface drainage) was chosen for its flexibility, light weight and lower cost characteristics when compared to the commonly used irrigation pipes. A lateral spacing (between two adjacent irrigation laterals) of 35m was used. The use of this spacing was based on the results obtained from a small scale single outlet gated irrigation test conducted in 2009 at Tsay Keh Beach. The laterals were laid along the higher elevation contour lines and allowed the irrigation water to flow under gravity towards the adjacent irrigation lateral laid at the down-slope side. Irrigation was limited to three laterals due to leaks along the line and at joints which negatively affected the flow rate and pressure. Leaks in piping appeared to be a result of manufacturing-defects as well as punctures caused (i.e., by sharp object like gravel; by rolling or pulling the tubing on rough ground surface during loading and unloading, etc.) during transportation.

The following were found from the test:

- Surface irrigation can carried out at the proposed location at Tsay Keh Beach by using the surface water from the Hydro Creek. The creek has sufficient water flow and suitable pressure head for the operation of surface irrigation at the beach.
- 2) Flexible plastic (drainage) tubing can be used as irrigation lines. The tubing is easy for transport/shipping and installation owing to its flexible and light weight natures. However, the tubing has less strength in resisting puncture (normally in the form of tiny holes) by sharp objects (including gravel at the beach) during transportation (particularly loading, unloading and hauling of tubing on rough surfaces). Water will leak through the tiny holes when the tubing is conveying water. The size of the tiny holes may be widened when the tubing is bended and the water pressure in the tubing increased. This will result in the increase of leaks. Therefore, cares are needed in handling the tubing to avoid the puncture to occur.
- 3) As leak can not be totally avoided, a speedy and effective method is needed to perform the repair. Use of duct tape in leak's repair can be successful under dry condition. However, leaks from irrigation lines can only be observed (or detected) when there is water flowing in it. Under the wet condition, duct tape is no longer effective for leak's repair.
- 4) Correct tee joints must be used in making the joint (i.e. joint of lateral and main lines) to avoid water leaks. The leaks at the joint affect the flow (i.e., reduced flow rate) in the irrigation line after the joint (i.e. downstream side of the joint).
- 5) The wetting zone induced by surface irrigation varies from place to place depending on the site characteristics including the land slope, soil properties and the irrigation flow stream (flow rate) of individual outlet (orifice). Wetting patterns observed from the irrigation test were conformed to the anticipated patterns and were similar to that observed in the test conducted in 2009. The test further confirmed that irrigation water will find the best route to flow (route with steeper slope). However, the distance of water flow decreases as the amount of the

coarse grain in the sand increases. The wetting zone was larger in areas that had the higher content of silt and clay than that in areas with large amounts of sand.

It was found that the size of wetted areas varied from several hundred square meters to 4200 m^2 . It is believed that larger wetted area could be achieved if there was no leak along the irrigation lines.

A debris-log berm test was proposed to be carried out at one of the two proposed locations at Shovel Creek. A site visit to location #1 at Shovel Creek was made on May 18, 2010. It was found that there were not sufficient debris logs for the proposed test (i.e. almost all the debris logs had disappeared). In addition, the site had signs of severe erosion and several deep creeks had been created. These creeks were too deep for the heavy construction machinery to cross. Because of these unexpected field conditions, it was decided that the test should not be conducted at this location. A site visit to location #2 found that the conditions (i.e., sufficient debris logs, etc.) at location #2 were suitable for the test. However, it was difficult to get the construction machinery to the site by land (i.e. too many deep creeks to cross) and the water level in the reservoir was too low for the delivery of construction machinery to the site by barge. Therefore, no debris-log berm test was carried out.

5.1.19.3 Status

This project was originally scoped to be a three-year feasibility study. Work was initiated in April 2008. Tillage and Irrigation trials concluded in 2010. Vegetation trials continue with annual reports expected in February of each year. The current estimated project completion date is with submission of the contractors' final reports in 2014.

5.1.20 GMSWORKS-22 – Williston Targeted Debris Management

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

BC Hydro Project Manager: Alan Chan-McLeod

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 and second 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 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 enhance 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 Moffattt & 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 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 nearshore 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. An Addendum to the TOR was submitted to the CWR in June 2011 outlining the change in budget to complete the remainder of the work.

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: The original proposal was conducted by HN Telecom Ltd. (HN). HN has conducted similar work for other clients. BCHydro Telecom will be contracting the installation of the new radio equipment in 2011.

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 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 was delayed for the fall of 2010 because of poor weather. Installation at three sites (Deception Cone, Wolverine, and Morfee) will take place in July 2011. These sites will provide emergency marine radio coverage to the Finlay and Parsnip arms of the Williston Reservoir.

A delay in land tenure approvals is preventing the Portage site from being developed. As Bull Head and Carbon Creek must be linked to Portage it has been decided to delay work at Bull Head and Carbon Creek until the Portage site is secured. Portage offers the only reasonable solution to providing radio coverage to the Dinosaur reservoir. It is hoped that a resolution to the land tenure problem can be found by Fall, 2011.

The maintenance portion of the project will continue through to 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 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: Contract was awarded to Worley Parsons Canada Services in August 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

A draft report was submitted to BC Hydro in February 2011.

5.1.27.3 Status

Report is under review by BCHydro.

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. A site visit was carried out in May 2011 by a BC Hydro representative and an engineering consultant from Moffatt & Nichol. At that time maintenance was not deemed necessary as the ramp, road and breakwater appear to be in good working condition.

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 will be carried out by BCHydro in partnership with local stakeholders.

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

During a January 2011 site visit it was determined that a more intensive maintenance program would be required to keep the popular boat launch site functioning. The precast panels which were placed in the river have suffered erosion and are at the point of failure. Maintenance of these items is deemed unfeasible.

A renovation plan has been designed by Moffatt & Nichol and works to update the boat launch area to a higher specification should take place in the summer of 2011.

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: The maintenance work for this Boat Launch site has been awarded to the Kwadacha First Nation.

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

5.1.30.2 Contractor's Report

No maintenance of the boat launch site took place in 2010. A site inspection will carried out in late summer 2011 to determine maintenance requirements.

5.1.30.3 Status

A maintenance contract is in place.

5.1.31 GMSWORKS-33 Boat Ramp Design Ingenika

Order Clause: Schedule A clause 4 (b) BC Hydro Project Manager: Alan Chan-McLeod

5.1.31.1 Overview

Project Objective: This project was intended to provide a recreational Boat Launch design suitable for the given site.

- Final Construction Design Drawings
- Cost Estimate

Project Description: This project will provide a set of design drawings for a recreational boat launch at Ingenika Point.

Contractor: The engineering design work was carried out by Moffatt & Nichol.

ToR Status: CWR approval to proceed to detailed design received by BC Hydro July, 2010. GMSWORKS 24A letter dated June 28, 2010; File: 76975-35/Peace.

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

5.1.31.2 Contractor's Report

Final designs were completed in March 2011. Designs were presented and vetted at community meetings that took place during the fall of 2010 and winter 2011.

5.1.31.3 Status

Designs have been submitted to Comptroller for review.

5.1.32 GMSWORKS-34 Boat Ramp Design Finlay Bay

Order Clause: Schedule A clause 4 (b)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.32.1 Overview

Project Objective: This project was intended to provide a recreational Boat Launch design suitable for the given site.

- Final Construction Design Drawings
- Cost Estimate

Project Description: This project will provide a set of design drawings for a recreational boat launch at Finlay Bay.

Contractor: The engineering design work was carried out by Moffatt & Nichol.

ToR Status: CWR approval to proceed to detailed design received by BC Hydro July, 2010. GMSWORKS-24B letter dated June 28, 2010; File: 76975-35/Peace.

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

5.1.32.2 Contractor's Report

Final designs were completed in March 2011. Designs were presented and vetted at community meetings that took place during the fall of 2010 and winter 2011.

5.1.32.3 Status

Designs have been submitted to Comptroller of Water Rights for review.

5.1.33 GMSWORKS-35 Boat Ramp Design 6 Mile Bay

Order Clause: Schedule A clause 4 (b)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.33.1 Overview

Project Objective: This project was intended to provide a recreational Boat Launch design suitable for the given site.

- Final Construction Design Drawings
- Cost Estimate

Project Description: This project will provide a set of design drawings for a recreational boat launch at 6 Mile Bay.

Contractor: The engineering design work was carried out by Moffatt & Nichol.

ToR Status: CWR approval to proceed to detailed design received by BC Hydro July, 2010. GMSWORKS-24B letter dated June 28, 2010; File: 76975-35/Peace.

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

5.1.33.2 Contactor's Report

Final designs were completed in March 2011. Designs were presented and vetted at community meetings that took place during the fall of 2010 and winter 2011.

5.1.33.3 Status

Designs have been submitted to Comptroller of Water Rights for review.

5.1.34 GMSWORKS-36 Boat Ramp Design Cut Thumb Bay

Order Clause: Schedule A clause 4 (b)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.34.1 Overview

Project Objective: This project was intended to provide an engineered design for a recreational Boat Launch suitable for the given site.

- Final Construction Design Drawings
- Cost Estimate

Project Description: This project will provide a set of design drawings for a recreational boat launch at Cut Thumb Bay.

Contractor: The engineering design work was carried out by Moffatt & Nichol.

ToR Status: CWR approval to proceed to detailed design received by BC Hydro July, 2010. GMSWORKS-24B letter dated June 28, 2010; File: 76975-35/Peace.

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

5.1.34.2 Contractors Report

Final designs were completed in March 2011. Designs were presented and vetted at community meetings that took place during the fall of 2010 and winter 2011.

5.1.34.3 Status

Designs have been submitted to Comptroller of Water Rights for review.

5.1.35 GMSWORKS-37 Boat Ramp Design Mackenzie Landing

Order Clause: Schedule A clause 4 (b)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.35.1 Overview

Project Objective: This project was intended to provide an engineered design for a recreational Boat Launch suitable for the given site.

- Final Construction Design Drawings
- Cost Estimate

Project Description: This project will provide a set of design drawings for a recreational boat launch at Mackenzie Landing.

Contractor: The engineering design work was carried out by Moffatt & Nichol.

ToR Status: CWR approval to proceed to detailed design received by BC Hydro July, 2010. GMSWORKS-24B letter dated June 28, 2010; File: 76975-35/Peace.

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

5.1.35.2 Contractor's Report

Final designs were completed in March 2011. Designs were presented and vetted at community meetings that took place during the fall of 2010 and winter 2011.

5.1.35.3 Status

Designs have been submitted to Comptroller of Water Rights for review.

5.1.36 GMSWORKS-40 Boat Ramp Design Blackfoot Park

Order Clause: Schedule A clause 4 (b)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.36.1 Overview

Project Objective: This project was intended to provide an engineered design for a recreational Boat Launch suitable for the given site.

- Final Construction Design Drawings
- Cost Estimate

Project Description: This project will provide a set of design drawings for a recreational boat launch at Blackfoot Park.

Contractor: The engineering design work was carried out by Moffatt & Nichol.

ToR Status: CWR approval to proceed to detailed design received by BC Hydro July, 2010. GMSWORKS-12/13 letter dated June 28, 2010; File: 76975-35/Peace.

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

5.1.36.2 Contractor's Report

Final designs were completed in March 2011. Designs were presented and vetted at community meetings that took place during the fall of 2010 and winter 2011.

5.1.36.3 Status

Designs have been submitted to Comptroller of Water Rights for review.

5.1.37 GMSWORKS-41 Boat Ramp Design Halfway River

Order Clause: Schedule A clause 4 (b)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.37.1 Overview

Project Objective: This project was intended to provide an engineered design for a recreational Boat Launch suitable for the given site.

- Final Construction Design Drawings
- Cost Estimate

Project Description: This project will provide a set of design drawings for a recreational boat launch at Halfway River.

Contractor: The engineering design work was carried out by Moffatt & Nichol.

ToR Status: CWR approval to proceed to detailed design received by BC Hydro July, 2010. GMSWORKS-12/13 letter dated June 28, 2010; File: 76975-35/Peace.

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

5.1.37.2 Contractor's Report

Final designs were completed in March 2011. Designs were presented and vetted at community meetings that took place during the fall of 2010 and winter 2011.

5.1.37.3 Status

Designs have been submitted to Comptroller of Water Rights for review.

A recommendation was made to delay approval of a new boat launch at Halfway River until the next stage in the Site C approval process as this site would be inundated if Site C were to proceed. Maintenance of the site will continue. There was unanimous consent with local stakeholders to hold off any construction until a final decision on Site C is made.

5.1.38 GMSWORKS-53 Boat Ramp Design Hudson's Hope

Order Clause: Schedule A clause 4 (b)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.38.1 Overview

Project Objective: This project was intended to provide an engineered design for a recreational Boat Launch suitable for the given site.

- Final Construction Design Drawings
- Cost Estimate

Project Description: This project will provide a set of design drawings for a recreational boat launch at Dinosaur Reservoir.

Contractor: The engineering design work was carried out by Moffatt & Nichol.

ToR Status: CWR approval to proceed to detailed design received by BC Hydro May, 2010. GMSWORKS-12/13 letter dated May 07, 2010; File: 76975-35/Peace.

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

5.1.38.2 Contractor's Report

Final designs were completed in March 2011. Designs were presented and vetted at community meetings that took place during the fall of 2010 and winter 2011.

5.1.38.3 Status

Designs have been submitted to Comptroller of Water Rights for review

5.1.39 GMSWORKS-54 Boat Ramp Design Dunlevy

Order Clause: Schedule A clause 4 (b)

BC Hydro Project Manager: Alan Chan-McLeod

5.1.39.1 Overview

Project Objective: This project was intended to provide an engineered design for a recreational Boat Launch suitable for the given site.

- Final Construction Design Drawings
- Cost Estimate

Project Description: This project will provide a set of design drawings for a recreational boat launch at Dunlevy.

Contractor: The engineering design work was carried out by Moffatt & Nichol. Extensive geotechnical investigations were carried out by EXP (formerly Trow Associates).

ToR Status: CWR approval to proceed to detailed design received by BC Hydro May, 2010. GMSWORKS-12/13 letter dated May 07, 2010; File: 76975-35/Peace.

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

5.1.39.2 Contractor's Report

Final designs were completed in March 2011. Designs were presented and vetted at community meetings that took place during the fall of 2010 and winter 2011.

5.1.39.3 Status

Designs have been submitted to Comptroller of Water Rights for review

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 Management Questions

The key management questions addressed by this monitoring program are:

- 1) Are there changes to sport fishing preference and/or pressure over time and if so, does the change potentially confound efforts to evaluate success of physical works project designed to improve fish habitat/productivity?
- 2) Can the creel survey data be used as in index of fish productivity is it sensitive to changes in the fish community?

5.2.1.2 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.

5.2.1.3 Contractor's Report

There is no contractor report for 2010.

5.2.1.4 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 Management Questions

The key management question addressed by this monitoring program is:

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?

5.2.2.2 Overview

Project Objective: 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.

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.

5.2.2.3 Contractor's Report

<u>Annual Report – Executive Summary</u>

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 2010 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 24 August to 23 September, 2010 using a boat electrofisher in nearshore habitats. Field sampling conditions (i.e., discharge, water clarity, and water temperature) were considered good. While water clarity and water temperature were within the range recorded since 2001, discharge remained very low during the entire field program. General fish community characteristics in 2010 were similar to results of previous investigations. Thirteen 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

One Arctic grayling was captured in Section 1 in 2010, which is consistent with results since 2001. 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 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, and body condition-at-age) all indicated general stability in Arctic grayling population health over time.

Arctic grayling catch rates were low and fish abundance was similar among Sections 3 and 5 in 2010. 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 generally similar among sections. Fish younger than Age 4 dominated and bull trout older than Age 7 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 complete 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 low during all years.

Mountain whitefish

In 2010, 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 and older fish were much less numerous. 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 small 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 suggested a decline in population health in all three sections. As found by previous index studies, mountain whitefish catch rates differed by habitat. Mountain whitefish catch rates were higher in habitats containing minimal physical cover (SFC habitat).

After a downward trend in catch rates recorded in Section 1 between 2004 and 2007, catch rates have remained stable. Mountain whitefish catch rates in Section 3 and Section 5 continue to exhibit a cyclic pattern. During most years of study mountain whitefish recruitment indices were lower in Section 1 compared to Section 3 and Section 5. For the first time since sampling commenced, the mountain whitefish recruitment index in Section 1 was similar to recruitment indices 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, and bull trout estimates were not available in Section 1, because no marks were recovered. The bull trout, population estimate was 200 (CV = 31.0%) in Section 3. The population estimate of bull trout in Section 5 was 365 (CV = 103.5%) 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 59 bull trout in Section 5. Bayes sequential model population estimates for mountain whitefish were 27,966 (CV = 10.7%) fish in Section 1, 25,285 (CV = 6.8%) fish in Section 3, and 24,268 (CV = 10.5%) 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 estimates for mountain whitefish in 2010 were approximately double the historical record of estimates deemed to be valid. The year-to-year increase in population size (2009 to 2010) was much greater than previously recorded and this increase is too large to be due to recruitment into the sampled population. We

believe that low water caused the fish to move into the study area before the start of sampling from unsampled areas. In other words, a different population was sampled in 2010. We believe that similar dynamics occurred in 2004.

Catchability

The estimated catchability coefficients were consistent for all sections within 2010. However, the coefficients were inconsistent across years and sections where the population estimates were deemed to be reliable or represent the same population. In 2010, the catch rate remained near the historical average despite a doubling of population size suggesting hyperstable catch rates or an as yet unknown negative influence on catchability. Examination of years having low catchability coefficients suggests a correlation with sample periods subjected to minimum flows, but the relationship was not consistent across all sections.

Mountain Whitefish Age Verification

Examination of between reader age interpretations derived from mountain whitefish scales indicated good precision over multiple years and readers. Similar results were recorded by among reader comparisons. The analyses did identify a negative bias in age interpretation for older fish. The under estimation of age affected the data set used for analyses of mountain whitefish biological characteristics during two of four years examined.

Paired comparisons of mountain whitefish ages derived from scales and otoliths indicated age interpretation from scales resulted in underestimation of mountain whitefish age of approximately 1.75 years. Based on a small sample (n = 46), the difference was constant across ages. Mountain whitefish growth rate based on otolith derived age was lower than growth rate based on scale derived age. These results support initial findings by Gazey (2011). As such, use of scales for ageing results in underestimation of mountain whitefish age.

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 2010 Peace River Fish Index Project indicated that the monitoring protocols are suitable to meet this goal, particularly for mountain whitefish. Based on the findings of the 2010 Peace River Fish Index Project we recommend the following:

- Repeat the standard program to extend the time series data. Sample Sections 1, 3, and 5 to extend sampling history. The continuous record of consistent and rigorous sampling is a valuable baseline for the target populations. Adding years to the data set will increase its value.
- 2) Maintain the current study design and sampling protocols.
- Continue coordination between the WLR program and the ongoing fisheries investigations related to the potential Site C dam in order to maximize the value of collected data.

- 4) Continue structured age verification tests initiated in 2010 as part of quality assurance protocols for the index project.
- 5) Develop a work plan to address the issue of under estimation of mountain whitefish age derived from scales. Options for consideration are as follows:
 - a) Replace use of scales with use of otoliths for mountain whitefish age interpretation. This would be labour intensive and would require lethal sampling of a large number of fish.
 - b) Develop a "correction factor" for scale derived ages using either otolith based ages for older fish or using incremental growth data for known aged marked fish that are recaptured. This approach would allow use of historical index data, but to the knowledge of the authors, has not been attempted to date.
 - c) If Option (b) is considered, discuss the conceptual idea of a correction factor for age bias with researchers who may have already developed an empirically based approach.

The ultimate purpose of the Fish Index Project is to assist in the evaluation of the effectiveness of Peace River management plans, designed to improve fish habitat and productivity, by monitoring target fish populations. The following are recommendations to adjust the current Fish Index Project in order to assist in the evaluation of the effectiveness of Peace River Side Channel Plan.

- Continue the standard program in Sections 1, 3, and 5 and maintain the current study design and sampling protocols. The adult cohort of Peace River fish populations, which is targeted by the Fish Index Project, is sufficiently mobile to allow monitoring of side channel restoration effects without requiring spatial adjustment to the current sections.
- Large-fish species expected to respond to side channel restoration should be added to the list of existing target species. Standard sampling protocols should be applied to those species (i.e., measurement of biological characteristics, catch rate, and fish density).

5.2.2.4 Status

Field work was successfully completed in 2010 and the annual report received in May 2011.

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 Management Questions

The key management questions 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?

5.2.3.2 Overview

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

5.2.3.3 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:

Fish stranding has been acknowledged as one of the expected outcomes of a spill event on the Peace River however, the magnitude of stranding is unknown. The fish stranding survey monitoring project is intended to quantify the impact of spills on fish populations in the Peace River and to determine if the magnitude of these impacts is significant to individual fish populations.

A previous stranding assessment conducted following the 1996 spill on the Peace River identified the highest risk areas for stranding were areas with shallow slopes and gravel bar areas associated with braided channels. This is consistent with the factors associated with greater stranding risk described in other stranding studies. Stranded fish identified during the surveys following the 1996 spill included mountain whitefish, suckers, sculpins, dace, northern pike, stickleback, young-of-the-year cyprinids, burbot, arctic grayling, rainbow trout, chub, northern pike minnow, and troutperch.

A survey methodology was developed to assess the magnitude of fish stranding following a spill in the Peace River downstream of the Peace Canyon Dam (PCN) to the confluence of the Pine River. The survey will also provide additional information on what fish species and life stages are most affected by a spill and identify areas with the highest risk of stranding. Stranding surveys will only be completed if there is a spill event where the discharge (Q_{out}) from the Peace Canyon Dam (PCN) is $\geq 2000 \text{ m}^3/\text{s}$ ($\geq 70,629 \text{ ft}^3/\text{s}$) for two days or longer. The survey will occur immediately after the spill when total discharge has returned to within normal operating range of $Q_{out} \leq 1982 \text{ m}^3/\text{s}$ ($\leq 70,000 \text{ ft}^3/\text{s}$).

The fish stranding surveys will occur at pre-selected index sites on the Peace River between the PCN and the confluence of the Pine River. A minimum of three index sites will be surveyed in each stratum (PCN to Lynx Creek, Lynx Creek to Halfway River and Halfway River to Pine River). Survey sites are further defined to include only the area above the river channel elevation at 70,000 cfs (1982 m³/s) that generally defined by the edge of terrestrial vegetation.

Aerial photos (1:5,000, and 1:40,000), and a digital elevation model of the study region provided by BC Hydro were the primary tools used in identifying potential sites for the stranding survey. Google Earth imagery was also used occasionally as an additional source of information to confirm site selection. Sites were selected based on characteristics stranding sites identified from a literature review, characteristics of sites where stranded fish were observed following the 1996 spill, and the characteristics observed during a field reconnaissance in May 2010. From this information, the survey sites were stratified into pools and transects.

A total of 77 transect and 41 pool stranding survey sites were identified from the map review and confirmed during the field reconnaissance. As there were more sites identified than could be surveyed in a single day, all transects and pools in each stratum were assigned a sampling priority based on considerations for obtaining a representative sample from each stratum and sampling logistics. Sites were prioritized to ensure that both pools and transects were sampled along the length of each of the strata.

The fish stranding ground surveys will occur on either the day of or the day following the return of the dam facilities to normal operating levels (discharge at PCN \leq 1982 m³/s). As the criteria in the Peace Spill Protocol require a spill of Q_{out} \geq 2000 m³/s for a minimum of two days, notification at the start of the spill will allow sufficient time for mobilization of field crews. Fish stranding surveys will be completed in a single day by three teams of two people. It is intended that surveys begin at the upstream end of the study area to correspond with the areas first exposed during downramping.

A minimum of one pool and two transects will be surveyed in each strata. Based on the level of effort used for the 1996 fish stranding survey it is expected that up to 30 sites could be surveyed in the study area. The number of sites surveyed will be partly dependent on the number of stranded fish observed at each site (higher numbers of fish increase the amount of time required per site) and the size of the spill (higher river stage will increase the length and area of transect that needs to be surveyed). The species and length will be recorded for all stranded fish observed. Any live fish will be salvaged and returned to either the main channel or a connected side channel.

Stranding risk will be defined as the number of observed fish stranded/isolated per meter of habitat dewatered at index sites and will be summarized as the main reporting metric. Data will be analyzed to assess stranding risk based on habitat type for the species and life stages observed. Overall, the analysis will identify stranding rate for type (and indicator of stranding risk) and extent of areas that are considered to be high stranding risk.

Flow mapping or orthorectified 1:5,000 air photos for the river at a discharge of 1,982 m³/s is required to confirm the selected locations of stranding survey transects and pools. This information will assist in restricting the field surveys of stranded fish to areas above the 1982 m³/s river level and in obtaining reliable estimates of the number of fish stranded.

5.2.3.4 Status

Opportunistic study to be implemented in the event of a spill. There has not been a spill event to date. Pre-spill work was completed 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 Management Questions

The key management questions addressed by this monitoring program are:

- 1) What is the magnitude of fish entrainment through the spillway during a spill event?
- 2) Is there a relationship between spill discharge rate and numbers of fish entrained through the spillway?
- 3) What species and sizes of fish are entrained through the spillway?
- 4) What rate of mortality is occurring in fish entrained through the spillway?

5.2.4.2 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: In the summer of 2008, as the spill risk at the Bennett Dam increased, BC Hydro contracted BioSonics Inc. (BioSonics) to undertake the hydroacoustic portion of the study should a spill occur. 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 and the hydroacoustic work in the near future.

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.

5.2.4.3 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.

5.2.4.4 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 Management Questions

The key management questions addressed by this monitoring program are:

- 1) What is the composition of the invertebrate and periphyton community in the side channels of the Peace River?
- 2) 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?
- 3) 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?

5.2.5.2 Overview

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. No further resubmission is anticipated at this time.

5.2.5.3 Contractor's Report

This project has not yet started.

5.2.5.4 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 Management Questions

The key management questions addressed by this monitoring program are:

- 1) What is the present distribution, including species composition and spatial area of riparian vegetation along the Peace River?
- 2) How has the spatial distribution and species composition of vegetation in the riparian zone along the Peace River changed over time?
- 3) What is the effect of a spill on spatial distribution and species composition of vegetation in the riparian zone along the Peace River?

The overall goal is to assess the vegetation community in the riparian zone with respect to changes that have taken place over time as a result of flooding due to a spill from the dam. This assessment will focus on composition and distribution of vegetation including flood-dependent species as well as the advancement/receding of vegetation in river bars and other areas.

5.2.6.2 Overview

Project Description: This monitoring program will occur in Years 9 and 10 of the Peace River management plans; however, implementation of this program is conditional on the occurrence of a spill event during the 10-year study period. Total discharge (Q_{out}) from the Peace Canyon facility during a spill must exceed 88,287 cfs (2500 cms) for two days or longer in order to proceed with this study.

This riparian habitat assessment will examine the impact of a spill event on largescale 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 and riparian assessment of study sites will occur 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.

5.2.6.3 Contractor's Report

This project has not yet started.

5.2.6.4 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 Management Questions

The key management questions addressed by this monitoring program are:

- 1) What is the response of side channel stage to fluctuations in discharge?
- 2) What physical processes are occurring in the beds of side channels of the Peace River and is there a trend over time?
- 3) Which fish species and fish life stages are using the side channels of the Peace River and are changes occurring over time?

The monitoring program will provide baseline information on the side channels of Peace River to determine the effects of the habitat manipulation on the side channels. In the event of a spill changes will be documented as part of separate monitoring program (PCR Side Channel Response); however, data relating to spill response will also be critical to understanding observations within this program.

5.2.7.2 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 spillinduced 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.

5.2.7.3 Contractor's Report

This project has not yet started.

5.2.7.4 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 Management Questions

The key management questions addressed by this monitoring program are:

- What is the effect of a spill on the physical state of the side channels? In particular, what processes occur, what changes are evident, and are the changes beneficial to fish?
- 2) What changes occur in fish use of side channels as a result of a spill?

5.2.8.2 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.

5.2.8.3 Contractor's Report

There is no contractor's report for 2010 as there was no spill.

5.2.8.4 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 Management Questions

There were no key management questions identified for this monitoring program.

5.2.9.2 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 (prespill, 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.

5.2.9.3 Contractor's Report

There is no contractor's report for 2010 as there has been no spill.

5.2.9.4 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 Management Questions

There were no key management questions identified for this monitoring program.

5.2.10.2 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: As the previous company retained for this project under contract has recently gone out of business, an RFP will be issued in 2011 to identify a new contractor capable of taking the aerial photography. 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.

5.2.10.3 Contractor's Report

There is no report for the past year as there was no spill.

5.2.10.4 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 Management Questions

The key management question addressed by this monitoring program is:

During a spill event at GMS, do dissolved supersaturated gases in the Dinosaur Reservoir and the Peace River reach a level that negatively impacts fish populations?

5.2.11.2 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.

5.2.11.3 Contractor's Report

There is no contractor's report for the past year as there was no spill.

5.2.11.4 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 Management Questions

- 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?

5.2.12.2 Overview

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.

5.2.12.3 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:

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 of floodplain-dwelling wildlife to spill events. In 1996, Diversified Environmental Services conducted an assessment of ungulate use of islands within the Peace River floodplain. 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 management questions, the following hypotheses will be tested by the monitoring program:

- Ho1: Ungulate mortality/habitat loss resulting from a spill significantly impacts the ungulate population in the Peace River floodplain downstream of Peace Canyon Dam.
- H₀₂: Beaver mortality/habitat loss resulting from a spill significantly impacts the beaver population in the Peace River floodplain downstream of Peace Canyon Dam.
- H₀₃: 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.
- Ho4: 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 2

No spills occurred during the spring/summer of 2010. However, baseline data collection for the 4 target taxa was completed within the study area (Peace Canyon Dam to confluence of Peace and Pine Rivers), including:

- Ungulates: the study area was divided into survey blocks using block boundaries from previous ungulate surveys conducted in the area. Aerial surveys were conducted over 7 survey blocks totalling 117.6 km²; survey time was 7.28 hours and 81 individual ungulates were detected.
- Riparian birds: point count surveys and nest-searching was conducted at 5 sites in the study area, with a total of 93 point count surveys being completed. Surveys detected 676 detection of 70 species, including 4 threatened or endangered species (Black-throated Green Warbler, Canada Warbler, LeConte's Sparrow, and Rusty Blackbird). Seventyseven nests were found, of which 46 were active during the 2010 breeding season.
- Beaver: aerial beaver structure surveys were conducted concurrently with aerial ungulate surveys. Most of the 99 total observations were of structures (bank lodges, lodges, dams, food caches), although three observations were also made of individual animals.
- Western toad: 2 days of amphibian surveys were conducted at 2 separate sites within the study area. Observations of amphibians were also made opportunistically during other surveys. Two species of amphibian (wood frog and western toad) and 1 species of reptile (common garter snake)

were observed (8 western toad, 19 wood frog, and 2 common garter snake).

All data collected during baseline surveys were error-checked, entered into a database, and exported to Excel for summary analysis.

Finally, a draft report summarizing all data collected and work conducted in Year 2 of the project was written and submitted to BC Hydro. This report also included a description of the peak- and post-spill survey protocols that would be followed in the event of a spill. Comments on the draft report were subsequently incorporated in a final report which was submitted to BC Hydro.

Issues Identified in Year 2

The primary issue in Year 2 was the difficulty of obtaining flow-mapping for the flow levels (i.e., > 70 000 cfs) that would trigger monitoring action. This made selection of sites to conduct baseline work more difficult, as it was not entirely clear whether individual sites would be flooded. To address this issue, we used a digital elevation model to generate sub-metre contour lines and select low-lying sites along the river channel with shallow gradients that were likely to be inundated in the event of a spill.

Work to be Completed in Year 3

The pre-spill baseline data collection of this project has now been completed, and the Year 2 report detailing pre-spill baseline data collected and peak-/post-spill survey protocols has been submitted to BC Hydro. If a spill >70 000 cfs occurs in Year 3, then the survey protocol will be followed to conducted peak- and post-spill surveys. Otherwise, no work is planned to occur.

5.2.12.4 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 Management Questions

The key management question addressed by this monitoring program is:

1) What are the species composition, abundance, and spatial distribution of fish in the Peace Arm of the Williston Reservoir?

5.2.13.2 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.

5.2.13.3 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 Management Questions

The key management questions addressed by this monitoring program are:

- 1) Is the tributary enhancement work effective at increasing usable habitat?
- 2) 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?
- 3) Is the area and quality of fish habitat created by the tributary enhancement maintained over time?

5.2.14.2 Overview

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.

5.2.14.3 Contractor's Report

Annual Report – Executive Summary

As part of the Peace River Water Use Plan (WUP), the Peace WUP Committee endorsed the Dinosaur Tributary Enhancement management plan (the Plan) to address the limited tributary habitat issue associated with the Reservoir. The first steps of the Plan were addressed through GMSWORKS-9 – Dinosaur Reservoir Inventory and Feasibility study, which was completed by Triton in 2009. That field program determined the quality and quantity of tributary habitat accessible to Dinosaur Reservoir fish, and confirmed that concerns about woody debris accumulations from upstream logging creating access restrictions near tributary/reservoir interfaces were unsubstantiated (Triton 2009).

A wide range of potential enhancement options were considered, and the best opportunity identified for enhancing the productive capacity of the Dinosaur Reservoir fishery was diverting Portage Creek and Bullrun Creek into the Reservoir (Triton 2009). 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, it was estimated through map interpretation that 21.5 km of new stream habitat could become accessible to reservoir fish through this initiative, which would have rearing and spawning habitat value (Triton 2009).

The present study is part of the monitoring requirement associated with GMSMON-14 – Dinosaur Reservoir Tributary Habitat, and the overall objective is to evaluate three key management questions associated with the implementation of the proposed fish habitat enhancement project:

- 1) Is the tributary enhancement work effective at increasing usable habitat for Dinosaur Reservoir fish?
- 2) Is the area and quality of fish habitat created by the tributary enhancement maintained over time?
- 3) Is the area and quality of fish habitat created by the tributary enhancement work sufficient to noticeably increase spawning and rearing opportunities for Reservoir fish?

As outlined in BC Hydro (2008b), these questions will be addressed through a five year monitoring program that will be implemented over a ten year period, including one year of baseline data collection and four years of data collection once the enhancement is completed. The present study represents Year 1 of the program, and the focus is to develop a monitoring framework and collect baseline data necessary to draw inferences about the management questions and to test the associated hypotheses in the final year of the monitoring program.

Based on field verification completed in 2010, it was confirmed that at least 20.4 km of habitat associated with the Portage/Bullrun system will become accessible to Dinosaur Reservoir fish following the diversion. Currently, Johnson Creek and Gething Creek offer the most habitat area with 21,320 m² and 20,250 m² respectively, followed by Starfish Creek as a distant third with 3,901 m² (Triton 2009). This is not to say that the Portage/Bullrun system would necessarily be more valuable to the productive fish capacity of the Dinosaur Reservoir than the contributions made by Johnson and Gething Creeks, because they are large tributaries with high value spawning habitat, but certainly a substantial contribution is expected to result from the proposed diversion. Overview habitat assessments were completed for each reach on Bullrun Creek and Portage Creek to evaluate the quality of habitat anticipated to be gained.

In order to compare between-site and interannual differences for a set of control and impact sites that were established, detailed habitat data was collected following the fish habitat assessment procedure (FHAP) and triple pass electroshocking was completed. Since fish distribution is typically clustered around preferred habitat elements within a stream, it was anticipated that non-parametric data analysis would be the most suitable statistical analysis approach. The permutation-based ANOSIM routine in PRIMER 6 can be used for comparing the significance of observed variation, but there was little point applying it in Year 1. This is because the impact sites will not carry forward to subsequent sampling years since the existing Reach 1 of Portage Creek will become deactivated following the diversion. As such, it will be necessary to establish a new set of five treatment sites within the newly constructed channel.

The wide range of fish size classes captured in this study include individuals from the young-of-year, juvenile, and adult life stages, which confirms that sufficient perennial habitat exists within Portage Creek to support all of the life history requirements for rainbow trout (i.e., rearing, spawning and overwintering). While the length-frequency distribution is currently weighted heavily toward the YOY life stage, a proportional increase of adults may not necessarily be detected once the Portage system becomes accessible to Reservoir fish since adfluvial spawners may no longer be

present at the time sampling occurs in late August. Utilization of Portage Creek by adfluvial fish could be definitively determined by shifting the sampling period to coincide with the spawning window for Rainbow Trout, and deploying fyke or hoop nets near the confluence with the Reservoir. However, this type of program would require weeks rather than days of sampling effort, which is cost prohibitive given the budget allocated to GMSMON-14. Therefore, it is conceivable the primary measure of project success will be based on indirect evidence (i.e., habitat quality and quantity).

With regard to scheduling the remaining four sampling events associated with GMSMON-14, it is suggested that Year 2 be completed the year after construction works are finished. For example, if construction is completed in the summer of 2012, Year 2 monitoring would occur in 2013 at a similar time as this baseline study (i.e., late August). Of primary interest during the Year 2 study will be determining how the new channel withstood its first exposure to a freshet. This timing will also allow approximately one full year for Reservoir fish to discover the newly accessible tributary habitat, and hopefully some adfluvial fish will choose the Portage Creek system for spawning. Since Rainbow Trout typically mature at age 3 in the Dinosaur Reservoir (Hammond 1986), it is suggested Year 3 sampling occur three years after Year 2 (i.e., 2016 under the present scenario), such that offspring from the first group of adfluvial spawners will have had an opportunity to mature and return to spawn themselves. The final two monitoring events could occur on alternating years (i.e., Year 4 in 2018 and Year 5 in 2020). This strategy would allow the second generation of offspring from the second and third adfluvial spawning events that occurred in 2014 and 2015 respectively to be sampled.

5.2.14.4 Status

This monitoring project commenced in June 2010 and is to be implemented every second year.

5.2.15 GMSMON-15 – Williston Wetland Habitat

Order clause: Schedule A 6(b) BC Hydro Project Manager: Karen Skibo

5.2.15.1 Management Questions

- 1) Are the enhanced (or newly created) wetlands used by waterfowl and other wildlife?
- 2) Is there a change in the abundance, diversity, and extent of vegetation in the enhancement area?
- 3) Is the area and quality of wildlife habitat created by the wetland enhancement maintained over time?

Given the nature of the sites selected by GMSWORKS-16, wildlife and vegetation are the focus of the enhancement, not fish, and the Management Questions for this monitoring program were modified accordingly. However, a fish assessment component remains a part of this monitoring program.

5.2.15.2 Overview

Project Objective: The objective of the monitoring project is to assess the effectiveness of a wetland enhancement trial 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, birds, 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: Cooper Beauchesne and Associates has been awarded the contract for Year 1 which began in April 2011.

ToR Status: This project was delayed to spring 2011 due to lack of resources. A full 10 years of monitoring is still planned and the budget is on track.

5.2.15.3 Contractor's Report

No contractor's report was received for work in 2010 as work had not yet started.

5.2.15.4 Status

Work began in April 2011 and is to be completed by February 2021. Annual reports are expected in February of each year.

5.2.16 GMSMON-16 – Williston Debris Trends

Order clause: Schedule A 6(g)

BC Hydro Project Manager: Alan Chan-McLeod

5.2.16.1 Management Questions

- 1) How is the volume of woody debris in Williston Reservoir changing over time?
- 2) Is woody debris collecting at trial and project sites associated with the Peace River Water Use Plan?
- 3) What are the primary sources for woody debris recruitment into Williston Reservoir and what is the rate of debris recruitment from these sources?

5.2.16.2 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.

5.2.16.3 Contractor's Report

This project has not yet begun.

5.2.16.4 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 Management Questions

- 1) Does fish abundance and diversity in tributaries increase as a result of enhancement?
- 2) Is the area and quality of fish habitat created by the tributary enhancement maintained over time?
- 3) Does riparian vegetation along tributaries increase in abundance and diversity as a result of enhancement?
- 4) Does abundance and diversity of song birds (passerines) around tributaries change as a result of enhancement?

- 5) Does amphibian abundance and diversity in tributaries change as a result of enhancement?
- 6) Does tributary enhancement change the area and quality of amphibian breeding habitat over time? If so, is the area and quality maintained over time?

5.2.17.2 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: Golder Associates Ltd. has been awarded the contract for Year 1 which began in April 2011.

ToR Status: This project was delayed to spring 2011 due to lack of resources. A full 10 years of monitoring is still planned and the budget is on track.

5.2.17.3 Contractor's Report

No contractor's report was received for work in 2010 as work had not yet started.

5.2.17.4 Status

This work began in April 2011 and is to be completed by February 2021. Annual reports are expected in February of each year.

5.2.18 GMSMON-18 – Williston Dust Control

Order clause: Schedule A 6(d)

BC Hydro Project Manager: Aaron Flett/Karen Skibo

5.2.18.1 Management Questions

The key management question addressed by this monitoring program is:

1) What is the impact of dust mitigation treatments on aeolian dust emission from the Finlay Reach of Williston Reservoir?

5.2.18.2 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 μ m (PM₁₀)and 2.5 μ m (PM_{2.5}), rainfall, temperature, and relative humidity. Data is collected from approximately early May to late June of each year.

Contractor: This work is being conducted by Nickling Environmental Ltd.

ToR Status: A ToR resubmission was approved in June 2009, April 2010, and June 2011 with respect to required changes to scope and budget. Presently, scope, schedule, and budget are in compliance.

5.2.18.3 Contractor's Report

During the 2009 and 2010 field seasons North Davis Flats Beach was used to conduct both the main tillage and tillage spacing experiments. Eight windstorms occurred at Davis Beach between May 12 and June 2, 2010. Two of the storms were back-to-back; therefore, data sets were obtained from six wind events. Two major tillage experiments were conducted: (i) the main tillage experiment and (ii) the tillage spacing experiment. In addition to the BSNE and E-Sampler data sediment fill in area in the main tillage experiment was measured by GPS mapping after each windstorm. Data were also collected on soil particle size distribution, erodible fraction and soil surface roughness. The objective of the tillage spacing experiment was to determine if suitable erosion control was possible by tilling in strips. In the tillage spacing study, sediment fill in by GPS mapping, soil roughness, and BSNE dust samples were obtained after each windstorm. Soil aggregate size distribution, soil textural classification, and the percentage of clay particles less than 10 µm in diameter were determined from samples collected from the ridges after the initial tillage as well as from non-tilled areas between tillage strips. The soil texture should not change during the erosion season, but the erodible fraction may change with additional rainfall.

In the main tillage experiment, GPS depositional data provided a good expression of the quantity of material being trapped by the tillage furrows. Each measurement area covered 15,000 m². In 2009 fill in on Block F was 71%, Block A was 16%, B 38%, C 25%, D 35%, and Block E 28%. In 2010 the fill in was 85% on Block F, 68% on Block E, 100% on Block D, 54% on Block C, 15% on Block B, and 16% on Block A. The wind erosion period in 2010 was much longer than in 2009. The beach soil surface was drier in 2010 compared to 2009 and winds more intense and frequent. The measured capacity of the chisel furrow is 0.002 m^3/m^2 . The total volume of eroded soil collected by the furrows in Block F in 2009 was 21.2 m³ and in 2010 was 25.6 m³. The chain readings of soil roughness indicate that a tilled soil surface will potentially reduce soil movement by 99%. However, when there are erodible soils upwind, dust will be picked up and carried over the tilled surface. The tilled surface will not remove all the dust from the wind stream, but will prevent additional dust from entering the wind stream. Essentially, there will be no erosion of the tilled area unless eroded material upwind of the tilled area moves onto the tilled area filling the furrows, or deep sandy soils are not covered with stable clods and ridges. As the furrows fill in the surface becomes smoother and less effective in trapping sand sediment.

Tillage must be perpendicular to dominant wind direction to be most effective. The 100 m wide tilled strips in the main tillage experiment reduced the mass of soil being transported by 46 to 67%. E-samplers at the upwind and downwind edges of both the tillage and check plots measure PM_{10} concentrations at a height of 2 m above the surface. The E-samplers show an overall average reduction in PM_{10} concentrations of 7.8% across the tilled Blocks while the check areas averaged 14.9% increase in PM_{10} concentration. Conditions were much different in 2010 but the numbers are similar. The check had a 7.2% increase while the tilled had a 9.9% decrease in PM_{10} across the tilled area. The first two storms in 2010 were from a NNW direction and the PM_{10} concentrations on Block A and B were high with a steady decrease in PM_{10} at the downwind E-sampler of Block F indicating that dust was coming from upwind beaches and there was a gradual increase in PM_{10} concentrations going across the blocks. Once the PM_{10} material gets into the wind, there is no method of getting it out of the wind stream. To minimize PM_{10} emissions, soils must not be allowed to erode.

The tillage spacing experiment indicates that soil texture was very important in identifying areas where strip tillage will be effective. If there is silt and clay within 30 cm of the soil surface, tillage will produce a rough and stable soil surface. The twisted chisel had an average furrow fill in of 29% and the lister 17%. Because of the variability between blocks there was no significant difference in fill area among the 1x, 2x, and 3x spacing treatments. The reduction on perpendicular roughness in the tillage strips from the beginning to the end of the spacing experiment was 30% for the chisel and 20% for the lister. There was no difference in erodible fraction or random roughness for the two tillage implements. Scientists have been working for over 70 years to develop tillage methods for croplands that will effectively control wind erosion. There are other soil roughening methods that may be effective at Williston, but additional experimentation would be required. We doubt that any one tillage implement will be equally effective for all soil conditions. We do know from our experiences in Williston that, to maximize erosion control, as much beach area as feasible should be tilled. Any non-tilled areas will serve as source areas of blowing dust.

Monitoring of regional air quality during the 2010 dust season was carried out around the Williston Reservoir using Partisol Dichotomous Samplers at six locations and E Samplers at four locations. Results of the regional monitoring study clearly indicated that the spring and summer of 2010 was far dustier than that of 2009, resulting in a large number of occurrences at most sites where the 24-hr average PM_{10} concentrations greatly exceed the 50 μ g/m³ threshold mandated by the Canada Wide PM_{10} Standard prior to 2010. This large increase in the number of very dusty days was particularly prevalent at Tsay Keh, Davis and Pete Toy monitoring sites. The frequency and magnitude of exceedances in 2010was most likely due to the very low pool of 2010 that kept large areas of beach exposed for extended periods.

In contrast to the PM₁₀ levels, relatively low levels of PM_{2.5} were found at all sites. PM_{2.5} levels were typically well below 20 μ g/m³ and well within the Canada Wide Standard (CWS) for airborne particulates of 30 μ g/m³ PM_{2.5} (24 hour averaging time) based on the 98th percentile of annual measurements, averaged over 3 consecutive years. In response to concerns expressed by Tsay Keh band members and others regarding possible health effects associated with high organic carbon levels, MinVol samplers were deployed at Tsay Keh Beach and Ivor Creek (High Point) during the summer months of 2010 to measure carbon levels associated with $PM_{2.5}$. Results indicate that elemental carbon values are very low (typically >1 µg/m³) with organic carbon values reaching maximum values of high as 9 µg/m³ at Tsay Keh and 6.8 µg/m³ at Ivor Creek/High Point. These levels are not particularly high and typical of what would be expected in forested environments with organic debris in the soils and on the beaches. As a comparison Gu et. Al (2010) found organic carbon levels associated with $PM_{2.5}$ in Tianjin, China in excess of 100 µg/m³, due primarily to the burning of coal for electrical power.

Our major recommendations to combat blowing dust on Williston Reservoir beaches in the future are:

- Develop and implement a detailed Management Plan for the implementation of dust control measures at Williston. This should be viewed as a living document that should be updated regularly as new knowledge from experiment and empirical evidence becomes available.
- Determine the major dust-emitting areas for each beach on Williston Reservoir. This information can be most readily obtained by helicopter during major wind storms. The dust-emitting areas can easily be mapped using GPS from the helicopter.
- 3) Determine soil texture to a depth of 40 cm in 50-meter-wide grids on all Williston beach areas that are potentially suitable for tillage (i.e., areas free of tree stumps). This can be accomplished by mounting a hydraulic soil probe on a Ranger off-road vehicle. The depth of sand covering the silt and clay layers can be determined by hand analysis. This information, along with the GPS coordinates from where each sample was obtained, would be entered into a hand-held data logger. Four such samples would be required for each hectare. Following completion of this grid soil textural sampling, a map can be generated for all Williston beaches to show where tillage will likely be effective and where Hydro and Tsay Keh should focus their tillage efforts. Such soil textural sampling is especially important for the dust emitting "hot spots" identified through GPS mapping by helicopter in Recommendation #2 (above). In addition to, and to complement soil mapping, we recommend that a VERIS electrical conductivity cart be employed to provide soil textural data from the surface 40 cm of soil. Such a cart could be pulled by an ATV and map by GPS at least 50 hectares per day. The soil textural maps would be a huge benefit in determining exactly what beach areas are suitable for tillage or other control measures.
- 4) Explore different tillage implements that have the potential to lift stable silt and clay clods from fairly deep soil depths (e.g., 40 cm). These implements will need to be rugged. Spinning disc and/or coulter blades will be more expensive and wear out more quickly in the abrading sand than shanks.
- 5) Seek solutions to reduce blowing dust from deep sands where tillage is not effective. Consider small-scale research on polymer-based soil stabilizers that can pass Canadian environmental standards when used a low rates (as they

have in some other countries). Only relatively low rates of stabilizer product combined with low volumes of water carrier should be evaluated, otherwise the cost of the stabilizer product will be prohibitive and the logistics of water application over large areas unrealistic. Pulverized wood chips may be spread on deep sand areas to control dust emissions.

5.2.18.4 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 Management Questions

This project is on hold (see section 5.2.19.4, below) and therefore has no management questions at this time.

5.2.19.2 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.

5.2.19.3 Contractor's Report

This project has not yet begun.

5.2.19.4 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 Management Questions

The key management questions addressed by this monitoring program are:

- 1) Does the recreational use of the Williston Reservoir boat ramps increase after boat access has been improved?
- 2) What is the frequency of use of newly constructed boat ramps?

5.2.20.2 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.

Contractor: This work was conducted by Synergy Applied Ecology.

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 increased 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.

5.2.20.3 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 in 2009 to assess use of the boat launch sites before and after improvements. This is an interim report presenting the results of the second year of monitoring at 6 recreation sites, 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. Boat launch facilities vary among sites and no improvements were made in 2009 or 2010. Vehicle counters and remote cameras were used to evaluate site use. Total use by site estimated from counter data varied from 66 visits at Strandberg to 796 visits at Cut Thumb Bay between June 16 and October 31 2010. The proportion of photovalidated site users that brought boats varied from 21.0% at Dunlevy to 56.8% at Elizabeth Creek. Overall, there is good correspondence in the results for monitoring Year 1 and Year 2, suggesting consistent use both within and among the 6 recreation sites.

5.2.20.4 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 Management Questions

No key management questions were identified.

5.2.21.2 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.

5.2.21.3 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 Management Questions

There were no key management questions identified for this monitoring program.

5.2.22.2 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 with an option for BCHydro to renew the contract for the subsequent several years.

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.

5.2.22.3 Contractor's Report

Annual Report - Management Summary

Millennia Research Limited (Millennia), John Clague, Simon Fraser University (SFU) and Focus Corporation (Focus) were contracted by BC Hydro to undertake archaeological site selection and monitoring within the drawdown zone of the Williston and Dinosaur reservoirs and the Peace River downstream of Dinosaur Reservoir (Dinosaur) and the Peace Canyon Dam; Millennia is the lead contractor for the project. The study is scheduled to take place over nine years and to provide quantitative measures of erosion effects caused by reservoir operations on archaeological features, artifacts and sediments. It follows an Overview study conducted by Millennia in 2009 under BC Hydro project GMSMON21A (Eldridge, et al. 2009). In accordance with the Order issued under the *Water Act*, the study is to be conducted using non-intrusive methods and does not require a permit under the *Heritage Conservation Act*. The study is to provide information that can be used in future Water Use Plan (WUP) processes.

Erosion has been identified as a threat to potentially intact archaeological sediments present in the Peace system. Using a combination of terrestrial LiDAR scanning, geological analysis and archaeological recording, the project team will assess the impacts of wind and wave erosion within monitoring stations established on landforms associated with previously recorded archaeological sites.

This report provides a summary of the approach, methods and results of the first year of investigation. Fieldwork for the project was conducted May 22-May 26 by crew consisting of individuals from the Kwadacha and McLeod Lake Indian Bands, Focus, and Millennia. The goal of this year's field work was the selection of a minimum of six monitoring stations and the gathering of baseline information against which the data gathered over the course of the project will be charted. Sites shortlisted in 2009 (GMSMON 21A) were subject to a final selection of six sites, with four in the Williston Reservoir and two in the Peace downstream of Dinosaur (there were no suitable candidates in the Dinosaur Reservoir). The final selection of three sites in the Finlay Reach of Williston was made with the agreement of BC Hydro and Tsay Keh Dene representatives, and Millennia Research. One of these sites was a highly significant site newly discovered by Tsay Keh elder Bill Poole in 2010, and was substituted for similar short-listed alternates due to its easier access. A single site on the Parsnip Arm was selected based on the presence of artifacts and features and relatively easy access. A site selected on the Peace River near Hudson Hope was found on field inspection to be unsuitable and was moved to an alternate shortlisted site near Ft St John. The last site selected was another short-listed site on the Peace River near Halfway River, where substantial excavations were undertaken by SFU in the 1970s.

Within the monitoring stations, cultural materials marked by the archaeological crew and terrain features were captured by the LiDAR scan and mapped using Real Time Kinematic (RTK), a high-end GPS with sub-decimetre accuracy. A high-resolution Digital Elevation Model (DEM) of the ground surface in each monitoring station was generated from the raw LiDAR data. The DEM, which interpolates the ground surface between the lowest points in the point cloud, can be used over the course of the project to quantitatively assess changes in the ground surface due to erosion.

Up to 30 artifacts and features at each site were individually identified, photographed, and where possible measured and weighed to assist in recognition and analysis of disruption or movement in future years of the study. Each was given a unique identifying number and the provenience of each was measured to ± 2 cm accuracy with an RTK GPS instrument. The artifacts were all left *in situ*.

A recommendation to improve this monitoring study is to increase the number of sites that are being examined. 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. Currently, the four sites from Williston are from very different environmental settings, and none can be dropped without major impacts to the study. However, the study could be greatly improved by adding another three sites, representing significantly different environmental and erosional contexts, to the study. However, enlarging the number of examined sites, while staying within Terms of Reference parameters, cannot be accommodated in the existing budget unless different approaches are taken. The significant project time-line of nine years allows for some flexible approaches to allow for study improvement: for instance, sites that appear to be relatively stable could be re-scanned at an interval greater than every year, to allow data gathering at an additional site.

Another study, linked to but independent of GMSMON 21B, is recommended as part of managing erosional impacts to archaeological sites in the reservoir. Such a study would clearly be outside the present GMSMON21B scope, and this proposed study will be discussed in the Williston Heritage Management Plan ProReport presently being prepared by Millennia Research under subcontract to Tsay Keh Dene. There has been relatively little survey of areas outside dust-abatement operable areas, however many of the significant sites have been found where peats are rapidly eroding. These locations are typically not operable, and sites have been found at the periphery of dust abatement survey or during non-dust archaeological survey. Such areas are easily identified using the high-resolution orthophotos flown in 2009. We recommend a small project to digitize the locations of eroding peats in order to facilitate an archaeological inventory of such areas.

5.2.22.4 Status

This monitoring project commenced in the spring of 2010 and will continue annually.

6 Peace WUP Project Costs

Table 6-1 summarizes the financial status of all Peace WUP projects as of 31 May 2011.

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

* Red values in parentheses denote overage.

Monitoring Programs Peace River Annual Report	Activity	Costs approved by CWR \$8,198	Total Forecast (Life to Date Actuals and Forecast) \$8,198	Variance Total to Approved \$0	Explanation	Corrective Action
Peace River and Dinosaur Reservoi Projects	ir Monitoring Program	¢202.081	¢202.001	0.3		Ι
GINSMON#TPCR CREEL SURVET	Direct Management	\$292,981 \$60,879 \$222,102	\$292,961 \$60,879 \$222,102	\$0 \$0		
GMSMON#2 PCR FISH INDEX		\$2,285,174 \$112,133	\$2,285,174 \$112,133	\$0 \$0		
GMSMON#3 PCR FISH	Implementation	\$2,173,041	\$2,173,041	\$0 \$0		
STRANDING	Direct Management	\$165,449 \$17,079	\$165,449 \$17,079	\$0 \$0		
GMSMON#4 WACB	Implementation	\$148,370	\$148,370	\$0		
ENTRAINMENT	Direct Management	\$362,544 \$35,945	\$362,544 \$35,945	\$0 \$0		
GMSMON#5 PCR PRODUCTIVITY	Implementation	\$326,599 \$1,133,979	\$326,599 \$1,133,979	\$0 \$0		
	Direct Management Implementation	\$129,576 \$1,004,403	\$129,576 \$1,004,403	\$0 \$0		
GMSMON#6 PCR RIPARIAN FLOODING		\$226,273	\$226,273	\$0		
	Implementation	\$31,213 \$195,060	\$31,213 \$195,060	\$0 \$0		
FISHERIES	Direct Management	\$841,652 \$148,761	\$841,652 \$148,761	\$0		
	Implementation	\$692,891	\$692,891	\$0		
RESPONSE	Direct Management	\$69,846 \$16.812	\$69,846 \$16.812	\$0 \$0		
GMSMON#9 PCR SPILL	Implementation	\$53,034	\$53,034	\$0		
HYDROLOGY	Direct Management	\$68,979 \$18,979	\$68,979 \$18,979	\$0 \$0		
GMSMON#10 PCR SPILL	Implementation	\$50,000	\$50,000	\$0		
PHOTOS	Direct Management	\$297,996 \$10,951	\$297,996 \$10,951	\$0 \$0		
GMSMON#11 PCR SPILL	Implementation	\$287,045	\$287,045	\$0		
	Direct Management	\$57,127 \$21,546	\$57,127 \$21,546	\$0 \$0		
GMSMON#12 PCR WILDLIFE	mprementation	\$35,581	\$35,581	\$0		
	Direct Management	\$20,214 \$20,214	\$20,214 \$20,214	\$0		
GMSMON#13 WLL FISH INDEX	Direct Management	\$124,909	\$73,816	\$0 \$51,093 \$1,500	Project is complete	
GMSMON#14 DNR TRIBUTARY	Implementation	\$110,613	\$61,020	\$49,593		
HABITAT	Direct Management	\$150,364 \$57,080	\$150,364 \$57,080	\$0 \$0		
GMSMGMT1 PEACE RIVER & DINO	Implementation SAUR RESERVOIR MANA	\$93,284 GEMENT PLAN PHYSICA	\$93,284 L WORKS PROJECTS	\$0		
GMSWORKS#1 PCR AERIAL PHOTOS		\$709,994	\$709,994	\$0		
	Implementation	\$15,317 \$694,677	\$15,317 \$694,677	\$0 \$0		
TGP/TEMP	Direct Management	\$254,554	\$254,554	\$0		
GMSWORKS#3 PCR TRIAL SIDE	Implementation	\$177,214	\$177,214	\$0		
CHANNELS	Direct Management	\$548,139 \$128,339	\$548,139 \$61,377	\$0 \$66.962		
GMSWORKS#4 PCR HYDRAULIC	Implementation	\$419,800	\$423,324	(\$3,524)		
HABITAT	Direct Management	\$134,816 \$17,728	\$93,468 \$19,216	\$41,348 (\$1,488)		
GMSWORKS#5 PCR HYDRAULIC	Implementation	\$117,088	\$74,252	\$42,836		
MODEL	Direct Management	\$270,648	\$269,350 \$29,665	\$1,298		
GMSWORKS#6 PCR MAINSTEM STAGE DISCHARGE	Implementation	\$238,900	\$239,083	(\$12 557)	Additional resources required	DM costs to be reduced during
	Direct Management	\$37,664 \$268,773	\$71,434 \$247,560	(\$33,770) \$21,213		
GMSWORKS#7 PCR RIPARIAN HABITAT ASSESSMENT	·	\$181,857	\$181,857	\$0		
	Direct Management Implementation	\$22,854 \$159,003	\$22,854 \$159,003	\$0 \$0		
GMSWORKS#8 DNR DEMONSTRATION TRIBUTARY		\$247,265	\$247,265	\$0		
	Implementation	\$63,222 \$184,043	\$63,222 \$184,043	\$0 \$0		
INVENTORY & FEASIBILITY	Direct Management	\$41,013 \$16,031	\$41,013	\$0 \$7 141	Project is complete	
GMSWORKS#10 PCR INDUSTRY	Implementation	\$25,000	\$23,125	\$1,875		
& TAYLOR WATER QUALITY ASSESSMENT		\$220,253	\$182,704	\$37,549		
	Direct Management Implementation	\$69,761 \$150,492	\$46,284 \$136,420	\$23,477 \$14,072		
GMSWORKS#12 DNR RECREATION ACCESS	Direct Marco	\$118,729	\$118,729	\$0		
GMSWORKS#13 DCP	Implementation	\$60,765 \$57,964	\$17,220 \$56,186	\$43,545 \$1,778		
RECREATION ACCESS	Direct Management	\$326,409	\$326,409	\$0 \$81 452		
GMSMGMT2 WILLISTON RESERVO	Implementation	\$229,584 MONITORING STUDIES	\$114,514	\$115,070		
GMSMON#15 WLL WETLAND HABITAT		\$981,420	\$981,420	\$0		
	Direct Management Implementation	\$157,922 \$823,498	\$157,922 \$823,498	\$0 \$0		
GMSMON#16 WLL DEBRIS		0017 77			Higher than anticipated implementation costs need to be	Invoicing is likely incorrect and need
TRENDS	Direct Management	\$215,563 \$46,859	\$233,059 \$33,902	(\$17,496) \$12,957		
GMSMON#17 WLL TRIBUTARY HABITAT	Implementation	\$1 467 158	\$1 467 158	(¢٥0,452) در		
	Direct Management	\$133,598	\$133,598	\$0		
GMSMON#18 WLL DUST CONTROL		\$4,784.865	\$4,784.865	\$0		
	Direct Management Implementation	\$184,905 \$4,559,960	\$184,905 \$4,559,960	\$0 \$0		
GMSMON#19 WLL EROSION CONTROL				\$0	Not Approved	
	Direct Management Implementation			\$0 \$0		
GMSMON#20 WLL RECREATION USE	Direct Mar	\$268,906	\$268,906	\$0		
GMSMON#21A M/L	Implementation	\$115,060	\$115,060	\$0 \$0		
ARCHAEOLOGICAL OVERVIEW ASSESSMENT		\$113 614	\$111.348	\$2 266	Project is complete	
	Direct Management Implementation	\$16,186	\$18,388	(\$2,202)		
GMSMON#21B WLL EROSION MONITORING OF				,		
ARCHAEOLOGICAL RESOURCES	Direct Management	\$705,659 \$119,954	\$705,659 \$119,954	\$0 \$0		
	Implementation	¢E0E 70E	© E O E 70 E	0.2		

		Costs approved by	Total Forecast (Life to Date Actuals	Variance Total to		
Monitoring Programs GMSMGMT2 WILLISTON RESERVO PROJECTS	Activity	CWR PHYSICAL WORKS	and Forecast)	Approved	Explanation	Corrective Action
GMSWORKS#14 WLL AIR PHOTOS & DEM	Direct Management	\$2,804,180 \$30,295	\$2,804,180 \$30,295	\$0 \$0		
GMSWORKS#16 WLL WETLAND	Implementation	\$2,773,885	\$2,773,885	\$0	Final reporting resulted in additional	
	Direct Management Implementation	\$143,076 \$12,656 \$130,420	\$148,451 \$14,956 \$133,495	(\$5,375) (\$2,300) (\$3,075)	Imp and DM costs	project is complete
GMSWORKS#17 WLL TRIAL WETLANDS	Direct Management	\$479,630	\$479,630	\$0	Project is complete	
GMSWORKS#18 WLL DEBRIS	Implementation	\$76,264 \$401,366	\$354,097	\$36,086 \$47,269		
FIELD SURVEY	Direct Management	\$258,412 \$20,735 \$237,677	\$258,412 \$15,297 \$237,643	\$0 \$5,438 \$34	Project is complete	
GMSWORKS#19 WLL TRIAL TRIBUTARY(S)		\$536,522	\$447,127	\$89,395		
GMSWORKS#20 WLL DUST SOIL	Implementation	\$135,156 \$401,366	\$385,602	\$73,632 \$15,764		
MAPPING	Direct Management	\$733,672 \$35,587 \$698,085	\$733,672 \$35,587 \$698,085	\$0 \$0 \$0		
GMSWORKS#21 WLL DUST CONTROL TRIAL		\$2,998,110	\$2,998,110	\$0 \$0		
	Direct Management Implementation	\$92,825 \$2,905,285	\$92,825 \$2,905,285	\$0 \$0	Additional work required to develop	This is a large program and
GMSWORKS#22 ONR WLL DEBRIS REMOVAL	Non-Remissible Direct	\$5,470,099	\$5,526,973	(\$56,874)	contracts and work plans additional helicopter costs	overages will be recovered through the life of the program
	Management Non-Remissible	\$75,919	\$228,640	(\$152,721)		
GMSWORKS#22 OR WLL DEBRIS	Implementation	\$5,394,180	\$5,298,332	\$95,848	Additional work required to develop contracts and work plans additional	This is a large program and overages will be recovered through
REMOVAL	Direct Management	\$5,470,099 \$75,919 \$5 204 180	\$5,617,666 \$1,250 \$5,616,415	(\$147,567) \$74,669	helicopter costs	the life of the program
GMSWORKS#23 WLL EROSION CONTROL TRIAL	Implementation	\$5,394,180	\$3,010,415	(\$222,233)	Not approved	
	Direct Management Implementation			\$0 \$0		
ACCESS	Direct Management	\$891,306 \$427,592	\$213,764 \$41,890	\$677,542 \$385,702		
GMSWORKS#25 WI I	Implementation	\$463,714	\$171,874	\$291,840	Costs for implementation were	Estimates have been readjusted
BATHYMETRIC MAPPING	Direct Management	\$1,219,603 \$48,957	\$1,400,014 \$50,460	(\$180,411) (\$1,503)	levels	the program on budget.
GMSWORKS#26 WLL COMMUNICATIONS/SAFETY	Implementation	\$1,170,646	\$1,349,553 \$1,352,459	(\$178,907) \$257 622		
	Direct Management Implementation	\$425,173 \$1,184,908	\$305,798 \$1,046,662	\$119,375 \$138,246		
GMSWORKS#27 WLL FINLAY RIVER ACCESS INFORMATION PLAN		\$82,146	\$73,700	\$8,446		
	Direct Management Implementation	\$21,284 \$60,862	\$12,198 \$61,502	\$9,086 (\$640)		
GMSMGMT3 INDUSTRY FEASIBILIT PROJECTS GMSWORKS#28a INDUSTRY	Y MANAGEMENT PLAN P		[
FEASIBILITY AND DESIGN STUDY	Direct Management	\$354,134	\$354,134	\$0		
GMSWORKS#28b INDUSTRY	Implementation	\$333,000	\$333,000	\$0 \$0		
FEASIBILITY AND DESIGN					New project with unapproved cost	Variance will self-correct when
STUDY	Direct Management		\$1,624,421 \$63.846	<u>(\$1,624,421)</u> (\$63.846)	forecasts	budget for ramp is approved.
STUDY GMSMGMT4 ORPHAN BOATPAMPS	Direct Management Implementation		\$1,624,421 \$63,846 \$1,560,575	(\$1,624,421) (\$63,846) (\$1,560,575)	forecasts	budget for ramp is approved.
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK	Direct Management Implementation Direct Management	\$280,376 \$91,709	\$1,624,421 \$63,846 \$1,560,575 \$237,757 \$46,218	(\$1,624,421) (\$63,846) (\$1,560,575) \$42,619 \$45,491	forecasts	budget for ramp is approved.
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP	Direct Management Implementation Direct Management Implementation Direct Management	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$390,221 \$48,891	(\$1,624,421) (\$63,846) (\$1,560,575) \$42,619 \$45,491 (\$2,872) \$15,933 \$42,818	forecasts	budget for ramp is approved.
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA	Direct Management Implementation Direct Management Implementation Direct Management Implementation	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$314,445 \$354,136	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$390,221 \$48,891 \$341,330 \$252,655	(\$1,624,421) (\$63,846) (\$1,560,575) \$42,619 \$45,491 (\$2,872) \$15,933 \$42,818 (\$26,885) \$101,481	forecasts	budget for ramp is approved.
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management Non-Remissible	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$314,445 \$354,136 \$165,469	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$390,221 \$48,891 \$341,330 \$252,655 \$81,218	(\$1,624,421) (\$63,846) (\$1,560,575) \$42,619 \$45,491 (\$2,872) \$15,933 \$42,818 (\$26,885) \$101,481 \$84,251	forecasts	budget for ramp is approved.
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management Non-Remissible Implementation	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$314,445 \$354,136 \$165,469 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$390,221 \$48,891 \$341,330 \$252,655 \$81,218 \$171,437	(\$1,624,421) (\$63,846) (\$1,560,575) \$42,619 \$45,491 (\$2,872) \$15,933 \$42,818 (\$26,885) \$101,481 \$84,251 \$17,230	forecasts	budget for ramp is approved.
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSMGMT5 BOATRAMP GMSWORKS#32 Boat Ramp Design Deserter's Dump	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management Non-Remissible Implementation Non-Remissible Implementation	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$314,445 \$354,136 \$165,469 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$390,221 \$48,891 \$341,330 \$252,655 \$81,218 \$171,437 \$54,866	(\$1,624,421) (\$63,846) (\$1,560,575) \$42,619 \$45,491 (\$22,872) \$15,933 \$42,818 (\$26,885) \$101,481 \$84,251 \$17,230 (\$54,866)	forecasts	budget for ramp is approved. Image: state s
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSMGMT5 BOATRAMP GMSWORKS#32 Boat Ramp Design Deserter's Dump	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management Non-Remissible Implementation Non-Remissible Direct Management Non-Remissible Direct Management Non-Remissible Direct Management Non-Remissible Direct Management Non-Remissible	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$314,445 \$354,136 \$165,469 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$390,221 \$48,891 \$341,330 \$252,655 \$81,218 \$171,437 \$54,866 \$1,489	(\$1,624,421) (\$63,846) (\$1,560,575) \$42,619 \$45,491 (\$2,872) \$15,933 \$42,818 (\$26,885) \$101,481 \$84,251 \$17,230 (\$54,866) (\$1,489)	forecasts	budget for ramp is approved.
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSMGMT5 BOATRAMP GMSWORKS#32 Boat Ramp Design Deserter's Dump GMSWORKS#33 Boat Ramp Design Ingenika	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management Non-Remissible Implementation	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$314,445 \$354,136 \$165,469 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$30,221 \$48,891 \$341,330 \$252,655 \$81,218 \$171,437 \$54,866 \$1,489 \$53,377 \$64,037	(\$1,624,421) (\$63,846) (\$1,560,575) \$42,619 \$45,491 (\$2,872) \$15,933 \$42,818 (\$26,885) \$101,481 \$84,251 \$17,230 (\$54,866) (\$1,489) (\$53,377) (\$64,037)	forecasts	budget for ramp is approved. Image: Second
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA GMSWORKS#32 Boat Ramp Design Deserter's Dump	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management Non-Remissible Direct Management Non-Remissible Implementation Non-Remissible Implementation Non-Remissible Direct Management	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$314,445 \$354,136 \$165,469 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$30,221 \$48,891 \$341,330 \$252,655 \$81,218 \$171,437 \$54,866 \$1,489 \$53,377 \$64,037 \$54,79	(\$1,624,421) (\$63,846) (\$1,560,575) \$42,619 \$45,491 (\$2,872) \$15,933 \$42,818 (\$26,885) \$101,481 \$42,818 \$42,813 \$42,813 \$42,813 \$42,814 (\$26,886) (\$1,489) (\$54,866) (\$1,489) (\$53,377) (\$64,037) (\$5,479)	forecasts	budget for ramp is approved. Image: state of the state of
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA GMSWORKS#32 Boat Ramp Design Deserter's Dump GMSWORKS#33 Boat Ramp Design Ingenika	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management Non-Remissible Direct Management Non-Remissible Direct Management Non-Remissible Implementation Non-Remissible Implementation Non-Remissible Implementation	\$280,376 \$91,709 \$188,667 \$406,154 \$314,445 \$354,136 \$165,469 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$390,221 \$48,891 \$341,330 \$252,655 \$81,218 \$171,437 \$54,866 \$1,489 \$53,377 \$64,037 \$5,479 \$58,558	(\$1,624,421) (\$63,846) (\$1,560,575) \$42,619 \$45,491 (\$2,872) \$15,933 \$42,818 (\$26,885) \$101,481 \$84,251 \$17,230 (\$54,866) (\$1,489) (\$53,377) (\$64,037) (\$54,79) (\$58,558)	forecasts	budget for ramp is approved. Image: Second
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA GMSWORKS#32 Boat Ramp Design Deserter's Dump GMSWORKS#33 Boat Ramp Design Ingenika	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management Non-Remissible Non-Remissib	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$314,445 \$354,136 \$165,469 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$390,221 \$48,891 \$341,330 \$252,655 \$81,218 \$171,437 \$54,866 \$1,489 \$53,377 \$64,037 \$55,578 \$55,558 \$63,296 \$55,854	(\$1,624,421) (\$63,846) (\$1,560,575) \$42,619 \$45,491 (\$2,872) \$15,933 \$42,818 (\$26,885) \$101,481 \$84,251 \$17,230 (\$54,866) (\$1,489) (\$53,377) (\$64,037) (\$54,79) (\$58,558) (\$63,296) (\$5,854)	forecasts	budget for ramp is approved. Image: Second
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA GMSWORKS#32 Boat Ramp Design Deserter's Dump GMSWORKS#33 Boat Ramp Design Ingenika GMSWORKS#34 Boat Ramp Design Finlay Bay	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management Non-Remissible Management Management Non-Remissible Management Management Non-Remissible Management Management Non-Remissible Management	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$314,445 \$354,136 \$165,469 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$390,221 \$48,891 \$341,330 \$252,655 \$81,218 \$171,437 \$54,866 \$1,489 \$53,377 \$64,037 \$55,479 \$58,558 \$63,296 \$5,854 \$57,442	(\$1.624.421) (\$63.846) (\$1.560.575) \$42,619 \$45,491 (\$2,872) \$15,933 \$42,818 (\$26,885) \$101,481 \$84,251 \$17,230 (\$54,866) (\$1,489) (\$54,866) (\$1,489) (\$53,377) (\$64,037) (\$54,79) (\$58,558) (\$63,296) (\$53,854)	Torecasts	budget for ramp is approved. Image: state of the state of
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA GMSWORKS#33 Boat Ramp Design Deserter's Dump GMSWORKS#33 Boat Ramp Design Ingenika GMSWORKS#34 Boat Ramp Design Finlay Bay	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management Non-Remissible Non-Remissib	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$14,445 \$354,136 \$165,469 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$390,221 \$48,891 \$341,330 \$252,655 \$81,218 \$171,437 \$54,866 \$1,489 \$53,377 \$64,037 \$54,866 \$1,489 \$53,377 \$64,037 \$55,479 \$58,558 \$63,296 \$5,854 \$55,854	(\$1,624,421) (\$63,846) (\$1,560,575) \$42,619 \$45,491 (\$2,872) \$15,933 \$42,818 (\$26,885) \$101,481 \$84,251 \$17,230 (\$54,866) (\$1,489) (\$53,377) (\$64,037) (\$54,665) (\$1,489) (\$53,377) (\$64,037) (\$55,479) (\$58,558) (\$63,296) (\$58,554) (\$57,442) (\$56,095)	forecasts	budget for ramp is approved. Variance will self-correct when budget for ramp is approved. Variance will self-correct when budget for ramp is approved. Variance will self-correct when budget for ramp is approved. Variance will self-correct when budget for ramp is approved. Variance will self-correct when budget for ramp is approved. Variance will self-correct when budget for ramp is approved.
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA GMSWORKS#32 Boat Ramp Design Deserter's Dump GMSWORKS#33 Boat Ramp Design Ingenika GMSWORKS#34 Boat Ramp Design Finlay Bay GMSWORKS#35 Boat Ramp Design 6 Mile Bay	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management Non-Remissible Non-Remissib	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$314,445 \$354,136 \$165,469 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$30,221 \$48,891 \$341,330 \$252,655 \$81,218 \$171,437 \$54,866 \$1,489 \$53,377 \$64,037 \$54,799 \$58,558 \$63,296 \$5,854 \$55,854 \$55,854 \$55,854	(\$1,624,421) (\$63,846) (\$1,560,575)	forecasts	budget for ramp is approved. Image: Second
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA GMSWORKS#32 Boat Ramp Design Deserter's Dump GMSWORKS#33 Boat Ramp Design Ingenika GMSWORKS#34 Boat Ramp Design Finlay Bay GMSWORKS#35 Boat Ramp Design 6 Mile Bay	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management Non-Remissible	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$314,445 \$354,136 \$165,469 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$1,560,575 \$44,218 \$191,539 \$390,221 \$48,891 \$341,330 \$252,655 \$81,218 \$171,437 \$54,866 \$1,489 \$53,377 \$64,037 \$54,866 \$1,489 \$53,377 \$64,037 \$55,479 \$55,558 \$63,296 \$55,854 \$55,856\$55,856 \$55,856 \$55,856\$55,856 \$55,856	(\$1,624,421) (\$63,846) (\$1,560,575) \$42,619 \$45,491 (\$2,872) \$15,933 \$42,818 (\$26,885) \$101,481 \$84,251 \$17,230 (\$54,866) (\$1,489) (\$54,866) (\$1,489) (\$54,377) (\$64,037) (\$54,79) (\$55,578) (\$63,296) (\$5,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,856) (\$51,422) (\$55,696)	forecasts	budget for ramp is approved. Image: Second
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA GMSWORKS#32 Boat Ramp Design Deserter's Dump GMSWORKS#33 Boat Ramp Design Finlay Bay GMSWORKS#35 Boat Ramp Design Finlay Bay GMSWORKS#35 Boat Ramp Design 6 Mile Bay	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management Non-Remissible Implementation	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$314,445 \$354,136 \$165,469 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$390,221 \$48,891 \$341,330 \$252,655 \$81,218 \$171,437 \$54,866 \$1,489 \$53,377 \$64,037 \$54,866 \$1,489 \$55,377 \$64,037 \$55,479 \$55,558 \$63,296 \$55,854 \$55,856\$55,856 \$55,856 \$55,856\$55,856 \$55,856 \$55,856\$55,856 \$55,856 \$55,856\$55,856 \$55,856 \$55,856\$55,856 \$55,856 \$55,856\$55,856 \$55,856 \$55,856\$55,856 \$55,856 \$55,856 \$55,856\$55,856 \$55,856 \$55,856\$55,856 \$55,856 \$55,856\$55,856 \$55,856 \$55,856\$55,856 \$55,856 \$55,856\$55,856 \$55,856 \$55,856\$55,856 \$55,856 \$55,856\$55,856 \$55,856\$55,856 \$55,856 \$55,856\$55,856 \$55,856\$55,856 \$55,856\$55,856 \$55,856\$55,856 \$55,856\$55,856 \$55,856\$55,856 \$55,856\$55,856 \$55,856 \$55,856\$55,856 \$55,856 \$55,856\$55,856 \$55,856 \$55,856\$56,856 \$56,856\$56,856 \$56,8	(\$1.624.421) (\$63.846) (\$1.560.575) \$42,619 \$45,491 (\$2,872) \$15,933 \$42,818 (\$26.885) \$101,481 \$84,251 \$17,230 (\$54,866) (\$1,489) (\$53,377) (\$64,037) (\$54,966) (\$5,479) (\$54,79) (\$58,558) (\$63,296) (\$53,296) (\$57,442) (\$57,442) (\$56,095) (\$4,666) (\$51,429) (\$59,696) (\$51,429) (\$59,696) (\$6,143)	forecasts	budget for ramp is approved. Image: Second
STUDY STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA GMSWORKS#32 Boat Ramp Design Deserter's Dump GMSWORKS#33 Boat Ramp Design Ingenika GMSWORKS#34 Boat Ramp Design Finlay Bay GMSWORKS#35 Boat Ramp Design 6 Mile Bay GMSWORKS#36 Boat Ramp Design Cutthumb Bay GMSWORKS#37 Boat Ramp	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$188,667 \$14,445 \$354,136 \$165,469 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$390,221 \$48,891 \$341,330 \$252,655 \$81,218 \$171,437 \$54,866 \$1,489 \$53,377 \$64,037 \$55,479 \$55,479 \$58,558 \$63,296 \$53,553 \$55,429 \$55,6095 \$4,666 \$51,429 \$59,696 \$6,143 \$53,553	(\$1,624,421) (\$63,846) (\$1,560,575) \$42,619 \$45,491 (\$2,872) \$15,933 \$42,818 (\$26,885) \$101,481 \$84,251 \$17,230 (\$54,866) (\$1,489) (\$54,866) (\$1,489) (\$53,377) (\$64,037) (\$54,79) (\$56,558) (\$53,377) (\$56,558) (\$53,296) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,856) (\$55,8	forecasts	budget for ramp is approved. Image: Second
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA GMSWORKS#32 Boat Ramp Design Deserter's Dump GMSWORKS#33 Boat Ramp Design Ingenika GMSWORKS#33 Boat Ramp Design Finlay Bay GMSWORKS#35 Boat Ramp Design 6 Mile Bay GMSWORKS#36 Boat Ramp Design 6 Mile Bay	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management Non-Remissible Direct Manageme	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$14,445 \$354,136 \$165,469 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$390,221 \$48,891 \$341,330 \$252,655 \$81,218 \$171,437 \$54,866 \$1,489 \$53,377 \$64,037 \$54,866 \$1,489 \$53,377 \$64,037 \$55,479 \$58,558 \$63,296 \$5,854 \$55,855 \$4,666 \$51,429 \$59,696 \$6,143 \$53,553 \$64,105 \$7,494	(\$1.624.421) (\$63.846) (\$1.560.575) \$42,619 \$45,491 (\$2.872) \$15,933 \$42,818 (\$26,885) \$101,481 \$84,251 \$17,230 (\$54,866) (\$1.489) (\$54,866) (\$1,489) (\$53,377) (\$64,037) (\$54,866) (\$1,489) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,854) (\$55,855) (\$64,105) (\$64,105) (\$7,494)	forecasts	budget for ramp is approved. Image: Second
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA GMSWORKS#32 Boat Ramp Design Deserter's Dump GMSWORKS#33 Boat Ramp Design Ingenika GMSWORKS#34 Boat Ramp Design Finlay Bay GMSWORKS#35 Boat Ramp Design 6 Mile Bay GMSWORKS#36 Boat Ramp Design 6 Mile Bay GMSWORKS#37 Boat Ramp Design Cutthumb Bay	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management	\$280,376 \$91,709 \$188,667 \$406,154 \$314,445 \$354,136 \$165,469 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$390,221 \$48,891 \$341,330 \$252,655 \$81,218 \$171,437 \$54,866 \$1,489 \$53,377 \$64,037 \$54,79 \$553,577 \$64,037 \$554,558 \$63,296 \$55,854 \$55,855 \$6,095 \$4,666 \$51,429 \$59,696 \$6,143 \$53,553 \$64,105 \$7,494	(\$1,624,421) (\$63,846) (\$1,560,575) \$42,619 \$45,491 (\$2,872) \$15,933 \$42,818 (\$26,885) \$101,481 \$84,251 \$17,230 (\$54,866) (\$1,489) (\$53,377) (\$64,037) (\$54,366) (\$1,489) (\$53,377) (\$64,037) (\$54,366) (\$53,377) (\$64,037) (\$55,558) (\$63,296) (\$53,558) (\$53,296) (\$53,554) (\$55,554) (\$55,554) (\$55,554) (\$55,554) (\$55,554) (\$55,554) (\$55,554) (\$55,554) (\$55,554) (\$55,555) (\$64,055) (\$55,4129) (\$55,606) (\$55,413) (\$55,553) (\$64,105) (\$7,494) (\$55,611)	forecasts	budget for ramp is approved. Image: Second
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA GMSWORKS#32 Boat Ramp Design Deserter's Dump GMSWORKS#33 Boat Ramp Design Ingenika GMSWORKS#33 Boat Ramp Design Finlay Bay GMSWORKS#35 Boat Ramp Design 6 Mile Bay GMSWORKS#36 Boat Ramp Design 6 Mile Bay GMSWORKS#37 Boat Ramp Design Cutthumb Bay GMSWORKS#37 Boat Ramp Design Mackenzie Landing GMSWORKS#40 Boat Ramp Design Mackenzie Landing	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$314,445 \$354,136 \$165,469 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$390,221 \$48,891 \$341,330 \$252,655 \$81,218 \$171,437 \$54,866 \$1,489 \$53,377 \$64,037 \$54,866 \$1,489 \$55,377 \$64,037 \$55,479 \$55,558 \$63,296 \$55,854 \$55,855 \$66,143 \$55,764 \$56,143 \$55,553 \$664,105 \$7,494 \$56,611 \$65,176 \$13,384	(\$1,624,421) (\$63,846) (\$1,560,575)	forecasts	budget for ramp is approved. Image: Second
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA GMSWORKS#32 Boat Ramp Design Deserter's Dump GMSWORKS#33 Boat Ramp Design Ingenika GMSWORKS#34 Boat Ramp Design Finlay Bay GMSWORKS#35 Boat Ramp Design 6 Mile Bay GMSWORKS#36 Boat Ramp Design Cutthumb Bay GMSWORKS#37 Boat Ramp Design Cutthumb Bay GMSWORKS#37 Boat Ramp Design Mackenzie Landing GMSWORKS#40 Boat Ramp Design Blackfoot Park	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$314,445 \$354,136 \$165,469 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$390,221 \$48,891 \$341,330 \$252,655 \$81,218 \$171,437 \$54,866 \$1,489 \$53,377 \$64,037 \$54,866 \$1,489 \$55,479 \$55,558 \$63,296 \$55,854 \$55,854 \$55,854 \$55,854 \$55,854 \$55,854 \$55,854 \$55,854 \$55,854 \$55,854 \$55,429 \$56,095 \$4,666 \$51,429 \$59,696 \$6,143 \$553,553 \$64,105 \$7,494 \$56,611 \$556,611 \$551,792 \$551,792 \$51,022	(\$1.624.421) (\$63.846) (\$1.560.575)	forecasts	budget for ramp is approved. Image: Second
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA GMSWORKS#32 Boat Ramp Design Deserter's Dump GMSWORKS#33 Boat Ramp Design Ingenika GMSWORKS#34 Boat Ramp Design Finlay Bay GMSWORKS#35 Boat Ramp Design 6 Mile Bay GMSWORKS#36 Boat Ramp Design 6 Mile Bay GMSWORKS#37 Boat Ramp Design Cutthumb Bay GMSWORKS#37 Boat Ramp Design Mackenzie Landing GMSWORKS#40 Boat Ramp Design Mackenzie Landing	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$188,667 \$181,445 \$354,136 \$165,469 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$390,221 \$48,8291 \$48,8291 \$341,330 \$252,655 \$81,218 \$171,437 \$54,866 \$1,1489 \$53,377 \$64,037 \$54,866 \$1,489 \$55,479 \$58,558 \$63,296 \$58,554 \$55,479 \$58,558 \$63,296 \$55,854 \$55,479 \$58,558 \$63,296 \$55,854 \$55,479 \$58,558 \$63,296 \$55,854 \$55,479 \$58,558 \$63,296 \$55,854 \$55,479 \$55,6095 \$4,666 \$51,429 \$59,696 \$6,143 \$53,553 \$64,105 \$7,494 \$56,611 \$65,176 \$51,792 \$551,792 \$551,792 \$551,792 \$551,792	(\$1.624.421) (\$63.846) (\$1.560.575)	forecasts	budget for ramp is approved. Image: Second
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA GMSWORKS#32 Boat Ramp Design Deserter's Dump GMSWORKS#33 Boat Ramp Design Ingenika GMSWORKS#33 Boat Ramp Design Finlay Bay GMSWORKS#34 Boat Ramp Design 6 Mile Bay GMSWORKS#35 Boat Ramp Design 6 Mile Bay GMSWORKS#36 Boat Ramp Design 6 Mile Bay GMSWORKS#37 Boat Ramp Design Cutthumb Bay GMSWORKS#37 Boat Ramp Design Mackenzie Landing GMSWORKS#40 Boat Ramp Design Blackfoot Park	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$184,445 \$354,136 \$165,469 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$390,221 \$48,891 \$341,330 \$252,655 \$81,218 \$171,437 \$54,866 \$1,489 \$53,377 \$64,037 \$54,866 \$1,489 \$53,377 \$64,037 \$55,479 \$58,558 \$63,296 \$5,854 \$55,479 \$58,558 \$63,296 \$5,854 \$55,479 \$58,558 \$63,296 \$5,854 \$55,479 \$58,558 \$63,296 \$5,854 \$55,479 \$58,558 \$63,296 \$5,854 \$55,479 \$55,6095 \$4,666 \$51,429 \$55,6095 \$4,666 \$51,429 \$55,6095 \$4,666 \$51,429 \$55,553 \$64,105 \$6,143 \$53,553 \$64,105 \$7,494 \$56,611 \$65,176 \$13,384 \$51,792 \$51,023 \$8,914 \$42,109 \$0	(\$1,624,421) (\$63,846) (\$1,560,575) (\$1,560,575) (\$2,872) \$42,819 (\$2,872) \$15,933 \$42,818 (\$26,885) \$101,481 \$84,251 \$17,230 (\$54,866) (\$1,489) (\$54,866) (\$1,489) (\$53,377) (\$64,037) (\$54,037) (\$54,037) (\$54,037) (\$55,558) (\$63,296) (\$53,5742) (\$53,554) (\$55,554) (\$55,554) (\$55,554) (\$55,554) (\$55,554) (\$55,554) (\$55,554) (\$55,554) (\$55,554) (\$55,554) (\$55,554) (\$55,555) (\$64,105) (\$55,1429) (\$55,1429) (\$55,1429) (\$55,143) (\$55,143) (\$55,143) (\$55,143) (\$55,143) (\$55,143) (\$55,143) (\$55,143) (\$55,143) (\$55,143) (\$55,143) (\$55,153) (\$64,105) (\$64,105) (\$64,105) (\$64,105) (\$65,179) (\$55,1792) (\$55,1792) (\$55,1792) (\$55,1023) (\$64,105) (\$64,105) (\$64,105) (\$64,105) (\$64,105) (\$65,176) (\$13,384) (\$55,1792) (\$55,1023) (\$64,105) (\$64,105) (\$55,1792) (\$55,1023) (\$64,105) (\$64,105) (\$64,105) (\$64,105) (\$13,384) (\$55,1792) (\$55,1023) (\$64,105) (\$64,105) (\$64,105) (\$64,105) (\$64,105) (\$65,176) (\$13,384) (\$55,1792) (\$55,1023) (\$64,105) (\$65,105) (\$64,105) (\$65,105) (\$64,105) (\$65,105) (\$65,1	forecasts	budget for ramp is approved. Image: Second
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA GMSWORKS#32 Boat Ramp Design Deserter's Dump GMSWORKS#33 Boat Ramp Design Ingenika GMSWORKS#34 Boat Ramp Design Finlay Bay GMSWORKS#35 Boat Ramp Design 6 Mile Bay GMSWORKS#36 Boat Ramp Design 6 Mile Bay GMSWORKS#37 Boat Ramp Design Cutthumb Bay GMSWORKS#37 Boat Ramp Design Mackenzie Landing GMSWORKS#40 Boat Ramp Design Mackenzie Landing GMSWORKS#41 Boat Ramp Design Halfway River	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management Direct Management Non-Remissible	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$314,445 \$354,136 \$165,469 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$390,221 \$48,891 \$341,330 \$252,655 \$81,218 \$171,437 \$54,866 \$1,489 \$53,377 \$64,037 \$54,866 \$1,489 \$55,377 \$64,037 \$55,479 \$55,558 \$63,296 \$55,854 \$55,854 \$55,854 \$55,854 \$55,854 \$55,854 \$55,854 \$55,854 \$55,854 \$55,854 \$55,854 \$55,854 \$55,854 \$55,855 \$63,296 \$55,854 \$55,854 \$55,854 \$55,854 \$55,854 \$55,854 \$55,855 \$63,296 \$55,854 \$55,855 \$63,296 \$55,854 \$55,854 \$55,854 \$55,855 \$64,105 \$54,666 \$51,429 \$59,696 \$6,143 \$553,553 \$64,105 \$7,494 \$56,611 \$65,176 \$13,384 \$551,792 \$551,023 \$8,914 \$42,109 \$0 \$0 \$0	(\$1,624,421) (\$63,846) (\$1,560,575) (\$1,560,575) (\$2,672) \$42,619 (\$2,672) \$15,933 \$42,818 (\$22,872) \$101,481 \$84,251 \$17,230 (\$54,866) (\$1,489) (\$54,866) (\$1,489) (\$53,377) (\$64,037) (\$54,377) (\$64,037) (\$54,79) (\$55,579) (\$55,579) (\$55,558) (\$63,296) (\$53,579) (\$55,554) (\$55,554) (\$55,554) (\$55,554) (\$55,555) (\$64,055) (\$54,666) (\$51,429) (\$55,554) (\$55,553) (\$64,105) (\$55,553) (\$64,105) (\$55,553) (\$64,105) (\$55,5179) (\$55,611) (\$55,176) (\$13,384) (\$55,792) (\$55,792) (\$51,023) (\$52,179) (\$51,023) (\$52,179) (\$51,023) (\$52,179) (\$51,023) (\$52,179) (\$51,023) (\$52,179) (\$51,023) (\$52,179) (\$51,023) (\$52,179) (\$51,023) (\$52,179) (\$51,023) (\$52,179) (\$51,023) (\$52,179) (\$51,023) (\$52,179) (\$51,023) (\$52,179) (\$51,023) (\$52,179) (\$51,023) (\$52,179) (\$51,023) (\$52,179) (\$52,179) (\$52,179) (\$52,179) (\$53,179) (\$54,105) (\$54,105) (\$54,105) (\$54,105) (\$55,176) (\$51,023) (\$52,179) (\$53,020) (\$54,020) (\$53,020) (\$54,020) (\$55,020) (\$	forecasts	budget for ramp is approved. Image: Second
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA GMSWORKS#32 Boat Ramp Design Deserter's Dump GMSWORKS#33 Boat Ramp Design Ingenika GMSWORKS#35 Boat Ramp Design Finlay Bay GMSWORKS#35 Boat Ramp Design 6 Mile Bay GMSWORKS#36 Boat Ramp Design 6 Mile Bay GMSWORKS#37 Boat Ramp Design Cutthumb Bay GMSWORKS#37 Boat Ramp Design Mackenzie Landing GMSWORKS#40 Boat Ramp Design Blackfoot Park GMSWORKS#41 Boat Ramp Design Blackfoot Park GMSWORKS#42 Boat Ramp Design Blackfoot Park	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$314,445 \$354,136 \$165,469 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$390,221 \$48,891 \$341,330 \$252,655 \$81,218 \$171,437 \$54,866 \$1,1489 \$53,377 \$64,037 \$54,866 \$1,489 \$55,377 \$64,037 \$55,479 \$55,5854 \$55,854 \$56	(\$1,624,421) (\$63,846) (\$1,560,575) (\$1,560,575) (\$42,619 (\$2,872) \$15,933 \$42,818 (\$26,825) \$101,481 \$84,281 (\$26,885) \$101,481 \$84,281 (\$26,885) (\$1,489) (\$54,866) (\$1,489) (\$54,966) (\$64,037) (\$64,037) (\$64,037) (\$64,037) (\$54,866) (\$53,377) (\$64,037) (\$54,866) (\$53,377) (\$64,037) (\$54,866) (\$53,578) (\$63,296) (\$53,558) (\$63,296) (\$53,558) (\$63,296) (\$53,558) (\$55,558) (\$55,6095) (\$55,6095) (\$54,666) (\$51,429) (\$55,6095) (\$54,666) (\$51,429) (\$55,553) (\$64,105) (\$54,105) (\$54,105) (\$7,494) (\$55,576) (\$53,553) (\$64,105) (\$54,105) (\$54,105) (\$54,105) (\$51,023) (\$51,023) (\$51,023) (\$52,109) (\$30,52,790)	forecasts	budget for ramp is approved.
STUDY GMSMGMT4 ORPHAN BOATRAMPS GMSWORKS#29 LYNX CREEK GMSWORKS#30 TAYLOR RAMP GMSWORKS#31 KWADACHA GMSWORKS#31 KWADACHA GMSWORKS#32 Boat Ramp Design Deserter's Dump GMSWORKS#33 Boat Ramp Design Ingenika GMSWORKS#34 Boat Ramp Design Finlay Bay GMSWORKS#35 Boat Ramp Design 6 Mile Bay GMSWORKS#35 Boat Ramp Design 6 Mile Bay GMSWORKS#36 Boat Ramp Design Cutthumb Bay GMSWORKS#37 Boat Ramp Design Cutthumb Bay GMSWORKS#37 Boat Ramp Design Mackenzie Landing GMSWORKS#40 Boat Ramp Design Blackfoot Park GMSWORKS#41 Boat Ramp Design Blackfoot Park GMSWORKS#41 Boat Ramp Design Blackfoot Park	Direct Management Implementation Direct Management Implementation Direct Management Implementation Non-Remissible Direct Management	\$280,376 \$91,709 \$188,667 \$406,154 \$91,709 \$188,667 \$118,667 \$188,667 \$188,667	\$1,624,421 \$63,846 \$1,560,575 \$46,218 \$191,539 \$390,221 \$48,891 \$48,891 \$341,330 \$252,655 \$81,218 \$171,437 \$54,866 \$1,489 \$53,377 \$64,037 \$54,866 \$1,489 \$55,479 \$58,558 \$63,296 \$58,554 \$55,479 \$58,558 \$63,296 \$55,854 \$55,479 \$55,6095 \$4,666 \$55,479 \$55,6095 \$4,666 \$55,429 \$55,6095 \$4,666 \$51,429 \$59,696 \$6,143 \$53,553 \$64,105 \$7,494 \$556,611 \$65,176 \$7,494 \$556,611 \$65,176 \$13,384 \$51,792 \$51,023 \$8,914 \$42,109 \$0 \$0 \$0 \$0 \$0 \$0 \$3,052,790	(\$1,624,421) (\$63,846) (\$1,560,575) (\$1,560,575) (\$2,872) \$42,819 (\$2,872) \$15,933 \$42,818 (\$26,885) \$101,481 \$84,251 \$17,230 (\$54,866) (\$1,489) (\$54,866) (\$1,489) (\$54,866) (\$54,966) (\$54,79) (\$56,578) (\$56,578) (\$56,5742) (\$56,695) (\$56,695) (\$56,695) (\$57,442) (\$57,442) (\$55,854) (\$57,442) (\$55,854) (\$57,442) (\$55,854) (\$57,442) (\$55,854) (\$57,442) (\$55,854) (\$57,442) (\$55,855) (\$64,105) (\$64,105) (\$64,105) (\$64,105) (\$64,105) (\$55,172) (\$55,172) (\$55,172) (\$55,172) (\$51,023) (\$51,023) (\$51,023) (\$51,023) (\$51,023) (\$51,023) (\$51,023) (\$51,023) (\$51,023) (\$51,023) (\$51,023) (\$53,052,790) (\$26,792)	forecasts	budget for ramp is approved. Image: Second

		Costs approved by	Total Forecast	Variance Total to		
Monitoring Programs	Activity	COSIS approved by CWR	and Forecast)	Approved	Explanation	Corrective Action
GMSWORKS#44 Boat Ramp Finlay Bay			\$1,058,379	(\$1,058,379)	New project with unapproved cost forecasts	Variance will self-correct when budget for ramp is approved.
	Non-Remissible Direct		\$24 379	(\$24,370)		
	Non-Remissible		\$4.004.000	(\$24,070)		
GMSWORKS#45 Boat Ramp 6	Implementation		\$1,034,000	(\$1,034,000)	New project with unapproved cost	Variance will self-correct when
Mile Bay	Non-Remissible Direct		\$1,931,996	(\$1,931,996)	forecasts	budget for ramp is approved.
	Management		\$31,996	(\$31,996)		
	Implementation		\$1,900,000	(\$1,900,000)	N	
Cutthumb Bay			\$3,614,164	(\$3,614,164)	forecasts	budget for ramp is approved.
	Non-Remissible Direct Management		\$34,168	(\$34,168)		
	Non-Remissible		\$3 579 996	(\$3,579,996)		
GMSWORKS#47 Boat Ramp	mplomontation		\$2,630,050	(\$2,620,050)	New project with unapproved cost	Variance will self-correct when
	Non-Remissible Direct		\$2,030,030	(\$2,030,030)	Torecasis	budget for ramp is approved.
	Management Non-Remissible		\$33,846	(\$33,846)		
GMSWORKS#48 Boat Ramp	Implementation		\$2,596,204	(\$2,596,204)	New project with unapproved cost	Variance will self-correct when
Blackfoot Park	Direct Management		\$508,030	(\$508,030)	forecasts	budget for ramp is approved.
	Implementation		\$11,989 \$496,041	(\$11,989) (\$496,041)		
GMSWORKS#49 Boat Ramp Dunlevy			\$1,403,125	(\$1,403,125)	New project with unapproved cost forecasts	Variance will self-correct when budget for ramp is approved.
•	Non-Remissible Direct		\$27.009	(\$27.009)		
	Non-Remissible		¢1.070.440	(\$1,000)		
GMSWORKS#51 Boat Ramp	Implementation		\$1,370,110	(\$1,370,110)	New project with unapproved cost	Variance will self-correct when
Hudsons Hope	Non-Remissible Direct		\$1,041,572	(\$1,041,572)	forecasts	budget for ramp is approved.
	Management		\$20,580	(\$20,580)		
	Implementation		\$1,020,992	(\$1,020,992)	New are in the state of the second second	
Halfway River			\$177,880	(\$177,880)	forecasts	budget for ramp is approved.
	Direct Management Implementation		\$25,309 \$152,571	(\$25,309) (\$152,571)		
GMSWORKS#53 Boat Ramp Design Hudsons Hope			\$59 147	(\$59 147)	New project with unapproved cost forecasts	Variance will self-correct when budget for ramp is approved
	Non-Remissible Direct		¢00,111	(\$6,625)		
	Non-Remissible		\$0,023	(\$50,523)		
GMSWORKS#54 Boat Ramp	Implementation		\$52,522	(\$52,522)	New project with unapproved cost	Variance will self-correct when
Design Dunlevy	Non-Remissible Direct		\$83,759	(\$83,759)	forecasts	budget for ramp is approved.
	Management Non-Remissible		\$8,691	(\$8,691)		
GMSWORKS#55 Blackfoot	Implementation		\$75,067	(\$75,067)		
Maintenance	Direct Management		\$0 \$0	\$0 \$0		
	Implementation		\$0 \$0	\$0 \$0		
GMSWORKS#56 Hudsons Hope Maintenance			\$0	\$0		
	Non-Remissible Direct Management		\$0	\$0		
	Non-Remissible		\$0	\$0		
GMSWORKS#57 Dunlevy			02	02		
maintenanoe	Non-Remissible Direct		¢0	\$0		
	Non-Remissible					
GMSWORKS#58 Mackenzie	Implementation		\$U	\$0		
Maintenance	Non-Remissible Direct		\$0	\$0		
	Management Non-Remissible		\$0	\$0		
CMSWORKS#50 Ingonika	Implementation		\$0	\$0		
Maintenance			\$0	\$0		
	Non-Remissible Direct Management		\$0	\$0		
	Non-Remissible Implementation		\$0	\$0		
GMSWORKS#60 Finlay Maintenance			\$0	\$0		
Maintenanoe	Non-Remissible Direct		¢0	\$0		
	Non-Remissible		\$0	\$0		
GMSWORKS#61 6 Mile	Implementation		\$0	\$0		
Maintenance	Non-Remissible Direct		\$0	\$0		
	Management		\$0	\$0		
	Implementation		\$0	\$0		
GMSWORKS#62 Cutthumb Maintenance			\$0	\$0		
	Non-Remissible Direct Management		\$0	\$0		
	Non-Remissible Implementation		\$0	\$0		
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