clarke geoscience ltd.

Greater Vernon Water Utility (GVWU)

Drought Management Plan

(Update Revised October 2011)

Prepared for:
Regional District of North Okanagan

File: 11-0100
October 25, 2011

5217 Benmore Ct.
Kelowna, British Columbia
V1W 4Z3
Phone/Cell: 250.826.4367
Email: clarke-geoscience@shaw.ca

Executive Summary

The following Drought Management Plan (DMP) provides the Regional District of North Okanagan (RDNO), Greater Vernon Water Utility (GVWU) with a decision-making framework and a means of proactively responding to drought. Hydrologic drought, or diminished water supply, results from periods of sustained low precipitation and high temperatures and may be triggered by a combination of climatic factors. This, in turn, has a negative impact on the community, the environment, and the economy.

The DMP specifies procedures and actions to be implemented at various stages of drought and water availability. These are provided in supporting documents including a Drought Response Plan (DRP), a Communications Plan, and a Water Restrictions Bylaw.

GVWU Water Supply Characteristics

Duteau Creek and Kalamalka Lake are the primary drinking water sources for GVWU. Although both are surface water sources, each have very different water resource characteristics as it pertains to the water utility. Water from the Duteau Creek source is collected and drawn from an upland (plateau) watershed and associated lakes, which serve as reservoirs. Kalamalka Lake is a valley-bottom lake and source water includes contributing surface water and groundwater.

The hydrologic regime of the Duteau Creek watershed is dominated by snow-melt and, therefore, snow pack depth and timing of snow melt dictate the supply status of upland reservoirs. Snow pack depth reaches the maximum in late March, early April. Snow melt starts to fill the reservoirs after this date. Historical data indicates that, by the middle of May, the seasonal snow pack is generally gone. This date represents the tail end of the snowmelt season and in good years, the reservoirs would be nearing capacity – typically reaching capacity by June. After this time, water supply is dependant on precipitation inputs. The summer period also corresponds to the period of peak irrigation demand, with maximum consumption between mid-July and mid-August. In the summer, because stored water is being consumed at a rate that far exceeds inflow, reservoir levels start dropping.

Kalamalka Lake, due to its large storage capacity and long turnover rate is much less susceptible to the annual variations in snow pack depth. Besides Upper Vernon Creek and Coldstream Creek, abundant groundwater springs provide source inflows to Kalamalka Lake.

Factors Influencing Susceptibility to Drought

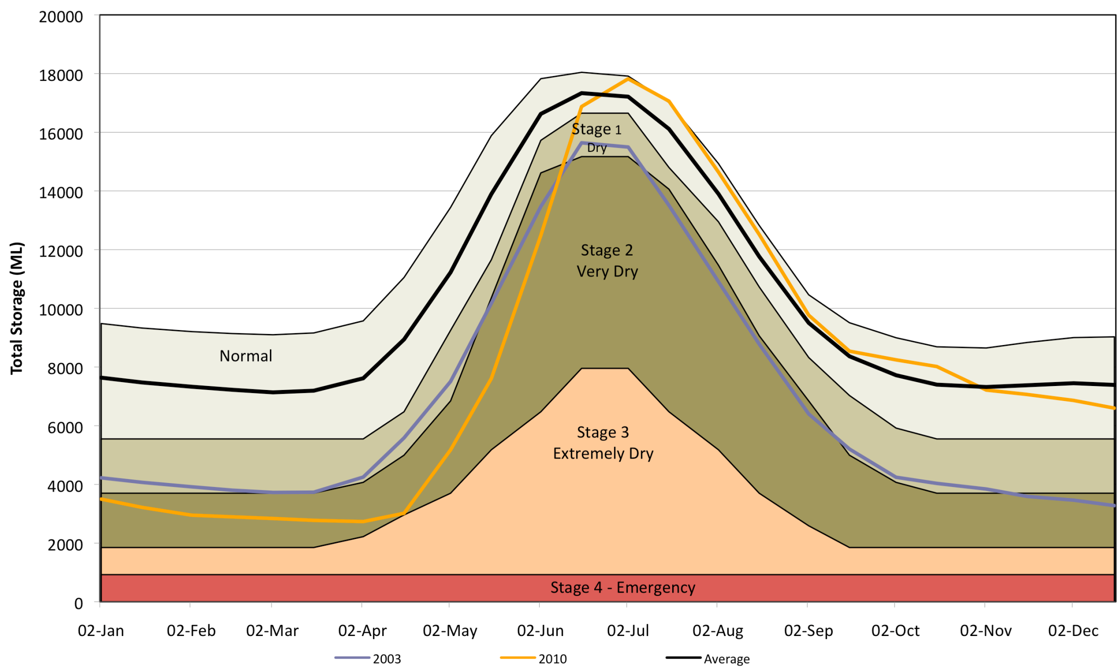
Factors that influence the susceptibility to drought include climate conditions such as winter snow pack and spring rains that serve to fill reservoirs, and summer temperatures that affect irrigation demand and deplete storage. Watershed factors (fire, mountain pine beetle, forest harvesting) and global climate trends and variability also have the potential to affect the water supply. These factors affect all water supply sources however, the Duteau Creek water supply is more susceptible to drought than Kalamalka Lake due to its smaller storage capacity.

Recommended Drought Forecast Approach

Drought forecast parameters, including reservoir storage levels, snow pack conditions, temperature and precipitation, watershed condition, and River Forecast Center bulletins, are considered together with seasonal irrigation demand to provide an indication of water supply status. The status triggers a corresponding short-term response to water supply shortages including the implementation of water restrictions. In the long-term, global climate trends and long-term trends in irrigation demand will provide information on the long-range water supply status. Longer-term supply forecasts will provide the information necessary for asset management planning and the applicable responses to water shortages.

For GVWU the recommended approach to determine a water supply status at any point of time includes the following actions:

1. Determine upland reservoir storage levels with respect to the Water Supply Stages outlined in the Trigger Diagram (below);
2. Determine whether upland snowpack storage levels are a) above 95% confidence limit of average; b) within 95% confidence limits of average; or c) below 95% confidence limit of average;
3. Consult the River Forecast Centre Bulletin to determine whether the water supply outlook for the Vernon region is favourable or unfavourable;
4. Assess relative irrigation water demand. Periods of high irrigation water demand will generally correspond to the growing season (between March 31 and September 1), while periods of low demand will be outside this time of year.



Water Supply Status

Water Supply Status, or Drought Stages, represent conditions under which the Drought Response Plan is implemented. These stages are described within the following Water Supply Status Matrix.

Drought Response Plan

A Drought Response Plan (DRP) is a key component of a Drought Management Plan. The DRP establishes a staged approach to water management in times of drought conditions by identifying and evaluating factors that will trigger response. This depends on various factors, such as water supply and demand forecasts.

The General Manager of Engineering, or Utilities Manager, are responsible for determining whether a DRP action is warranted, implementing stages of the DMP, utilizing staff, committees, and other resources as necessary. Specific roles and responsibilities are clearly defined in the Communications Plan document.

Drought response measures are to be considered when additional supply cannot be accessed and to sustain a supply that can meet demand. The measures may be operational actions related to utility infrastructure, regulating spill rates, or adjusting the agricultural turn-on date. Response measures may be conservation measures, intended to reduce water demand. Demand-side management as a means of water conservation should, at this time, be the primary focus and this may be accomplished, in part, through the measures specified in the Water Restrictions Bylaw. The Water Restrictions Bylaw outlines specific water conservation measures by activity (residential, commercial, public, and agricultural) for each drought stage. The decision to implement various drought response measures depends on the time of year and water supply status condition.

GVWU Water Supply Status Matrix

Water Supply Status	Normal	Stage 1 - Dry	Stage 2 – Very Dry	Stage 3 – Extremely Dry	Stage 4 – Emergency
Definition	**Average**	**Mild drought**	**Moderate drought**	**Severe drought**	**Loss of Supply**
Explanation of Supply Status and Trigger Factors	The Normal Status is defined by the average storage condition. Storage volumes that are within the 95% confidence limit of average are considered to be within normal limits. Storage volumes within the Normal Water Supply Status are sufficient to meet supply needs at current levels of demand.	The Stage 1 Status represents an early drought condition and is the first indication of potential water shortage. Stage 1 is triggered when storage conditions are below the 95% confidence limit of average. The Stage 1 condition is triggered when storage levels are 30-90% of the total available storage in the upland Duteau reservoirs, depending on the time of year.	Stage 2 Supply Status will occur during prolonged periods of no rain and hot and dry weather and/or with below-average snow pack conditions. This represents moderate level of drought when the water supply is becoming stressed. The Stage 2 condition is triggered when storage levels are 20-82% of the total available storage in the upland Duteau reservoirs.	A Stage 3 Supply Status represents severe drought conditions. This occurs when water supplies are experiencing a critical shortage. The Stage 3 condition is triggered when storage levels are 10-43% of the total available storage in the upland Duteau reservoirs.	Stage 4 Status is defined as the current base winter consumption levels, representing minimum water use (30 ML/day). During Stage 4 Status, the GVWU Emergency Response Plan and Provincial Emergency Program will be invoked. Representing a loss of supply, water is only available for consumptive and sanitary purposes. At this stage, fire protection may be compromised.
Goal	Encourage water use efficiencies, drought awareness and preparedness.	Encourage good stewardship and voluntary conservation measures in an effort to reduce water use by roughly 10%. Measures are encouraged to reduce potential move to Stage 2 Supply Status.	Reduce water use by about 20% to conserve supply and reduce potential move to Stage 3 Supply Status. Introduce Stage 2 water use restrictions that are more specific and more stringent to sufficiently reduce demand.	Reduce water use by about 50% to maintain critical water supply. Introduce Stage 3 water use restrictions that minimize outdoor water use.	Maintain minimum water supply to maintain basic community health and basic needs. (90% reduction)
Drought Regulations and Response	Permanent water use restrictions, water use efficiency, and best practices promoted.	Stage 1 Restrictions, characterized by reduced lawn and garden sprinkling.	Stage 2 Restrictions characterized by reduced agricultural water use, lawn and garden sprinkling and other outdoor water use.	Stage 3 Restrictions, characterized by severe restrictions in outdoor water use, including agricultural water use.	Stage 4 Restrictions, characterized by a prohibition of outdoor water use.
Communication and Enforcement	Normal levels of communication and education. Roll out best practices and conservation practices.	Heightened awareness and increased public communication. Enforcement level and effort increased, including increased monitoring of large users. Warnings issued and some tolerance.	High level of education and communication maintained. Enforcement efforts increased. Moderate fines issued and lower tolerance.	High level of education and communication. High level of enforcement. Zero tolerance on abusers. Moderate fines issued.	High level of education and communication. High level of enforcement. Zero tolerance on abusers. Stiff fines issued.

Acknowledgements

The author would like to acknowledge significant input and comments to the updated Drought Management Plan received from the Regional District of North Okanagan. Renee Clark, RDNO Water Quality Manager spearheaded and managed the project, providing data and review comments throughout. Jennifer Miles, RDNO Water Sustainability Coordinator, provided valuable input and is responsible for the preparation of accompanying Appendices (including the Communications Plan, Drought Response Team information, and Water Use Bylaw). Arnold Badke, General Manager of Engineering, and Zee Marcolin, Acting General Manager of Engineering, also provided comments and review on draft versions of the DMP. We are also grateful for input from members of the Drought Response Team, which was obtained on several occasions during the project.

Table of Contents

List of Figures

List of Tables

List of Appendices

1.0 INTRODUCTION AND OBJECTIVES

The following Drought Management Plan (DMP) was prepared at the request of the Regional District of North Okanagan (RDNO), Greater Vernon Water Utility (GVWU). It updates the 2007 DMP completed for Greater Vernon Services (EBA 2007).

A DMP provides the local water utility with a decision-making framework to deal with drought. The objective of the DMP is to provide a means of proactively responding to periods of hydrologic or supply drought. Hydrologic drought results from periods of sustained low precipitation and high temperatures. Similarly, a supply drought results from periods of sustained high water demand at a time when supply is insufficient to meet this demand. Periods of drought, triggered by a combination of climatic factors, may lead to diminished water supplies, which will, in turn, have a negative impact on the community, the environment, and the economy.

The DMP provides the framework for a Drought Response Plan (DRP), a Communications Plan, and a Water Restrictions Bylaw. These documents specify procedures and actions to be implemented at various stages of drought and water availability. The Communication Plan (Appendix A) outlines specific communication strategies, including periodic and emergency consultation with a Drought Response Team (DRT). Terms of Reference for the DRT are attached (Appendix B). The Water Restrictions Bylaw (Appendix C) provides appropriate levels of water use restrictions for specific activities based on their potential impact on the water resource. Response to an emergency loss of supply may occur at extreme stages of drought or during other catastrophic emergencies, such as contamination. Other guiding documents for emergencies are provided in the RDNO and Greater Vernon Water Utility (GVWU) Emergency Plans.

The RDNO General Manager of Engineering, the Utilities Manager, or any other person that the Board may from time to time delegate the authority, will be responsible for implementing all stages of the DMP.

1.1 GVWU SERVICE AREA

Greater Vernon Water Utility (GVWU) serves as the primary water purveyor for the following jurisdictions with the Regional District of North Okanagan, as defined in the current bylaw No. 1764:

- City of Vernon;
- District of Coldstream;
- Electoral Area B;
- Portions of Electoral Area C (excluding Silver Star Ski Resort);
- Portions of Electoral Area D; and,
- Portions of the Township of Spallumcheen.

1.2 COMPONENTS OF THE DROUGHT MANAGEMENT PLAN

Methods used to develop the Drought Management Plan are consistent with the planning templates provided by the BC Ministry of Environment in "Dealing with Drought: A Handbook for Water Suppliers in British Columbia, Ver. 2." (2009).

The Drought Management Plan includes several components as shown in Figure 1.1. Firstly, the current and future GVWU Water Supply (Section 2.0) and Demand (Section 3.0) is characterized. Information on supply and demand is largely derived from data provided in the Master Water Plan completed in 2002 (NOWA). Based on these characteristics, the DMP outlines specific factors that influence the potential for drought in the GVWU service area (Section 4.0). Water supply status and corresponding drought stages are defined in Section 5.0. Next, the DMP identifies various parameters used to forecast the water supply condition, or the potential for drought. This drought forecast approach is presented in Section 6.0. Upon completing the forecast, a Drought Response Plan (DRP) is presented (Section 7.0). The DRP includes a decision-tree approach to determining applicable short-term water supply status. The DRP also has several supporting documents; a Communications Plan (Appendix A), details regarding the Drought Response Team (DRT) (Appendix B). and the Water Restrictions Bylaw (Appendix C).

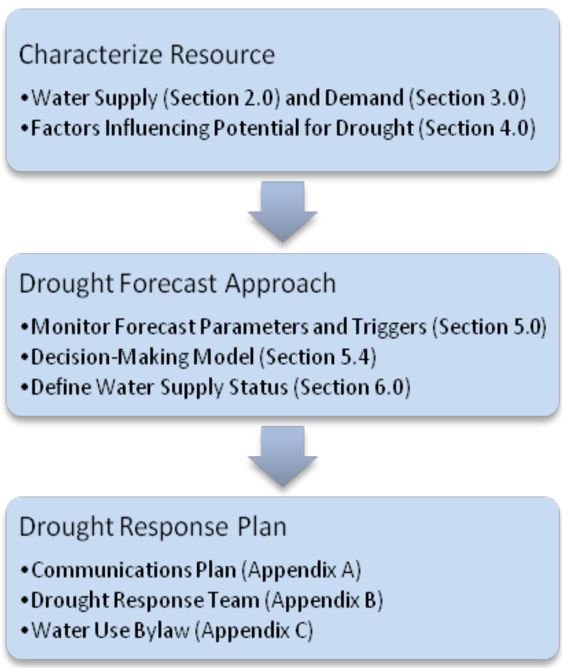


Figure 1.1 Components of the Drought Management Plan

2.0 GVWU WATER SUPPLY CHARACTERISTICS

The following characterizes existing and future water supply sources within the GVWU service area. Sources include surface water, groundwater, and reclaimed water.

Duteau Creek and Kalamalka Lake are the primary drinking water sources for GVWU. Although both are surface water sources, each have very different water resource characteristics as it pertains to the water utility. Water from the Duteau Creek source is collected and drawn from an upland (plateau) watershed and associated lakes, which serve as reservoirs. Kalamalka Lake is a valley-bottom lake and source water includes contributing surface water and groundwater. The following provides additional details on each of these two primary sources, and other secondary water sources.

2.1 DUTEAU CREEK SOURCE

The Duteau Creek watershed is situated southeast of Vernon within the Thompson Plateau physiographic region. The watershed is characterized by a gently undulating upland area containing numerous lakes, and is dissected by steep-sided valleys.

The GVWU intake (Headgates Intake) on Duteau Creek is located at 660 m elevation and defines the end-point of the Community Watershed; a watershed area of 182 km^2 originating in the Grizzly Hills (elev. 1800 m). A portion of the adjacent Harris Creek watershed is also diverted into the Duteau Creek watershed to augment supply.

The hydrologic regime of the Duteau Creek watershed is dominated by snow-melt and, therefore, snow pack depth and timing of snow melt dictate the supply status of upland reservoirs. Mean daily discharge on Duteau Creek, measured at Headgates is 0.67 m^3/s and the maximum daily discharge was 16.2 m^3/s recorded in the spring of 1990[1]. Flows are regulated at Headgates to ensure minimum fish flow requirements. Peak stream flows on Duteau Creek occur between late-April and mid-June. Three hydrometric stations, installed, owned and operated by GVWU/RDNO (Heart Ck, Duteau Ck, and Curtis Ck) are situated in the upper watershed and have been in operation since 2008, obtaining data on natural flows. The stations operate during the snow-free period (May to November) and indicate that peak flows occur, on average, in early June.

The Duteau Creek water supply system consists of three upland reservoirs (Haddo, Aberdeen, and Grizzly) that are located approximately 14 km upstream (20-22 km by road) of the Headgates Intake. The three reservoirs, and one additional impoundment reservoir, have a total storage capacity of 18,291 ML (see Table 2.1 below). The total annual licensed capacity for Duteau Creek is 24,922 ML.

Table 2.1: Maximum Storage Capacity of Upland Lakes and Reservoirs in Duteau Creek Watershed

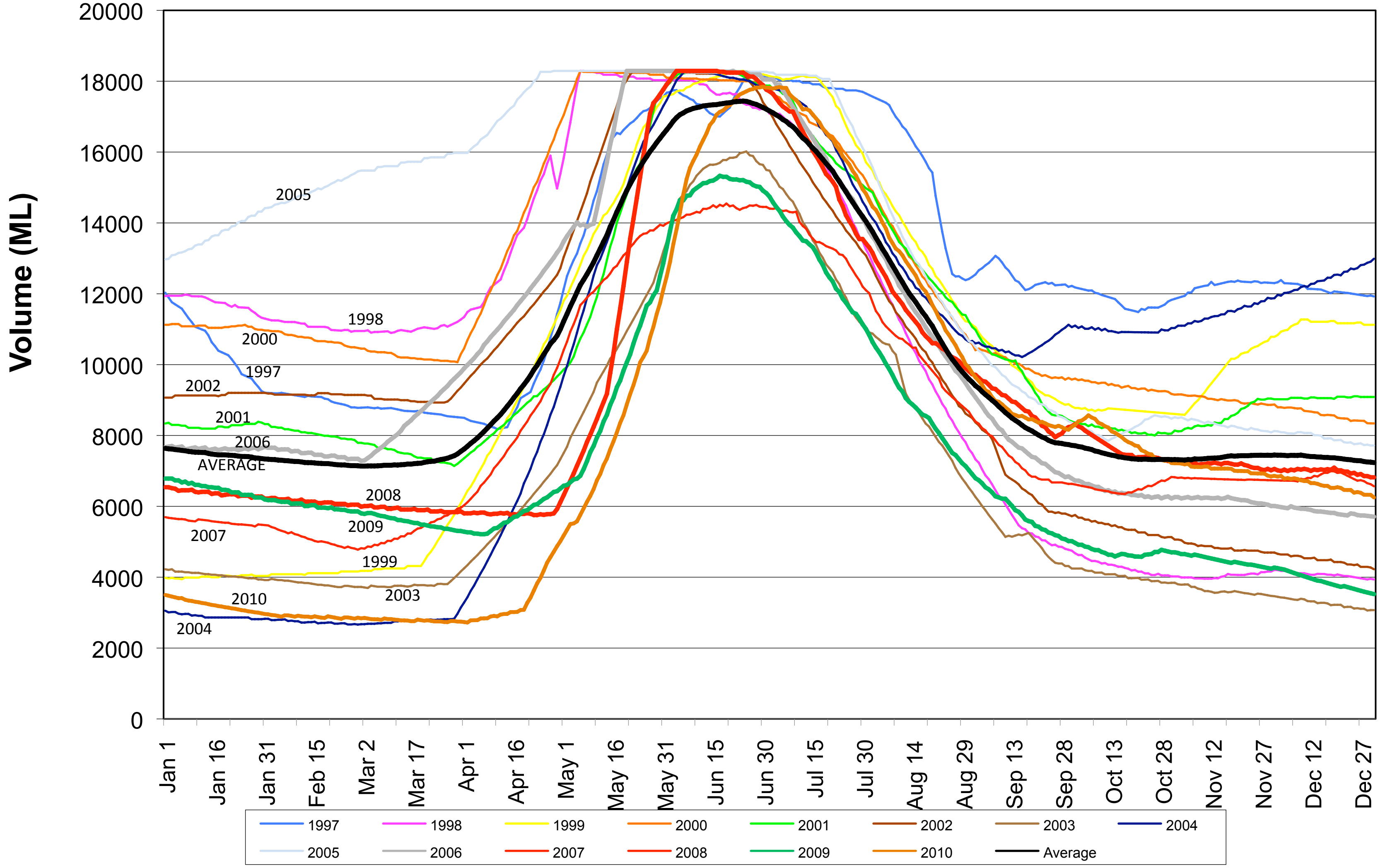
Storage Reservoir	Volume (ML)
Aberdeen	10,301
Haddo	2,723
Grizzly	5,267
TOTAL	**18,291**

Source: GVWU (2011)

[1] Headgates hydrometric station operated until 1995. It is no longer collecting data.

Figure 2.1 Total Upland Reservoir Storage (1997 to 2010)

(Aberdeen, Haddo and Grizzly Reservoirs)



2.1.1 Seasonal Storage Trends

Total upland reservoir storage for Aberdeen, Haddo and Grizzly Reservoirs for the period from 1997 to 2010 is shown in Figure 2.1. The following characteristics regarding seasonal variations in storage, are noted as follows:

- **Spring -** The date of maximum snow pack is typically in late March, early April. Snow melt starts to fill the reservoirs after this date, so all years show a distinct date of reservoir filling. These dates vary and occur as early as the beginning of March (2005, 2006) and may be delayed, in some cases, as late as mid-April or early-May (2008, 2010).

  Historical data indicates that, by the middle of May, the seasonal snow pack is generally gone. This date represents the tail end of the snowmelt season and in good years, the reservoirs would be nearing capacity. After this time, water supply is dependant on precipitation inputs.

- **Summer** – By early June, the reservoirs are at, or nearing, capacity and then start to drop. Since 1987, there have been seven years in which the reservoirs did not fill (noted on Figure 4.2). Four of these years have occurred in the past decade. The summer period also corresponds to the period of peak irrigation demand, with maximum consumption between mid-July and mid-August. During late summer, because stored water is being consumed at a rate that far exceeds inflow, reservoir levels start dropping.

2.2 KALAMALKA LAKE SOURCE

Kalamalka Lake is a valley-bottom lake that flows via lower Vernon Creek into Okanagan Lake. The lake has a surface area of 35 km^2 and an average depth of 142 m, which is considered deep relative to its size.

Source flows into Kalamalka Lake include upper Vernon Creek (draining the Oyama Creek watershed), Coldstream Creek, and abundant groundwater springs. Groundwater is considered to be a significant contributor to the lake and is responsible for its glacier-blue colour in the summer. The lake typically reaches full-pool by the end of June. A weir on the lower Vernon Creek outlet controls lake levels and is operated by the BC Ministry of Environment.

Due to its depth and lack of contributing sources, the lake has a low rate of turnover (55-65 years). Water quality issues and additional source characterization are addressed in a recent Source Water Assessment report (Larratt Aquatic, 2010).

GVWU operates a single drinking water intake on Kalamalka Lake. The North Kal intake is located 250 m off the north shore of the lake at a depth of approximately 20 m. The North Kal intake system capacity is currently 40 ML/day[2] but could be expanded to a maximum of 60 ML/day with infrastructure upgrades (A. Cotsworth, *personal communication,* 2011).

[2] Highest recorded peak day flow in 2010 was 43 ML/day

The system capacity is limited by existing infrastructure. Currently, the intake pump house operates using two 400 HP and two 200 HP pumps. Pump upgrades are required to increase supply capacity. Current pipeline infrastructure (combination of 300 mm and 450 mm diameter pipe) between the pump house and the treatment plant limits the supply capacity. Upgrades to a 750 mm diameter pipe are currently 10-20% complete. However, the remaining pipe needs to be fully ungraded to attain a 60 ML/day supply capacity. In addition, further upgrades are required at the Treatment Plant and downstream of the plant to increase system supply capacity.

The total annual GVWU licensed capacity from Kalamalka Lake is 8,781 ML. According to the Water Master Plan (2002), the Kalamalka Lake source is almost fully utilized. In times of drought, water usage from Kalamalka Lake is governed by the Water Act, which honours water rights based on a first in time, first in right basis. Outflows from Kalamalka Lake, which are controlled by the BC Ministry of Environment, are governed by the Fish Protection Act, and the protection for fish can override existing water rights.

2.3 OTHER SURFACE WATER SOURCES

Historically, Nobel Canyon, a tributary of Coldstream Creek, was used for domestic water supply in Lavington but was abandoned in (approx.) 1998 due to slope stability issues. In 2000, BX Creek was removed as a water supply source due to impaired water quality. Licences for both sources are still held by GVWU. The Deer Creek source, now separated for agricultural use, is supplied by the King Edward Lake reservoir with a total storage of 1,546 ML. Total annual licensed capacity for Deer Creek is 3,699 ML.

2.4 GROUNDWATER SOURCES

Residents of Lavington and the Coldstream area east of McClunie Road received their water from Antwerp Springs until January 2010. Antwerp Springs consists of two wells, one well (#1) is 13 m deep with a capacity of 3.5 ML/day and the other (#2) is 62 m deep with a capacity of 4.9 ML/day.

In January 2010, the shallow well (Antwerp #1) was compromised and resulted in a Do Not Drink Water notification. Extensive disinfection of the reservoirs and water system was undertaken. Antwerp Springs Well #1 groundwater well has now been dedicated to irrigation supply and will be available for agricultural use when agricultural separation occurs in the area. Antwerpt Springs Well #2 groundwater well is undergoing modifications to upgrade the supply in consultation with Interior Health. Pending approval, Well #2 will be used during peak use periods, in very dry conditions. Residents of this area currently receive their water from the Duteau Creek water supply.

Coldstream Ranch Wells No. 1 and 2 supplement the GVWU water supply by providing groundwater during seasonal peak demand. Well No. 1 supplements the domestic supply but both wells will eventually be dedicated to agricultural use once agricultural separation is accomplished in the area. Groundwater from Wells No. 1 and 2 is combined with the surface water supply from Duteau Creek and Deer

Creek. Well No.1 is 50 m deep with a capacity of 9.5 ML/day and Well No. 2 is 24 m deep with a capacity of 4.6 ML/day.

2.5 USE OF RECLAIMED WATER

The City of Vernon also supplies reclaimed water for irrigation in the Commonage and Bella Vista area totalling 800 hectares. The City provides approximately 4,500 ML/year for irrigation use. Reclaimed water is used to irrigate agricultural land (pasture) and three local golf courses, the Ministry of Forests research facility, and the PRT nursery. Total available supply is provided by a series of relatively small reservoirs to a current capacity of approximately 9,400 ML.

Use of reclaimed water reduces the demand for fresh, treated water and is considered an effective water conservation measure. Use of reclaimed water lies outside the influence of the measures proposed by the DMP.

2.6 ABILITY TO COMBINE SOURCES

Each major source supplies water to a different service area within the region. While the Duteau Creek source is largely distributed to agricultural users (up to 80% during peak water use periods), the Kalamalka Lake source largely provides water to the developed urban area within the City of Vernon and Coldstream. Since Duteau Creek is more dependant upon a seasonal snowpack and spring weather conditions, it is also more prone to supply shortages associated with drought. So when Duteau Creek is experiencing drought conditions, the ability for sources to be combined and shared between customers is being pursued.

According to the RDNO Utilities Manager, the ability to combine sources is primarily limited by water pressure differential (A. Cotsworth, *personal communication*, 2011). Due to elevation, the Duteau Creek system is generally at a higher pressure than Kalamalka Lake, so it is difficult to move water from the Kalamalka Lake source into the Duteau Creek supply system. GVWU does, however, have a pumping system that can transfer up to 11 ML/day into the Duteau Creek system. Alternately, it is much easier to transfer water from the Duteau Creek source. Up to 27 ML/day may be transferred from the Duteau Creek system to the Kalamalka Creek system. According to the Utilities Manager, however, these transfer rates depend on many factors and cannot necessarily be relied upon during drought conditions.

2.7 GVWU FUTURE WATER SUPPLY CHARACTERISTICS

2.7.1 Duteau Creek Source

Duteau Creek watershed is considered to be fully utilized for domestic and irrigation use due to downstream fisheries concerns (NOWA 2002). Future capacity may be considered by diverting water from adjacent watersheds, or by increasing storage capacity.

GVWU recently completed a water supply study to identify potential for expansion in the Duteau Creek watershed. The potential benefits of increasing storage on the Aberdeen Plateau include an improved ability to respond to changes in freshet due to logging (in response to mountain pine beetle) and climate change, and to attenuate floods. Balancing potential impacts, a combined approach that includes reducing consumption through Demand-Side Management strategies is also being considered.

2.7.2 Kalamalka Lake Source

Kalamalka Lake is considered to be almost fully utilized for domestic and irrigation water use (NOWA 2002). The current annual license volume of 8,781 ML accounts for approximately 92% of the annual average domestic demand projected in 2011 (NOWA 2002).

The BC Ministry of Environment (MOE), Water Management Branch operates the outlet gate at the mouth of Vernon Creek according to an Operating Plan. The Operating Plan specifies lake level targets, intended to meet requirements for shoreline fisheries usage. The lake levels are dictated by inflows and are attained through the operation of the outlet gate.

Current flow requirements to downstream Vernon Creek are specified to meet the requirements of downstream fish resources. The Department of Fisheries and Oceans requires a minimum flow of 0.085 m^3/s be maintained for fisheries requirements and the discharge is currently being regulated (by MOE) at 0.100 m^3/s. The discharge rates also assist in controlling lake levels such that specified lake level targets are being met and that, at full pool, there will be sufficient supply to meet all licensed demand for points of diversion on the lake.

Water availability studies were completed in 1977 and 1992. The studies concluded that Kalamalka-Wood Lake would be able to supply an annual water use of 12,000 ML and that under these circumstances, the supply has a very low risk of water shortage (MOE, 1977 and MWLAP, 1992). No information is provided on the risks and ability to provide additional water to GVWU.

2.7.3 Groundwater Sources

A report on Antwerp Springs and Wells 1 and 2 estimated an average annual potential yield from groundwater is between 4,000 and 5,000 ML (NOWA 2002). It is considered that groundwater in the Coldstream area could provide a secondary or supplementary or dedicated irrigation source.

A well head protection plan, currently in progress, suggests that the shallow wells are no longer suitable for domestic use and that the deeper wells may require treatment (for high manganese levels). In the meantime, groundwater from these sources is considered suitable for emergency purposes and irrigation.

2.7.4 Use of Reclaimed Water

Although currently limited by infrastructure, further development of the reclaimed water source as a means of reducing pressure on freshwater supply is intended in the Greater Vernon area. However, it is beyond the jurisdiction of GVWU to assess the potential of this source to supply customer demands.

2.7.5 Other Potential Future Sources

Deer Creek at the outlet of King Edward Lake is considered a limited source for expanding irrigation water supply (NOWA 2002). Upgrades were completed in 2011 to provide a seasonal supplement to the irrigation supply. Its future potential is limited due to potential water quality issues and small size of the watershed (21 km^2).

BX Creek, once an original source of water for the City of Vernon, was decommissioned in 2000 due to water quality issues. According to NOWA (2002) there is little opportunity to increase the quantity of supply as there is no storage detention in place. However, there is potential to establish this source as a dedicated irrigation zone.

Coldstream Creek has been identified as an additional domestic water source. The small size of the watershed and additional capital costs for water treatment, however, may not benefit GVWU in the long term. However, there is potential to establish this source for irrigation use.

2.7.6 Summary

Available water supply and GVWU annual license volumes reported here are based on those identified in the 2002 Master Water Plan (NOWA 2002). These license volumes are shown in the following Table 2.2. It is noted that there are some discrepancies between the reported numbers and the current volumes reported by GVWU. Resolving these will require a more than cursory examination of the diverse sources and storage vs. non-storage license volumes. It is recommended that the Master Water Plan update, planned for 2012, identify and reevaluate these supply sources and license volumes.

TABLE 2.2: GVWU ANNUAL WATER LICENSE VOLUMES

Water Source	GVWU License Volumes (ML)
Kalamalka Lake	8,781
Duteau Creek	27,448
Deer Creek (King Edward Reservoir)	3,699
BX Creek	7,367
Okanagan Lake	210

Source: NOWA Working Paper 7, 2002

Future potential water supply for domestic and irrigation purposes is very much dependant upon licensed capacity of the two major sources (Kalamalka Lake and Duteau Creek) and other undeveloped sources such as Okanagan Lake and groundwater. Reduced demand for fresh water may be accomplished by further development of the reclaimed water system, reduction of leakage and infrastructure losses, and through demand-side water management.

3.0 GVWU WATER DEMAND CHARACTERISTICS

3.1 EXISTING DEMAND

Historically, the total annual water use in the GVWU area is estimated to be 22,000 to 23,000 ML (NOWA 2002) (QDS Quadra Development Solutions Inc. 2005). Agricultural irrigation accounts for a large proportion of the total (estimated to be up to 80% during peak days). Metered residential water use accounts for approximately 10% of the total supply, while Industrial-Commercial-Institutional (ICI) water users account for only 2% of the total supply (based on peak day demand estimates). Unaccounted for water, which includes leakage, hydrant-flushing, fire-fighting, inaccurate meters, theft, and other similar uses, accounts for approximately 6% of the total supply. A summary of peak day demand for various sources, provided in Table 3.1 below, indicates that seasonal demand is significantly higher than the base (winter) demand.

TABLE 3.1: PEAK DAY DEMAND SUMMARY (2005)

	Base Demand (ML/d)	Seasonal Demand (ML/d)	Total (ML/d)
Metered Use			
Residential	6.2	25.4	31.6
ICI	2.8	3.9	6.9
Unmetered Use			
Residential	6.6	22.6	29.2
Agricultural	0	230.8	230.8
Leakage	4.7	0	4.7
Total	**20.3**	**282.9**	**300.2**

Source: Kerr Wood Leidal Associates Ltd. (2006) using 2005 data. Metered data was not available to be included in this table. Unmetered use is theoretical.

The peak day demand from all sources is estimated to be 300 ML/day (KWL 2006). Residential demand is estimated to be 60 ML/day and agricultural irrigation demand is estimated to be 230 ML/day. Currently, water use at all residences is metered. It is, therefore, recommended that this data be made available to revise and update the peak day demand table (Table 3.1).

Identifying and understanding periods of peak demand is important for water management. Periods of peak demand require specific management, in the regulation of reservoir levels for example, to ensure that supply is adequate.

Water use summarized by month was calculated for GVW (using 2010 data) and is provided in Table 3.2 below. The data indicates that 56% of annual water use occurs during the months of June, July, and August. In the summer months, average daily water use is as high as 173 ML/day, which is almost seven times higher than the winter base water use (approximately 25 ML/day). In May and September water use is 9% of total annual demand and the remaining 35% water use is spread between October and April.

Using the SCADA (Supervisory Control and Data Acquisition) system flow rates from the Duteau Creek and Kalamalka Lake sources are examined. Data from 2010 are presented in Figure 3.1. The data indicate that peak flow rates occur between mid-July and mid-August. Peak day water use in 2010 occurred on July 29 at 212 ML/day (total from all sources). The maximum withdrawal rate during the peak water demand period is considered to be between 2 to 3 m^3/s.

The data indicate that there is a consistent peak in water use between 8 pm and 10 pm, with peaks at approximately 9:30 pm. The peak day water usage is considered to be reflective of domestic irrigation through manual watering.

TABLE 3.2: AVERAGE MONTHLY WATER USE FROM ALL SOURCES (2010)

Month	Average Water Use (ML/day)	Percent of Annual Demand (%)
January	24.2	3.3
February	25.3	3.4
March	24.9	3.4
April	34.4	4.7
May	64.0	8.7
June	78.2	10.6
July	159.5	21.7
August	173.1	23.5
September	69.4	9.4
October	35.5	4.8
November	25.4	3.5
December	21.5	2.9
Total	735.5	100

Source: RDNO SCADA data (daily totals ML from Duteau and Kalamalka Lake sources) (2010)

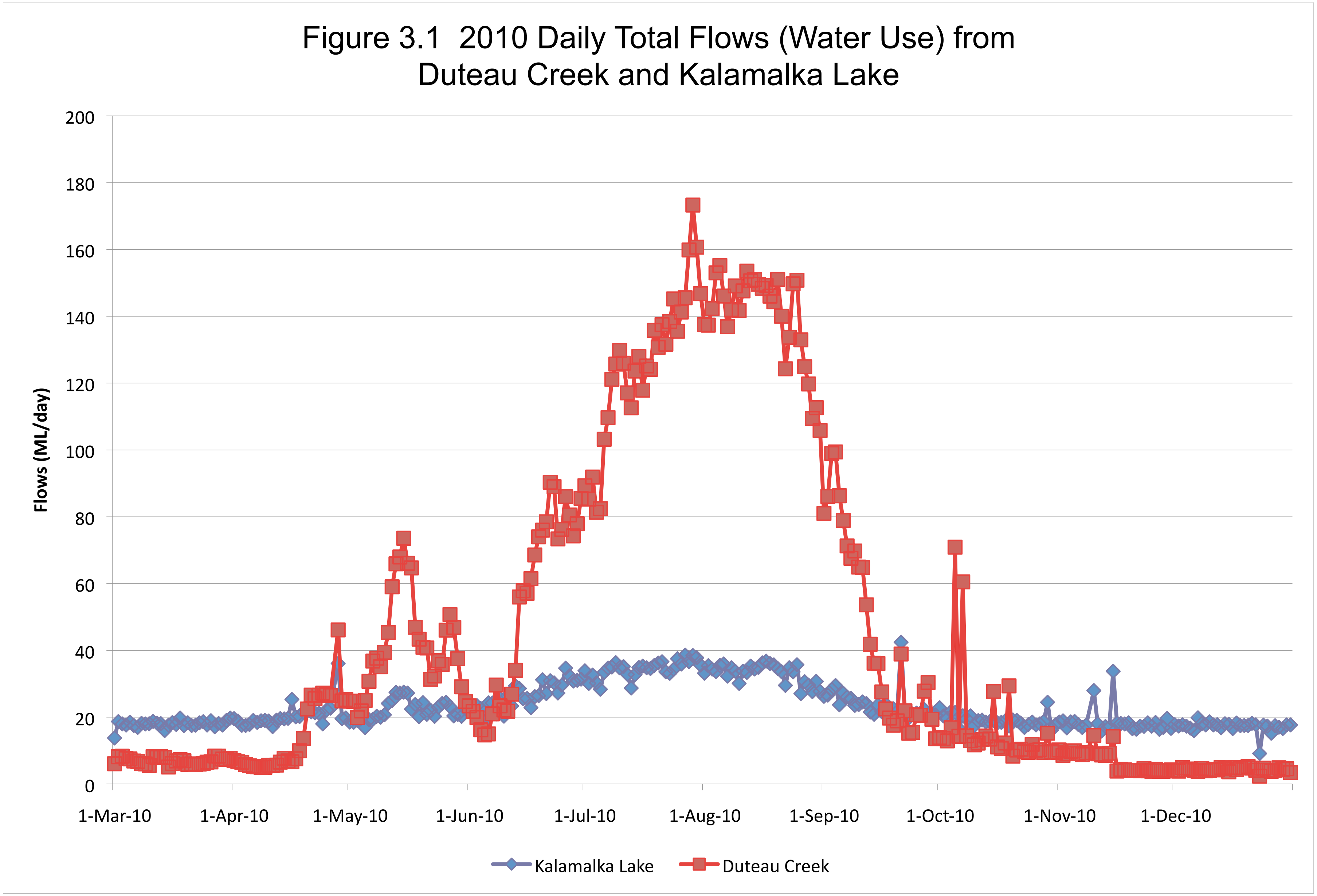


Figure 3.1 2010 Daily Total Flows (Water Use) from
Duteau Creek and Kalamalka Lake
Flows (ML/day)
0
20
40
60
80
100
120
140
160
180
200
1-Mar-10
1-Apr-10
1-May-10
1-Jun-10
1-Jul-10
1-Aug-10
1-Sep-10
1-Oct-10
1-Nov-10
1-Dec-10
Kalamalka Lake
Duteau Creek

3.2 FUTURE DEMAND

The Master Water Plan provides an "average range" of projected water demands to 2041 and is summarized in Table 3.3 (NOWA 2002).

TABLE 3.3: PROJECTED WATER DEMAND

Year	Projected Water Demands[1]					
	Residential		Agricultural		Total	
	Average Annual (ML/yr)	Maximum Day (ML/d)	Average Annual (ML/yr)	Maximum Day (ML/d)	Average Annual (ML/yr)	Maximum Day (ML/d)
2011	10,586	58	13,166	178	23,752	236
2021	12,860	70	13,484	182	26,344	252
2031	16,273	89	13,805	187	30,078	276
2041	20,651	113	14,129	191	34,781	304

1. Projected demand was determined by NOWA utilizing existing water demands (Working Paper 1), potential changes in community and land uses (Working Paper 3), and water conservation goals (Working Paper 4).

Annual residential water use is expected to increase to 20,651 ML by 2041, which is directly related to estimated population growth. Annual agricultural water use is expected to decrease from 55% of total to 41% of the projected total annual water use due to growth in urban demand.

4.0 FACTORS INFLUENCING THE POTENTIAL FOR DROUGHT

To provide some context and background to the Drought Management Plan, the following information characterizes the hydrological nature of the GVWU water supply system with respect to its vulnerability to drought. Outlined here are the factors and characteristics specific to the GVWU system that influence the potential for a drought to occur.

4.1 WINTER SNOWPACK

The annual winter snowpack drives the hydrological regime of the Duteau Creek watershed (as shown by precipitation data in Figure 4.1), so variability in accumulation and melt are dominant factors influencing the water supply condition. Snow accumulation, expressed as snow water equivalent (SWE, mm), represents stored water that is later released, by melt, into the upland reservoirs, filling them for future use.

Historical snow pack data (1970 to 2011) is available from a snow course near Edwin Lake (Station #IF01A). For the period of record, the average snow depth in the upper Duteau Creek watershed on Mar 1 is 55 cm, representing a SWE of 138 mm. The historical data (shown in Figure 4.2) show a decreasing trend in snow accumulation (recorded on April 1 of each year). Figure 4.2 also shows years (after 1986) when the reservoirs did not fill. Generally, it appears that the ability to fill

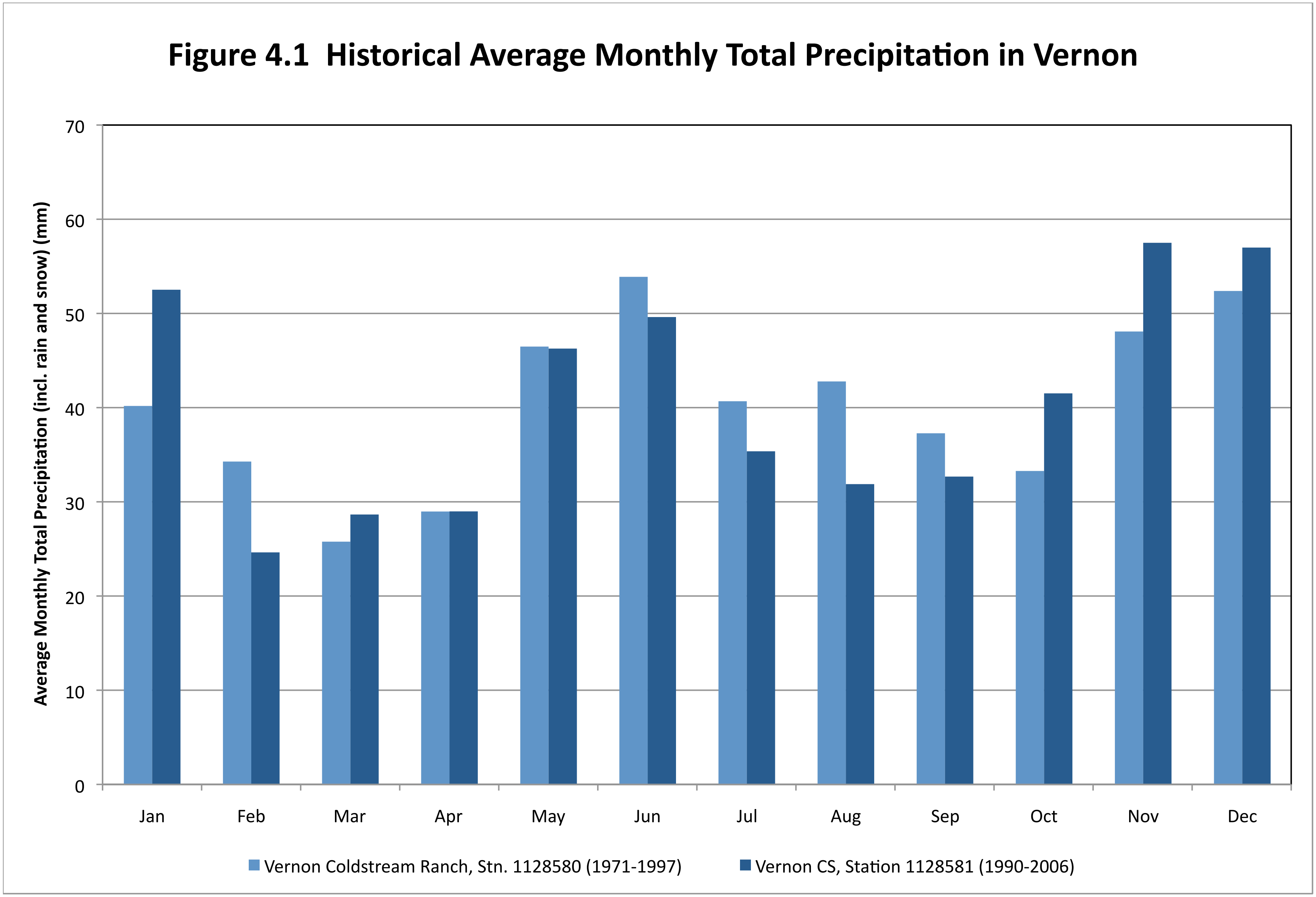
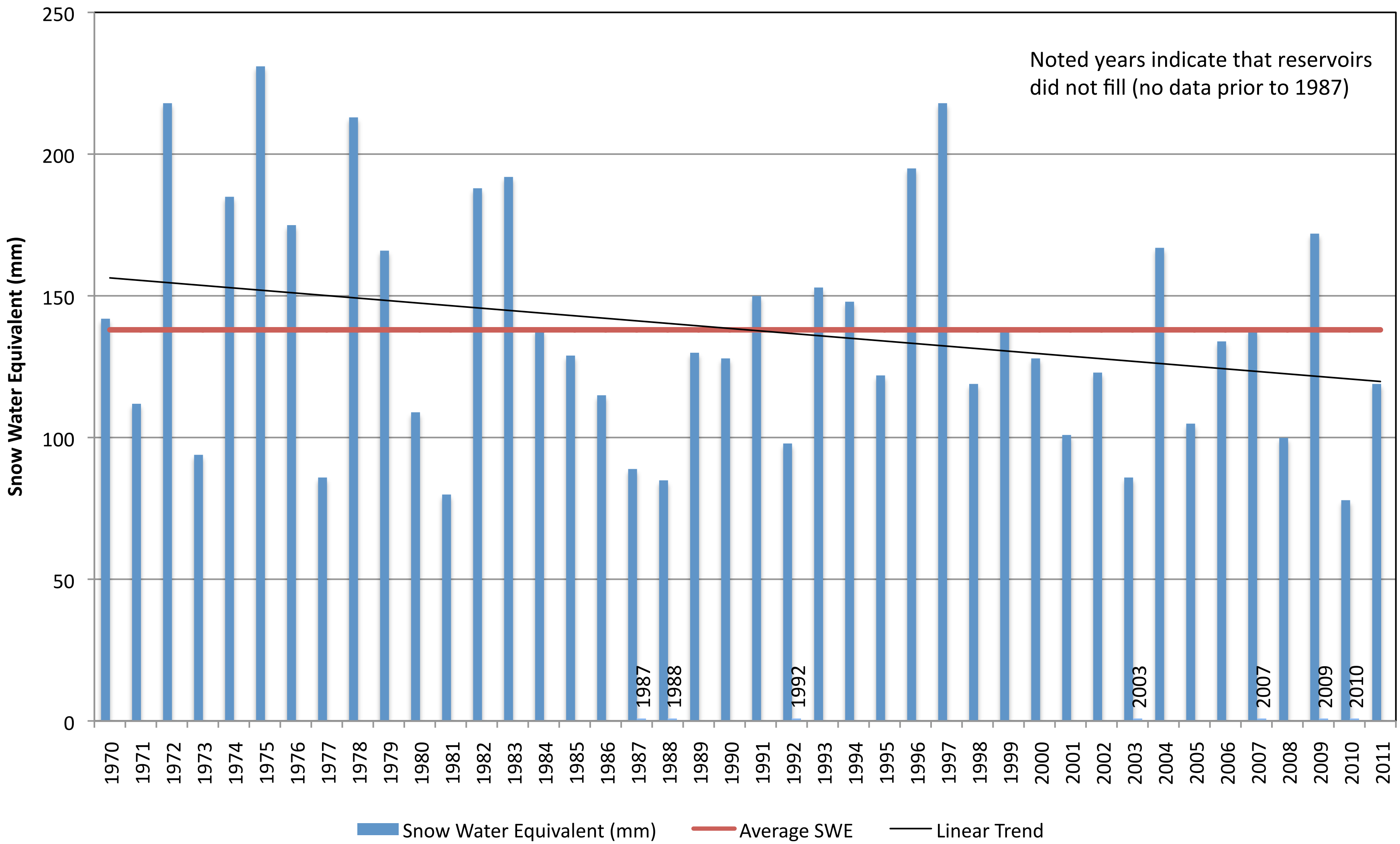


Figure 4.1 Historical Average Monthly Total Precipitation in Vernon
Average Monthly Total Precipitation (incl. rain and snow) (mm)
0
10
20
30
40
50
60
70
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Vernon Coldstream Ranch, Stn. 1128580 (1971-1997)
Vernon CS, Station 1128581 (1990-2006)

Figure 4.2 Historical Snow Water Equivalent Duteau Climate Station (1970-2011) (Mar 1 data)



reservoirs is compromised when the accumulated snow pack is less than 100 mm SWE on March 1.

With a decreasing trend in upper elevation snowpack, the Duteau Creek watershed becomes more sensitive to potential water supply shortages and has a greater potential to be affected by drought.

4.2 SPRING RAINS

Spring rains serve to replenish the upland reservoirs, if not already full, for future water supply. The spring rains are important from the perspective of drought potential because these rains can avert a drought situation if a less than average snow pack is present and/or the reservoirs are not full entering into the spring.

Precipitation in the Vernon area is characterized by wet, rainy May-June followed by dry July-August (see Figure 4.1). Figure 4.1 summaries average monthly total precipitation for two stations in the Vernon area spanning a period of 35 years. Both stations, Vernon Climate Station (Station 1128581) and Vernon Coldstream Ranch (Station 1128580) are situated at valley-bottom locations. Thus, do not necessarily reflect climate conditions in the higher elevation watershed.

One recent example of the importance of spring rain occurred in 2010. Entering into the spring of 2010, GVWU was faced with low reservoirs levels from the previous year, combined with a lower than average snowpack. Just as GVWU entered into a Stage 3 drought situation, the area received higher than average rainfall in May/June. The spring rain was largely responsible for replenishing the reservoirs and raising the drought level (to Stage 2).

4.3 SUMMER CLIMATE AND FALL RESERVOIR LEVELS

Summer climate conditions directly affect rates of water consumption and upland reservoir levels, which is a factor influencing the potential for drought conditions in the GVWU service area. During hot, dry summers (July - August) outdoor water use for irrigation increases, putting greater pressure on the water supply.

As shown in Figure 4.1, rain during the early summer months accounts for a considerable proportion (40%) of the total annual precipitation (487 mm). Much is localized and of a convective nature, so the distribution across the watershed is variable. In comparison, the total annual precipitation in Vernon is low compared to Vancouver (1110 mm).

Various factors, including summer climate and irrigation demand, affect reservoir levels in the fall. Fall reservoir levels are an important factor influencing the potential for drought in the subsequent year as these levels establish a pre-winter supply status. When reservoirs do not fill in the spring and/or are diminished to critical levels in the summer/fall, then the supply condition becomes much more reliant on winter snowpack and spring rains for the subsequent year.

4.4 WATERSHED FACTORS

The Duteau Creek water supply is vulnerable to changes in runoff attributed to various watershed factors (Kerr Wood Leidal and Dobson Engineering, 2008; M.J. Milne and Associates Ltd., 2011). Watershed factors including loss of forest cover due to fire, mountain pine beetle attack and forest harvesting have the potential to affect the Duteau Creek water supply.

Approximately 24% of the watershed is comprised of pine-leading stands that are susceptible to Mountain Pine Beetle (M.J. Milne and Associates Ltd., 2011) and a portion of these stands will be salvaged through timber harvesting. Given the future loss of forest cover, effects on snow accumulation, snow melt, runoff and streamflow are expected. With respect to the water supply situation, increases in runoff will be attenuated by the upland reservoirs. However, with the advancement of the spring freshet, reservoir inflows will occur earlier in the spring, and water will need to be stored (perhaps for longer periods of time). Otherwise, earlier melt conditions may affect low flow conditions later in the year.

Forest stand age/species composition may also affect the watershed hydrology as this is thought to influence the uptake of water from the soil. Younger stands are thought to use more water than mature stands so there is a potential affect on the low flow conditions as water normally entering the reservoirs is lost to vegetation update and transpiration (M.J. Milne and Associates Ltd., 2011).

It is recommended that RDNO remain well informed regarding conditions in the Duteau Creek watershed. Periodic updates of the Watershed Source Assessment and/or Risk Analysis will provide useful information regarding potential effects on the water supply.

4.5 GLOBAL CLIMATE TRENDS

The GVWU water supply and the potential for drought is directly influenced by global climate trends and variability. Large-scale atmosphere-ocean interactions may influence climate conditions pertaining to drought on a local scale.

Projected warming in southern British Columbia will result in drier summers and wetter winters (Pike, *et al.*, 2010). For a snow-melt dominated watershed such as Duteau Creek, this will manifest to a shorter snow accumulation season with less snow stored over the winter, more winter precipitation falling as rain, a shift in timing and magnitude of annual peak flows with an earlier start to the spring freshet and a lengthening of the low flow season in the late-summer or early-fall.

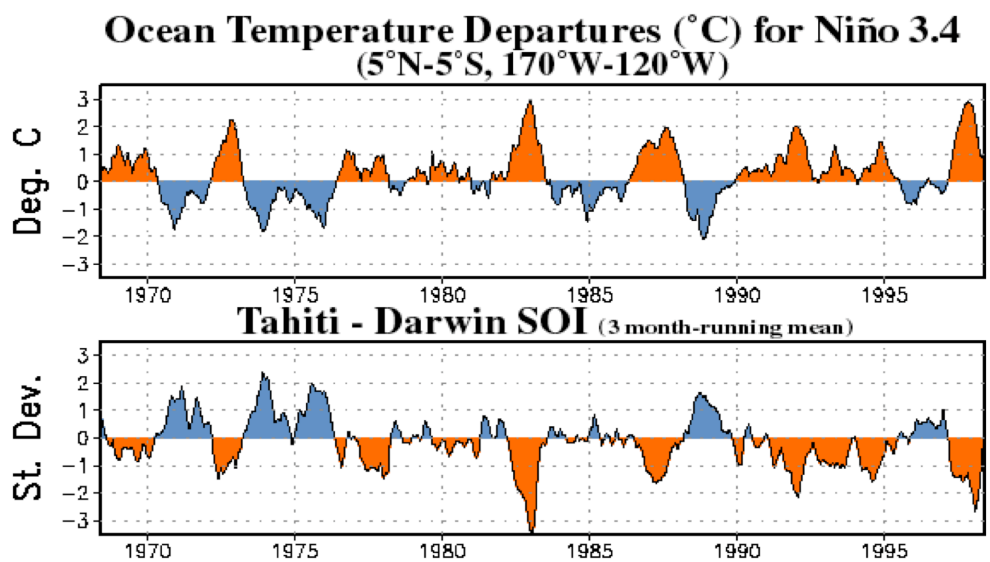
A short description of some key global climate interactions follows:

4.5.1 El Nino-Southern Oscillation (ENSO)

The ENSO phenomenon is a cycle generated in the equatorial region west of South America. When stronger than average equatorial winds blow from the west, this impedes the upwelling of cold deep water in the east Pacific Ocean. In western Canada, this El Nino effect, results in warmer and drier winters with reduced snowfall, followed by warmer and sometimes drier summers. The opposite effect, dubbed La Nina, results in above-average precipitation and cooler winters in western North America.

The ENSO cycle occurs on a somewhat periodic basis roughly every two to seven years (five years on average) and lasts between nine months and two years (NOAA, Climate Prediction Center). Figure 4.3 illustrates the time series of ocean temperature departures and the Southern Oscillation Index (SOI); a measure of large-scale differences in air pressure that roughly corresponds to changes in ocean temperatures. Negative phases of the SOI, or periods of above average (warm) ocean temperatures (El Nino episodes), have occurred eight times in the past 30 years (1982/83, 1986/87, 1991-92, 1994/95, 1997/98, 2002/2003, 2004/2005, and 2009/2010). Positive SOI values, or periods of below average (cool) ocean temperatures (La Nina episodes), have occurred six times in this same period (1984/85, 1988/89, 1995/96, 1998-2000, 2007/2008, and 2010/2011) (NOAA, Climate Prediction Center URL: www.cpc.ncep.noaa.gov).

Although the predictive nature and the causes of the ENSO mechanism are not completely understood, the periodicity of this large-scale climate phenomenon must be considered in the context of interpreting local climate patterns.

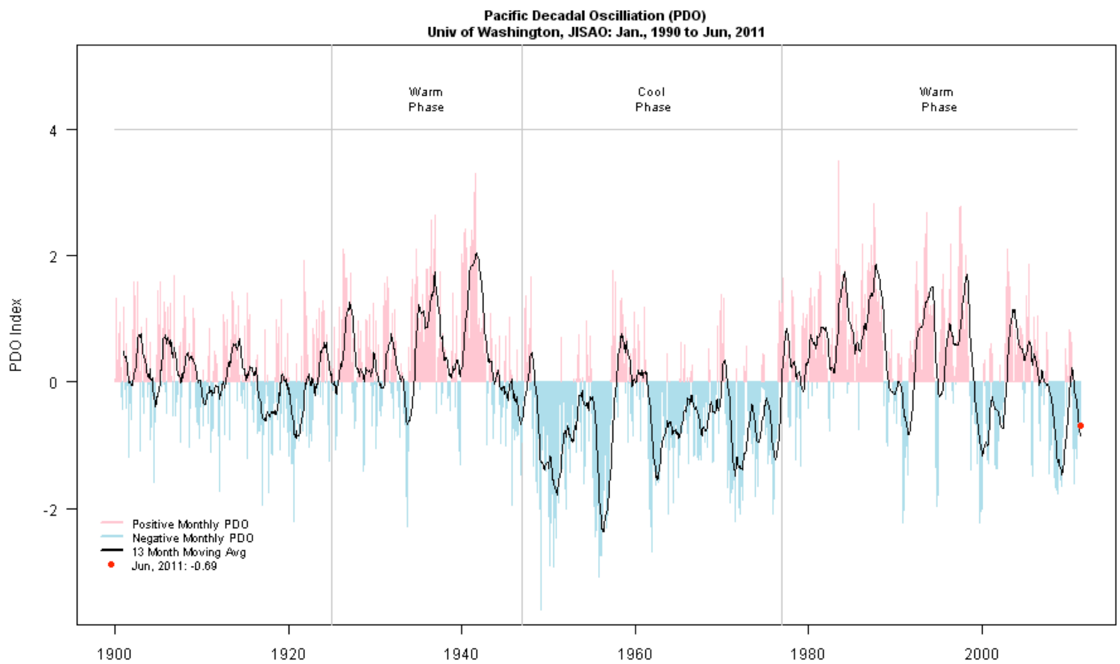


Source: U.S. National Weather Service, Climate Prediction Center (National Oceanic and Atmospheric Administration)

FIGURE 4.3 - THE SOUTHERN OSCILLATION INDEX (SOI)

4.5.2 Pacific Decadal Oscillation (PDO)

The Pacific Decadal Oscillation (PDO) is similar and possibly related to ENSO but operates on a different time scale (decades as opposed to seasons). It is marked by fluctuating ocean surface temperatures in the north-central Pacific as well as near the Gulf of Alaska. The PDO has the most significant effect on weather patterns in western North America – with two PDO events in the 20th century, lasting 20-30 years (Figure 4.4). A warm phase and a cold phase PDO have corresponding effects on regional climate.



Data source: University of Washington, Joint Institute for the Study of Atmosphere and Ocean (JISAO)

FIGURE 4.4 - THE PACIFIC DECADAL OSCILLATION (PDO)

4.5.3 Arctic Oscillation (AO)

The Arctic Oscillation (AO) is a climate pattern dictated by differences in atmospheric pressure between polar regions and the middle latitudes. A cold (negative) phase will bring higher-than-normal air pressure over the polar regions and lower-than-normal air pressure over mid-latitude regions, while the warm (positive) phase has the opposite effect. Fluctuations occur on the order of weeks and months, rather than the seasonal periodicy of ENSO. The AO has a significant influence on winter weather in north and eastern North America especially.

5.0 DROUGHT FORECAST APPROACH

5.1 BACKGROUND

The following characterizes a drought forecast approach as a means of predicting future water supply conditions. By recognizing the potential for future drought, the drought response measures may be implemented to reduce the incidence and/or potential impact of water shortages.

5.1.1 Statistical Approaches

Water supply forecasts may be made using statistical models derived from mathematical relationships between predictor variables (such as snow pack, precipitation, antecedent streamflow, etc.) and the seasonal streamflow volume of interest (USDA, 2006). Statistical models are relatively simple to calibrate and use and are generally accurate. They do, however, require long historical records (preferably greater than 20 years), and they are not able to represent all known physical processes affecting stream flow.

The multiple linear regression and principal components regression analyses are most common and recommended for the prediction of seasonal runoff (Garen, 1992). Greater forecast accuracy is obtained when the model is based on actual data (not predicted data) and when some effort has been made to select an optimal combination of variables.

When forecasts are generated through statistical analysis, the results may be reported as an "index" value. It is important to frame forecasts with antecedent conditions to help users appreciate the relevance of a particular forecast. For example, forecasts may be related to "average or normal" conditions.

Simulation models, alternatively, attempt to represent physical processes affecting stream flow in a watershed and are able to run on a continuous basis. Simulation models require significantly more input data than statistical models and are more difficult to calibrate and interpret.

An alternate approach for the prediction of drought is the Surface-Water Supply Index (SWSI) approach. The SWSI has been used since the early 1980s as an indicator of water availability in the western US. In areas where water supply is dependant upon a seasonal snow pack, the SWSI is considered appropriate.

The SWSI provides an indication of water supply, or reservoir storage. Instead of expressing this as a percentage of average, the SWSI approach uses historical data to express supply as a probability of non-exceedance and uses predictive relationships between variables (such as snowpack, precipitation, stream flow, and reservoir storage) to develop forecasts (Garen, 1993).

The challenge associated with developing a SWSI for the Duteau Creek water supply is a lack of historical data for variables that are obtained from sources outside the snow accumulation zone (i.e. natural stream flow and precipitation).

To develop a statistical water supply forecast, or to develop drought indices such as the SWSI, additional data as noted above, is required. It is recommended that the use of a statistically-rigorous drought index be evaluated for GVWU and that monitoring requirements for future application of a model be identified and established since, for many models, a long period of record is required before any comparison to average conditions is possible.

5.2 RECOMMENDED FORECAST PARAMETERS

A recommended and useable drought forecast approach provides a means for GVWU to evaluate the water supply status and to predict potential water shortages. Recommended parameters, used together in a decision-making approach (discussed in Section 5.3 and Section 7.0), provide a basis for a drought forecast response.

The following forecast parameters are considered key:

5.2.1 Storage Levels in the Upland Duteau Creek Reservoirs (Aberdeen, Haddo, Grizzly)

Storage levels in the upland Duteau Creek Reservoirs (Aberdeen, Haddo, and Grizzly) are considered a primary drought forecast parameter. The drought forecast trigger levels are developed as a percentage of the average reservoir storage conditions calculated for the period of Jan 1997 to December 2010.

The trigger graph is shown in Figure 5.1 and is tabulated in Table 5.1. The seasonal variability of trigger levels reflects seasonal variability in average reservoir storage levels.

Storage levels indicate that a Stage 1 condition is triggered when storage levels are 30 to 90% of the total available reservoir storage, depending on the time of year. A Stage 2 condition is triggered when storage levels are 20 to 82% of the total available reservoir storage. A Stage 3 condition is triggered when storage levels are 10 to 43% of the total available reservoir storage. Stage 4 emergency conditions are triggered at the minimum possible storage level, based on meeting the measured base winter consumption rates of approximately 30 ML/day.

The trigger storage levels were derived by reviewing levels experienced in previous drought years. Using the 2003 drought year as an indicator year of water supply shortages, for example, the record indicates that reservoir levels leading into the hot, dry summer were 20% of the total available storage.

5.2.2 Snowpack Conditions at Aberdeen Lake (Stn. 1F01A, 1310 m elevation)

Snowpack conditions measured in the headwaters at Aberdeen Lake is another key drought forecast parameter. Snowpack data, obtained monthly through the winter, is compared to average conditions for the station (see Figure 4.1). Data obtained for March and April will provide an indication of potential storage in the Duteau Creek catchment. Data from two new snow course stations (#2701 and #2702), operating since 2008, will soon provide useful snow pack data in forested vs. clearcut locations in the upper watershed.

GVWU is also investigating the establishment of other climate monitoring instrumentation. These include: soil moisture probes and piezometers to monitor groundwater conditions in the upper watershed.

5.2.3 Spring and Summer Temperature and Precipitation at the Vernon Climate Station (Stn. 1128581)

Spring and summer temperature and precipitation in Vernon is another key drought forecast parameter. The Vernon Climate Station (Station 1128581) provides current and ongoing (also real-time) climate data, including a rough indication of late-spring precipitation inputs to the upland reservoirs. Although this data is obtained for a valley-bottom location, the data may be compared with long-term averages to determine relative trends (Figure 4.1).

This parameter is not specifically identified in the decision-tree matrix. Real-time temperature and precipitation provide information on current condition. However,

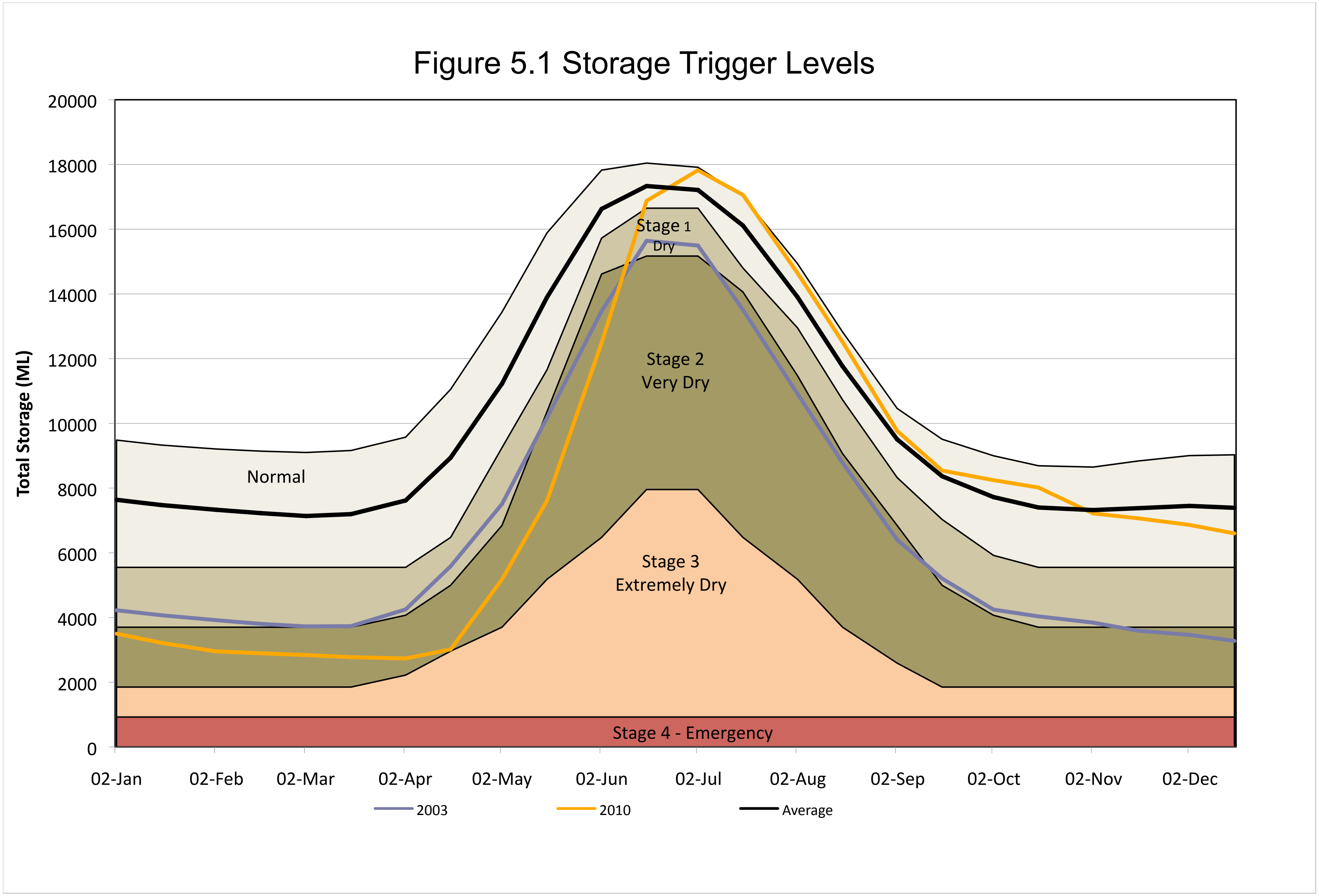


Figure 5.1 Storage Trigger Levels
Total Storage (ML)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Normal
Stage 1
Dry
Stage 2
Very Dry
Stage 3
Extremely Dry
Stage 4 - Emergency
02-Jan
02-Feb
02-Mar
02-Apr
02-May
02-Jun
02-Jul
02-Aug
02-Sep
02-Oct
02-Nov
02-Dec
2003
2010
Average

TABLE 5.1: STORAGE TRIGGER LEVELS (TABULATED DATA)

	Stage 1		Stage 2		Stage 3		Stage 4	
Date	% of total reservoir storage	Trigger Storage Level (ML)	% of total reservoir storage	Trigger Storage Level (ML)	% of total reservoir storage	Trigger Storage Level (ML)	% of total reservoir storage	Trigger Storage Level (ML)
2-Jan	30	5550	20	3700	10	1850	5	925
16-Jan	30	5550	20	3700	10	1850	5	925
2-Feb	30	5550	20	3700	10	1850	5	925
16-Feb	30	5550	20	3700	10	1850	5	925
2-Mar	30	5550	20	3700	10	1850	5	925
16-Mar	30	5550	20	3700	10	1850	5	925
2-Apr	30	5550	22	4070	12	2220	5	925
16-Apr	35	6475	27	4995	16	2960	5	925
2-May	50	9250	37	6845	20	3700	5	925
16-May	63	11655	56	10360	28	5180	5	925
2-Jun	85	15725	79	14615	35	6475	5	925
16-Jun	90	16650	82	15170	43	7955	5	925
2-Jul	90	16650	82	15170	43	7955	5	925
16-Jul	80	14800	76	14060	35	6475	5	925
2-Aug	70	12950	62	11470	28	5180	5	925
16-Aug	58	10730	49	9065	20	3700	5	925
2-Sep	45	8325	37	6845	14	2590	5	925
16-Sep	38	7030	27	4995	10	1850	5	925
2-Oct	32	5920	22	4070	10	1850	5	925
16-Oct	30	5550	20	3700	10	1850	5	925
2-Nov	30	5550	20	3700	10	1850	5	925
16-Nov	30	5550	20	3700	10	1850	5	925
2-Dec	30	5550	20	3700	10	1850	5	925
16-Dec	30	5550	20	3700	10	1850	5	925

trends are more difficult to predict using this data alone. Consideration for the use of this parameter is recommended for future forecasting.

Climate data for the higher elevation area of the watershed are not currently available. It is recommended that a climate station be installed in the headwaters, such that temperature and precipitation may be monitored. There would be some advantage to establishing a real-time monitoring station, in the event that late spring climate conditions dictate water supply status. The station would also provide relevant and useful data for future drought forecasting.

5.2.4 River Forecast Centre (RFC) Bulletins

Important water supply information is available from the BC Ministry of Forests, Lands and Natural Resource Operations (formerly BC Ministry of Environment) River Forecast Centre at URL: http://bcrfc.env.gov.bc.ca/bulletins. The bulletins, published 8 times per year between January 1 and June 15th report on snow data and provide commentary on the flood risk and water supply outlook for major watersheds in the province. The early spring (March – May) reports are particularly relevant for the upcoming water supply season and should be incorporated into the GVWU forecast approach. Based on geographic location, summaries for "Okanagan Drainage" and the "South Thompson Drainage" are relevant for GVWU.

5.2.5 Global Climate Commentary

A global climate commentary is a useful parameter in terms of obtaining a overview of large-scale climate patterns and the influence on long-range water supply. Bulletins are issued by the U.S. NOAA National Weather Service, Climate Prediction Centre at:

URL: http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/enso.shtml.

The bulletins provide commentary on the El Nino/Southern Oscillation (ENSO) atmosphere-ocean interaction and its affect on other global climate patterns such as PDO and AO.

5.3 APPROACH SUMMARY

The relation between available drought parameters and the corresponding response is summarized in the following schematic (Figure 5.2).

Drought forecast parameters, including reservoir storage levels, snow pack conditions, temperature and precipitation, watershed condition, and River Forecast Center bulletins, are considered together with seasonal irrigation demand to provide an indication of water supply status. The status triggers a corresponding short-term response to water supply shortages including the implementation of water restrictions. In the long-term, global climate trends and long-term trends in irrigation demand will provide information on the long-range water supply status. Longer-term supply forecasts will provide the information necessary for asset management planning and the applicable responses to water shortages.

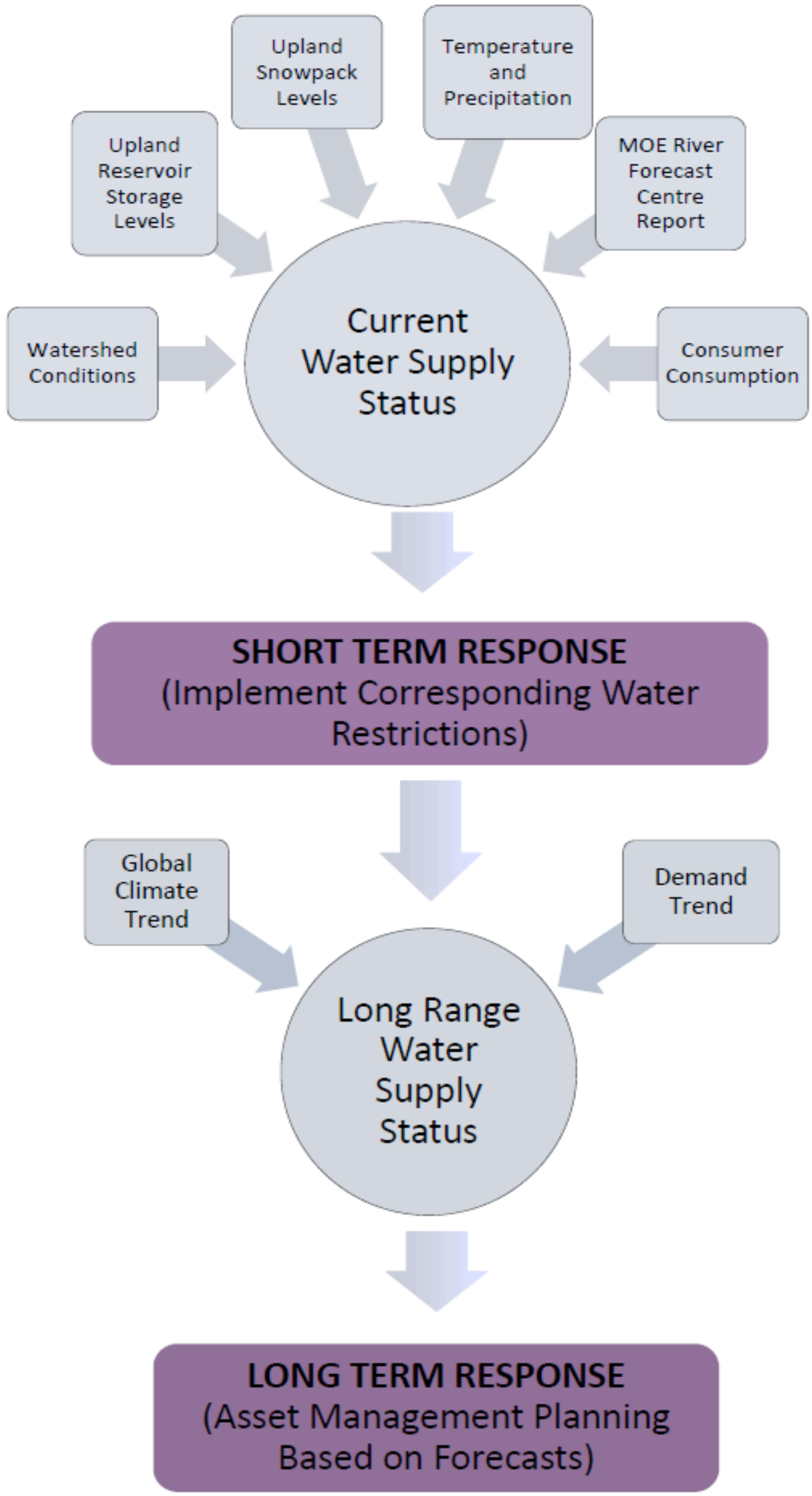


FIGURE 5.2 RELATION BETWEEN DROUGHT FORECAST PARAMETERS AND RESPONSE

5.3.1 Drought Response Decision-Tree

A decision tree (Figure 5.3) was developed to guide the process for determining the appropriate drought response in a given situation. It is essentially a graphic representation of the preceding discussion on trigger factors. The decision branches on the tree are based on customer demand as well as the current and forecasted state of the watershed. It should be used to guide decision-makers in weighing information and understanding the potential outcomes when deciding what drought response action to undertake.

For GVWU the sequence of actions followed to determine a water supply status at any point of time includes:

1. Determine upland reservoir storage levels with respect to the Water Supply Stages outlined in the Trigger Diagram (as per Figure 5.1);
2. Determine whether upland snowpack storage levels are a) above the 95% confidence limits of average; b) within 95% confidence limits of average; or c) below the 96% confidence limits of average (as per Figure 4.2.);
3. Consult the River Forecast Centre Bulletin to determine whether the water supply outlook for the Vernon region is favourable or unfavourable;
4. Assess relative irrigation water demand. Periods of high irrigation water demand will generally correspond to the growing season (between March 31 and September 1), while periods of low demand will be outside this time of year.

Figure 5.3 DROUGHT RESPONSE DECISION-TREE

Upland Reservoir Storage Levels (see Fig. 5.1)	+	Upland Snowpack Levels (see Fig 4.2)	+	River Forecast Centre Report	+	Irrigation Water Demand (corresponds to growing season)	➔	WATER SUPPLY STATUS (Short-Term Response - Implement corresponding Water Restrictions)
Normal		Above Avg		Favourable		Low		NORMAL
Normal		Above Avg		Favourable		High		NORMAL
Normal		Above Avg		Unfavourable		Low		NORMAL
Normal		Above Avg		Unfavourable		High		NORMAL
Normal		Average		Favourable		Low		NORMAL
Normal		Average		Favourable		High		NORMAL
Normal		Average		Unfavourable		Low		NORMAL
Normal		Average		Unfavourable		High		NORMAL (elevated level)
Normal		Below Avg		Favourable		Low		NORMAL
Normal		Below Avg		Favourable		High		NORMAL
Normal		Below Avg		Unfavourable		Low		NORMAL (elevated level)
Normal		Below Avg		Unfavourable		High		STAGE 1
Stage 1		Above Avg		Favourable		Low		NORMAL
Stage 1		Above Avg		Favourable		High		NORMAL
Stage 1		Above Avg		Unfavourable		Low		NORMAL (elevated level)
Stage 1		Above Avg		Unfavourable		High		NORMAL (elevated level)
Stage 1		Average		Favourable		Low		NORMAL
Stage 1		Average		Favourable		High		NORMAL (elevated level)
Stage 1		Average		Unfavourable		Low		STAGE 1
Stage 1		Average		Unfavourable		High		STAGE 1
Stage 1		Below Avg		Favourable		Low		STAGE 1
Stage 1		Below Avg		Favourable		High		STAGE 1
Stage 1		Below Avg		Unfavourable		Low		STAGE 1
Stage 1		Below Avg		Unfavourable		High		STAGE 2
Stage 2		Above Avg		Favourable		Low		NORMAL (elevated level)
Stage 2		Above Avg		Favourable		High		NORMAL (elevated level)
Stage 2		Above Avg		Unfavourable		Low		NORMAL (elevated level)
Stage 2		Above Avg		Unfavourable		High		STAGE 1
Stage 2		Average		Favourable		Low		STAGE 1
Stage 2		Average		Favourable		High		STAGE 1
Stage 2		Average		Unfavourable		Low		STAGE 2
Stage 2		Average		Unfavourable		High		STAGE 2
Stage 2		Below Avg		Favourable		Low		STAGE 2
Stage 2		Below Avg		Favourable		High		STAGE 2
Stage 2		Below Avg		Unfavourable		Low		STAGE 2
Stage 2		Below Avg		Unfavourable		High		STAGE 3
Stage 3		Above Avg		Favourable		Low		STAGE 1
Stage 3		Above Avg		Favourable		High		STAGE 1
Stage 3		Above Avg		Unfavourable		Low		STAGE 1
Stage 3		Above Avg		Unfavourable		High		STAGE 2
Stage 3		Average		Favourable		Low		STAGE 1
Stage 3		Average		Favourable		High		STAGE 2
Stage 3		Average		Unfavourable		Low		STAGE 3
Stage 3		Average		Unfavourable		High		STAGE 3
Stage 3		Below Avg		Favourable		Low		STAGE 3
Stage 3		Below Avg		Favourable		High		STAGE 3
Stage 3		Below Avg		Unfavourable		Low		STAGE 3
Stage 3		Below Avg		Unfavourable		High		STAGE 4
Stage 4		Above Avg		Favourable		Low		STAGE 3
Stage 4		Above Avg		Favourable		High		STAGE 3
Stage 4		Above Avg		Unfavourable		Low		STAGE 3
Stage 4		Above Avg		Unfavourable		High		STAGE 4
Stage 4		Average		Favourable		Low		STAGE 3
Stage 4		Average		Favourable		High		STAGE 4
Stage 4		Average		Unfavourable		Low		STAGE 4
Stage 4		Average		Unfavourable		High		STAGE 4
Stage 4		Below Avg		Favourable		Low		STAGE 4
Stage 4		Below Avg		Favourable		High		STAGE 4
Stage 4		Below Avg		Unfavourable		Low		STAGE 4
Stage 4		Below Avg		Unfavourable		High		STAGE 4

6.0 WATER SUPPLY STATUS DESCRIPTION

Water Supply Status, or Drought Stages, represent conditions under which the Drought Response Plan is implemented.

Water supply status, as it corresponds to the upland reservoir level, is shown on the Storage Trigger Level graph (Figure 5.1). This forms the basis of the Drought Management Plan. A characterization of different levels of water supply status is provided in the following Water Supply Status Matrix (Table 6.1). Revisions to a previous matrix were made based on a review of recent (2010) experience applying the Drought Response Plan, and through review of Drought Response Plans prepared by other municipalities, such as the City of Kelowna. Comments and feedback from RDNO and from members of the Drought Response Team (DRT) were also incorporated.

A description of each supply status stage (or drought stage) contained in Table 6.1 is presented as follows:

6.1 NORMAL CONDITIONS

The "Normal" Supply Status is defined by the average storage condition. Storage volumes that are within the 95% confidence limit (established using 1997 to 2010 data) are considered to be within normal limits. Storage volumes within the Normal Water Supply Status are sufficient to meet supply needs at current levels of demand.

Since the GVWU service area is naturally dry during the summer months, the water supply status may be stressed even when reservoir levels are within the Normal status (average) levels. For this reason, some level of awareness that conservation techniques are always required to protect the community against drought conditions is required. At the Normal supply status the overall goal is to encourage water use efficiencies and promote drought awareness and preparedness. Through the use of permanent water use restrictions to promote best practices, there would be increased awareness even during "normal" conditions.

6.2 STAGE 1 – DRY CONDITIONS

The "Stage 1" Supply Status represents an early (or mild) drought condition and is the first indication of potential water shortage. Entering Stage 1, there should be heightened awareness in the community. Public communication will inform of on-going status, potential future shortages and further restrictions. Stage 1 may be triggered when storage conditions in the upland Duteau Creek reservoirs decrease below the 95% confidence limit of average. This represents a condition when storage levels are 30 to 90% of the total available reservoir storage, depending on the time of year.

The overall goal during Stage 1 conditions is to encourage stewardship and voluntary conservations measures in an effort to reduce water use by roughly 10%. Water use restrictions, primarily focused on outdoor water use, are introduced to reduce the potential move to a Stage 2 supply status.

Table 6.1 Water Supply Status Matrix

Water Supply Status	Normal	Stage 1 - Dry	Stage 2 – Very Dry	Stage 3 – Extremely Dry	Stage 4 – Emergency
Definition	**Average**	**Mild drought**	**Moderate drought**	**Severe drought**	**Loss of Supply**
Explanation of Supply Status and Trigger Factors	The Normal Status is defined by the average storage condition. Storage volumes that are within the 95% confidence limit of average are considered to be within normal limits. Storage volumes within the Normal Water Supply Status are sufficient to meet supply needs at current levels of demand.	The Stage 1 Status represents an early drought condition and is the first indication of potential water shortage. Stage 1 is triggered when storage conditions are below the 95% confidence limit of average. The Stage 1 condition is triggered when storage levels are 30-90% of the total available storage in the upland Duteau reservoirs, depending on the time of year.	Stage 2 Supply Status will occur during prolonged periods of no rain and hot and dry weather and/or with below-average snow pack conditions. This represents moderate level of drought when the water supply is becoming stressed. The Stage 2 condition is triggered when storage levels are 20-82% of the total available storage in the upland Duteau reservoirs.	A Stage 3 Supply Status represents severe drought conditions. This occurs when water supplies are experiencing a critical shortage. The Stage 3 condition is triggered when storage levels are 10-43% of the total available storage in the upland Duteau reservoirs.	Stage 4 Status is defined as the current base winter consumption levels, representing minimum water use (30 ML/day). During Stage 4 Status, the GVWU Emergency Response Plan and Provincial Emergency Program will be invoked. Representing a loss of supply, water is only available for consumptive and sanitary purposes. At this stage, fire protection may be compromised.
Goal	Encourage water use efficiencies, drought awareness and preparedness.	Encourage good stewardship and voluntary conservation measures in an effort to reduce water use by roughly 10%. Measures are encouraged to reduce potential move to Stage 2 Supply Status.	Reduce water use by about 20% to conserve supply and reduce potential move to Stage 3 Supply Status. Introduce Stage 2 water use restrictions that are more specific and more stringent to sufficiently reduce demand.	Reduce water use by about 50% to maintain critical water supply. Introduce Stage 3 water use restrictions that minimize outdoor water use.	Maintain minimum water supply to maintain basic community health and basic needs. (90% reduction)
Drought Regulations and Response	Permanent water use restrictions, water use efficiency, and best practices promoted.	Stage 1 Restrictions, characterized by reduced lawn and garden sprinkling.	Stage 2 Restrictions characterized by reduced agricultural water use, lawn and garden sprinkling and other outdoor water use.	Stage 3 Restrictions, characterized by severe restrictions in outdoor water use, including agricultural water use.	Stage 4 Restrictions, characterized by a prohibition of outdoor water use.
Communication and Enforcement	Normal levels of communication and education. Roll out best practices and conservation practices.	Heightened awareness and increased public communication. Enforcement level and effort increased, including increased monitoring of large users. Warnings issued and some tolerance.	High level of education and communication maintained. Enforcement efforts increased. Moderate fines issued and lower tolerance.	High level of education and communication. High level of enforcement. Zero tolerance on abusers. Moderate fines issued.	High level of education and communication. High level of enforcement. Zero tolerance on abusers. Stiff fines issued.

Public communication and education become important during this stage and an increased level of enforcement and monitoring effort for large water users is justified. At this stage some tolerance to misuse may be permitted and warnings may be issued.

6.3 STAGE 2 – VERY DRY CONDITIONS

"Stage 2" Supply Status represents very dry conditions and will occur when prolonged periods of no rain and hot and dry weather, combined with below average snow pack conditions. This represents moderate level of drought when the water supply is becoming stressed. The Stage 2 status is triggered when storage levels in the upland Duteau reservoirs are 20 to 82% of the total available storage, depending on the time of year.

Entering a Stage 2 condition will require water use restrictions, monitoring and enforcement. The goal during this stage is to reduce overall water use by approximately 20% to conserve water supply and to reduce the potential move to Stage 3 Supply Status. The restrictions introduced at this stage would be more specific and more stringent in order to sufficiently reduce demand.

A high level of public communication and education is important at this stage. Enforcement and monitoring efforts are increased and moderate fines and lower tolerance of abuse should be permitted.

6.4 STAGE 3 – EXTREMELY DRY CONDITIONS

A "Stage 3" Supply Status represents severe drought, or extremely dry, conditions. This occurs when water supplies are experiencing a critical shortage. The Stage 3 condition is triggered when reservoir storage is 10 to 43% of the total available, depending on the time of year. Extensive reductions in water use are required to maintain water supply for critical services such as fire protection and consumptive and sanitary water supply. Outdoor water use is severely restricted and/or prohibited.

Overall goal at this stage is to reduce water use by about 50% to maintain a critical water supply. Outdoor water use is virtually prohibited with exceptions only for health and safety purposes. Due to critical levels of water supply, a high level of communication and enforcement is required. Zero tolerance of water abuse is recommended and moderate fines should be issued for non-compliance. Use of the Municipal Ticket Information system may be considered.

6.5 STAGE 4 – EMERGENCY CONDITIONS

"Stage 4" Supply Status represents an emergency condition characterized by a loss of supply. Loss of supply may be associated with drought but could also be triggered due to contamination or loss of infrastructure. Stage 4 supply condition is defined by the current base winter customer consumption levels (30 ML/day), assumed to represent minimum consumptive and sanitary water use. During Stage 4 Status, the GVWU Emergency Response Plan and Provincial Emergency Program will be invoked. Representing a loss of supply, no spare water is available. Any available water is to be used for consumptive and sanitary purposes. At this stage, fire protection may be compromised.

7.0 DROUGHT RESPONSE PLAN

7.1 INTRODUCTION

A Drought Response Plan (DRP) is a key component of a Drought Management Plan. The DRP establishes a staged approach to water management in times of drought conditions by identifying and evaluating factors that will trigger response. This depends on various factors, such as water supply and demand forecasts.

The General Manager of Engineering, or Utilities Manager, are responsible for determining whether a DRP action is warranted, implementing stages of the DMP, utilizing staff, committees, and other resources as necessary. Specific roles and responsibilities are clearly defined the Communications Plan document.

It should be noted that the Response Plan applies to all water supplied by the GVWU but does not apply to the use of rainwater, gray water, recycled, reclaimed water or other sources of water outside the GVWU water supply system.

7.2 DROUGHT RESPONSE MEASURES

Drought response measures are actions to be considered in an effort to improve the supply status condition. The measures may be operational actions related to utility infrastructure, or they may be conservation measures, intended to reduce water demand. The decision to implement various drought response measures depends on the time of year and water supply status condition, as illustrated in the decision tree.

The Drought Response Plan, includes a sequence of activities, roles and responsibilities for each drought stage. The Water Restrictions Bylaw and Communications Plan, included as appendices to this report, describe other measures to consider in addition to those outlined here.

Additionally, an Emergency Response Plan (ERP) is required to establish public communication protocols in the event of an emergency situation, or catastrophic loss of water supply (e.g. Stage 4 Supply Status). The ERP would provide policies and procedures for responding to a crisis situation.

7.2.1 Operational Measures

At the early part of the season, operational measures to increase storage include regulating spill rates, or adjusting the agricultural irrigation turn-on date (from April 15 to April 30). In the first few months of the year, drought forecast parameters should be monitored. Of relevance at this time of year are forecasted reservoir inflows, climate, supply volume, and demand.

7.2.2 Demand-Side Measures

After April 1, when the snow pack has reached its maximum, the ability to manipulate storage operationally becomes more limited. As water demand increases in May and June, implementation of water conservation measures is a way to reduce water demand.

Peak demand occurs between July 1 and August 31. Summer precipitation and inflows to the reservoir are seasonally depressed, so consumption is the critical factor governing supply. Demand-side management as a means of water conservation should, at this time, be the primary focus and this may be accomplished, in part, through the measures specified in the Water Restrictions Bylaw.

The Water Restrictions Bylaw outlines specific water conservation measures by activity (residential, commercial, public, and agricultural) for each drought stage. Revisions to the current bylaw were made based on comments and feedback from the Drought Response Team. A revised proposed bylaw is presented in the attached Appendix A, along with background on the Drought Response Team consultation process.

8.0 CONCLUSIONS

A drought management plan is developed for the use of GVWU to effectively manage water supplies. The drought management plan identifies the factors contributing to potential water shortages, defines the different stages of drought, provides a means of forecasting potential shortages and a means of responding. A drought response plan outlines an approach to determine the water supply status based on specific watershed conditions. The response plan forms the basis for implementing a variety of drought response measures.

9.0 RECOMMENDATIONS

Based on the results of the drought management plan update, the following recommendations are provided:

- GVWU should determine feasibility of increasing supply capacity from Kalamalka Lake through infrastructure improvements if license capacity exists. For example, pump upgrades at the West Kal intake and improvements to the pipeline infrastructure to the treatment plant would increase supply capacity;
- The DMP should be considered in conjunction with Master Water Plan update, planned for 2012. The Master Water Plan should identify and evaluate current water sources and licence volumes, the potential for expansion of existing water sources, assess demand management policies needed to achieve supply management goals, and identify potential future water sources. The Master Water Plan should also consider the 50-year drought and multi-year drought scenarios;
- It is recommended that the peak water demand summary table (Table 3.1) be updated using more recent metered data and customer counts;
- Periodic (5 year) updates of a Watershed Risk Analysis are recommended to evaluate current watershed factors with respect to water supply conditions;

- It is recommended that the use of a statistically-rigorous drought index, such as the Surface Water Supply Index, be evaluated for GVWU and that monitoring requirements for future application of a model be identified and established;

- Incorporate and/or establish new hydrometric and climate data from upper watershed station locations as this becomes available. This includes: hydrometric data, snow pack data, precipitation data, and possibly soil moisture; and,

- The DMP should be revisited and updated every five (5) years to incorporate new data, validate the DRP forecast approach, and evaluate response.

- The Communication Plan, Drought Response Team activities and the Water Use Bylaw should be considered "living documents" and be reviewed and updated periodically.

10.0 CLOSURE

We trust that this report meets your current requirements. If you have any questions or comments, please contact the undersigned.

Prepared by:

Clarke Geoscience Ltd.

PROFESSIONAL
PROVINCE OF
J.A. CLARKE
25319 10/25/11
BRITISH COLUMBIA
GEOSCIENTIST

Jennifer Clarke

Jennifer Clarke, M.Sc., P.Geo.
Director
Tel. 250-826-4367
clarke-geoscience@shaw.ca

11.0 REFERENCES

Cotsworth, A. 2010. Personal Communication. Engineer – Greater Vernon Water, Regional District of North Okanagan, Vernon, BC.

EBA. 2007. Drought Management Plan. Prepared for Greater Vernon Services. Dated March 14, 2007. Kelowna, BC.

Garen, D.C. 1992. Improved Techniques in Regression-Based Streamflow Volume Forecasting. Journal of Water Resources Planning and Management. American Society of Civil Engineers. Vol. 118, No. 6, pp. 654-670.

Garen, D.C. 1993. Revised Surface-Water Supply Index for Western United States. Journal of Water Resources Planning and Management. American Society of Civil Engineers. Vol. 119, No. 4, pp. 437-454.

Greater Vancouver Regional District (GVRD) 2004. 2004 Water Shortage Response Plan. Dated May 20, 2004. Retrieved from http://www.gvrd.bc.ca/water/pdfs/ 2004WaterShortageResponsePlan.pdf.

Kerr Wood Leidal Associates Ltd. 2006. GVS Water Model Update, KWL File 773.020, December 2006. Vancouver, BC.

Kerr Wood Leidal Associates Ltd. and Dobson Engineering Ltd. 2008. Duteau Creek Watershed Assessment and Recommendations for Source Protection. Prepared for RDNO, Greater Vernon Water. Vernon, BC.

Larratt Aquatic. 2010 Source Assessment of the RDNO-GVWU Kalamalka Lake Intake (draft). Kelowna, BC.

M.J. Milne and Associates Ltd. 2011. Watershed Risk Analysis for Duteau Creek. Prepared for the Ministry of Forests, Lands and Natural Resource Operations, Kamloops. Dated June 10, 2011. Vernon, BC.

Ministry of Environment. 1977. Kalamalka-Wood Lake Basin Water Availability Study. File 0273896-1. Penticton, BC.

Ministry of Environment. 2009. Dealing with Drought: A Handbook for Water Suppliers in British Columbia. Published June 2004 and updated July 2009. Victoria, BC.

Ministry of Water, Land and Air Protection. 1992. Kalamalka-Wood Lake Water Supply Hydrology. B. Letvak, Water Management Branch. Penticton, BC.

North Okanagan Water Authority (NOWA). 2002. Master Water Plan. Summary Report and Technical Working Papers. April 2002. Vernon, BC.

Pike, R.G., K.E. Bennett, T.E. Redding, A.T. Werner, D.L. Spittlehouse, R.D. Moore, T. Murdock, J. Beckers, B.D. Smerdon, K.D. Bladon, V.F. Foord, D.A. Campbell and P.J. Tschaplinski. 2010. Climate Change Effects on Watershed Processes in British Columbia. Chapter 19 in: Compendium of Forest Hydrology and Geomorphology in British Columbia. Land

Management Handbook 66. Victoria, BC [URL: http://www.forrex.org/program/water/compendium.asp]

QDS Quadra Development Solutions Inc. 2005. Greater Vernon Water—Demand Side Management Reference Document. Prepared in association with LandInfo Technologies Inc., and UBC Department of Geography. Dated November 2, 2005. Vernon, BC.

USDA. 2006. Natural Resources Conservation Service. National Water and Climate Centre. Water Supply Forecasting – A Short Primer. [URL: http://www.wcc.nrcs.usda.gov]