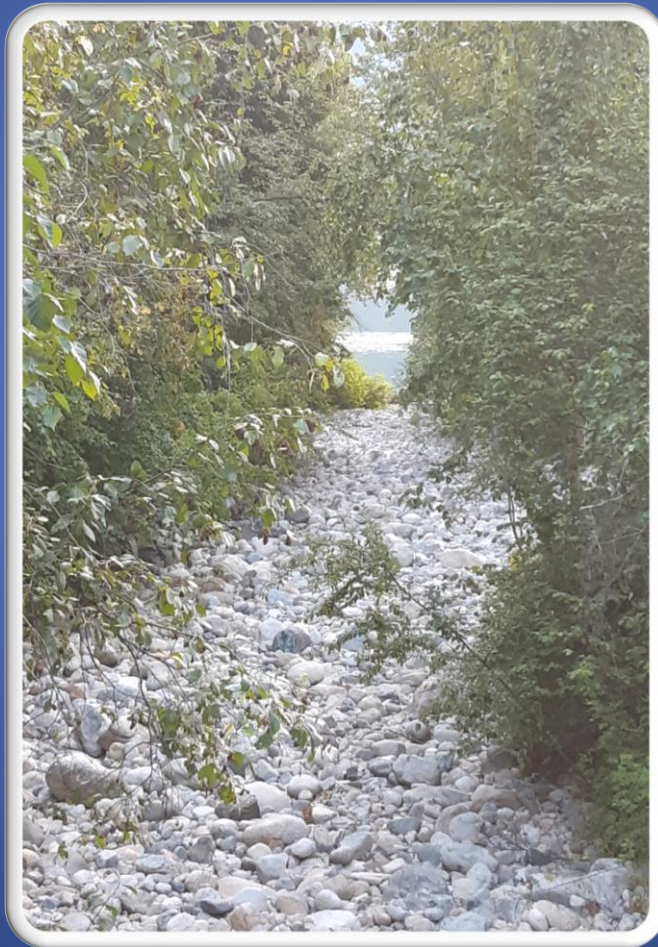


REGIONAL DISTRICT OF KOOTENAY BOUNDARY DROUGHT MANAGEMENT PLAN: KETTLE RIVER WATERSHED



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Executive Summary

Since the early 2000's, Boundary area residents have become increasingly aware of low flows and declining fish stocks in the Kettle River Watershed. These concerns prompted the development of the Kettle River Watershed Management Plan (KRWMP). The KRWMP (Regional District of Kootenay Boundary, 2015) outlines actions towards an integrated and ecosystem-based watershed management approach, with a focus on drought management. Four out of the five years between 2015 and 2019 experienced either very dry (Provincial drought level 3) or extremely dry (Provincial drought level 4) conditions, prompting concerns for fish survival and causing adverse economic, ecological and health impacts. Climate projections for this region suggest that drought conditions will become more common, highlighting the need for committed drought planning and management in the Boundary.

In response to actions outlined in the KRWMP, and with support from the Regional District of Kootenay Boundary (RDKB), Boundary Directors, Provincial and Local Government staff, water suppliers, and the public, the RDKB initiated the development of regional Drought Management Plans.

Four documents are being developed to support drought management in the Boundary Region of the RDKB:

- (1) RDKB Drought Management Plan: Kettle River Watershed (DMP),
- (2) RDKB Drought Management Plan: Nine Mile Creek,
- (3) RDKB Boundary Drought Response Plan, and
- (4) RDKB Boundary Drought Management Public Engagement Strategy.

Together, these Plans will support collaboration between the Province, RDKB, water suppliers and water users, as collective and focused efforts are necessary for successful drought management in the Boundary Region. The DMP details recommendations for water rights holders and stakeholders; public engagement and communication strategies; water and watershed monitoring; and adaptive management approaches.

Realizing that water management and conservation has been a component of many individual practices, it is important that these efforts continue and all water users in the Boundary region work consistently towards careful management of this finite resource. Continuing from the important conservation and land management work already underway, drought management is a key action that can help to reduce the severity of a drought thereby lessening negative impacts. This work is all the more important now as we prepare for a changing climate, which is forecasted to include warmer and wetter winters in combination with warmer springs shifting to hotter and drier summers.

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List of Abbreviations

BMP	Best Management Practices
CEFT	Critical Environmental Flow Threshold
DMP	RDKB Drought Management Plan: Kettle River Watershed
DMT	Kettle River Watershed Drought Management Team
DRP	RDKB: Boundary Drought Response Plan
ECCC	Environment and Climate Change Canada
EFP	Environmental Farm Plan
FLNRORD	Forests Lands, Natural Resource Operations and Rural Development
GDD	Growing Degree Days
KBFA	Kootenay Boundary Farm Advisors
KBR	Kootenay Boundary Region – Province of BC
KRW	Kettle River Watershed
KRWMP	Kettle River Watershed Management Plan
LG	Local Government
MOTI	Ministry of Transportation and Infrastructure
ORW	Okanagan River Watershed
PES	RDKB: Boundary Drought Management Public Engagement Strategy
RCP	Representative Concentration Pathways
RDKB	Regional District of Kootenay Boundary
RDNO	Regional District of North Okanagan
TOR	Thompson Okanagan Region – Province of BC
WSC	Water Survey of Canada
WSWG	Water Suppliers Working Group

1.0 Introduction

Water is vital for sustaining all life. Our relationship with and access to water can shapes our quality of life, as understood through this excerpt from the Sylix Water Declaration:

"When we take care of the land and water, the land and water takes care of us".

Okanagan Nation Alliance (2020)

The climate change for the Kettle River Watershed (KRW) is forecast to include drier summers, higher annual temperature and an earlier snowmelt (University of Victoria, 2020). Along with the anticipation that both the frequency and magnitude of extreme events will increase. Accordingly, the management and adequate conservation of water to support a healthy ecosystem and economy is becoming more and more important.

A common assumption is that water use cannot noticeably affect the flow from large rivers in the KRW. However, discharge measurements taken on the Kettle River in Laurier, Washington show that the Kettle River can be affected by water withdrawal. During very dry years¹ and based on water use in 2012, water users are already licensed to divert enough water for the river to be flowing 38 to 90% lower than what would have occurred naturally (Summit Environmental Consultants, 2012). This is attributed to surface water withdrawals as well as groundwater withdrawals, as groundwater extraction can affect surface water levels.

A simplified version of the water cycle (Figure 1.1 and 1.2) helps remind us that water movement through the earth is cyclical; what happens on the surface can affect groundwater, which then flow back towards the surface, evaporating and falling again as precipitation.

¹ In this circumstance, Summit Environmental (2012) defines a "very dry year" to be when the water level in the Kettle River reaches a monthly low flows that, based on statistics, would be expected to occur once in every 50 year (1 in 50 year return period).

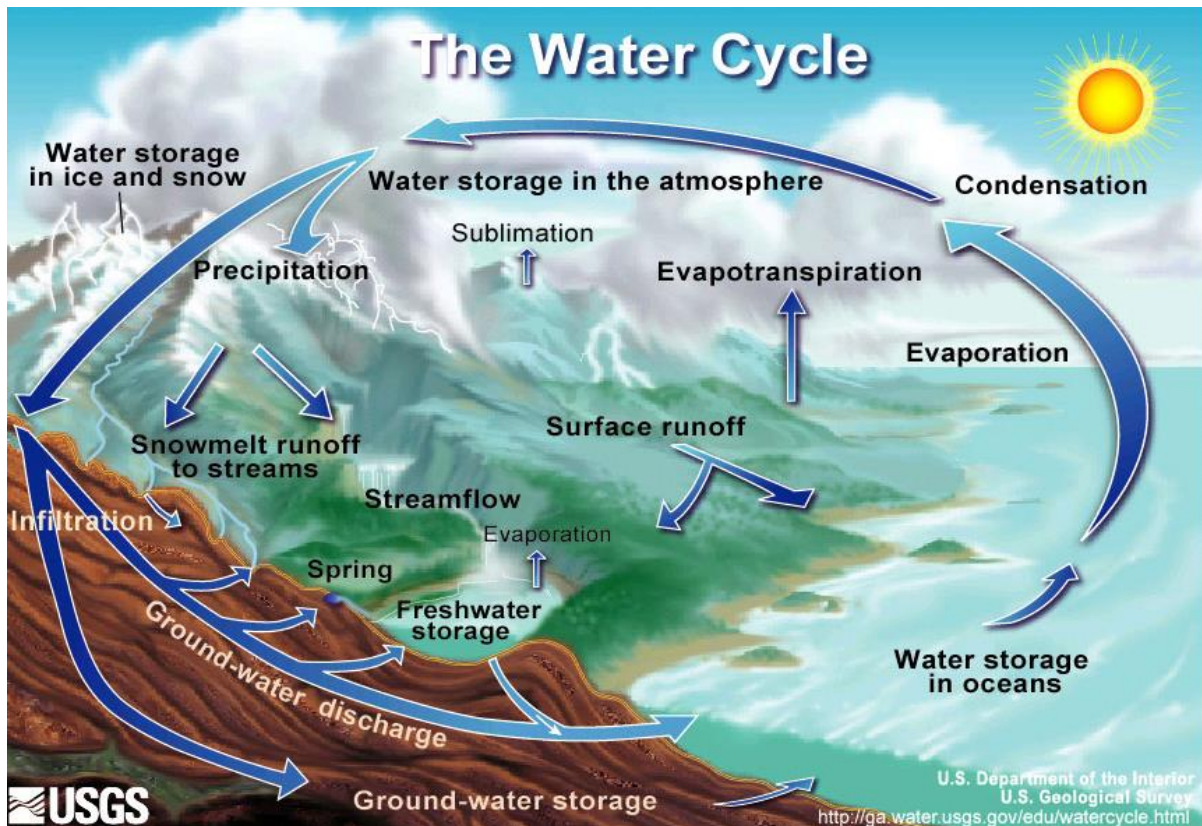


Figure 1.1 Water cycle. Source: U.S. Geological Survey

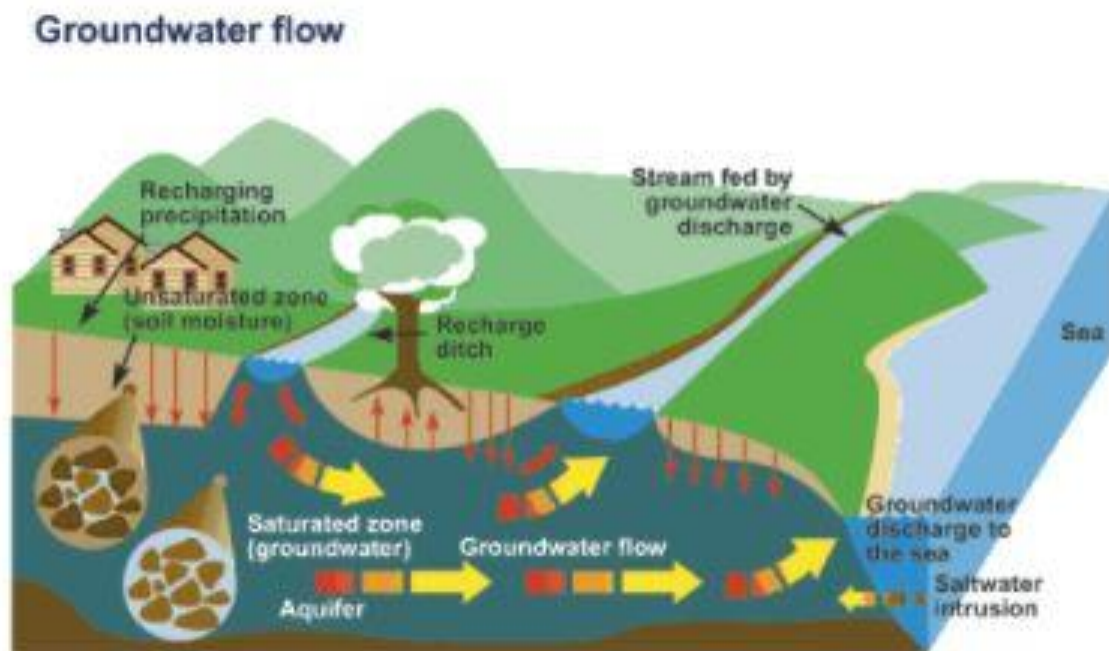


Figure 1.2 Groundwater flow. Source: Environment and Climate Change Canada (2013)

During the late summer, surface and some groundwater water users can substantially reduce the volume of water flowing (discharge) in the Kettle River. Engaging with water users to understand their role in water conservation is key for drought management in the KRW.

The information and tools proposed in this DMP have been designed to support all water users in the KRW to have a more active role in the region's water management. Understanding and planning for drought prior to an emergency allows for a more informed, effective and collaborative response.

This DMP is a living document; the aim is for this document to adapt and change as new ideas and information becomes available.

1.1 Background

Since the early 2000s, KRW residents and local government elected officials have increasingly expressed concerns with the low water levels in the rivers throughout the KRW. Public interviews and surveys were conducted in 2012, indicating that many Boundary residents felt drought was a main threat to the Kettle River (Watt, Graham; KRWMP Stakeholder Advisory Group, 2014). Which became one of the main reason for the development of the Kettle River Watershed Management Plan (KRWMP). Published in 2015, the KRWMP addresses the need for effective drought management through the directives towards improve water security by developing and implementing drought management plans and water storage strategies (Regional District of Kootenay Boundary, 2015).

In 2015, the RDKB formed the Water Suppliers Working Group (WSWG), which consists of both municipal and independent water suppliers. This group was developed for water suppliers to discuss water related issues, share information, and gain access to learning opportunities. That same year, the Province recognized the need for the KRW to have its own Provincial drought rating, compared to previous years where the KRW drought classification was directly connected with to the drought level for the Okanagan River Watershed (ORW).

In 2017, the RDKB was invited to participate in the provincially lead Thompson Okanagan Region (TOR) Drought Team meetings. Having an RDKB representative at these meetings has been useful, as RDKB provides essential on-the-ground information to the Province, and can provide information about proposed Provincial actions to Boundary water suppliers and regional stakeholders.

In 2017, the RDKB Boundary Directors, water suppliers (municipal and independent), First Nations, provincial government staff and the public supported the development of the drought management plans. Taking into consideration the two Boundary region watersheds, KRW and ORW, four documents are being developed to increase access to information and recommend Boundary region drought management actions:

1. RDKB Drought Management Plan: Kettle River Watershed (DMP) provides background information, details on historic and projected droughts, impacts, and challenges with drought management in the KRW and provides recommendations to reduce drought impacts. It focuses on the planning and preparation stage of drought management.
2. RDKB Drought Management Plan: Nine Mile Creek (DMP) provides background information, details on historic and projected droughts, impacts, and challenges with drought management in the Nine Mile Creek watershed, located within the ORW. Offers recommendations towards helping reduce drought impacts, while focusing on the planning and preparation stage of drought management.
3. RDKB Boundary Drought Response Plan (DRP) outlines recommended actions to be taken during all stages of provincially identified drought.
4. RDKB Boundary Drought Management Public Engagement Strategy (PES) details engagement practices designed to occur throughout the year, during the planning and preparation period and active drought events.

1.2 Purpose and Audience

The purposes of the DMP is to provide a summary of drought conditions and impacts in the KRW and to recommend actions to be taken during the planning and preparation period. The DRP provides actions for the government and water users to take during a drought, while the PES details information on a variety of communication and education strategies in support of drought awareness.

Working to reduce the severity of the drought and associated drought impacts through efficient water use and effective water management can improve community sustainability and resiliency. Benefits include:

- Increased efficient use of water by Water Suppliers and large water users could decrease the use of water that, in turn, can reduce operating costs.
- Increasing the reliability and availability of drinking water and water for recreation, which includes water access for swimming, boating and fishing.
- Supporting KRW ecosystems for all organisms as we maximize available water during the summer months.
- Reducing the need for the Province to have to apply water restrictions or declare a water shortage, which could stop non-domestic water withdrawal.

1.3 Objectives

The DMP objectives are:

- Summarize historical and current drought information for the KRW.
- Identify local challenges that exist when managing drought in the KRW.

- Recommend actions for the Province, Local Governments (LG), water suppliers and water users that support a coordinated drought management approach.
- Provide drought management recommendations to be conducted during the “Planning and Preparation” period, typically from November to April.

2.0 Plan Area

The RDKB has two distinct regions: Kootenay and Boundary. Figure 2.1 highlights the location of the Boundary portion, the area covered by this plan.

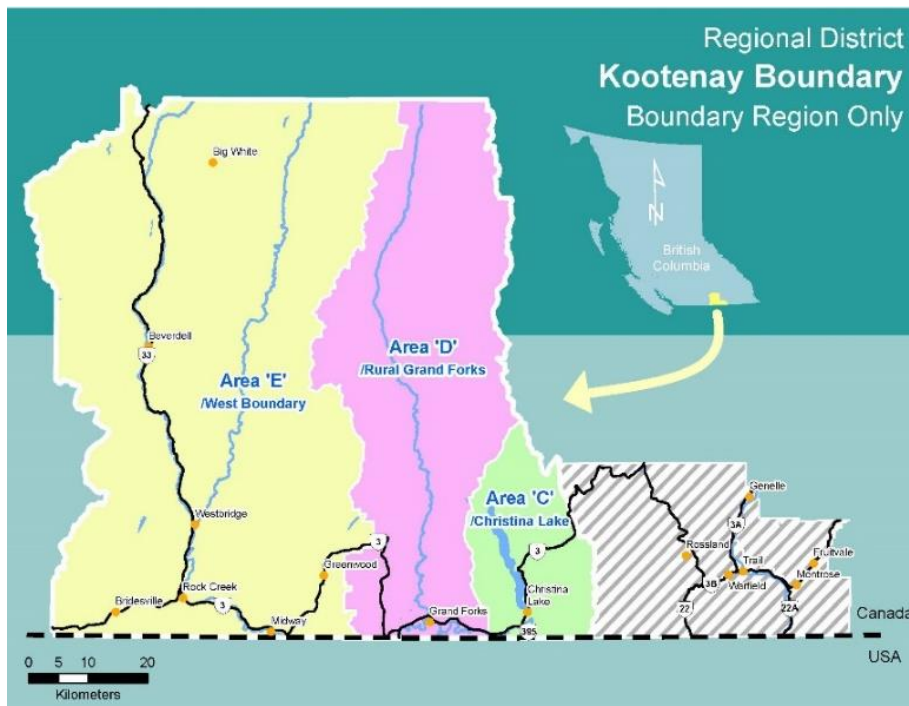


Figure 2.1 Map of the Boundary portion of the Regional District of Kootenay Boundary consisting of Electoral Areas C/Christina Lake, D/Rural Grand Forks and E/West Boundary, and the City of Grand Forks, City of Greenwood and Village of Midway.

There are two main watersheds in the Boundary portion of the RDKB: KRW and ORW (Figure 2.2). This DMP covers the KRW portion that is located within the RDKB, which accounts for 65 % of the watershed. The remaining approximately 35 % of the KRW is located in other local government jurisdictions: 10% in the Regional District of North Okanagan (RDNO) to the north, 0.1 % in the Regional District of Central Okanagan to the west, and 25 % in Washington State (WS), United States of America to the south (Figure 2.3). As the KRW extends outside of the RDKB, close communication with RDNO and WS will ensure continuity and improve our ability to manage for future impacts as we collectively prepare for and respond to drought conditions.

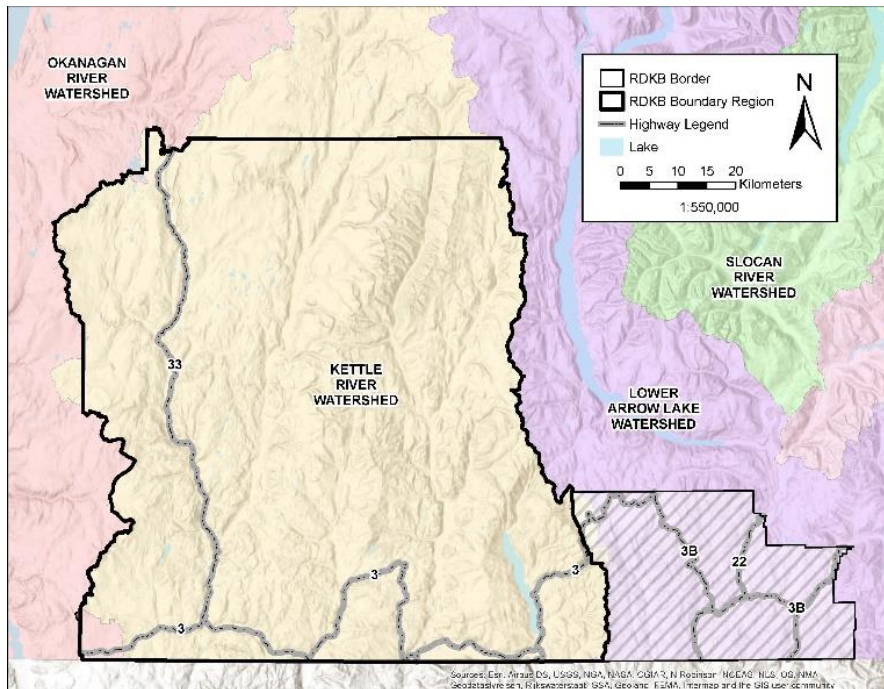


Figure 2.2 Main watersheds in the Boundary portion of the RDKB: Okanagan River (orange) and Kettle River (yellow).

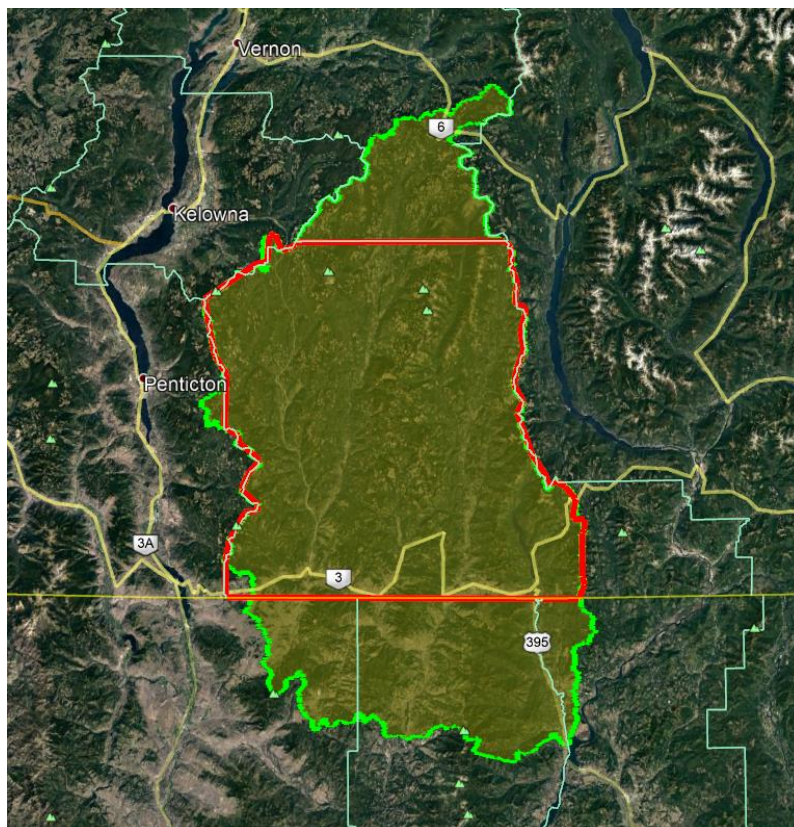


Figure 2.3 Kettle River Watershed (lime green) and the RDKB Boundary region (red). The US border shown as a straight horizontal yellow line. Google Earth 2016 image.

There are nine (9) sub-basins in the KRW, with eight (8) located either in whole or in part in Canada (Figure 2.4). Each sub-basin has unique characteristics, including varying economic and ecological water needs and water availability. For detailed information on each sub-basin characteristics, such as geologic, elevation ranges, hydrological and climatic monitoring stations, water use, biogeoclimatic ecosystem classification (BEC) zones, species-at-risk, vegetation communities and the technical method of defining the sub-basins, see the report "Kettle River Watershed Management Plan: Phase 1 Technical Assessment" (Summit Environmental Consultants, 2012).

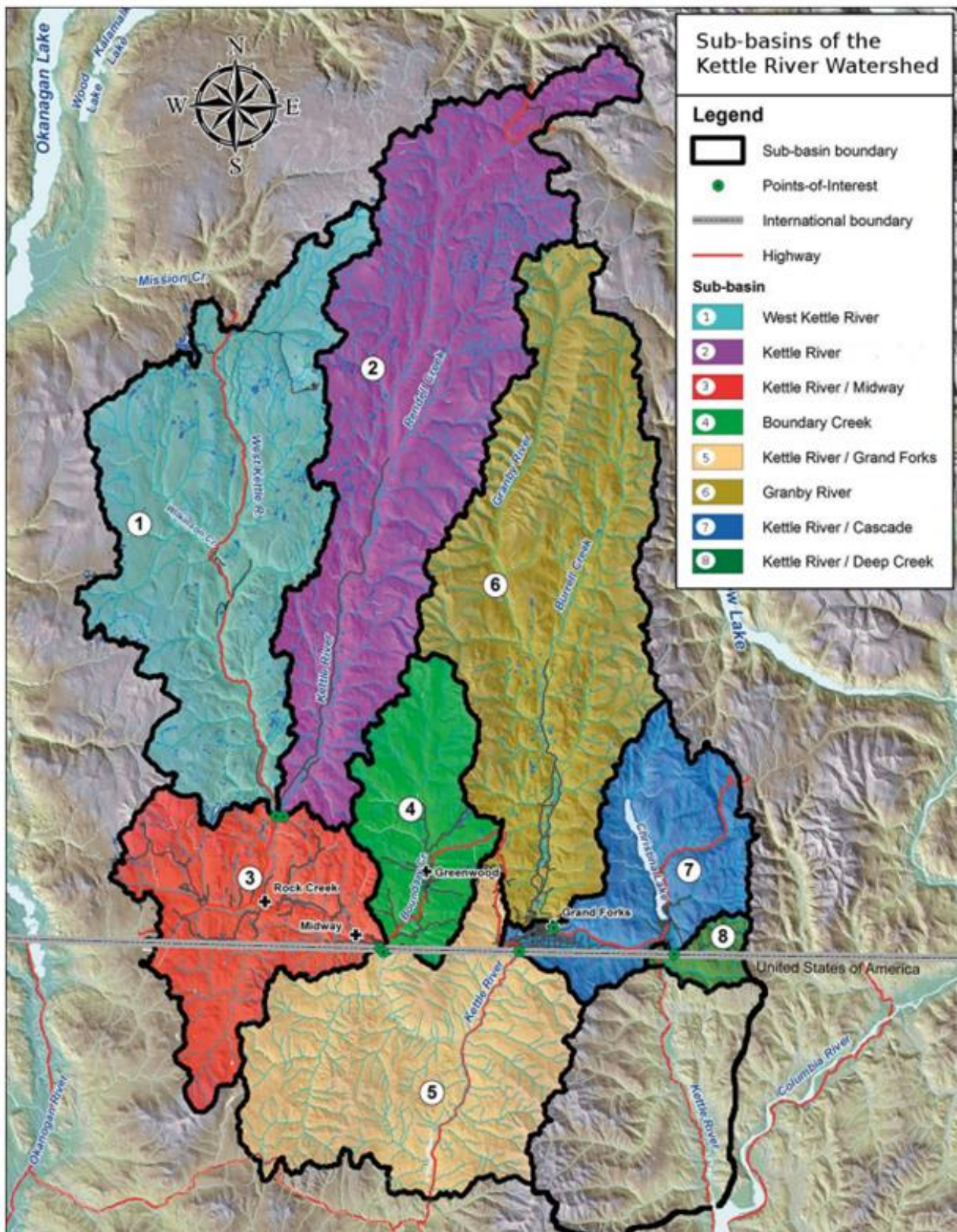


Figure 2.4 Kettle River Watershed with sub-basins (Summit Environmental Consultants, 2012).

3.0 BC Provincial Legislation and Drought Guidance Documents

3.1 Legislation

The following are the four (4) sections from the *Water Sustainability Act* (WSA) (Province of BC, 2020) created to manage water use during times of water scarcity. These sections outline the water user who would have priority over another user, and how and when water restrictions can be enforced.

WSA Part 2: Licensing, Diversion and Use of Water

Section 22: Precedence of rights

The Province of BC may enforce restriction of water use during times of water scarcity. This is known as implementing FITFIR (First in Time First in Right), which prioritizes water rights by the water licence priority date and purpose. However, during these times of scarcity, essential household use of water is only partially restricted – a maximum of 250 litres of water per day for domestic purpose is permitted as outlined in Section 22 (11).

WSA Part 3: Protecting Water Resources

Division 5: Temporary Protection Orders

Section 86: Declarations of significant water shortage

A temporary measure used to declare an area with having a significant water shortage. This declaration is made prior to substantial water use curtailment.

Section 87: Critical environmental flow protection orders

After a water shortage has been declared, this order allows for the critical environmental flow threshold (CEFT) to be determined for each affected stream. The CEFT is the quantity of water required to remain in the stream in order to ensure the survival of a fish population.

Section 88: Fish population protection orders

After a water shortage (Section 86) has been declared, the CEFT has been determined (Section 87) and the survival of a fish population may be or may become threatened, the Minister can restrict water withdrawal from either a stream or an aquifer that is hydraulically connected to a surface water source.² Consideration must be given to the needs of agricultural users prior to the ruling.

² For information on hydraulically connected aquifers within the Boundary region, please see the Kettle River Watershed Management Plan: Phase 1 Technical Assessment (Summit Environmental Consultants, 2012).

3.2 Provincial Drought Response Plans

The Boundary region is covered by the British Columbia Drought Response Plan (Province of BC, 2018). In March 2020, the Province shifted drought management of the Boundary region from the TOR to its Kootenay Boundary³ regional office (KBR). Prior to March 2020, the Boundary region was included in the TOR Drought Response Implementation Plan (Province of BC, 2016).⁴ The Provincial drought plan defines how Provincial drought levels are determined and identifies the roles and responsibilities during a drought for different groups including the Federal Government, Provincial Government, Regional (Provincial) Drought Management Team, and Local Governments. The Provincial Drought Response Plan focuses on the Provincial level drought response and guides the local level response.

4.0 Drought in the Kettle River Watershed

Drought is ultimately the lack of water, usually caused by a lack of precipitation over an extended period, resulting in water shortages for human and environmental needs (Province of BC, 2018). There are five types of drought: meteorological drought, hydrological drought, agricultural drought, socioeconomic and ecological drought (Province of BC, 2018; National Centres for Environmental Information, 2020).

- *Meteorological drought:* Dry weather patterns causing less precipitation compared to normal precipitation amounts for that time of year.
- *Hydrological drought:* Low water levels in rivers, lakes, aquifers or a combination of different sources, usually due to extended periods of low or no precipitation.
- *Agricultural drought:* When crops are affected from lack of available water in the soil or livestock do not thrive because of water availability concerns.
- *Socioeconomic drought:* Meteorological and hydrological drought so severe that there are impacts to the supply and demand of various commodities. The demand for an economic good exceeds the supply due to weather related events. Drought levels will affect tourism.
- *Ecological drought:* A prolonged and widespread deficit in regional water supplies (extended hydrological drought) that has resulted in multiple stresses across ecosystems.

The provincial drought levels are largely based on information associated with meteorological and hydrological drought.

³ Even though the Kootenay Boundary portion of the name is similar, the area defined by the RDKB is only the far western portion of the area covered by the KBR Provincial office.

⁴ As of June 2020, the RDKB continues to attend the TOR drought calls in order to remain up-to-date on drought concerns in the area, especially in the Okanagan Highland Plateau area.

4.1 Climate Characteristics and Drought Trends in the Kettle River Watershed

4.1.1 Climate Characteristics for the Kettle River Watershed

The north-south mountain ranges of the Okanagan Highland and Monashee Mountains plus associated valleys strongly influence the climate within the KRW. The KRW exhibits a snow (nival) dominated hydrological regime, resulting in a large spring melt (freshet) following by reduced precipitation during the summer months. There are no large glaciers in the KRW, as a result, the Kettle River does not respond to glacial melt as can often support streams during the summer months (Allen, Scibek, Wei, & Whitfield, 2004). The Boundary region covers two Ecodomain classifications, the area west of Greenwood classified as "Dry", while the areas east of Greenwood classified as "Humid Temperate" (Demarchi, 2011). With this humid temperate to semi-arid climate⁵, summer precipitation occurs mostly from convective activity, with winter precipitation mostly falling as snow (Scibek, Allen, Cannon, & Whitfield, 2007). The KWR normally experiences relatively hot drier summers, bordered by spring and fall rains. As meteorological and hydrological drought are strongly controlled by climate, the intensity and timing of the precipitation and temperature readings will dictate the presence and severity of the drought, especially during the late summer months. There are 10 active climate stations in the Boundary region (Table 4.1, Figure 4.1); managed by different organizations including Environment and Climate Change Canada (ECCC); Ministry of Environment and Climate Change Strategy (ECCS); Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD); and Ministry of Transportation and Infrastructure (MOTI).

Table 4.1 The 10 active climate stations in the Boundary region.

Owner or Manager	Station Name (Number)
ECCC	Billings near Grand Forks (No. 1140876)
ECCC	Midway (No. 1135126)
ECCS	Grano Creek (No. 2E07P)
FLNRORD – BC Wildfire Service	Beaverdell (No. 390)
FLNRORD – BC Wildfire Service	Idabell Lake (No. 1261)
FLNRORD – BC Wildfire Service	Rock Creek (No. 394)
FLNRORD – BC Wildfire Service	Grand Forks (No. 392)
FLNRORD – BC Wildfire Service	Eight Mile (No. 391)
FLNRORD – BC Wildfire Service	Nicoll (No. 393)
MOTI	McCulloch (No. 33099)

⁵ The Koppen climate classification for the Boundary region is Dfb: Humid Continental Mild Summer (PlantMaps, 2020).

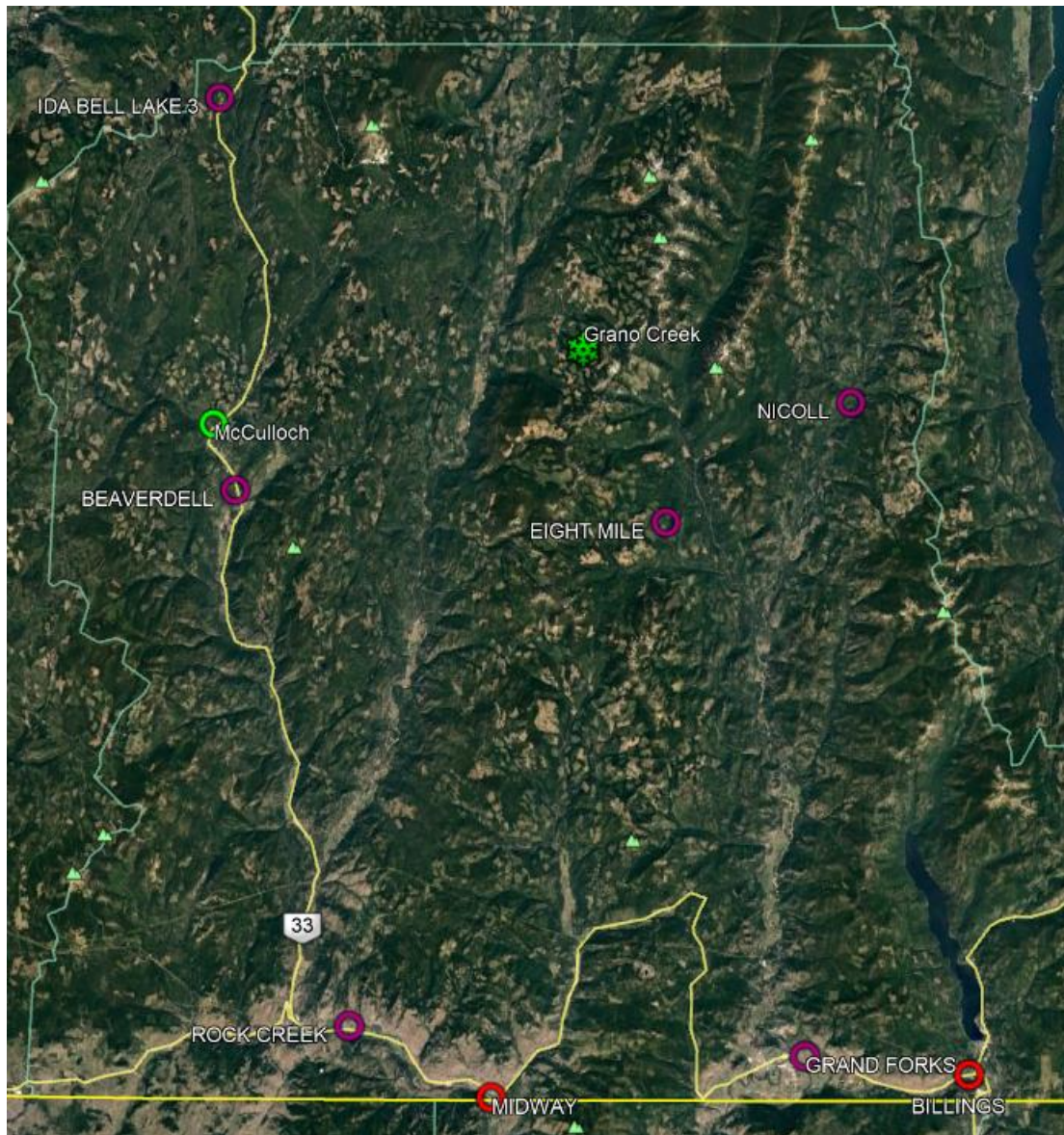


Figure 4.1 Location of the 10 weather stations in the Boundary region, as identified in Table 4.1, on 2016 Google Earth image.

Climate normals (Government of Canada, 2020) have been calculated from 1981 to 2010 for three stations in the Boundary: Grand Forks, Midway and Beaverdell North (Table 4.2). Grand Forks shows an annual average temperature and precipitation of 8.0°C and 534.3 mm respectively. Located to the northwest of Grand Forks and higher in elevation, Beaverdell North reports a drier and cooler climate with an average annual temperature and precipitation of 5.0°C and 485.9 mm, respectively. Midway, south of both Grand Forks and Beaverdell North has the lowest annual precipitation of the three stations, at 470 mm, and an average annual temperature between the two at 7.6°C .

Table 4.2 Environment Canada Climate Normals from 1981 to 2010 (Government of Canada, 2020)

	Grand Forks	Midway	Beaverdell North
Station Number	1133270	1135126	1130771
Latitude/Longitude	49.03N/118.47W	49N/118.77W	49.48N/119.05W
Elevation (m)	531.90	571.00	838.20
Annual daily average temperature (°C)	8.0	7.6	5.0
Coolest daily average temperature (°C) by month	-4.2 (December) -3.6 (January)	-4.3 (December) -4.2 (January)	-7.0 (December) -6.1 (January)
Warmest daily average temperature (°C) by month	19.9 (July) 19.7 (August)	19.3 (July) 18.7 (August)	15.9 (July) 15.6 (August)
Total annual precipitation (mm)	534.3	470.1	485.7
Lowest months of precipitation (mm)	28.8 (September) 29.1 (August)	22.3 (September) 24.6 (October)	27.9 (March) 29.0 (February)
Highest months of precipitation (mm)	62.5 (June) 60.2 (May)	70.6 (May) 58.4 (June)	61.8 (June) 54.4 (May)

4.1.2 Surface and Groundwater Monitoring

There are nine surface water level stations and three groundwater observation wells monitored in the Boundary region (Table 4.3 and Figure 4.2). These stations are monitored by Federal or Provincial governments, with the surface water monitoring occurring mostly on larger water systems within the Boundary region.

Table 4.3 Surface water and groundwater monitoring stations for the Boundary region.

Owner or Manager	Station Name (Number)
Water Survey of Canada	West Kettle River Near McCulloch (08NN015)
Water Survey of Canada	Trapping Creek near the mouth (08NN019)
Water Survey of Canada	Lost Horse Creek near Christian Valley (08NN028)
Water Survey of Canada	Kettle River near Westbridge (08NN026)
Water Survey of Canada	West Kettle at Westbridge (08NN015)
Water Survey of Canada	Granby River at Grand Forks (08NN002)
Water Survey of Canada	Burrell Creek above Gloucester Creek (08NN023)
NOAA ⁶	Kettle near Ferry (FRYW1)
NOAA	Kettle at Laurier (LAUW1)
BC Government	Beaverdell (Obs Well 306)
BC Government	Midway (Obs Well 444)
BC Government	Grand Forks (Obs Well 217)

⁶ National Oceanic and Atmospheric Administration, U.S. Department of Commerce

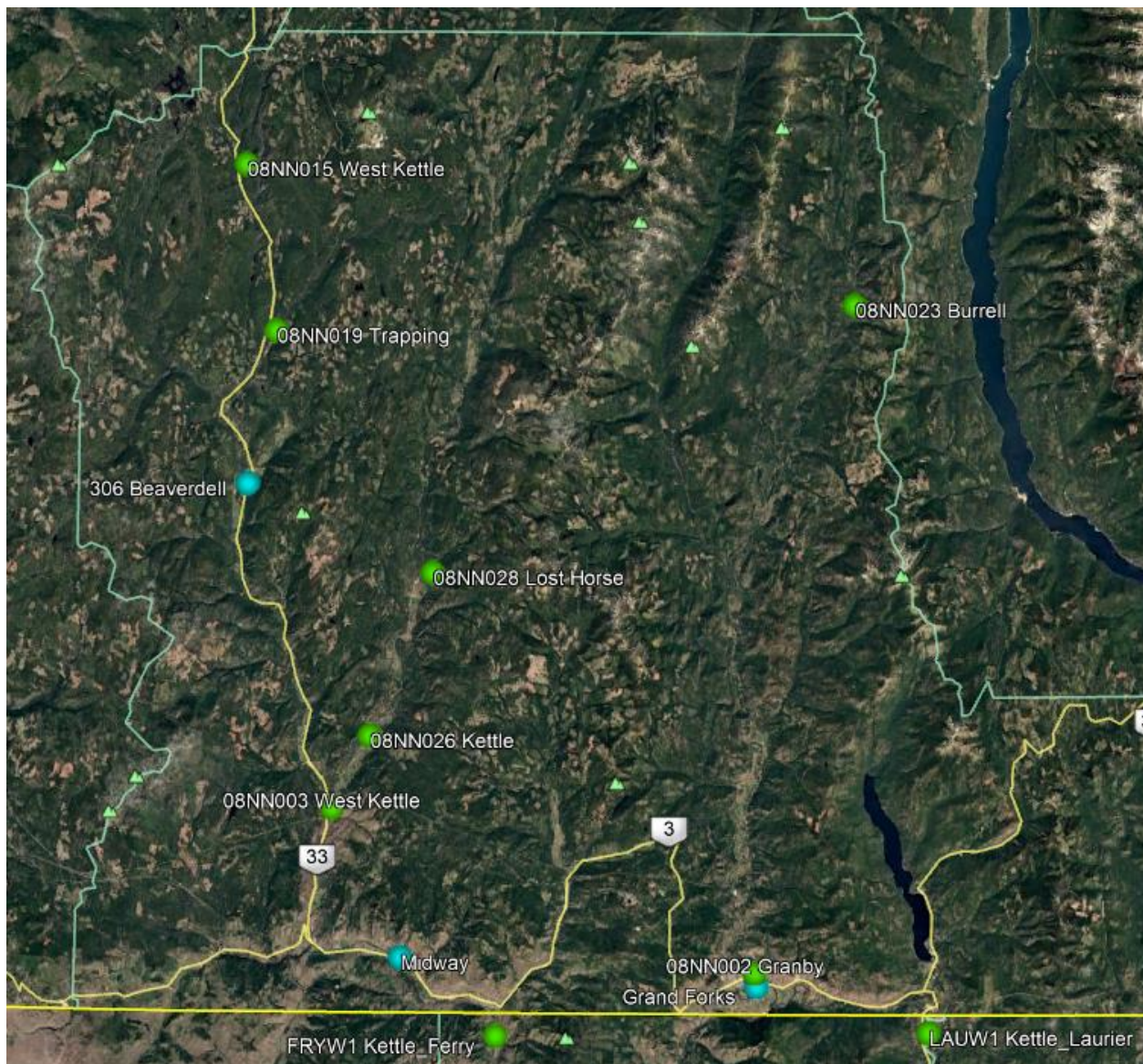


Figure 4.2 Location of surface and groundwater monitoring stations for the Boundary region (Table 4.3) on 2016 Google Earth image.

Realizing there is a connection between surface water and groundwater, monitoring the water level for both is important when trying to understand water availability and water movement in the Boundary region. Studies reported in 2007 showed that the Kettle River discharge is greater than the flow of water from its tributaries during the summer months (Scibek, Allen, Cannon, & Whitfield, 2007). On average, during freshet the Kettle River provides approximately 15% of its flow into aquifer storage (recharging the Grand Forks valley aquifer), and will release this water back into the Kettle over the next 30-60 days as baseflow (Scibek, Allen, Cannon, & Whitfield, 2007). When pumping from these hydraulically connected aquifers, a reduction in flow from the aquifer to the river (baseflow) can occur. As a result, to lessen the loss of water from surface water sources, a request to stop pumping from hydraulically

connected groundwater wells may be required. Due to the time lag between pumping from a groundwater well and the hydraulically connected surface water source, this request may be made before significant concerns have been identified. The length of time of the lag is dependent on a number of factors including the distance of the groundwater well from the surface water source, elevation change between the two locations, soil type, geology, and atmospheric conditions.

4.1.3 Historic Drought Trends in the Kettle River Watershed

A detailed hydrological assessment was completed for the KRW (Summit Environmental Consultants, 2012) assessing monthly discharge over a 70-year period by sub-watershed. No statistically significant increase or decrease of the Kettle River monthly discharge was found from 1929 to 2010. However, a slight downward trend (decrease in discharge) was observed from 1981 to 2010. Since 2010, drought has been experienced in the KRW a number of times, most recently during the years 2015, 2017, 2018 and 2019 (Table 4.4).

Drought conditions in the KRW can escalate quickly. In 2003, the watershed experienced above normal flows during the spring freshet, with flows declining rapidly during that summer months resulting in water levels becoming low enough to cause significant harm to fish (White, 2013). In 2017 and 2018, spring freshet was well above average,⁷ followed by low flows later in the season (Province of BC, 2020). Having many valleys in the Boundary region where the surface water and groundwater closely interact, often known as hydraulically connected aquifers, the practice of conserving surface and groundwater is essential.

Several drought records since 2006 illustrate the impacts:

- During the summer of 2006, one of the lowest levels since 1929 when records began, fish kills were reported in the lower section of the Kettle River, downstream of Christina Lake (Andrusak, 2007).
- In 2015, many areas in the KRW experienced significant disruption from both forest fires and drought conditions. As the residents of the Rock Creek area (Kettle and West Kettle Rivers) were battling wildfires, the water level in the West Kettle River was dropping significantly. Provincial staff advised the Regional District that they anticipated a need for regulatory action, which would include restricting water withdrawal, under the *Water Act*⁸ and *Fish Protection Act*. In the end, the arrival of fall rains stopped the need for the regulatory action. The record low water during the summer months is visible in the 2015 Kettle River hydrograph (Figure 4-3).

⁷ In 2018, a new peak discharge records were set for both the Granby and Kettle Rivers based on Water Survey of Canada monitoring data.

⁸ The BC Government *Water Sustainability Act* was brought into force in 2016, prior to this water use and management was regulated provincially by the *Water Act*.

- In 2017, the Province declared a drought level four (4) for the KRW. As a result, the Province to send letters to all non-domestic surface water licence holders recommending that they stop withdrawing water. Further discussion in Section 4.2.1.

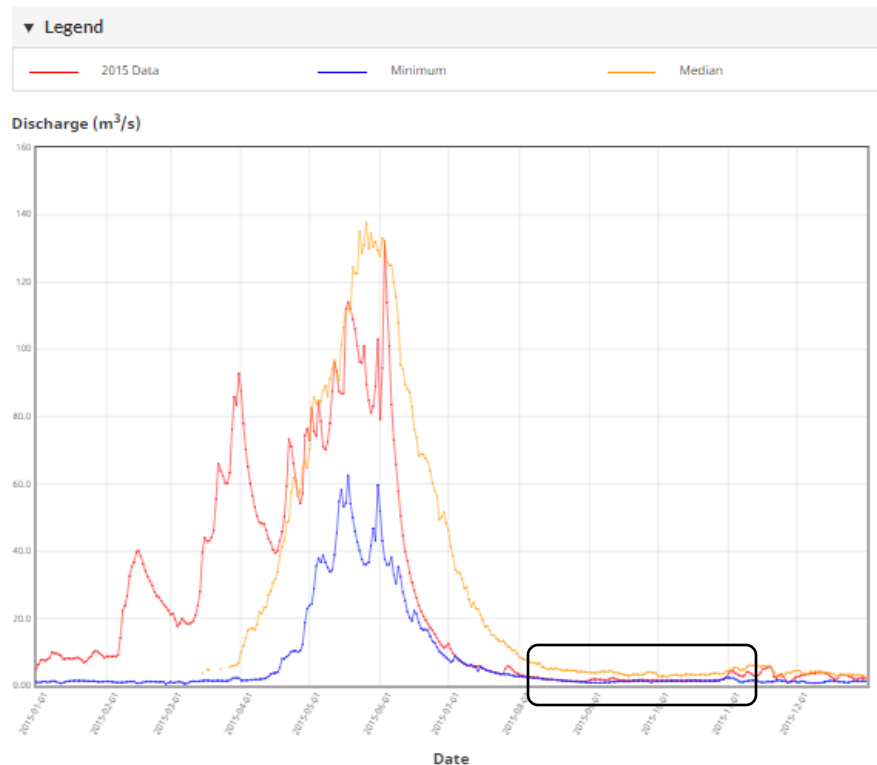


Figure 4.3 Kettle River near Westbridge (08NN026) year 2015, showing the daily flow (red), compared to the median (orange) and minimum (blue) flow values over a 40-year period 1975-2016. Highlighted by the black box, record low flows reported during the summer months.

4.1.4 Current Drought Trends in the Kettle River Watershed

Drought has been occurring through the KRW for decades. The Province determines the drought level for the KRW, which in turn directs Provincial response, a process explained in the DRP. Table 4-4 is a summary of the Provincial drought classification numbering and associated interpretation.

Table 4.4 Provincial drought level summary (Province of BC, 2018)

Level	Conditions	Significance	Objective
1 (Green)	Normal Conditions	There is sufficient water to meet human and ecosystem needs	Preparedness
2 (Yellow)	Dry Conditions	First indications of a potential water supply problem	Voluntary conservation
3 (Orange)	Very Dry Conditions	Potentially serious ecosystem or socioeconomic impacts are possible	Voluntary conservation and restrictions
4 (Red)	Extremely Dry Conditions	Water supply insufficient to meet socio-economic and ecosystem needs	Voluntary conservation, restrictions and regulatory action as necessary.

Unfortunately, the presence of high spring flows does not prevent or even indicate what might be the drought potential for the upcoming year. In the KRW, both floods and drought can and do happen in the same year (Table 4.5). In 2017 and 2018 after long periods of normal conditions (level 1: green) following the spring flooding, by mid to late summer most of the rivers in the KRW were experiencing low flows and very dry conditions (level 3: orange).

Another notable drought trend is the short transition times between drought levels. In 2015, the transition time between dry conditions (level 2) and extremely dry conditions (level 4) was approximately three weeks. Level 4 drought in 2015 was experienced very early in the season (July 23) causing negative impacts for both the agricultural community and those responding to wildfires. In 2017, the time between normal conditions (level 1) and extremely dry conditions (level 4) was approximately nine weeks. The following year, 2018, the time between normal conditions (level 1) and very dry conditions (level 3) was approximately four weeks.

Table 4.5 Provincial designated drought levels for KRW (Province of BC, 2020). Legend drought level: 1 (green), 2 (yellow), 3 (orange) and 4 (red).

	May 1 to 31	June 1 to 15	June 15 to 30	July 1 to 15	July 15 to 30	August 1 to 15	August 15 to 31	Sept 1 to 15	Sept 15 to 30
2015						July 23 rd , the KRW was separated from the ORW			
2016									
2017								Level 4 continued until Oct 26 th	
2018									
2019									

4.1.5 Projected Drought Trends in the Kettle River Watershed

The Pacific Climate Impacts Consortium calculates and interprets climate change forecasting for British Columbia, presenting data in a user-friendly format with the “Plan2Adapt” platform (University of Victoria, 2020). Forecasted climate trends for the RDKB in the 2050s⁹ compared to the baseline historical period of 1961-1990 include:

- Increase in annual mean temperature by +3.2 °C (+2.1 °C to +4.4 °C); and
- Annual increase in precipitation of +2.1 % (-3.3 % to +6.4 %); however a decrease in summer precipitation of -5.2 % (-39 % to +5.1 %) and increase in winter precipitation by +1.1 % (-3.7 % to +5.2 %).

With the forecasted increase in annual temperatures and precipitation, it is anticipated that the KRW will experience more rain during the winter months, which can both reduce the snow accumulation and contribute to more rain-on-snow events. The quantity and timing of snowmelt dictates the discharge and timing of the spring melt (freshet). Both of these factors have a large influence on the aquifer recharge and hydrological response in the KRW.

In a snow-dominated regime, the rivers recharge hydraulically connected aquifers during spring freshet. During the summer months, the same aquifers release water back to the rivers in the form of baseflow. A reduction in or loss of winter snowpack from either lack of accumulation or early freshet from a rain-on-snow event can affect the amount of water in both the rivers and aquifers, and ultimately the baseflow. If the Boundary experiences more water being released during freshet over a shorter period instead of a more gradual melt, very high water during the spring melt (freshet) could become more common.

Climate forecast modelling is not an exact science, and is strongly influenced by the dates used as the baseline,¹⁰ quality of data inputted, projected emission scenarios and interpretation of the results. Climate change projections will vary as different inputs are used and scientists work to estimate possible emission scenarios. For instance, PCIC often present forecasting using the high emissions scenario, RCP¹¹ 8.5, to help people prepare for the worst, whereas the Research Climatologist Colin Mahony from the Chief Foresters Office, FLNRORD, focuses his projections using the moderate emissions scenario of RCP 4.5 as he feels it may be more representative of the local situation (Mahony & MacKillop, 2020). As a result, one can find varying climate projections for an area. Appendix 1 provides four examples of reports showing climate projections for the Boundary region and surrounding areas.

⁹ The forecast is based on the climate normals average from 2040 to 2069, and is represented by the year 2050.

¹⁰ Climate Normals are used as the baseline for climate forecasting. These normals are a 30-year average and represent the historical climate conditions to compare a modelled change in climate.

¹¹ RCP: Representative Concentration Pathways

1. Plan2Adapt: Kootenay Boundary 2050 and 2080 (University of Victoria, 2020), forecasts produced prior to the second version of the model being produced during Spring 2020.
2. BC Agriculture and Food Climate Action Initiative: Two Page Summary (BC Agriculture & Food Climate Action Initiative, 2019)
3. ClimateData.ca (Environment and Climate Change Canada, 2013) (Canadian Centre for Climate Services of ECCC, 2020) mean annual temperature and total precipitation for the community of Rock Creek.
4. Pacific Climate Centre (Prairie Climate Centre, 2019) projection for the Municipality of Grand Forks.

The point is to look at the overall trends; realizing projections are produced from and for varying interpretations, timelines and emission scenarios. With that in mind, the following provide some of the projections for the Boundary region derived using the high emission scenarios:

- The BC Agriculture and Food Climate Action Initiative (2019) reports that Grand Forks is projected to have an annual increase in temperature by 2050¹² of 3.2 °C and a 19 % reduction in summer precipitation but overall increase in annual precipitation;
- Using a baseline of 1976-2005, the Prairie Climate Centre (2019) reports that Grand Forks will experience a mean annual temperature increase of 2 °C (2021-2050) and 4 °C (2051-2080) compared to the baseline. Reports an overall mean annual increase in precipitation, with a small mean summer reduction in precipitation, 4 and 7 mm respectively, however reporting a very large range between 50-211 mm.
- The Canadian Centre for Climate Services of ECCC (2020) provides an annual (modelled) average temperature for Rock Creek of 6.4 °C between 1981-2010. With this modelled baseline and forecasting using the high emission scenario, the mean temperature is forecasted to increase to 8.1 °C for 2021-2050, 10 °C for 2051-2080 and 11.4 °C for 2081-2110. The modelled annual increase in precipitation, derived from an earlier baseline (1951-1980) of 500 mm, is projected to increase, based on the 30-year averages, at 4 %, 9 % and 10 % respectively.
- Summer flows on the Kettle River are projected to decrease due to the warmer temperatures and reduced summer precipitation (BC Agriculture & Food Climate Action Initiative, 2019).
- The timing of the peak flow for the rivers in the Boundary would shift to an earlier date in the event that Boundary experienced earlier warm spring temperatures (Prairie Climate Centre, 2019). This would also affect hydraulically connected aquifers such as the Grand Forks aquifer, which would

¹² The year 2050 is an average, and represents the period between 2040 and 2069.

be expected to show a similar timing shift to the river water level (Scibek, Allen, Cannon, & Whitfield, 2007).

- The growing degree days (GDD)¹³ are projected to increase throughout the KRW, with the Grand Forks areas reporting an increase of 756 GDD (base temperature of 5 °C) by the 2050s (BC Agriculture & Food Climate Action Initiative, 2019).

These climate change projections suggest a likely earlier and more intense drought conditions in the KRW, along with warmer and drier ecosystems throughout the Boundary region (Mahony & MacKillop, 2020). With a shift in precipitation patterns and the increase in GDD, residential and commercial water users may be inclined to increasing surface and groundwater water withdrawal, thereby placing additional pressure on some already strained water systems. Using projected climate change information, C. Mahony has Potential impacts from the climate change forecasts are widespread, affecting many business sectors, ecosystems and our public health (Climate Action Secretariat, 2016; BC Agriculture & Food Climate Action Initiative, 2019; Canadian Centre for Climate Services of ECCC, 2020).

4.2 Impacts from Drought in the Kettle River Watershed

4.2.1 Drought Impacts: Current and Historical

Many throughout the Boundary can provide personal experiences connected to drought. The following are a few examples of economic, ecological, health and safety impacts resulting from drought in the KRW:

Economic impacts:

- Agricultural: Early September 2017, level 4 drought was declared by the province. Letters were sent to non-domestic surface water licence holders requesting a 100 % reduction of all water withdrawal. Since the request for water reduction occurred near the end of the irrigation season, impacts to the agricultural community were minimal. If the request to reduce water withdrawal had been received earlier in the season, as was the case in other parts of BC, the potential for impact would have been much greater.
- Tourism and outdoor recreation: The KRW is an outdoor recreational tourism destination, with many outdoor activities directly or indirectly connected to our rivers and water levels, such as boating (motor and non-motor), water sports, fishing, biking, hiking, camping, ATV (All-Terrain Vehicle) use, horseback riding and the many different options in outdoor guiding. With

¹³ Growing degree days (GDD) is a weather-based indicator for assessing crop development. GDD are calculated by taking the average of the daily maximum and minimum temperatures compared to a base temperature (BC Agriculture & Food Climate Action Initiative, 2019). Base temperatures are usually 10 °C for grapes, and 5 °C for cereals and many grasses.

prolonged drought, river levels drop and water quality becomes a concern directly affecting fishing access, boating and all water sports. In addition, during periods of low water levels, the rivers are especially sensitive to bank erosion and sediment inputs as this can negatively affect the stream's water quality.

Ecological impacts:

- The number and size of rainbow trout in the Kettle River has diminished. Studies completed by the BC Government (Andrusak, 2007; White, 2013) indicates that Kettle River trout populations have suffered due to an increase in human activities, low flows and high temperatures. As a result, more stringent fishing regulations were put in place for the KRW in 2015, including catch and release for rainbow trout and a fishing ban for the Kettle River between July 25 and August 25 (Forests, Lands, Natural Resource Operations and Rural Development, 2019).
- Kokanee populations were impacted by drought conditions around Christina Lake, most recently during the low waters of 2017 and 2018. Insufficient water in many of the Kokanee spawning tributaries caused fewer fish being able to spawn as recorded during the Kokanee Salmon Enumeration Program run by the Christina Lake Stewardship Society.¹⁴
- The summer of 2017 was one of the driest on record for the Southern Interior resulting in significant increase in tree mortality and symptoms of drought stress. The most damage was observed in mature and semi-mature lodgepole pine stands and some mature Douglas-fir stands in the Kettle River and West Kettle River watersheds and some areas around Christina Lake (MacLauchlan & Buxton, 2018).

Health and Safety:

- There are many shallow domestic groundwater wells in the Boundary region. Many are domestic wells, and are typically shallower than the production wells located in the same aquifer. During periods of drought, these shallow wells will experience loss of water sooner as the water level in the aquifer drops. Over the past few years, very low water levels have been reported in domestic wells, particularly in the West Boundary.¹⁵ In 2017, one West Boundary resident described their domestic water level as being so low that the family could not use their house shower for the month of September.

¹⁴ Capyk, 2018. *Christina Lake Stewardship Coordinator correspondence, Nov. 13, 2018.*

¹⁵ Gee, 2017. *Personnel Communication with Director Gee, West Boundary resident about low domestic well level.*

4.2.2 Potential Future Impacts of Drought in the KRW

Water security is a current concern for many Boundary water users, a situation that will worsen following forecasted climate change and its effect on the ground and surface water systems, ultimately increasing the potential for water conflicts among users. If there is less water available for human use during the summer months, this could affect domestic drinking water supplies, businesses and livelihoods.

Some future impacts of droughts in the KRW could include:

Economic Impacts:

- Negative impacts to businesses: Loss of access to water from Provincial regulatory restriction on water use could significantly impact agriculture that is dependent on irrigation, tourism depended on outdoor recreation, and industries depended on water (such as for cooling). Furthermore, there would be indirect impacts to neighbouring businesses and affected employees.
- Diminished opportunities for economic growth as many streams in the KRW have a Water Allocation Restriction¹⁶ currently in place. These restrictions can identify a stream to be either (1) full allocated, recommending no additional water licences, or (2) possible water shortage, more information is needed before issuing any more water licence. Once a restriction has been placed on a stream, acquiring new water licences, other than for domestic use, can become very difficult.¹⁷ Water allocation restrictions also affect groundwater licence from a hydraulically connected aquifer. For the Boundary region, this could include many of the valley bottom aquifers, as they are often unconfined so are hydraulically connected to the surface water systems.
- Warmer winters with the possibility of increased precipitation may result in an increase in rain on snow events. This could change the stability of the snow in mountainous terrain, affecting the number of avalanches or landslides experienced. This could affect not only winter recreation, but also transportation routes through susceptible areas.

Ecological, health and safety impacts:

- As more people rely on access to groundwater, shallow wells may start experiencing increased periods of no water, as deeper wells are drilled and community wells support longer irrigation seasons and heavier use. Reducing the aquifers water level could cause a reduction in baseflow levels at nearby streams, water access for plants and riparian areas, and access to water in the shallow dug wells.

¹⁶ Information and definitions associated with Water Allocation Restrictions can be found at the following website: <https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-licensing-rights/water-allocation-restrictions>

¹⁷ Aubrey, 2019. *Personal Communication re: Water Allocation Restrictions*.

- Water quality impacts from increased algae presence, reduced dilution of any deleterious inputs (legal or illegal), or increased sedimentation from exposed banks could cause risks to drinking water and aquatic health.
- Periods of 'no flow' were predicted to occur in the KRW as early as 2050 (Watt & KRWMP Stakeholder Advisory Group, 2014). This could result in major risks to the aquatic and streamside ecosystems, including loss of spawning and rearing access for fish populations.
- As the water levels drop, many of the streams have experienced an increase in water temperature due to the high surface air temperature and reduction in shade vegetation caused by erosion and human disturbance. These high temperatures can be fatal to some Kettle River fish species, such as Rainbow Trout that may not survive at water temperatures above 24 °C (Andrusak, 2007).
- Loss of water for fire protection, both residential and wildfires.

4.3 Water Culture and Use in the Kettle River Watershed

For many water users, water in the Boundary region is considered abundant. For those that are charged, the fee for water use is either based on area or quantity of water used, with the quantity fee based method found to encourage water conservation. Water use in the Boundary Region is higher than in most other places in BC (Columbia Basin Rural Development Institute, 2012), which is likely, a combination of a warm and dry summer climate, and water use practices that do not adequately consider water resource limits (Watt & KRWMP Stakeholder Advisory Group, 2014). Based on information from the Kootenay Boundary Water Tool, the four main purpose categories for water licensing in the KRW are Agriculture, Commercial, Domestic/Municipal, and Power; with a fifth category "Other" used to contain the volume from water licences that do not fit into the other four categories (Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 2020). Agriculture accounts for approximately 77% (41,904,174 cubic meters per year) of the water licenced in the KRW (Figure 4.4).

Understanding the limitations of the availability of water is important towards water conservation and stewardship. In 2016, groundwater licensing become mandatory in British Columbia for all non-domestic users, as outlined in the *Water Sustainability Act*. Recognizing the role of groundwater as a fundamental component in the hydrological cycle has been vital as we implement drought management practices.

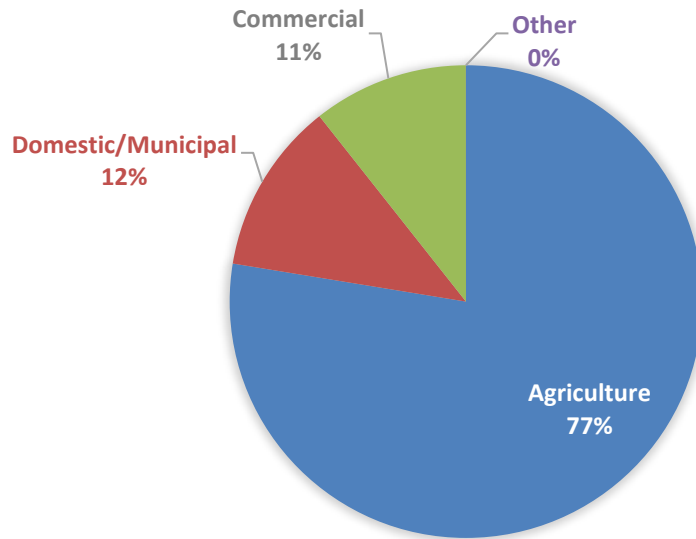


Figure 4.4 Water Licences for the Kettle River Watershed by total annual volume (surface and ground water combined), dated November 2020. (Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 2020).

The RDKB has been engaged in community education and outreach to increase awareness of water conservation and stewardship practices. These activities include:

- outreach booths at local events,
- workshops and presentations,
- community meetings and presentation on the state of the watershed, and
- social media communications.

These engagement strategies provide an opportunity to talk about our water legislation, watershed characteristics and future scenarios, to promote water-conserving practices, and to understand constraints to adopting those practices.

5.0 Drought Management Challenges

There are many challenges when attempting water conservation, drought management, and supporting water allocation among many different users. With effective water conservation practices and drought management, these efforts may lessen the need for the Provincial regulatory restriction of water use, while supporting all ecosystems in the KRW. Table 5.1 describes the environmental, socio-economic, governance and conditions of the Boundary region, and how these factors contribute to challenges encountered when managing for drought. Appendix 2 briefly summarizes these challenges, while suggesting options in responses.

Table 5.1 Drought management challenges in the Boundary region

	Regional Characteristic	Drought Management Challenge
1.0	Environmental Conditions	
1.1	KRW covers a large area	• Difficult to reach residents during drought with consistent messaging and one that is tailored to a specific water source.
1.2	Snow-melt (nival) dominated	• With a warmer spring, snow melting is forecasted to happen earlier. This could result in a longer period where rivers rely on groundwater inputs, baseflow, as their water source.
1.3	Semi-arid climate	• Long summers with higher temperatures and reduced summer rain can result in a higher water demand or need. • Warmer periods will increase evaporation potential.
1.4	Shallow un-confined aquifers prominent in valley bottoms	• High-demand aquifers closely connected to surface water. • High groundwater withdrawals worsen low flow conditions (Wei, Allen, Carmichael, & Ronneseth, 2010). • Many studies show the Grand Forks aquifer to be unconfined and at-risk. Fewer studies have been conducted on other aquifers in the region, so little information is known on potential impacts at these locations due to withdrawals, low water events, and a changing climate (Summit Environmental Consultants, 2012).
2.0	Socio-Economic Factors	
2.1	Popular angling destination	• Recovering from overfishing that occurred over past decades (Andrusak, 2007), the fish population in the Kettle River is vulnerable to low flows and the high temperatures. As a result, fishing closures may occur more often during these drought conditions.
2.2	Water use culture	• High to very high water use compared to other areas in BC (Columbia Basin Rural Development Institute, 2012) • Misunderstandings from residents related to the watershed such as the frequency, duration and intensity of drought (2015-2018) continue. (Collective Roots personal communication with residents at outreach events). • Sentiment that the Provincial Drought Levels are only in place to protect the fish, and that aquifers have unlimited available water. • Common belief that groundwater pumping from aquifers do not affect river water levels.
2.3	Agriculture is a major economic driver in the Boundary Region	• Some producers require 24 hours of watering due to their crop type or irrigation system. • During hot and dry weather, additional water is required to maintain crops. • Efficient irrigation systems can be expensive making it prohibitive to change current practices. • Many users still rely on surface water, without water storage back up, for irrigation.

	Regional Characteristic	Drought Management Challenge
		The Granby and West Kettle Rivers have water allocation restrictions in place; therefore, it is difficult to acquire a new surface water licences for non-domestic use.
2.4	Lack and expense of water storage infrastructure	- There is limited water storage in the KRW, with the exception of Christina Lake, the reservoirs at Big White and Baldy, and smaller agricultural reservoirs (dug outs). - Although water storage could be effective, the environmental risk and financial expense for developing a large-scale water storage, is often very high.
2.5	Land use practices	Barriers to implementing best management practices (BMP) increases risk of surface and groundwater contamination. The barriers to BMPs may include time, money, education or knowledge required for implementation.
3.0	Governance Structure	
3.1	Abundance of private wells governed by Province	Local Government reaching out to individual well owners to support water conservation recommendations but are not the groundwater regulator. When Grand Forks, Midway or Greenwood have implemented water use restrictions (bylaws), private well owners may not be following the same reduction in water use or may not have the infrastructure to change their water use practices.
3.2	Different management practices by large water users and water suppliers	Among members of the WSWG, there are different perspectives on how to respond to drought, and drought management. The concern is when two users are withdrawing from the same source but applying different water conservation practices.
4.0	Other Challenges	
4.1	No central data storage location, data not collected for all sources	- Water quantity and quality data is collected by some municipalities and Irrigation Districts, but there is no central data storage location. - Water quantity data is collected provincially but not for all sources or aquifers, including some larger tributaries such as Boundary Creek.
4.2	Introduction of non-domestic groundwater licensing requirement	To ensure that residents are aware of the new groundwater licensing requirement, for all non-domestic use, and apply for a licence prior to the revised deadline of March 1, 2022. An understanding of groundwater is essential to managing and understanding water availability.
4.3	Surface water quality	Surface water is commonly used by residents at Christina Lake as their domestic water source (RDKB, 2017). Although the water quality at Christina Lake is generally very good, the water quality from tributaries to the Lake are more susceptible to low flows and water quality issues.

6.0 Water Supplier Details

Interviews were conducted with a representation of Boundary water suppliers from different sized systems and purpose use within the KRW. In the end, this included all three municipalities, two irrigation districts, one community group, and one privately owned utility.¹⁸

Water Suppliers in the KRW rely on various water sources including reservoirs, surface water, groundwater or a combination of these sources. Information on the water supplier works, water licence and estimate water use up to 2012 can be found in the Phase 1 Technical Assessment by Summit Environmental (2012). Various governance structures exist including municipalities, improvement or irrigation districts (boards of directors), privately owned businesses, community groups, and the RDKB.

During the interviews, many water suppliers noted that they are already taking steps to help reduce water use and improve water quality. Some strategies include promoting water conservation year-round via social media, website and face-to-face interactions, implementing bylaws (some year-round) and installing water meters. Many cited that further measures could continue to be taken in support of water conservation.

Table 6.1 is a summary of Water Supplier details organized by sub-basin. The information in this table is a combination of details accessed from the Summit Environmental Consultants' report such as the water use type and licensed amounts of water (2012) and drought management specific interview responses collected during this study such as vulnerability to drought. Table 6.2 includes a summary of the current water conservation and drought management practices currently implemented by various water suppliers, as well as options for additional measures. For a list of names of the approximately 65 water suppliers recognized by Interior Health for the Boundary region one can either contact Interior Health directly or access this information through their website: <https://drinkingwaterforeveryone.ca/advisorymap/>.

¹⁸ Due to time constraints, interviews with all major water suppliers was not possible.

Table 6.1 Summary of Water Supplier drought vulnerability by sub-basin

Water User/Supplier	Governance Structure	Source(s) of Water	Groundwater Vulnerability/ risk of contamination	Drought Risk Level	Drought Risk Factors	Water Use Purpose	Licensed Water Use: 2012 Megalitres/year	Water Users Payment Structure
Sub-Basin 1 - West Kettle River								
Southeast Kelowna Irrigation District	Irrigation District	Surface Water (Tributary of West Kettle)	N/A	Moderate	Increasingly low flow trends in West Kettle however reservoir filled during freshet	Irrigation/Waterworks/ Storage	4317.2/414.8/ 5239.8	Unknown
Big White Water Utility Ltd.	Water Utility Ltd.	Surface Water & Reservoir	N/A	Moderate	Increasing demand however reservoirs filled during freshet	Waterworks/Commercial/ Snowmaking/Storage	49.8/8.3/ 3.7/597	By Volume
Individual Water Licence Holders	Province	Surface & Groundwater	High due to unconfined, shallow aquifers	High	Increasingly low flow trends in West Kettle	Irrigation/Other	3278.9/773.7	Provincial: volume and purpose
Sub-Basin 2 – Kettle River								
Individual Water Licence Holders	Province	Surface & Groundwater	High for un-confined aquifers	High	Increasing low flow trends in the Kettle and limited storage/reservoirs capacity compared to withdraw volumes from ground/surface water	Irrigation/Other	6116/965.6	Provincial: volume and purpose

Water User/Supplier	Governance Structure	Source(s) of Water	Groundwater Vulnerability/ risk of contamination	Drought Risk Level	Drought Risk Factors	Water Use Purpose	Licensed Water Use: 2012 Megalitres/year	Water Users Payment Structure
Sub-Basin 3 – Kettle River/ Midway								
Village of Midway	Municipal	Groundwater (Aquifer 478)	High	Moderate	Vulnerable aquifer but moderate demand	Waterworks	4314.2	Flat Rate
School District 51 Midway School	School District 51	Groundwater (Aquifer 478)	High	Moderate	Vulnerable aquifer but moderate demand	Irrigation/Drinking water	Unknown	Provincial: volume and purpose
Bridesville	Waterworks District	Groundwater (un-mapped aquifer)	Unknown	Unknown	N/A	Waterworks	Unknown	Flat Rate
Mt. Baldy Ski Resort	Waterworks Inc.	Surface (McKinney Creek) & Groundwater	Unknown	Moderate	Surface water use but new well drilled & storage used	Waterworks/Storage	16.7/127.5	Flat Rate
Individual Water Licence Holders	Water Licence from Province	Surface & Groundwater	High for un-confined aquifers	Moderate	Increasing low flow trends in the Kettle and minimal storage	Irrigation/Other	13249/1748.4	Provincial: volume and purpose
Sub-Basin 4 – Boundary Creek								
City of Greenwood	Municipal	Groundwater (un-mapped aquifer, most likely un-confined)	Moderate to High	Moderate	Likely un-confined aquifer but moderate demand	Waterworks	636	Flat Rate
Individual Water Licence Holders	Privately Held Water	Surface & Groundwater	Moderate to High	High	Low flow trends in Boundary Creek as creek can go	Irrigation/Mining/ Other	3920.4/331.9/ 933.8	Provincial: volume and purpose

Water User/Supplier	Governance Structure	Source(s) of Water	Groundwater Vulnerability/ risk of contamination	Drought Risk Level	Drought Risk Factors	Water Use Purpose	Licensed Water Use: 2012 Megalitres/year	Water Users Payment Structure
	Licence from Province				subsurface during summer months			
Sub-Basin 5 – Kettle River/ Grand Forks								
Covert Irrigation District	Irrigation District	Groundwater (Aquifer 158) Surface Water (July Creek)	High	High	High demand with history of low/no flows in July Creek	Irrigation	354.6	Flat Rate (domestic) By Area (agriculture)
SION Improvement District	Improve-ment District	Groundwater (Aquifer 158) & Surface Water	High	Moderate	Vulnerable aquifer with increasing orchard demands however very deep well	Waterworks	33.2	By Land Area
Individual Water Licence Holders	Water Licence from Province	Groundwater & Surface Water	High for un-confined aquifers	High	Low and no flows in streams	Other	52.5	Provincial: volume and purpose
Sub-Basin 6 – Granby River								
SION Improvement District	Improve-ment District	Groundwater (Aquifer 158) & Reservoir	High	Moderate	Vulnerable aquifer with high demand however deep well & reservoir system	Irrigation	389.9	By Land Area
City of Grand Forks	Municipal	Surface Water (Granby River) & Groundwater (Aquifer 158)	High	Moderate	Vulnerable aquifer with high demand however significant water conservation efforts	Waterworks	1493.4	By Volume

Water User/Supplier	Governance Structure	Source(s) of Water	Groundwater Vulnerability/ risk of contamination	Drought Risk Level	Drought Risk Factors	Water Use Purpose	Licensed Water Use: 2012 Megalitres/year	Water Users Payment Structure
Individual Water Licence Holders	Water Licence from Province	Groundwater (Aquifer 158) & Surface Water	High	High	Vulnerable aquifer with high demand, lack of reservoir/storage	Irrigation/Other	3006.2/89.8	Provincial: volume and purpose
Sub-Basin 7 – Kettle River/ Cascade								
City of Grand Forks	Municipal	Groundwater (Aquifer 158) & Surface Water (Kettle River, various creeks)	High	Moderate	Sensitive aquifer, high demand	Irrigation/Waterworks/ Ponds	1.3/829.6/ 5	By Volume
SION Improvement District	Improvement District	Groundwater (Aquifer 158)	High	Moderate	Sensitive aquifer, high demand	Waterworks/Irrigation	13.3/205.4	By Land Area
School District 51 Hutton/Perley Schools	School District 51	Groundwater (Aquifer 158)	High	Moderate	Sensitive aquifer, high demand	Irrigation	Unknown	Provincial: volume and purpose
Grand Forks Irrigation District	Irrigation District	Groundwater (Aquifer 158)	High	Moderate	Sensitive aquifer, high demand, well levels show good re-charge	Domestic/Irrigation	2919	Flat Rate
Christina Lake	Water Utility (RDKB)	Surface water (Christina Lake)	Low	Low	Very large water source with historically good water quality	Waterworks	599	Flat Rate

Water User/Supplier	Governance Structure	Source(s) of Water	Groundwater Vulnerability/ risk of contamination	Drought Risk Level	Drought Risk Factors	Water Use Purpose	Licensed Water Use: 2012 Megalitres/year	Water Users Payment Structure
Sutherland Creek	Waterworks District	Groundwater (Aquifer 479 & Aquifer 480)	Moderate/High	Moderate	One of two aquifers are sensitive; however, reservoir is used.	Waterworks	248.9	Unknown
Fife Water Users Community	Association	Reservoir fed by surface water (Italy & Sutherland Creek)	N/A	High	Small un-covered reservoir collecting year round from surface water	Domestic	Unknown	Flat Rate

Table 6.2 Summary from interviews with water supplier offering current drought management practices and next steps to consider

Current Drought Management Strategies	Main drought concerns for water source	Possible Next Steps
Water consciousness is part of culture and tourism (conservation notices in hotels & businesses)	Evaporation losses from reservoir, possible water quality issues in summer months	Further water metering
Water metering, restrictive use bylaws, land management practices, public outreach	Hydraulically connected aquifer with high demand	Monitor surface water levels upstream and downstream of withdrawal sites
Year-round promotion of water conservation through social media, website and bylaws	Risk that Creek flows subsurface	Further study of connectivity between surface water source and aquifer
Land management practices, high engagement with water users during watering restriction periods	Unconfined aquifer, unknown connectivity, industrial users share aquifer	Focus irrigation use on trees during Drought Level 3 and 4, reducing grass watering
High level of involvement and knowledge of water system including relationship with forestry	Evaporation losses, surface water reliance, water quality	Study required to determine volume of water in reservoir at capacity
Communication network (operator-to-client relationship), equipment leak checks	Hydraulically connected aquifer with high demand	Follow Municipal bylaws
Encourage water conservation via website and general communication network	Water consumption is unmetered, abandoned wells may pose water quality threat	Follow Municipal bylaws

7.0 Recommendations for Planning and Preparing for Drought

For effective drought management, the planning and preparing stage (Table 7.1) needs to happen continuously, throughout the year. Actions required in response to a current drought classification are described in the corresponding DRP. The recommendations in Table 7.1 identify the party or parties connected with each action; each party and their role in drought management is described below. Even though Table 7.1 was written for government and larger water users, many of the suggestions and recommendations can be altered to accommodate the needs of the small water user in support of water conservation.

7.1 Role of the Province in Drought Management

The role of the Province is to monitor the climate and hydrology in large watersheds, determine watershed-based drought levels, and issue streamflow advisories. The Province is responsible for monitoring water levels and flow, determining CEFT for critical streams and implementing regulatory action as per outlined in the WSA. As described in Section 3.0, the Province has developed various guiding documents for managing drought. The Province governs surface and groundwater water use by means of issuing and regulating water licences.

7.2 Role of the RDKB in Drought Management

The RDKB works with water suppliers and stakeholders to encourage water conservation and coordinate local drought management and response. They have the overall role of engaging and educating the public to improve the understanding and practices associated with watershed and drought management.

7.3 Role of Water Suppliers in Drought Management

The Water Suppliers are responsible for working with individual water users. Their governance structure often includes a board of directors or council who acts as the decision-making body. The Water Supplier operators makes recommendations to their board based on water supply data and provincial and regional recommendations.

The Water Suppliers are responsible for providing water, collecting fees, and providing information related to water conservation and drought when applicable. Water Supplier structure and procedures reference the provincial guidance document: *Dealing with Drought: A Handbook for Water Suppliers* (Province of BC, 2016). For the purpose of Table 7.1, the definition of Water Supplier includes Municipal and Independent Operators.

Table 7.1 Recommendations for the RDKB, Province, and Water Suppliers¹⁹ to plan and prepare for drought

#	Item	Recommendations	Responsible Party	Notes
1.	Public Engagement			
1.1	Public Outreach – General	Conduct public outreach activities as identified in the PES	RDKB	RDKB is responsible for distributing local information and engaging the public on, but not limited to, watershed issues, water conservation options and climate change projections for the KRW.
1.2	Public Outreach – Water Supplier Customers	- Communicate to customers on the current state of the watershed. - Identify a location where users can access information at any given time (e.g. on website page, seasonal newsletter, with bill).	Water Suppliers	Current communication strategies reported by water suppliers include; orientation packages for new user hook-ups, messaging on water bills, door-to-door outreach when issues arise and water user to water user interactions (Collective Roots Consulting, 2019).
1.3	Public Outreach - Individual Large Scale Users	- Continue dialogue with independent users through workshops and presentations. - Connection with large-scale users to determine most effective communication strategies.	RDKB Province	Communication still needs to be made by the RDKB with all large-scale users.
1.4	Public Outreach - Groundwater Licensing for non-domestic wells	- Consider holding additional workshops to support residents wanting to submit a groundwater licence application. - Additional advertising campaign for groundwater licensing for non-domestic wells.	RDKB to support as needed Province	During 2017 and 2018, the RDKB and Province funded watershed wide workshops to help residents license their pre-existing non-domestic groundwater use. More workshop are recommended.

¹⁹ Municipal and Independent Operators are combined under the Water Supplier label.

#	Item	Recommendations	Responsible Party	Notes
1.5	Public Outreach during a Drought	Public drought outreach could be a combined effort by the Province, RDKB, and Water Suppliers as outlined in the DRP and PES.	Province RDKB Water Suppliers	Refer to DRP and PES for details.
1.6	Public Awareness - Environmental Farm Plan (EFP)	- Consider supporting EFP advertising campaign how it can support improving irrigations systems, water conservation and drought management on agricultural lands. - Continue to support the Kootenay Boundary Farm Advisors (KBFA).	RDKB Province	- The EFP has incentives for water conservation and watershed protection. - The KBFA provides information and support to the Boundary agriculture community, promoting the EFP and conducting agricultural focused workshops.
2.	Communication			
2.1	Regional (Provincial) Drought Team	- RDKB to provide a LG liaison to represent Boundary in Provincial drought communications. - RDKB to record drought season actions and future drought recommendations by creating post-drought debriefs. - RDKB to supply information from Provincial drought meetings to Water Suppliers. - Water Suppliers to provide local information to RDKB.	Province runs meetings RDKB to participate Water Suppliers to provide information to RDKB	Provincial drought meetings allow for: - Efficient dissemination of information, - Two-way communication, - Early local awareness regarding when Provincial Drought Levels will be changed, and - Working together to develop communication that is sensitive to the local community.
2.2	WSWG meetings	- Hold WSWG meetings bi-annually. - Maintain Terms of Reference (TOR) and WSWG list of contacts. - Bring relevant information to the group, such as through workshops, presentations, presenters.	RDKB to hold WSGS meetings, to be attended by Water Suppliers (and Province when appropriate)	The KRWMP Action 1.4.2 pertains to development of a Water Supply Working Group. These meetings allow for information sharing, and water supplier coordination.

#	Item	Recommendations	Responsible Party	Notes
2.3	Provincial Drought Portal	Monitor drought portal (Province of BC, 2020) for new drought information.	RDKB Water Suppliers	This portal contains relevant and up-to-date information related to drought.
2.4	Provincial Water Authorization Specialist	- Regular communication between the RDKB and Water Authorization Specialist. - Coordinate partnerships for workshops and public meetings pertaining to water use in the KRW, especially in areas with WSA compliance concern.	RDKB and Province to coordinate	The Specialist could: - Attend WSWG meetings and public meetings to share information, and - Assist to plan and implement local workshops (such as a Groundwater Licensing Workshops).
3.0	Coordination with Indigenous Communities and First Nations			
3.1	Watershed Co-governance with Indigenous communities and First Nations	Continue engagement with the Indigenous communities through the Kettle River Watershed Advisory Council meetings.	RDKB	The Okanagan Nation Alliance has reviewed the Kettle River Watershed Management Plan through Enowkinwix (a process of decision making of accessing ideas through dialogue to ensure co-existence with Tmix (life force or everything in nature)).²⁰ This could be incorporated into future versions of the DMP.
4.0	Drought Response			
4.1	Drought Response Plan development based on source & sub-basin	- Develop coordinated drought responses based on drought risk in each sub-basin. - Consider including large private water users.	RDKB to support Water Suppliers via meetings and information	Interviews with the water suppliers indicated that unique features of sub-basin needs to be considered when responding to drought on a watershed wide basis.

²⁰ Terbasket, 2018. *Personal Communication Re: Kettle River Watershed Management Plan; Sylix (Okanagan) Centric Discussion Paper* (In development).

#	Item	Recommendations	Responsible Party	Notes
4.2	Emergency Plans for Loss of Water Supply	Create a 'Loss of Water Supply' plan for vulnerable sub-basins.	Water Suppliers to create plans for alternative supply options RDKB to support	Loss of water supply would be managed by RDKB Emergency Services under a task number from EMBC and dealt with on a case-by-case basis.
5.0	Data Collection and Management			
5.1	Data Management	Develop a data collection system where water suppliers can upload and store data either, included in or complimentary to the provincial monitoring system.	RDKB and Province	- The Province collects water levels and discharge in nine locations for surface water and three locations for groundwater. - Many of the water suppliers collect water data on a sub-basin aquifer level.
5.2	Community-Based Water Level Monitoring	Consider developing a Community-Based Water Monitoring group.	RDKB	As recommended in the KRWMP (Action 3.2.3), Stream Keepers Groups could be developed and could collect data on tributaries not currently monitored by the Province.
5.3	Data Collection	Consider installing real-time gauges in additional locations (e.g. Boundary Creek, downstream of Kettle and Granby confluence).	Province in coordination with the RDKB	
5.4	Data Monitoring	Consider having a secondary and/or backup monitoring system in place (e.g. in field observations) during a drought.	Province in coordination with the RDKB	During 2018 and 2020, inconsistency between observed flow and WSC reported rating curve discharge was significant, causing concern with the reliability of the real-time data.
6.0	Additional Considerations			
6.1	Stream Watch List	Regular review and update of the Boundary area Stream Watch list.	Province in coordination with the RDKB	Includes streams that are vulnerable to drought, have active surface water licences, and/or are fish

#	Item	Recommendations	Responsible Party	Notes
				bearing (such as July Creek and Boundary Creek).
6.2	Annual fishery closure in the KRW	- Consideration could be given to extending the current fishing ban to mid-September. - Some tributaries in the KRW should be considered for increased fishing restrictions (Forests, Lands, Natural Resource Operations and Rural Development, 2019).	Province	- Low flows and high temperatures have continued into September over the past few years. - Some KRW tributaries continue to be at risk of low flows.
6.3	Integrity of Natural Water Storage	Investigate land use regulations for industry (forestry, mining, ranching) and impacts on natural function of watershed storage (wetlands, forests, riparian areas).	RDKB and Province to coordinate	The Threat Assessment of Riparian Areas (Coleshill & Watt, 2017) found that the cumulative impacts from industry in the KRW were high enough to impact watershed function integral to sustaining water health.
6.4	Water storage	Support the use and/or investigation of maintained and well-managed dugouts by independent water users.	RDKB through the KBFA	Large-scale water storage is expensive but smaller scale water storage may be obtainable.
6.4	Bylaws	Consider developing enforceable bylaws related to water use restrictions, with a focus on areas with high vulnerability to drought.	Water Suppliers RDKB	In some areas, bylaws are in place to support water restrictions.
6.5	Drought resistant species of plants	Consider planting drought resistant plants and use xeriscaping techniques.	Water Suppliers (in particular Municipalities)	Encourage the planting of drought tolerant plant species and agricultural practices that support water conservation.

8.0 Drought Management Team

The Province of BC has recommended in the Dealing with Drought: Handbook for Water Suppliers Report (Province of BC, 2016) that local authorities develop a local Drought Management Team (DMT). The DMT could include representation from water suppliers, First Nations, local government and water user groups including industry and agriculture. The first suggestion in the handbook is for local government to review current groups to determine if an existing group could act as the DMT. The Kettle River Watershed Advisory Council (KRWAC) may be a fit for a regional DMT as they are composed of a broad range of Boundary stakeholders; a sub-committee may be required that would focus on the implementation of the DMP and DRP.

Many of the responsibilities outlined in the Handbook for Water Suppliers were taken on by RDKB consultants in the past and have been included in the recommendations table above (Table 7.1). These include items such as:

- Public outreach,
- Interacting with politicians to manage drought, and
- Interacting with stakeholders.

Items yet to be address include data collection and identifying goals and timelines for water reduction. It is recommended that the DMT would support and guide future drought management actions along with implementing recommendations in this DMP.

9.0 Conclusion

Warm and drier summers are common in the KRW. With climate change projections, drought conditions may occur more often, start earlier and last longer. Recognizing water is a finite resource, water security is vital towards the ecological, economic and health sustainability of the KRW. Joint water conservation efforts and collective decision-making are needed for effective drought management, a necessary step towards a resilient KRW.

This DMP outlines water conservation and drought management key actions focused on reducing the severity of drought and the associated negative impacts, and provides information and methodologies toward minimizing the economic, social and environmental impacts associated with drought in the Boundary. Information presented throughout this report is summarized in Appendix 2, focusing on the challenges experienced in the Boundary region and recommendations towards addressing them.

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Appendix 1 Climate Change Projections and Forecasting

- 1. Plan2Adapt: Kootenay Boundary 2050 and 2080 (University of Victoria, 2020). Projections produced using the old version of the Plan2Adapt tool. Tool was updated in the Spring of 2020.



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Summary of Climate Change for Kootenay Boundary in the 2050s

Climate Variable	Season	Projected Change from 1961-1990 Baseline	
		Ensemble Median	Range (10th to 90th percentile)
Mean Temperature (°C)	Annual	+1.9 °C	+1.2 °C to +2.8 °C
Precipitation (%)	Annual	+6%	-2% to +10%
	Summer	-11%	-23% to -2%
	Winter	+6%	-4% to +17%
Snowfall* (%)	Winter	-14%	-23% to -1%
	Spring	-56%	-76% to -12%
Growing Degree Days* (degree days)	Annual	+361 degree days	+206 to +528 degree days
Heating Degree Days* (degree days)	Annual	-687 degree days	-975 to -417 degree days
Frost-Free Days* (days)	Annual	+24 days	+14 to +36 days

The table above shows projected changes in average (mean) temperature, precipitation and several derived climate variables from the baseline historical period (1961-1990) to the **2050s** for the **Kootenay Boundary** region. The ensemble median is a mid-point value, chosen from a PCIC standard set of Global Climate Model (GCM) projections (see the 'Notes' tab for more information). The range values represent the lowest and highest results within the set. Please note that this summary table does not reflect the 'Season' choice made under the 'Region & Time' tab. However, this setting does affect results obtained under each variable tab.

* These values are derived from temperature and precipitation. Please select the appropriate variable tab for more information.

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Summary of Climate Change for Kootenay Boundary in the 2080s

Climate Variable	Season	Projected Change from 1961-1990 Baseline	
		Ensemble Median	Range (10th to 90th percentile)
Mean Temperature (°C)	Annual	+2.9 °C	+1.7 °C to +4.6 °C
Precipitation (%)	Annual	+6%	+2% to +14%
	Summer	-14%	-31% to +6%
	Winter	+11%	+2% to +27%
Snowfall* (%)	Winter	-21%	-41% to -6%
	Spring	-78%	-89% to -17%
Growing Degree Days* (degree days)	Annual	+541 degree days	+315 to +955 degree days
Heating Degree Days* (degree days)	Annual	-1006 degree days	-1577 to -606 degree days
Frost-Free Days* (days)	Annual	+38 days	+20 to +62 days

The table above shows projected changes in average (mean) temperature, precipitation and several derived climate variables from the baseline historical period (1961-1990) to the **2080s** for the **Kootenay Boundary** region. The ensemble median is a mid-point value, chosen from a PCIC standard set of Global Climate Model (GCM) projections (see the 'Notes' tab for more information). The range values represent the lowest and highest results within the set. Please note that this summary table does not reflect the 'Season' choice made under the 'Region & Time' tab. However, this setting does affect results obtained under each variable tab.

* These values are derived from temperature and precipitation. Please select the appropriate variable tab for more information.

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2. BC Agriculture and Food Climate Action Initiative: Two Page Summary (BC Agriculture & Food Climate Action Initiative, 2019)



Climate Action Initiative
BC AGRICULTURE & FOOD

Kootenay and Boundary

Climate Change Scenarios: 2020, 2050 & 2080

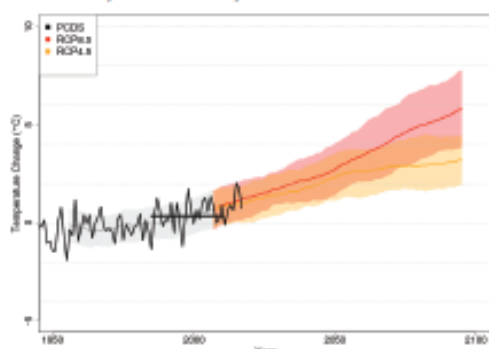
TEMPERATURE (by 2020 & 2050)

- Annual average is 1.6°C warmer (by 2020) (+3.2°C by 2050) Baseline¹: 2.5°C
- 24 more frost free days annually (by 2020) (+49 days by 2050) Baseline: 155 days
- 266 more growing degree days² annually (by 2020) (+580 days by 2050) Baseline: 969 days

¹ Baseline (for all variables) is the average of the variables from 1971 to 2000.

² Growing degree days (GDD) is a weather-based indicator for assessing crop development. GDD are calculated by taking the average of the daily maximum and minimum temperatures compared to a base temperature (usually 10°C for grapes; 5°C for cereals and many grasses). GDD accumulate over the growing season.

Change in Annual Average Temperature in Kootenay and Boundary

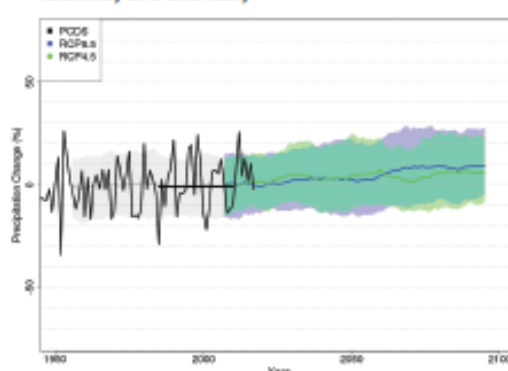


RCP (Representative Concentration Pathways) 8.5 is a high GHG emissions model. RCP 4.5 is a medium GHG emissions model. The bold coloured lines indicate the mid-point of the models, shading indicates the projected model range. The black line represents PCDS (Provincial Climate Data Set) and is the historic climate data collected from BC.

PRECIPITATION (by 2050)

- Grand Forks
Spring +12% (baseline: 150mm)
Summer -15% (baseline: 125mm)
Winter +7% (baseline: 150mm)
- Creston
Spring +11% (baseline: 156mm)
Summer -13% (baseline: 133mm)
Winter +6% (baseline: 192mm)
- Cranbrook
Spring +12% (baseline: 111mm)
Summer -11% (baseline: 146mm)
Winter +7% (baseline: 119mm)
- Invermere
Spring +13% (baseline: 83mm)
Summer -9% (baseline: 144mm)
Winter +8% (baseline: 79mm)

Change in Annual Average Precipitation in Kootenay and Boundary



Source (both graphs): Pacific Climate Impacts Consortium. Additional info at: <https://pacificclimate.org/data/statistically-downscaled-climate-scenarios>

HYDROLOGY

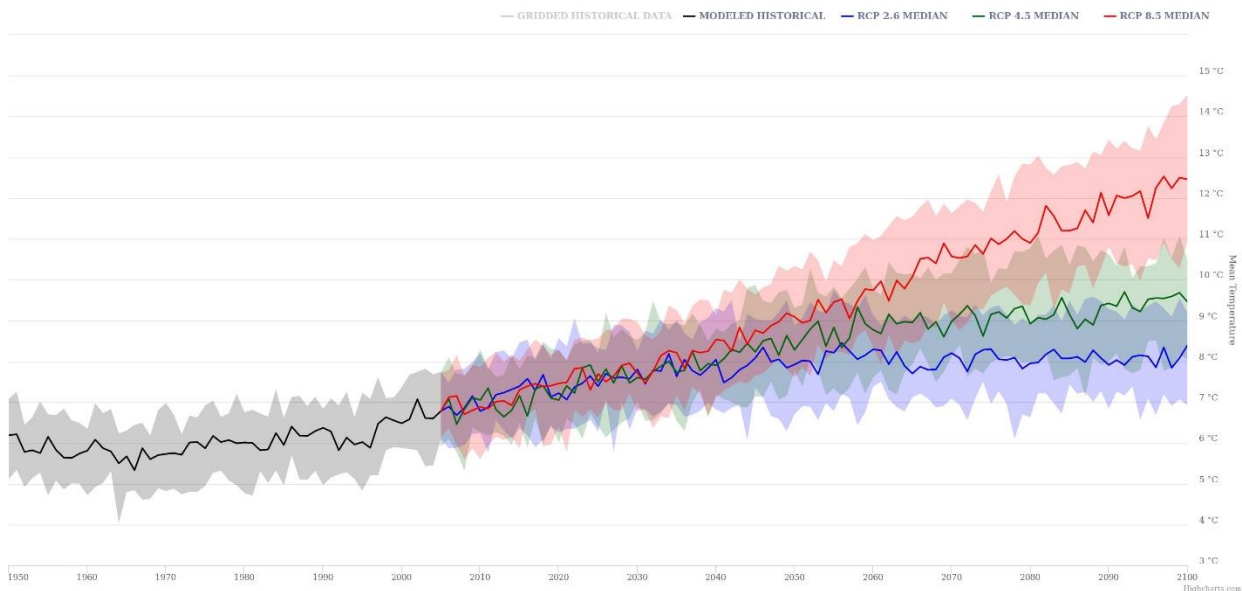
- Less precipitation falling as snow due to warmer temperatures, less snow pack building and converting to spring runoff
- Increased streamflow in winter (Columbia & Kootenay River watersheds)
- Decreased streamflow in summer (Columbia -1%, Kootenay -36%)
- Snowpack may melt more quickly in spring, increasing flows

Hydrology and Extremes Source: Pacific Climate Impacts Consortium

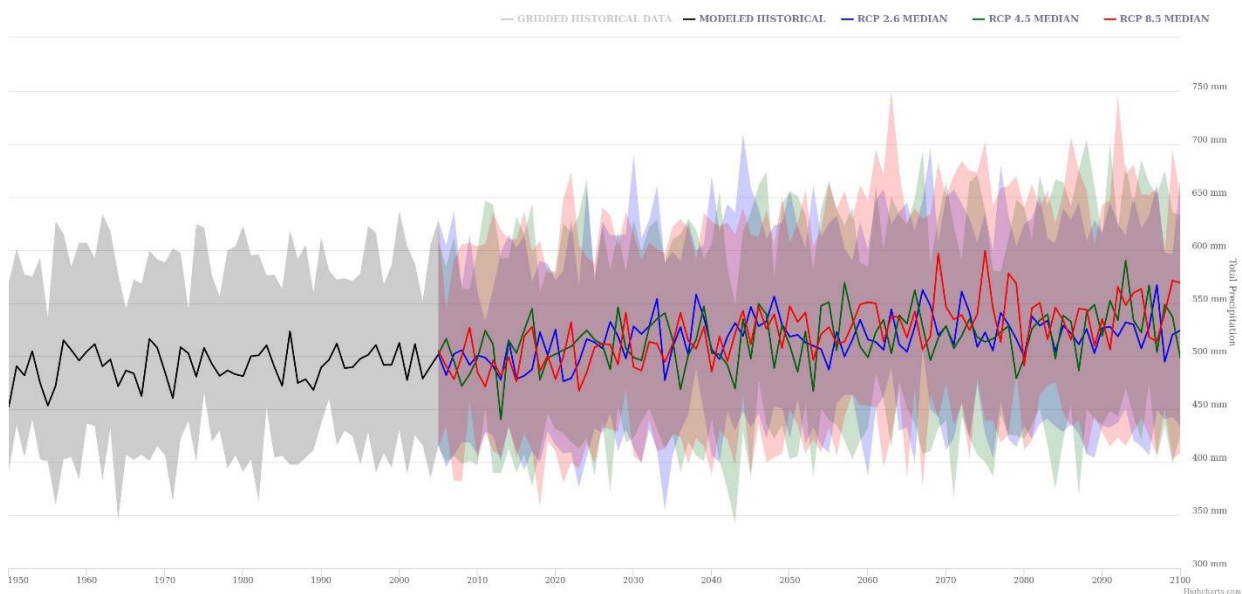
EXTREMES (2050)

- Over twice the number of days over 25°C
Baseline: 19 days. +25 days by 2050 (+48 days by 2080)
- Over 3 times the number of days over 30°C
Baseline: 4 days. +13 days by 2050 (+26 days by 2080)
- Increased frequency and magnitude of extreme rainfall events (particularly in winter and fall)
- 23% reduction in annual frost days (nights when the minimum temperature drops below 0°C)
Baseline: 210 days. -49 days by 2050 (-82 days by 2080)

3. ClimateData.ca (Canadian Centre for Climate Serices of ECCC, 2020)
Location: community of Rock Creek, B.C.



Projected change in the mean temperature for the community of Rock Creek. ClimateData.ca.



Projected change in the total precipitation for the community of Rock Creek. ClimateData.ca

4. Prairie Climate Centre (2019) Climate Atlas of Canada (version 2)

Location: Municipality of Grand Forks, BC

Climate Atlas Report

Municipality: Grand Forks



RCP 8.5: High Carbon climate future

GHG emissions continue to increase at current rates

Variable	Period	1976-2005 Mean	2021-2050			2051-2080		
			Low	Mean	High	Low	Mean	High
Precipitation (mm)	annual	641	530	666	811	548	699	863
Precipitation (mm)	spring	158	107	167	238	115	177	247
Precipitation (mm)	summer	133	59	129	211	51	126	208
Precipitation (mm)	fall	141	85	146	212	94	156	226
Precipitation (mm)	winter	209	147	223	300	159	240	332
Mean Temperature (°C)	annual	5.9	6.7	7.9	9.1	8.3	9.9	11.4
Mean Temperature (°C)	spring	5.8	5.8	7.8	9.9	7.4	9.5	11.6
Mean Temperature (°C)	summer	16.2	16.8	18.4	20	18.5	20.7	22.9
Mean Temperature (°C)	fall	5.9	6	7.6	9.1	7.7	9.6	11.5
Mean Temperature (°C)	winter	-4.4	-5.2	-2.5	-0.2	-3.3	-0.6	1.9
Tropical Nights	annual	0	0	0	0	0	2	6
Very hot days (+30°C)	annual	15	13	29	47	27	48	70
Very cold days (-30°C)	annual	0	0	0	0	0	0	0
Date of Last Spring Frost	annual	May 10	March 23	April 21	May 15	Feb. 21	April 1	May 5
Date of First Fall Frost	annual	Sep. 28	Sep. 20	Oct. 8	Oct. 25	Sep. 30	Oct. 20	Nov. 7
Frost-Free Season (days)	annual	138	134	166	202	158	199	246

RCP 4.5: Low Carbon climate future

GHG emissions much reduced

Variable	Period	1976-2005 Mean	2021-2050			2051-2080		
			Low	Mean	High	Low	Mean	High
Precipitation (mm)	annual	640	528	666	815	536	677	823
Precipitation (mm)	spring	158	110	167	229	114	171	238
Precipitation (mm)	summer	133	60	129	211	55	125	206
Precipitation (mm)	fall	141	88	150	210	87	150	217
Precipitation (mm)	winter	209	143	222	302	149	229	316
Mean Temperature (°C)	annual	5.9	6.4	7.6	8.8	7.3	8.7	10
Mean Temperature (°C)	spring	5.8	5.5	7.6	9.7	6.6	8.6	10.6
Mean Temperature (°C)	summer	16.2	16.5	18.1	19.8	17.2	19.2	21.2
Mean Temperature (°C)	fall	5.9	5.8	7.4	8.9	6.6	8.3	9.8
Mean Temperature (°C)	winter	-4.4	-5.3	-2.8	-0.6	-4.1	-1.7	0.5
Tropical Nights	annual	0	0	0	0	0	0	1
Very hot days (+30°C)	annual	15	12	27	44	16	36	57
Very cold days (-30°C)	annual	0	0	0	0	0	0	0
Date of Last Spring Frost	annual	May 10	March 30	April 27	May 17	March 11	April 15	May 13
Date of First Fall Frost	annual	Sep. 27	Sep. 18	Oct. 6	Oct. 24	Sep. 22	Oct. 11	Oct. 28
Frost-Free Season (days)	annual	137	129	160	194	138	176	219

Where did this data come from?

Global Climate Models (GCMs) are used to depict how the climate is likely to change in the future. Since no one climate model can be considered 'correct', it is important to use many GCMs to capture a range of possible conditions. The GCM data we used were obtained from the Pacific Climate Impacts Consortium (PCIC). PCIC collected temperature and precipitation data produced by 24 different models and used advanced statistical techniques to create high-resolution (daily, 10km) versions of the data for all of Canada (for more information visit pacificclimate.org).

What are the RCP 8.5 and RCP 4.5 future climate scenarios?

One of the most important inputs into GCM simulations of the future climate is the expected concentration of greenhouse gases (GHGs; especially carbon dioxide) in the atmosphere as a result of human activity. In the scientific literature these future GHG concentrations are used to calculate Representative Concentration Pathways (RCPs). The High Carbon scenario (RCP8.5) assumes that we continue to emit very large amounts of carbon dioxide from the burning of fossil fuels; the Low Carbon scenario (RCP4.5) assumes that drastic reductions of emissions in the coming decades will stabilize the concentration of GHGs in the atmosphere by the end of this century. We did not use RCP2.6, an even lower emissions scenario.

How are the minimum, mean, and maximum calculated?

We used an ensemble of 24 different GCMs to analyze the future climate. The mean values are the average values of this ensemble over the 1976-2005, 2021-2050 and 2051-2080 periods. The range of values in each time period is indicated by the High (90th percentile) and Low (10th percentile) values in the tables. This means about 10% of the predicted values are above the "High" value, and 10% are lower than the "Low" value.

The Climate Atlas of Canada

The Climate Atlas of Canada (climateatlas.ca) is an interactive tool for citizens, researchers, businesses, and community and political leaders to learn about climate change in Canada. It combines climate science, mapping and storytelling to bring the global issue of climate change closer to home, and is designed to inspire local, regional, and national action and solutions.

Source

Prairie Climate Centre (2019). Climate Atlas of Canada, version 2 (July 10, 2019). <https://climateatlas.ca>

Disclaimer

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Appendix 2 Summary of Drought Management Challenges and Actions

Regional characteristics and drought management challenges from Table 5.1 are summarized below, along with recommended or suggested actions in an effort to improved water conservation, watershed and drought management here in the KRW.

	Regional characteristic	Drought management challenge	Suggested response to challenges as described in this DMP
1.0	Environmental Conditions		
1.1	KRW covers a large area	Communication for specific water source(s).	Refer to PES
1.2	Snow-melt (nival) dominated	Climate change projects, could negatively impact water levels, including baseflow quantity.	Table 7.1: Recommendations for the RDKB, water suppliers, and the Province to work together for coordinated drought management.
1.3	Semi-arid climate	Hot and dry summers can reduce water levels, while increase evapotranspiration potential.	Table 7.1: Recommendations for the RDKB and Province to promote water conservation, the EFP and KBFA efforts.
1.4	Shallow un-confined aquifers prominent in valley bottoms	Groundwater withdrawals from hydraulically connected aquifers can affect surface water levels.	Table 7.1: Recommendations for the RDKB and water suppliers to work together to develop coordinated drought management practices and drought response. Refer to PES for public education activities.
2.0	Socio-Economic Factors		
2.1	Popular angling destination	Overfishing and drought conditions has resulted in fishing closures.	Table 7.1: Recommendation for the Province to consider additional fishing closures tied to water level and temperature needs.
2.2	Water use culture	Boundary region has higher water use compared to BC average, efforts needed to increase water conservation and efficient use of both surface and groundwater.	Table 7.1: Recommendations to water suppliers to increase water conservation tactics, which could include bylaws, change in payment systems, water meters, etc. Refer to PES for public engagement activities.
2.3	Agriculture is a significant economic driver for the Boundary Region	Implementing effective agricultural water use can be expensive and often requires a change in practice. New water licences are becoming hard to acquire, these new water-conserving practices could be essential for long-term viability.	Table 7.1: Recommendations for the RDKB and Province to promote and support EFP and KBFA efforts.
2.4	Lack and expense of	Minimal water storage potential occurring in the Boundary region.	Table 7.1: Recommendations for RDKB to review

	water storage infrastructure		possibility of supporting small-scale agriculture water storage.
2.5	Land use practices	Not implementing Best Management Practices, which can lead to surface and groundwater contamination.	Table 7.1: To build and maintain relationships with industry (i.e. forestry, mining, ranchers) in support and protection of water quality and water use.
3.0	Governance Structure		
3.1	Abundance of private wells governed by Province	Working with private well owners to reduce water use in-line with drought recommendations.	Table 7.1: Recommendations for RDKB to continue outreach to large scale water users. Refer to PES for public engagement activities.
3.2	Different management practices by large water users and water suppliers	Problems when different water conservation and drought management actions occur from users withdrawing from the same source.	Table 7.1: Recommendations for RDKB and water suppliers to continue WSWG meetings, improve communication and education on water conservation.
4.0	Other Challenges		
4.1	No central data storage location, data not collected for all sources	Increased need for publically available hydrological data on various sized water sources.	Table 7.1: Recommendations for RDKB and Province to develop and maintain a publically available data storage system.
4.2	Introduction of non-domestic groundwater licensing requirement	Non-domestic groundwater licensing is now mandatory in BC; deadline for existing applications is March 01, 2022.	Table 7.1: Recommendations for Province to consider additional advertising and workshops. RDKB to support.
4.3	Surface water quality	Water quality concerns can be more common when water levels are low due to less water for dilution, increased sediment and increased biological contamination.	Table 7.1: Recommendations for RDKB and province to develop and continue water quality data collection and storage of information, which would include the Christina Lake tributaries.