REPORT

District of Invermere

DROUGHT MANAGEMENT PLAN

0953.0063.01 / March 2011

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March 29, 2011 File: 0953.0063.01

Mr. Chris Prosser
District of Invermere
PO Box 339
Invermere, B.C., V0A 1K0

VIA EMAIL: **cao@invermere.net**

Attention: **Chris Prosser, Chief Administrative Officer**

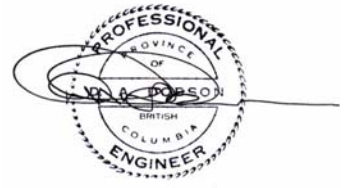
RE: **FINAL REPORT - District of Invermere: Drought Management Plan**

Urban Systems Ltd. is pleased to provide a final report outlining the Paddy Ryan Reservoir system and a Drought Management Plan for the District of Invermere (District). The intent of the Drought Management Plan is to define, quantify and understand the balance that exists between an available water source and supply, and the current and projected water consumption patterns of the District.

We trust this report meets your requirements. If you have any questions please do not hesitate to contact either of us.

Sincerely,

URBAN SYSTEMS LTD.



Don Dobson, P.Eng.
Senior Water Engineer

Lynda Cooke, P.Eng.
Senior Municipal Engineer

EXECUTIVE SUMMARY

This report has been prepared to provide the District of Invermere (District) with a response plan for dealing with droughts. The report summarizes the conditions that would indicate the potential for below normal supply in Goldie Creek; it provides a summary of the estimated runoff in Goldie Creek for normal years and for the 1 in 10 year low flow years and it also summarizes the typical water demand in the district.

For the District, the principle surface water source is Goldie Creek, which is diverted into the Paddy Ryan Reservoir system (PRR) (refer to overview map, Figure 1.1). The PRR system is a series of three reservoirs: the first reservoir (Reservoir #1) is supplied by Goldie Creek after priority water licence allocations are met. Water travels from Reservoir #1 to #2 via seepage since the slide gate on the sluiceway is inoperable and from Reservoir #2 to #3 by adjusting the gate on the sluiceway through Dam #2. The intake to the District's distribution system and the diversion works to Abel Creek are located in the south dam at Reservoir #3. The District has never indicated significant water shortages; however, in order to be proactive, considering climate change scenarios, and preparing for future population growth and infrastructure expansion, the District has begun to review its water supply requirements and uses.

There was limited data available on the flows in Goldie Creek and also on the flows diverted from Goldie Creek to the Paddy Ryan Reservoirs. There was also limited demand data available to determine average water demand by the District. However, based on the available supply and demand data the analysis suggests that there is sufficient water available to meet the community's demand during normal runoff years as well as during a 1 in 10 year low flow in Goldie Creek.

The intake works consist of a concrete weir across Goldie Creek and diversion works to the District's pipeline that included a 600mm diameter diversion pipe controlled by a manual slide gate and an intake box that has been designed to provide the licensed flows to the District's intake plus two other water licensees. Control of the flow to the District's reservoirs is regulated by adjusting the slide gate on Goldie Creek.

Due to the limited available data the preliminary Drought Management Plan has been prepared based on local knowledge of the water supply and demand supported by regional data from active snow courses, hydrometric and climate stations as well as information from the Ministry of Environment River Forecast Centre. The decision to implement water restrictions is based on staff review of current supply and demand and is summarized below. If staff determines that the flows in Goldie Creek are below normal during the month of May, and the regional precipitation trends are below normal, then it is recommended that Stage 1 restrictions be implemented on June 1. If the supply trends and flows in Goldie Creek continue to be below normal by mid-June, then staff should recommend implementation of Stage 2 restrictions on June 15. Decisions to move to Stage 3 restrictions – no outdoor watering, would be based on flows in Goldie Creek, cumulative precipitation to July, and the level of demand. Staff should recommend to Council increased water restrictions if the determine that conditions are below normal for any combination of stream flows, reservoir levels, or regional precipitation.

Drought Management Action Plan

Water Restriction	Date	Goldie Creek Flows	Reservoir Levels	Regional Precipitation	Action
Stage 1	All Year	Normal	Normal	Normal	Stage 1 is the standard water restriction all year
	April	Normal	Normal	Below Normal	The District staff to monitor supply and demand
	April 15	Below Normal	Below Normal	Below Normal	Advise public of conditions
	May 15	Below Normal	Below Normal	Below Normal	Advise public of conditions
	May 21	Below Normal	Below Normal	Below Normal	The District staff to recommend to Council that Stage 2 required on June 1
Stage 2	June 1	Below Normal	Below Normal	Below Normal	Stage 2 restrictions implemented
	June 21	Below Normal	Below Normal	Below Normal	The District staff to recommend to Council that Stage 3 required on July 1
Stage 3	July 1	Below Normal	Below Normal	Below Normal	Stage 3 restrictions implemented
	July / August	Below Normal	Below Normal	Below Normal	Stage 3 restrictions to continue unless supply improves.

It is recommended that the District move towards a more proactive approach to water supply management by establishing a hydrometric station on Goldie Creek, re-establish the Invermere Climate station, and upgrade the Paddy Ryan reservoir monitoring system. Having these upgraded sources of information will assist the District in having a better understanding of the ongoing performance of the reservoirs and be able to ensure that the drought response is appropriate in low flow years. It is also recommended that the District confirm the live storage volumes in the reservoirs, repair the slide gate at Dam #1 and confirm that there is no requirement to release water to Abel Creek.

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

1.1 Drought Management Plan Overview

What is a drought? According to the Ministry of Environment (MOE) (2009), a drought can be defined as "*a recurrent feature of climate involving a deficiency of precipitation over an extended period of time, resulting in a water shortage*". Droughts generally occur when there is a combination of sustained low precipitation and high rates of evaporation, which result in low water flows in streams and/or low water storage levels (MOE 2009). In the southern interior of B.C. (i.e. Invermere), droughts have occurred as a result of insufficient snow accumulation, hot and dry weather, a delay in fall rains, and a combination of these factors (MOE 2009).

For the District of Invermere (District), the climatic location of Invermere is such that water availability varies from year to year. The local climate in the Eastern Trench suggests that water supply is periodically scarce and drought conditions are expected from time to time. Climate change forecasts for Invermere predict 0 – 5% increases in winter precipitation and 5 – 10% increases in summer precipitation; however, due to predicted temperature increases, earlier spring runoff and subsequently an earlier onset of low summer flows is expected to cause more water stress in the later summer and early fall (Walsh 2010). Ultimately, the variability of climate and water supply warrants the District to evaluate water abundance or shortages by keeping in mind the level of severity and responding appropriately.

For the District, the principle surface water source is Goldie Creek, which is diverted into the Paddy Ryan Reservoir system (PRR) (refer to overview map, Figure 1.1). The PRR system is a series of three reservoirs: the first reservoir (Reservoir #1) is supplied by Goldie Creek after priority water licence allocations are met. Water travels from Reservoir #1 to #2 via seepage since the slide gate on the sluiceway is inoperable and from Reservoir #2 to #3 by adjusting the gate on the sluiceway through Dam #2. The intake to the District's distribution system and the diversion works to Abel Creek are located in the south dam at Reservoir #3. The District has never indicated significant water shortages; however, in order to be proactive, considering climate change scenarios, and preparing for future population growth and infrastructure expansion, the District has begun to review its water supply requirements and uses.

Consequently, in 2006, the District began to address water supply concerns by implementing Bylaw 1297, "*A Bylaw to Prescribe Water Use Restrictions*" (District of Invermere 2006). The Bylaw is intended to assist in the protection, preservation, and maintenance of the District's water supply through water use restrictions during periods of limited supply. The restrictions outlined by the Bylaw are in accordance with the severity of supply limitations (three separate stages), and are generally related to domestic outdoor use (i.e. residential irrigation) (District of Invermere 2006).

The implementation of the Bylaw is a first step towards long term sustainability of water supply; however, in order to minimize the effects of drought and to understand the intricacies of the PRR system under all climatic conditions and demand requirements, a drought management plan (DMP) is essential. A DMP has three main objectives: (1) understanding the community's water supply; (2) improving the

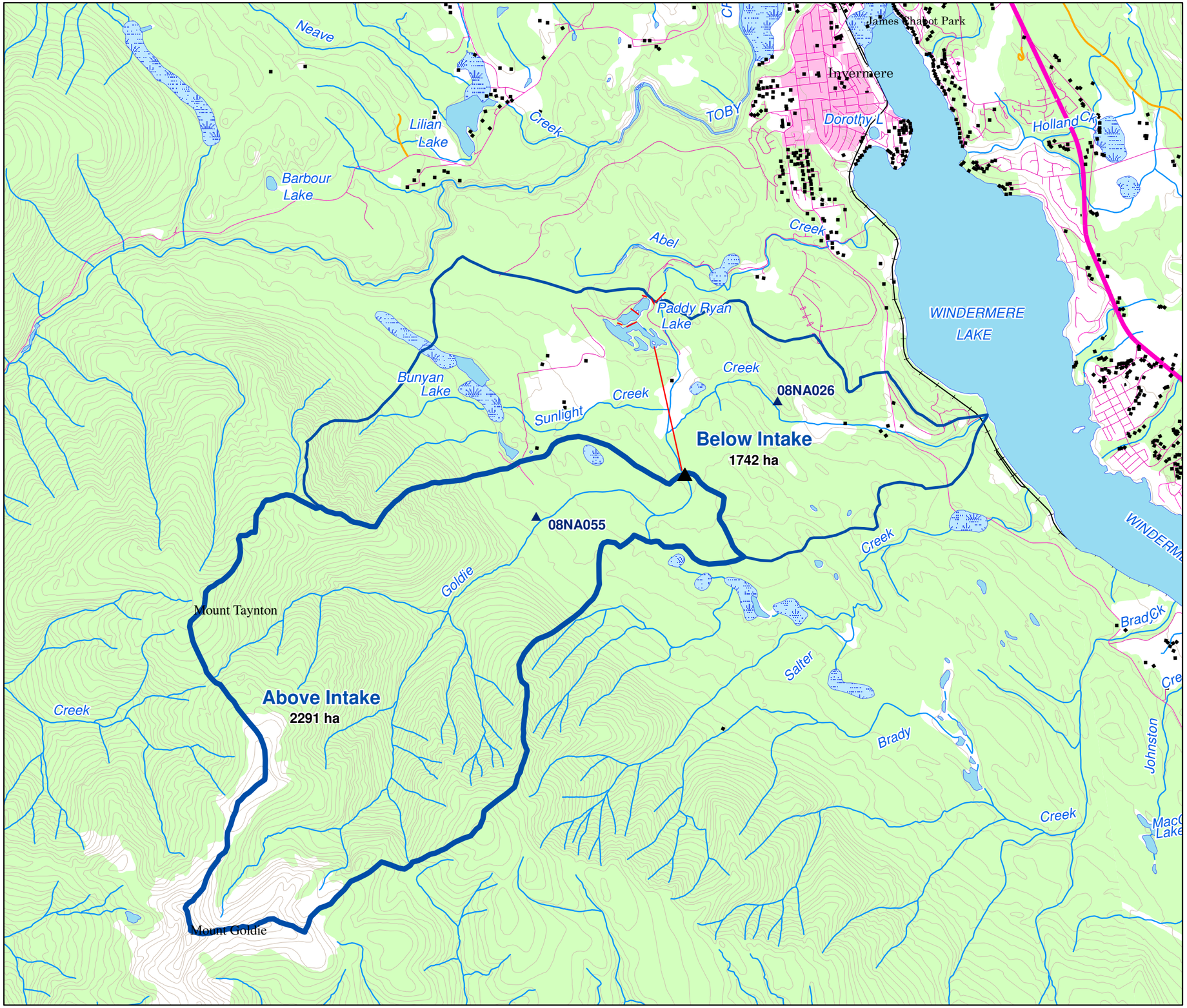
community's water use efficiency; and (3) communicate, educate, and participate (MOE 2009). This report represents a DMP for the District, summarizing the community's water supply system, the community's water supply and demand requirements, the recommended operation of the water supply system under drought conditions, and the necessary data requirements and measures needed for a sustainable system into the future.

1.2 Drought Management Plan Objectives

The objectives of the DMP for the District are as follows:

1. Quantify the characteristics of water availability in the Goldie Creek watershed and estimate relative levels of water shortage;
2. Develop key action steps to improve our understanding of watershed specific drought triggers;
3. Examine the relationship between supply and demand and characterize the risk of water shortage in multiple water supply conditions;
4. Examine alternative water sources; and
5. Identify key conservation initiatives to reduce water use:
   - Confirm, or not, that the existing conservation bylaw is consistent with a responsible drought management plan; and
   - Discuss the community-specific water use conditions that lead to effective drought management techniques.

Overall, this drought management plan is intended to define, quantify and understand the balance that exists between an available water source and supply, and the current and projected water consumption patterns of the District. And where appropriate, identify measures to enable reliable water supply during a drought given a practical level of conservation.



Invermere.mxd

Figure 1.1District of Invermere

Drought Management Plan
Goldie Creek
Area Above Intake

Legend

- Above Intake
- Below Intake
- Lake
- Land
- Man-made waterbody
- River
- Wetland
- 082K09_water_c_l
- Hydrometric Stations - Discontinued
- Intake
- Building
- Main Road
- Seconday Road
- Street
- Limited use road
- Trail
- Railway
- Built up area
- Contour (100 feet)
- Vegetation

Projection:BC Albers
Datum:NAD83

1:50,000

800 400 0 800 1,600 2,400 3,200

metre

URBAN SYSTEMS®

Map produced for:
Urban Systems Ltd.
304-1353 Ellis Street, Kelowna, BC V1Y 1Z9

FPS Drafting & Geomatics Ltd.

Map produced by:
FPS Drafting & Geomatics Ltd.
2784 Paris Street, Penticton, BC, V2A 8G2

2.0 PADDY RYAN RESERVOIR SYSTEM WATER SUPPLY ASSESSMENT

2.1 General Overview

The PRR system is used by the District as its principle water source; the source of supply for the PRR system is Goldie Creek. The District relies on a collection of streams, reservoirs, diversion structures, intakes, and spillways to collect, store, and discharge flows from Goldie Creek and into the PRR system. Three reservoirs are included in the PRR system, with inflows into Reservoir #1 and outflows out of Reservoir #3. The District does not currently monitor surface water inflows into the PRR system; however, water transferred to the District intake is monitored by the District SCADA system and water released to Abel Creek is recorded manually from a staff gauge by District staff. A general schematic of the PRR system is provided in Figure 1.2.

According to the Ministry of Environment reports on file on EcoCat[1], the combined storage in the PRR system is approximately 436 acre-feet. The Goldie Creek diversion pipeline outlet is located in Reservoir #1. Full pool on the reservoir is 969.48 m ASL. The storage volume at full pool is approximately 202 acre-feet. Full pool on Reservoir #2 is approximately 967.46 m ASL and the storage volume at full pool is approximately 135 acre-feet. For Reservoir #3 the full pool elevation is also 966.52 m ASL and the storage volume is approximately 99 acre-feet.

Discussions with District staff (G. Gyurkovits, pers. comm., 2010) provided an overview of the PRR system as follows:

- A 16-inch (0.41 m) diameter culvert with a sliding gate is located directly on Goldie Creek. A cement weir has been installed at this diversion location, including a channel bypass. The channel bypass is generally operational under high water conditions and when the District close, or reduce flows into the diversion culvert; the sliding gate is operated manually;
- Water diverted from Goldie Creek is transferred through the culvert into a holding pond (i.e. "grit pond") where the majority of coarse suspended sediment and gravels settle out;
- From the holding pond, a box weir allocates water supply based on water license priority. The box weir is split into four separate compartments, where each compartment fitted with diversion pipes sized to meet each respective water license allocated volume. Water flows into each compartment individually after each water license allocation is achieved; if there are insufficient inflow volumes to meet a licensed allocation, the subsequent compartment does not receive water. Additionally, an overflow weir is located adjacent to the box weir to handle inflows from Goldie Creek that exceed the design inlet capacity of the box weir;
- The four water licensee's included in the box weir and maximum diversion rate, in order of priority, are as follows:
    1. District of Invermere (Waterworks) – 0.044 m^3/s;
    2. Royal Antler Ranch (Irrigation/Domestic) – 0.006 m^3/s;

[1] Ministry of Environment EcoCat web site - http://a100.gov.bc.ca/pub/acat/public/search.do

3. District of Invermere (Waterworks) – 0.078 m^3/s; and
4. Jim McKay (Irrigation) – 0.006 m^3/s;

- Water from the box weir that is diverted for District use, drains to a small collection area, which flows into an intake pipe (maximum pipe capacity of 0.236 m^3/s) that diverts the flow to Reservoir #1;
- The diversion works do not include an overflow spillway, therefore during high flows in Goldie Creek District staff must regulate the diversion flows carefully so that the capacity of the box weir and pipeline are not exceeded;
- Reservoir #'s 1, 2, and 3 are hydraulically connected through gates. The District indicated that the management of reservoir levels is through the gate connecting Reservoir #'s 2 and 3; the gate connecting Reservoir #'s 1 and 2 is rusted shut and no operational measures can be applied to directly manage water levels. The water levels in each reservoir are monitored manually using staff gauges;
- Water in Reservoir #3 is diverted to the District water supply intake and Abel Creek. The District operates a SCADA system to monitor volumes diverted for District consumption, while Abel Creek flows are recorded manually at an outflow weir. The District noted that no minimum fishery flow releases are required to be met in Abel Creek;
- Water in Abel Creek is supplemented by Sunlight Creek flows, which is diverted around the PRR system due to ranchland contaminant concerns. Sunlight Creek enters the Abel Creek spillway via a pipe directly downstream of the Reservoir #3 outlet; and
- The District indicated that there is one confirmed point of diversion on Goldie Creek (for irrigation purposes) above the Goldie Creek diversion culvert and another diversion out of the intake pipe between the box weir and Reservoir #1 for domestic purposes.

Figure 1.2 District of Invermere Goldie Creek / Paddy Ryan Reservoir Water Supply System.

2.2 Water Balance

In order to properly assess the water supply capability of the PRR system for the development of the drought management plan, the overall water balance is required to understand the complexities of the system. The general water balance of the PRR system is as follows:

$$\Delta S_{PRR\ System} = \text{Inflows} - \text{Outflows} \qquad \text{Eq.1}$$

where inflows to the system are from Goldie Creek and precipitation (and possible groundwater contributions) and outflows are through Abel Creek releases, District water supply requirements, seepage, and evaporation. A detailed summary of the water balance procedure is provided in Appendix A.

2.2.1 Goldie Creek Water Supply

The District does not monitor surface water discharge in Goldie Creek; therefore, water supply volumes of Goldie Creek and total inflow volumes into the culvert diversion ($Q_{in,Intake1}$; Eq. A5 – Appendix A) have not been historically recorded. As a result, in order to properly develop a drought management plan and understand the water balance, available water supply volumes are required.

A review of Water Survey of Canada (WSC) hydrometric stations within proximity to the PRR system identified twenty-three potentially relevant stations to the investigation; however, upon review of watershed size and Columbia River valley aspect, period of record, regulation type, and proximity to Invermere, two stations were identified as useful (Table 1.1).

Table 1.1 Hydrometric Stations near the PRR System.

Station Name	WSC Station Number	Drainage Area (km^2)	Period of Record	Type of Regulation
Goldie Creek (South Fork) near Invermere	08NA055	17.6	1961 – 1970	Natural
Columbia River at Nicholson	08NA002	6,660	1903 – 2008	Natural

Goldie Creek has historically been monitored at two separate locations: at a location above the District's culvert diversion (WSC Station 08NA005, "Goldie Creek (South Fork) near Invermere") and at a location below the District's culvert diversion (WSC Station 08NA026, "Goldie Creek near Invermere"). The downstream station was not considered relevant to this investigation since the WSC noted this station as regulated.

Due to the lack of hydrometric records in the vicinity of the PRR system, Goldie Creek historic records measured at "Goldie Creek (South Fork) near Invermere" were utilized to estimate water supply volumes. To reduce the effects of the station's particular period of record, the mean monthly discharge was adjusted to a long term monthly mean on the flow records of "Columbia River near Nicholson" (WSC Station 08NA002), for which a record extends from 1903-2008. The drainage area of the Goldie Creek

WSC hydrometric station drains approximately 4 km^2 less than Goldie Creek at the culvert diversion location; however, due to the significant change in topography (from steep mountainous to valley bottom) between sites, it is assumed that the discharge estimated at the WSC station location would be representative of flows at the culvert diversion[2]. The mean monthly natural volume ($Q_{in,Nat}$; Eq. A5 – Appendix A) of Goldie Creek at the culvert diversion is presented in Table 1.2.

Table 1.2 Mean and 10-year low flow natural and regulated monthly volumes of Goldie Creek at the culvert diversion.

Type	Mean Monthly Natural Volume (m^3/day)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	5,180	5,654	6,070	8,365	30,220	50,264	28,447	15,107	11,060	8,256	7,827	6,399
Q10 Low	3,989	4,580	4,916	5,688	18,736	35,185	20,482	11,682	8,627	6,027	5,792	4,863
Mean Monthly Adjusted Volume (m^3/day)												
Mean	5,180	5,654	6,070	8,365	17,288	37,332	15,515	15,107	11,060	8,256	7,827	6,399
Q10 Low	3,989	4,580	4,916	5,688	5,804	22,253	7,550	11,682	8,627	6,027	5,792	4,863

As noted by the District, there is one confirmed point of diversion above the culvert diversion on Goldie Creek (Figure 1.1). The point of diversion is allocated for water licenses C114230 and C114193, which are issued for irrigation purposes, for the period May 15 to July 15 annually, and up to a maximum volume of 500 acre-feet and 150 acre-feet respectively. Assuming the maximum licensed extraction for the period of use, the mean monthly adjusted volume of Goldie Creek at the culvert diversion ($Q_{in,Intake1}$; Eq. A5 – Appendix A) is presented in Figure 1.2 and Table 1.2.

[2] This assumes that the majority of runoff in Goldie Creek is supplied by the headwaters, with minor contributions from the valley floor topography.

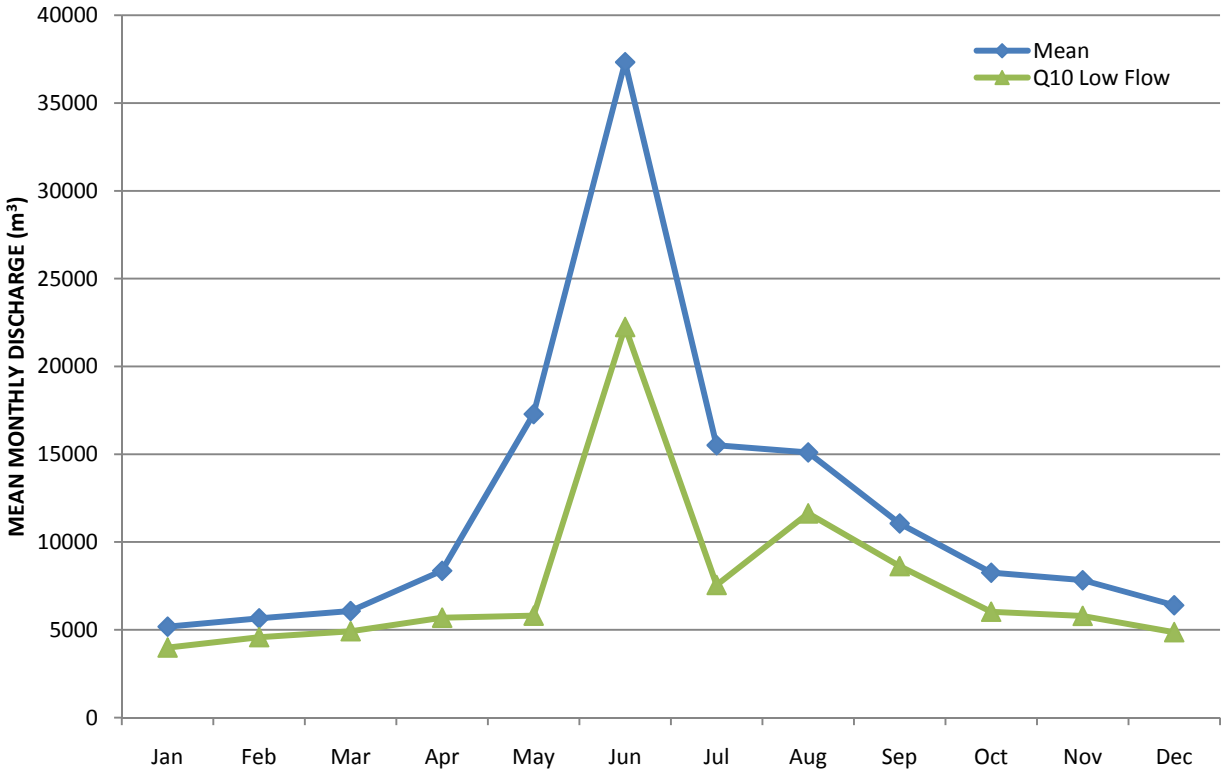


Figure 1.3 Mean and 10-year low flow adjusted monthly discharge of Goldie Creek at the culvert diversion.

In order to address the PRR system drought management concerns, the 10-year return period natural monthly low flow statistic was also calculated (Table 1.2). The 10-year low flow statistic for Goldie Creek was calculated using the monthly ratio of the 10-year low flow to the mean monthly flow calculated for "Columbia River near Nicholson" (WSC Station 08NA002)[3]. The 10-year monthly low flow statistic was determined for the Columbia River, using the B.C. Ministry of Environment, Lands, and Parks Flood Frequency Analysis program (version 1.1), which included the following frequency distributions: Pearson Type III, Log-Pearson Type III, Log-Normal, and Gumbel. Each monthly distribution included a visual inspection, with poor fits excluded; an average of the results obtained from the four distributions was used as the representative value. The natural 10-year low flow statistic was also adjusted for the upstream licenses, assuming full water license extraction (Table 1.2).

2.2.2 Paddy Ryan Reservoir System Water Demand

The PRR system is influenced by water demands from three separate sources: water licences, District requirements, and Abel Creek outflows; each water demand is outlined below.

[3] The drainage areas of the Columbia River and Goldie Creek watersheds are significantly different from one another; however, since the investigation is focusing on mean monthly volumes, the ratio of is assumed representative.

2.2.2.1 Water Licenses

All active water licenses on Goldie Creek are summarized in Table 1.3. The total volume of water currently licensed on Goldie Creek is approximately 1,468,000 m^3 (1,190 acre-feet) for irrigation, 1,542,000 m^3 (1,250 acre-feet) for storage, 5.6 m^3/day (1,500 gallons per day) for domestic use, and 3,313,000 m^3/year (875,100,000 gallons/year) for waterworks. Additionally, there are two active water license applications currently under review for dust control (757 m^3/year (200,000 gallons/year)) and fire protection (1,893 m^3/year (500,000 gallons/year)). The Ministry of Environment reports that Goldie Creek is currently fully recorded with possible water shortages and no further water licenses would be issued.

Table 1.3 Summary of active water licenses on Goldie Creek and Paddy Ryan Reservoirs.

Water License No.	Volume	Use	Licensee
C064859	300 AF	Irrigation	District of Invermere
C064859	36,500,000 GY	WWLA	District of Invermere
C051365	500 GD	Domestic	Royal Antler Ranch
C051365	73 AF	Irrigation	Royal Antler Ranch
C026458	500 GD	Domestic	D.R & S.P Moneo
C026458	20 AF	Irrigation	D.R & S.P Moneo
C064861	547,500,000 GY	WWLA	District of Invermere
C064860	21,000,000 GY	WWLA	District of Invermere
C043970	35 AF	Irrigation	J.A. & J.P. McKay
C114230	500 AF	Irrigation	C. Zehnder
C114231	500 AF	Storage	C. Zehnder
C059982	306,600,000 GY	WWLA	District of Invermere
C060003	350 AF	Storage	District of Invermere
C114193	150 AF	Irrigation	C. Zehnder
C114208	400 AF	Storage	C. Zehnder
C100245	500 GD	Domestic	M.J. Terpstra

Note:
1. ILA = Irrigation Local Authority; WWLA = Waterworks Local Authority; GY = Gallons/year; GD = Gallons/day

The majority of water licences are accounted for within the box weir distribution (i.e. the District, Royal Antler Ranch, and J.A. McKay) and the reservoir system (i.e. the District); however, a diversion pipe and canal is located upstream of the District's point of diversion for irrigation purposes (i.e. C. Zehnder). Active use of water licences C026458 and C100245 have not been recorded by the District; however, the water licensee (for C100245) has recently approached the District about extraction possibilities from the reservoir system (G. Gyurkovits, pers. comm., 2010).

Discussions with the District also noted the extraction of water from the intake pipe between the box weir and Reservoir #1; the District indicated that the water was used for domestic purposes (G. Gyurkovits,

pers. comm., 2010). However, the licence number, point of diversion, and licensed volume is unknown and not noted on available mapping (MOE 2010).

2.2.2.2 District of Invermere

The District extracts water out of Reservoir #3 via a water supply intake; the volume of extraction is monitored through its SCADA system. District provided water use information for 1994-1996 and 2003-2005 (Table 1.4). The reason behind the decrease in mean monthly water use between the 1994-1996 and 2003-2005 recorded periods is unknown. The lines noted as Q10 Low indicate the estimated 1 in 10 year low flows in Goldie Creek and have been added to illustrate how the District's demand compares to these flows.

Table 1.4 Mean monthly water use by the District, 1994-1996 and 2003-2005.

Year	Mean Monthly Water Use (m^3/day)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1994	2,302	2,216	2,048	2,711	5,325	4,378	7,522	6,583	2,913	2,548	2,103	2,058
1995	2,248	2,279	2,430	2,758	5,088	5,514	3,793	4,114	2,013	2,103	1,976	2,061
1996	2,237	2,810	2,750	2,157	3,114	4,689	5,792	8,672	1,964	n/a	n/a	n/a
Mean	**2,262**	**2,435**	**2,409**	**2,542**	**4,509**	**4,860**	**5,702**	**6,456**	**2,297**	**2,325**	**2,039**	**2,059**
Q10 Low[2]	3,989	4,580	4,916	5,688	5,804	22,253	7,550	11,682	8,627	6,027	5,792	4,863
2003	1,348	1,389	1,337	1,482	2,028	3,400	5,441	5,129	2,669	1,495	1,353	1,345
2004	1,460	1,438	1,312	1,802	2,567	3,517	4,364	3,740	1,892	1,564	1,469	1,616
2005	1,589	1,606	1,970	2,592	3,473	2,440	3,078	4,014	2,369	n/a	n/a	n/a
Mean	**1,466**	**1,495**	**1,540**	**1,901**	**2,689**	**3,119**	**4,295**	**4,294**	**2,310**	**1,530**	**1,411**	**1,481**
Q10 Low[2]	3,989	4,580	4,916	5,688	5,804	22,253	7,550	11,682	8,627	6,027	5,792	4,863

Note:

1. n/a = data not available.
2. Adjusted Q10 Low flows from Table 1.2.

2.2.2.3 Abel Creek

The flow in Abel Creek downstream of Reservoir #3 is provided by flows diverted from the reservoir plus the diversion of Sunlight Creek. In 2007, a thin plate weir was installed at the inlet of the outflow channel to increase the storage capacity of Reservoir #3; the thin plate weir is 0.15 m (6-inches) high, 1.07 m (42-inches) wide, and is raised 0.08 m (3-inches) above the sill level of the outflow channel (G. Gyurkovits, pers. comm., 2010). When reservoir levels are below the top of the weir, the outflow is dynamic, and depending on reservoir levels, outflow volumes can be estimated through a combination of rectangular weir, submerged rectangular orifice, and sharp crested weir equations.

The District monitors the level of Reservoir #3 at the Abel Creek outflow weir, but the District has not calculated outflow volumes. The outflow to Able Creek is primarily controlled by the water level in the reservoir therefore, when the reservoir levels are below the sill of the outflow weir, no flow is contributed to Abel Creek. Review of the District records from 2005-2009, indicate that for the period of record water levels in Reservoir #3 have been maintained above the sill level. The water level data at the weir was used along with appropriate weir formulas to estimate the average monthly flows from the reservoir to

Abel Creek. Refer to Appendix B for details on how the flows to Abel Creek were estimated; the results of the analysis are summarized in Table 1.5. No minimum flow requirements for Abel Creek were noted by the District (G. Gyurkovits, pers. comm., 2010).

Table 1.5 Mean Monthly Outflow Volumes to Abel Creek, 2005-2009.

Year	Mean Monthly Outflow Volume (m^3/day)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2005	n/a	n/a	n/a	n/a	n/a	12,020	11,433	9,579	10,085	10,493	8,978	6,208
2006	5,712	3,946	1,758	5,010	9,812	10,230	8,368	8,591	7,634	7,357	6,810	5,598
2007	4,231	1,901	1,900	4,058	10,065	13,051	8,703	7,958	6,915	5,969	4,491	2,150
2008	2,067	1,371	1,247	1,392	6,307	16,328	12,009	8,330	7,420	6,024	3,841	1,616
2009	1,212	1,069	1,044	1,218	1,362	11,506	13,223	9,953	5,625	4,086	n/a	n/a
Mean	**3,305**	**2,072**	**1,487**	**2,919**	**6,886**	**12,627**	**10,747**	**8,872**	**7,536**	**6,786**	**6,030**	**3,893**

Note:

1. n/a = data not available

2.3 Water Availability Summary

A full water balance review could not be completed for the PRR system due to the lack of data on concurrent inflows from Goldie Creek and outflows to the District intake and Abel Creek. However, a very general review of the water balance (broad overview assessment) is considered the most appropriate option under these circumstances (i.e. lack of supplementary water balance data).

Based on a review of the adjusted mean and 10-year low flow monthly inflow estimates for Goldie Creek (Table 1.2) and the District's mean monthly water use records (Table 1.4), on a monthly standpoint, there appears to be a low to moderate concern of water supply shortage for the District. The results indicate that there should have been no significant water shortages in the District to date.

Table 1.6 illustrates the water balance for a normal year based on preliminary estimates of Goldie Creek flows and normal demand. It should be noted that the only month where demand would be supported by storage is October. Table 1.7 illustrates the water balance for a 1 in 10 year low flow year based on preliminary estimates of Goldie Creek flows and normal demand. For this scenario, at normal Stage 1 demand, storage would be required to support demand for the months of May and from July through January. These values indicate what could occur if further water restrictions were not implemented at the appropriate times.

Table 1.6 Water balance under normal conditions.

Source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Goldie Supply	5,180	5,654	6,070	8,365	17,288	37,332	15,515	15,107	11,060	8,256	7,827	6,399
District Demand	1,466	1,495	1,540	1,901	2,689	3,119	4,295	4,294	2,310	1,530	1,411	1,481
Abel Cr. Release	3,305	2,072	1,487	2,919	6,886	12,627	10,747	8,872	7,536	6,786	6,030	3,893
Balance	679	2,087	3,043	3,545	7,713	21,586	746	1,941	1,214	-60	386	1,025

Table 1.7 Water balance under 1 in 10 year low flow conditions.

Source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Goldie Supply	3,989	4,580	4,916	5,688	5,804	22,253	7,550	11,682	8,627	6,027	5,792	4,863
District Demand	1,466	1,495	1,540	1,901	2,689	3,119	4,295	4,294	2,310	1,530	1,411	1,481
Abel Cr. Release	3,305	2,072	1,487	2,919	6,886	12,627	10,747	8,872	7,536	6,786	6,030	3,893
Balance	-512	1,013	1,889	868	-3,771	6,507	-7,219	-1,484	-1,219	-2,289	-1,649	-511

This conclusion has been based on a significant number of assumptions associated with this broad overview assessment, as follows:

1. The mean and 10-year low flow natural monthly inflow estimates for Goldie Creek are representative of the current monthly flows (Table 1.2);
2. The water licenses upstream of the District's point of diversion on Goldie Creek extract the maximum volume of water allocated under both mean and 10-year low flow conditions. Also, the same volume of water is extracted daily for the entire period of allocation;
3. The adjusted mean and 10-year low flow monthly inflow estimates at the culvert intake are representative of the monthly flows (Figure 1.1 and Table 1.2);
4. Groundwater inflows and seepages, evaporation, and precipitation are negligible;
5. No minimum outflow to Able Creek is required to be met by the District; and
6. The mean monthly water use data for the period of 2003 – 2005 is representative of current water demand (Table 1.4).

In order to confirm the water supply availability for the District, more water data is required, particularly actual inflows from Goldie Creek at the point of diversion. As a result, this broad assessment provides an overview only; it would be inappropriate to develop detailed community plans around the current water balance model due to the large number of unknowns and assumes that the supply is adequate based on the full live storage of 436 acre-feet is available in the PRR system on June 1st.

3.0 DISTRICT OF INVERMERE DROUGHT MANAGEMENT PLAN

The District drought management plan is based on a review of the water supply and the estimated community demand based on projected climate conditions. Since the District currently cannot control the release of water from Reservoir #1, the available storage in Reservoirs #2 and #3 provides very limited reserves and should not be a consideration in the plan at this time. The District currently has a general understanding of the following:

a. Snow pack - Winter snow pack based on information from the Panorama ski hill. Staff should have a general idea of how the current winter snow pack compares to previous years, i.e. is the snow pack above normal or below normal. Snow course data is also available from the Ministry of Environment snow courses at Sinclair Ridge (2C01), Sullivan Mine (2C04) and East Creek (2D08P). A very useful reference is the provincial River Forecast Centre where data on snow packs, stream flows and drought conditions are available. The web site addresses are:

   http://a100.gov.bc.ca/pub/mss/stationlist.do

   http://www.env.gov.bc.ca/rfc/bulletins/watersupply/current.htm

b. Climate data - The closest active Environment Canada climate station is Kootenay NP West Gate (sta#1154410) however the station is not accessible to the District for real time data. The closest climate station with real time data is at the Cranbrook Airport (sta#1152102) that likely does not provide representative data for the Invermere area;

c. Hydrometric data – Real time hydrometric data is available for the Kootenay River at Kootenay Crossing (08NF001) and the Spillimacheen River near Spillimacheen (08NF011). Web site address:

   http://www.wateroffice.ec.gc.ca/google_map/google_map_e.html?search_by=p&province=BC

   Real time data from these station combined with historical means, maximums and minimums will provided useful trends in regional stream flows;

d. Goldie Creek flows – The District staff have local knowledge of flows and can compare current flows to the same period for other years;

e. Reservoir levels – The District staff have records of manual water levels for each reservoir for the past several years; and

f. District demand data – SCADA data of demand is available for several past years.

To assess the likelihood of a drought, the District staff needs to consider how the past winters cumulative snow pack compares to "average" years. In addition, the District staff need to consider if the previous fall rains compared to normal years as well as how the fall temperatures compared. Fall rains and temperatures are indicators of the condition of the soil moisture in the watershed as it went into the winter. If the soil was dry and the snow pack was near normal, this could be a precursor to below normal runoff. On the other hand if the soil moisture was above normal a normal snow pack could result in higher than normal spring runoff. Additionally, the District staff also need to consider the current flows in Goldie Creek. Are they "about normal" for the time of year or higher or lower?

Drought Management Plan Overview

April – Starting in April as the snow starts to melt, the District staff need to assess the local snow pack in watershed based on the Panorama data and data on the Ministry of Environment River Forecast Centre, the flows in Goldie Creek, the soil moisture in the District and current precipitation. If the snow pack is below normal, the soil moisture in the District is below normal and there has been limited precipitation, it is likely that outdoor watering demands will be higher than normal if the pattern continues. If the flows in Goldie Creek are also below normal, then staff should advise management that present conditions suggest a potential for a drought. **Action: April 15 – Public to be advised of water supply conditions and reminded that Stage 1 water restrictions are in place all year.**

May – If the trends of below normal precipitation and lower flows in Goldie Creek continue into May, then District staff should recommend to management that the public be advised of possible drought conditions. If conditions do not improve by the third week in May, the District staff should recommend that the Stage 1 water restrictions in Bylaw 1297 continue. **Action: May 15 - Public to be updated on water supply conditions and reminded that Stage 1 water restrictions are in place all year. May 21 – The District staff should recommend to Council that Stage 2 water restrictions be implemented on June 1. Public should be updated on water supply conditions.**

June – If the District staff determines that the runoff volumes in early June are well below normal, that the precipitation is below normal, and that the demand is above normal at Stage 1 restrictions, they should recommend that the demand be further controlled by moving to Stage 2 restrictions. **Action: June 1 – Stage 2 water restrictions are implemented. Public notified of further water restrictions and updated on water supply conditions. June 21 – The District staff to update Council on water supply conditions and recommend the requirement for Stage 3 water restrictions if water supply conditions continue to deteriorate.**

July – The decision to implement further restrictions will be based on the flows in Goldie Creek, the cumulative precipitation to date for the April – July period and the comparison of the current demand to average demand. Since the District has very limited storage in Reservoirs #2 and #3, i.e. ~340 acre-feet at full supply, normal demand for the July – August period would total over 200 acre-feet which suggests that the District has very limited capacity deal with low flows in Goldie Creek. **Action: The District staff to keep Council advised of water supply conditions. If supply improves Council could support moving back to Stage 2 or Stage 1 depending upon supply.**

3.1 Bylaw 1297

Bylaw 1297 is also known as "A Bylaw to Prescribe Water Use Restrictions". The bylaw was adopted in 2006 and is intended "*to assist in the protection, preservation and maintenance of the water supply to users at all times by implementing water-use restrictions during times of limited supply. These restrictions are staged in accordance with the severity of supply limitations, and are generally applied to the use of sprinkler systems, whether automatic or manual.*" The bylaw focuses on reducing outdoor watering that typically accounts for approximately 75% of total domestic water use and establishes the following restriction stages:

Stage 1 – Alternate Days Watering

No person shall:

(a) use a sprinkler to water a lawn, trees, and shrubs growing on a property that is:

(i) addressed with an odd house number except during restricted hours on odd numbered calendar days; and

(ii) addressed with an even house number except during restricted hours on even numbered calendar days.

(b) use an appliance, except a hand-operated hose equipped with a shut-off nozzle, or a micro-irrigation or drip-irrigation system to water trees, shrubs, flowers or vegetables on any day.

Stage 2 – Twice a Week Watering

No person shall:

(a) use a sprinkler to water a lawn, trees, and shrubs growing on a property that is:

(i) addressed with an odd house number except during restricted hours on Mondays and Thursdays; and

(ii) addressed with an even house number except during restricted hours on Tuesdays and Fridays.

(b) use an appliance, except a hand-operated hose equipped with a shut-off nozzle, a hand-held container or a micro-irrigation or drip-irrigation system to water trees, shrubs, flowers or vegetables on any day.

Stage 3 – No Watering

No person shall:

(a) use a sprinkler to water a lawn, trees and shrubs growing on a property and only use a hand-operated hose equipped with a shut-off nozzle, a hand-held container or a micro-irrigation or drip-irrigation system to water trees, shrubs, flowers or vegetables on a property that is:

(i) addressed with an odd house number except during restricted hours on odd numbered calendar days; and

(ii) addressed with an even house number except during restricted hours on even numbered calendar days.

3.2 2010 Preliminary Drought Management Plan

The following is an overview of the water supply conditions to date in 2010 and recommended drought management:

a. Snow pack – For the Sinclair Pass snow course the normal April 1 snow water equivalent is 135mm. The April 1, 2010 reading was 41mm. For the Sullivan Mine snow course the April 1 normal snow water equivalent is 313mm and the reading for April 1, 2010 was 135mm. Based on these values it is likely that the snow pack in the Goldie Creek watershed is well below normal;

b. Precipitation – Precipitation in the East Kootenays has been well below normal;

c. Goldie Creek flows – Due to the well below normal precipitation, higher than normal winter temperatures, it is likely that Goldie Creek flows are well below normal already and will remain well below normal throughout the summer unless there is above normal precipitation over the summer;

d. Ministry of Environment Drought Forecast – At the time of this report, MOE classifies the East Kootenays as a Drought Level 3. A Level 3 is defined as follows:

> ***Level 3*** *– Very Dry conditions – Potential for low stream flows and water supply shortages (including groundwater aquifers) are highly probable unless significant rainfall occurs in the next month. Water conservation is urged. Water restrictions at the local level should be considered and drought management plans should be reviewed.*

e. Drought Management - Based on the current conditions, the District should have implemented a minimum of Stage 1 water restrictions already and if the Goldie Creek flows are well below normal and if demands are above normal, the District should consider moving immediately to Stage 2 restrictions.

4.0 SUMMARY AND RECOMMENDATIONS

4.1 Summary

Unfortunately the District has limited data on which to develop a detailed drought management plan. On the supply side the data for Goldie Creek flows is limited and likely out of data since the hydrometric station was discontinued in 1970. There was no date on the actual flows diverted from the creek into the Paddy Ryan Reservoirs and only daily manual gauge readings for the water levels in the three reservoirs and these gauges were not referenced to a geodetic bench mark so it was not possible to relate the water level readings to the storage curves for the reservoirs that were set to the geodetic datum.

The District does have continuous data for water demand based on a flow meter in the District's supply pipeline immediately downstream of Reservoir #3 that is connected to the District's SCADA system. Demand data was provided for the periods 1994-1996 and 2003-2005. However the average monthly demand values for the two periods differed significantly with the average demands for 2003-2005 being significantly less than those for 1994-1996. It is not known why there was the variance between the two periods. It was decided to use the averages for the latter period for the analysis in this report. As a consequence of not being able to accurately relate reservoir inflows to outflows the water balance model results in this report should be considered preliminary until more data is available. The water balance analysis was also complicated by the diversion from Reservoir #3 to Abel Creek. The estimated volume of water that has been spilled to the creek exceeds the typical demand by the community.

The analysis was further complicated by the fact that the flow between Reservoir #1 and #2 occurs as uncontrolled seepage through the dam. It was noted that the sluice gate at Dam #1 is inoperable. However, it was noted that the turbidity in Reservoir #2 was significantly improved from that in Reservoir #1 as a result of the natural filtering that occurs as the water passes through the fill in the dam. In this regard there is a very notable water quality benefit from the current operations that would be lost if the flow between the two reservoirs was via the sluice pipe. On the other hand since the District does not control the release from storage in Reservoir #1, the only real usable storage is in Reservoirs #2 and #3. During times of drought when all the storage may be required to meet the District's demands, the storage in Reservoir #1 would not be available. There are also safety concerns for the system related to the inoperable sluice gate that needs to be addressed.

It appears, based on discussions with District staff that the system is managed in a reactive manner based on the knowledge and experience of District staff since they lack the necessary data required to be able to be proactive. Basically the supply to the reservoirs, and the overall control of inflow to the reservoirs is based on staff experience after they consider the system demand and the reservoir levels. They can then decide to either increase or decrease the flow diverted from Goldie Creek to the intake works. This can only be accomplished by manually adjusting the slide gate at the intake pipe at Goldie Creek.

The drought management has been developed based on the available data for the District's system and using information from other regional sources to help guide the plan. The plan depends upon the knowledge of staff with regards to source conditions and demand conditions. In the absence of local climate data, snow pack data, and hydrometric data the plan uses regional data that is available plus information from the Ministry of Environment River Forecast Centre to provide guidance as well as local observations of the flows in Goldie Creek and the operator's knowledge of "normal" stream flows at the intake. Using this information staff can make informed decisions regarding appropriate levels of water restrictions.

The following section provides details on the recommendations to improve the collection of data required to develop a more detailed drought management plan that would be based on data not assumptions.

4.2 Recommendations

The following recommendations, listed in order of priority, are provided in categories; required for basic system operation, and useful but not required immediately.

a. Required for basic system operation:

- Metric metal staff gauges to be installed on all reservoirs set to the geodetic datum and water levels recorded daily;
- Metric metal staff gauges to be installed on Goldie Creek at the point of diversion, and in the "grit" pond and the water level recorded daily;
- Establish a hydrometric station at the former WSC Station 08NA005 Goldie Creek (South Fork) near Invermere site with continuous recording equipment and a flow measuring program with the data downloaded monthly;
- Determine if there is any requirement to release water to Abel Creek from Reservoir #3 and if there are any required minimum flows;
- If the flow meter in the District's pipeline downstream of Dam #3 has not been calibrated within the last three years, arrange to have the meter tested and its calibrations confirmed;
- Repair the slide gate at Dam #1 and assess the impact of its operation on the water quality in Reservoirs #2 and #3;
- Investigate the possibility of increasing the storage in Reservoir #3 from 966.52 m ASL to 967.46 m ASL (the same level as Reservoir #2) that would provide an additional 35 acre-feet of storage;
- Confirm the reservoir capacity tables for the three reservoirs and also the actual live storage volumes for each reservoir; and
- Re-establish the climate station Invermere (station # 1153655), or establish a new climate station at an appropriate location in Invermere that will continuously record a

minimum of temperature, precipitation, relative humidity, and wind speed and direction. The station should be connected to the District's SCADA system.

b. Useful but not required immediately:

- Install continuous water level recorders on the three reservoirs that are connected to the SCADA system;
- Install a continuous water level recorder in the "grit" pond that connected to the SCADA system;
- Install an automated gate at the diversion from Goldie Creek that can be controlled remotely from the system operations centre;
- Install a communications system at the Goldie Creek hydrometric station that reports to the SCADA system;
- Establish a standard snow course at the Panorama ski hill in co-operation with the ski hill owners and share the data with the ski hill; and
- Establish a climate station at District's intake below Reservoir #3 that will continuously record a minimum of temperature, precipitation, relative humidity, and wind speed and direction and is connected to the District's SCADA system.

c. Revised Drought Management Plan

- When additional data is available for flows in Goldie Creek, diverted flow volumes to the PRR and reservoir levels, this preliminary Drought Management Plan needs to be revised using the improved volumetric data that can be used to trigger the implementation of additional water restrictions as required.

REFERENCES

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APPENDIX A

GOLDIE CREEK / PADDY RYAN RESERVOIR WATER BALANCE PROCEDURE

Appendix A

Goldie Creek/Paddy Ryan Reservoir Water Balance Procedure

The general water balance of the Paddy Ryan Reservoir (PRR) system is as follows:

$$\Delta S_{PRR\ System} = \text{Inflows} - \text{Outflows} \quad \text{Eq.A1}$$

where inflows to the system are from Goldie Creek and precipitation (and possible groundwater contributions) and outflows are through Abel Creek releases, District of Invermere (District) water supply requirements, seepage, and evaporation. Due to the particulars of the PRR system, the general water balance is too simplistic and is re-written to include the variables specific to the system through the following series of equations:

$$\Delta S_{PRR\ System} = Q_{in,Reservoir} - (Q_{out,District} + Q_{out,Abel}) \pm \Delta WB \quad \text{Eq.A2}$$

$$Q_{in,Reservoir} = Q_{in,Intake2} - Q_{out,WL2} \quad \text{Eq.A3}$$

$$Q_{in,Intake2} = Q_{in,Intake1}\ (\text{max } 0.236\ m^3/s) \quad \text{Eq.A4}$$

$$Q_{in,Intake1} = (Q_{in,Nat} - Q_{out,WL1})\ (\text{max } 0.269\ m^3/s) \quad \text{Eq.A5}$$

where,

$\Delta S_{PRR\ System}$ = Change in PPR system storage volume (decrease in PRR system storage is negative and increase in PRR system storage is positive in Eq. A2);

$Q_{in,Reservoir}$ = Net volume of surface water inflow to Reservoir #1 through the intake pipe;

$Q_{out,District}$ = Volume of water used for District water supply purposes out of Reservoir #3;

$Q_{out,Abel}$ = Volume of outflow out of Reservoir #3 to Abel Creek;

ΔWB = Net volume change in the remaining water balance terms. This term is included in Eq.A2 to encompass groundwater inflows and outflows and evaporation;

$Q_{in,Intake1}$ = Volume of surface water diverted by the culvert located on Goldie Creek. The maximum capacity of the culvert diversion is 0.269 m^3/s;

$Q_{in,Intake2}$ = Net volume of surface water diverted to the intake pipe feeding Reservoir #1 after specific box weir water license allocations are met. The maximum capacity of the intake pipe is 0.236 m^3/s;

$Q_{out,WL1}$ = Volume of surface water diverted out of Goldie Creek above the culvert diversion by water licensed allocations; and

$Q_{out,WL2}$ = Volume of surface water diverted out of the intake pipe feeding Reservoir #1 by water licensed allocations.

APPENDIX B

RESERVOIR #3 OUTFLOW VOLUMES TO ABLE CREEK - CALCULATIONS

Appendix B

Reservoir #3 Outflow Volumes to Abel Creek - Calculations

The water level measured by the District of Invermere at the Abel Creek outflow weir was used along with appropriate weir equations to estimate the average monthly flows from the Reservoir #3 to Abel Creek. The weir equations used were as follows:

1. Submerged Rectangular Orifice (water levels between 0.08 – 0.15 m measured at outflow weir)

$$Q = C_d a\sqrt{2gh} \qquad \text{Eq.B1}$$

where,

Q = discharge out of Reservoir #3 into Abel Creek outflow channel (m^3/s);

C_d = coefficient of discharge (assumed 0.61 (United States Department of the Interior (2001));

a = area of the orifice (m^2);

g = acceleration due to gravity (m/s^2); and

h = centerline of head (m).

2. Sharp Crested Weir (water levels >0.15 m measured at the outflow weir)

$$Q = \frac{2}{3} C_d b\sqrt{2g} h^{3/2} \qquad \text{Eq.B2}$$

where,

Q = discharge out of Reservoir #3 into Abel Creek outflow channel (m^3/s);

C_d = coefficient of discharge (calculated through C_d =0.61+(0.08(h/P), where P is the height of the weir crest above the bed);

b = breadth of the weir (m);

g = acceleration due to gravity (m/s^2); and

h = head above crest of weir (m).

When water levels are above the thin plate weir, Able Creek outflow is calculated by both the submerged orifice and sharp crested weir equations.