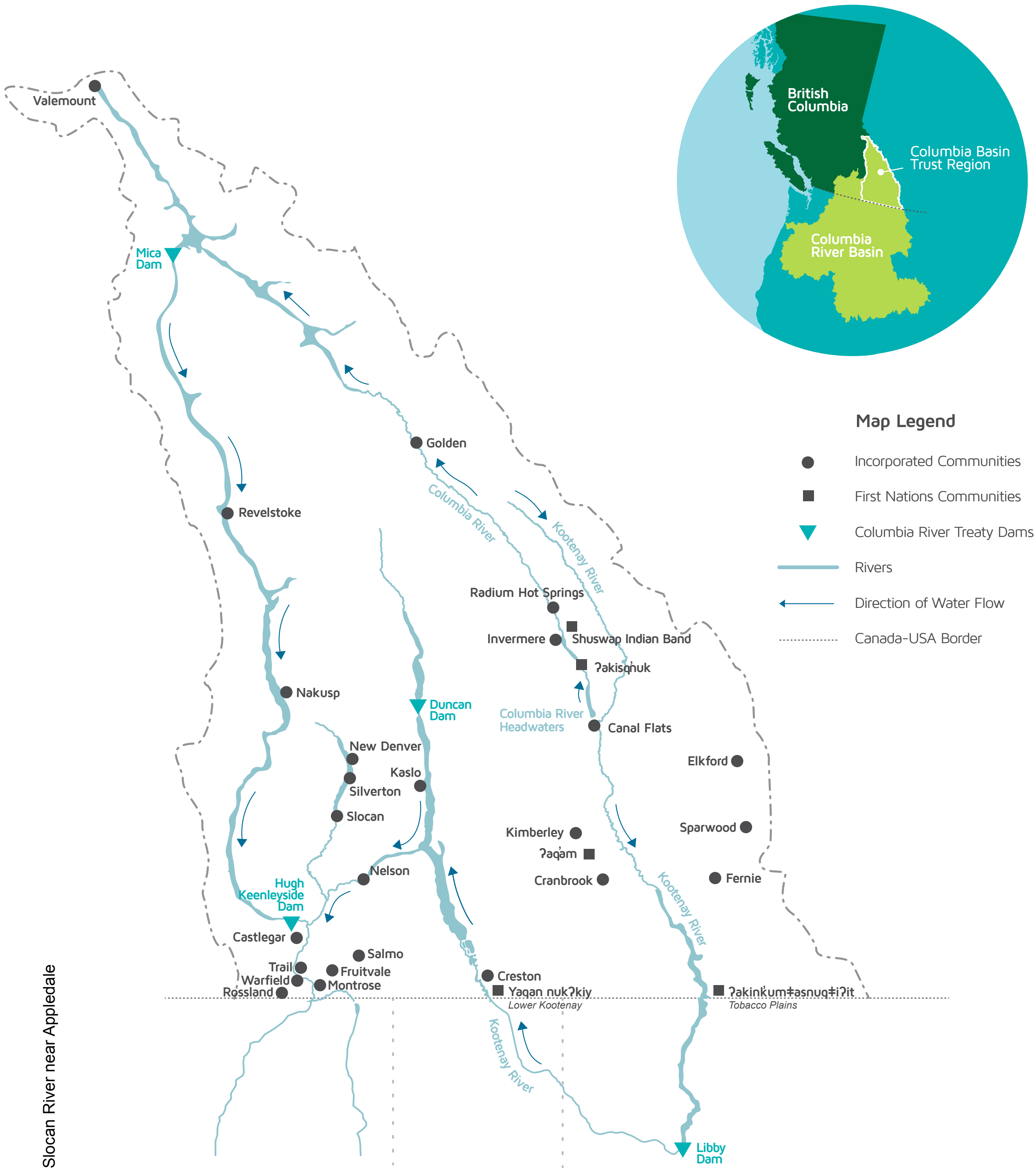
Highlights:
Water Monitoring and Climate Change in the Upper Columbia Basin

Columbia Basin Trust Region



Cover: Slocan River near Appledale


Tributary creek to Kootenay Lake

Introduction

A natural abundance of clean, fresh water defines the Columbia River Basin in Canada, and is an indispensable element of ecosystems and communities across the region. The region's water resources occur in a variety of forms, including rivers, streams, lakes, wetlands, groundwater, snowpack and glaciers. Since both climate and land use can influence the quality and quantity of water resources, understanding relevant changes and trends is increasingly important for communities and resource managers.

Responding to growing demand for current information about water resources, Columbia Basin Trust (the Trust) commissioned a study about water knowledge in the Trust region (Basin). The findings are presented in a report titled *Water Monitoring and Climate Change in the Upper Columbia Basin*. Highlights of the report are summarized here, including information about the Basin's hydrologic regions and water resources, the current status of water monitoring and future opportunities, and the impacts of current and projected climate changes on Basin water resources.

The Columbia River is the fourth largest river in North America based on annual discharge. The Basin contributes 40 per cent of the annual runoff, even though it is only 15 per cent of the total Columbia River watershed by area.


Columbia River at Castlegar

The Basin's Hydrologic Regions

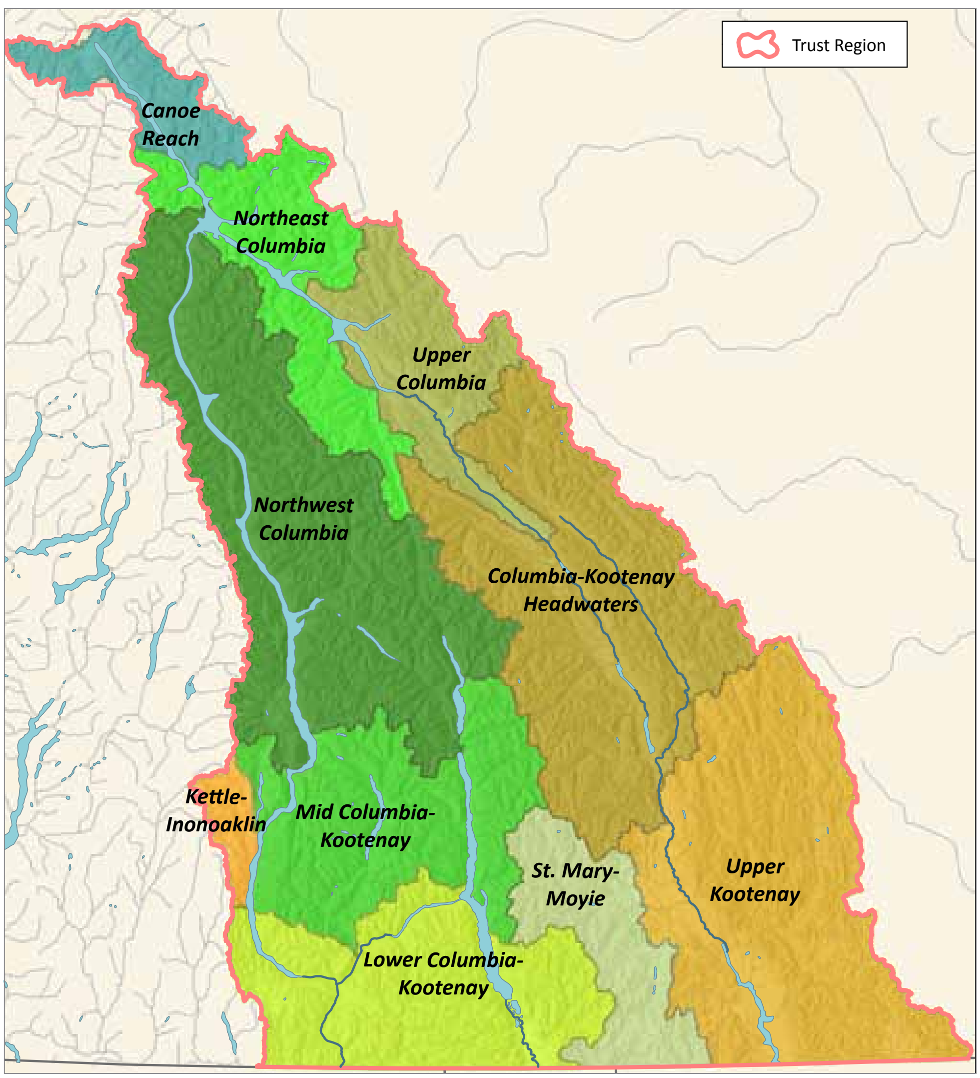
Climate in the Basin varies significantly over it's approximately 80,000 km^2 area, shaped largely by Pacific coastal influences from the west, continental influences in the east and minor boreal influences in the north. Ten distinct hydrologic regions have been identified based on watershed boundaries and averages of climate and streamflow. These are illustrated in Figure 1.

Climate influences water resources in numerous ways. Changes in temperature drive changes in precipitation and can also significantly influence annual and seasonal streamflow. Changes in the volume of precipitation influence lakes, wetlands, surface runoff and groundwater recharge.

The Basin's wettest hydrologic region is the Northwest Columbia, with annual average precipitation of 1,200 mm. This is twice the average annual precipitation of the Basin's driest hydrologic region, the Columbia-Kootenay Headwaters.

The warmest hydrologic region, the Lower Columbia-Kootenay, has an annual average temperature 3°C warmer than the coldest region, the Canoe Reach.

Figure 1: Basin hydrologic regions, based on climate and streamflow characteristics.




Sunset from Idaho Peak, looking over Slocan Lake and the Valhalla Range

Pressures on Basin Water Resources

Human activities, land use and climate change have influenced and will continue to influence Basin water resources in terms of quality and quantity. As the climate changes, assumptions based on past ecosystem behaviour and water availability will need to be updated to reflect the impact of new climate patterns and conditions. This also highlights a growing need to monitor and understand the changes taking place to support responsive and sustainable water stewardship, water-use planning, land-use planning and effective natural hazard detection and response.

Changing Climate, Changing Waters

Basin weather records over the last hundred years show that average annual temperatures have increased from 0.7 to 1.7°C and that weather extremes such as hot spells and intense rainfall events are happening more frequently. Average annual Basin temperatures are projected to rise from 2 to 4°C by 2100, with average annual winter temperatures projected to rise even more, as shown in Figure 2.

Smaller snowpacks, melting glaciers and higher temperatures (especially in summer) point to a future with lower summer flows in Basin rivers and streams, increased incidences of drought and seasonal changes to groundwater levels. More precipitation falling as rain instead of snow during colder months—as shown in Figure 3—will have consequences for the volume of snowpack and the scale and timing of peak spring runoff.

In this century, the consequences of these changes may be greater in warmer and drier parts of the Basin, and less pronounced in cooler and wetter areas. Water quality concerns are expected to increase and new challenges are likely to result from wildfire events, shifts in aquatic ecosystems and the spread of invasive species.

More rain, less snow in winter

Using data from ClimateBC[1], Figures 2 and 3 provide examples of how winter temperature and precipitation have already changed and are projected to continue changing in five of the Basin's 10 hydrologic regions.

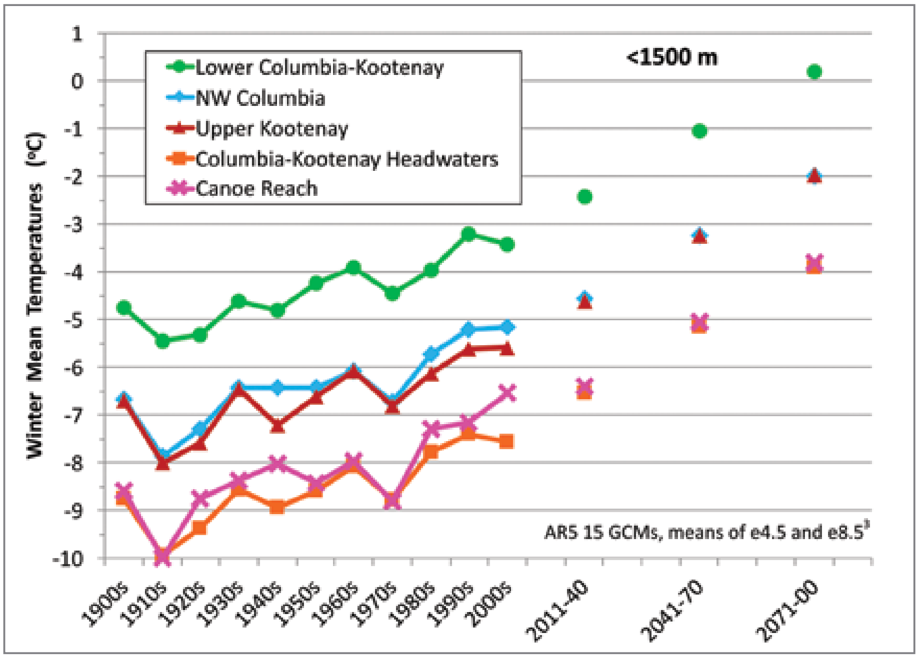


Figure 2: Historic and projected winter temperature for five contrasting hydrologic regions in the Basin.

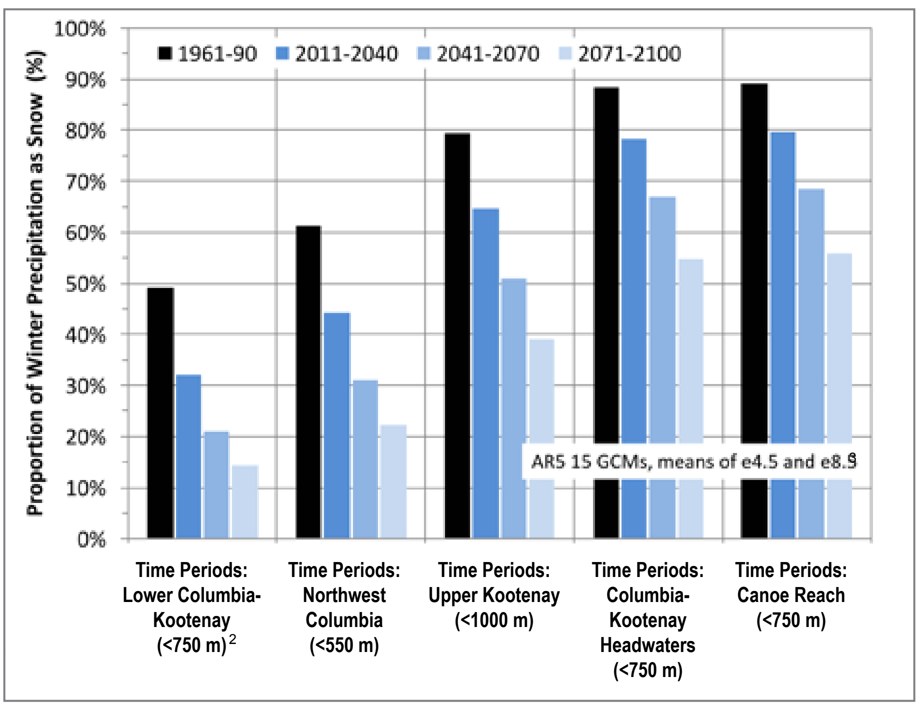


Figure 3: The percentage of winter precipitation that falls as snow in the populated valley bottoms of five of the Basin's hydrologic regions, both historically and projected.

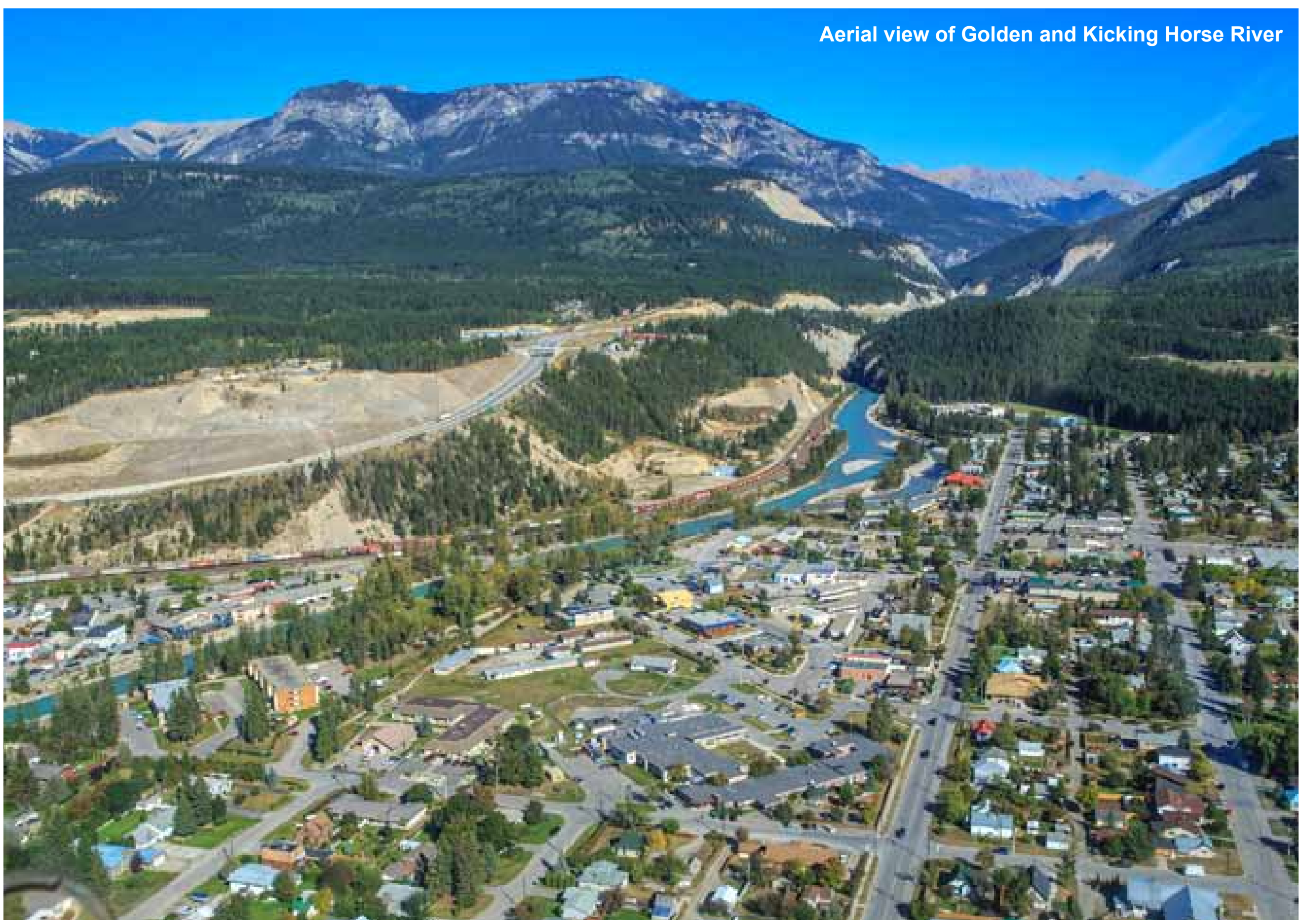
1 See http://cfcg.forestry.ubc.ca/projects/climate-data/climatebcwna/#ClimateBC.
2 The valley-bottom elevation level for this region.
3 For more information about the global climate models and greenhouse gas emission scenarios used to produce this chart, please see section 1.4.2 of the full report, *Water Monitoring and Climate Change in the Upper Columbia Basin*.

Land use

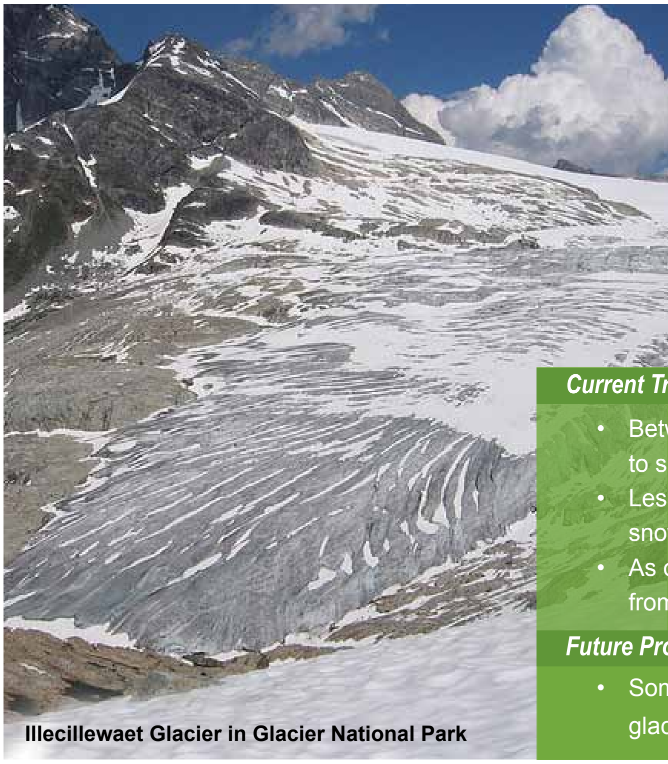
Both water quality and quantity are influenced by human activities and land use, including alterations to the natural landscape. Common land uses affecting water resources in the Basin include dams and reservoirs, agriculture, industry, forestry, human settlements, and linear developments such as railways, utility corridors, paved and unpaved roads.

The construction of 19 dams and reservoirs for flood control and hydropower generation in the 20th century flooded rivers and lakes, wetlands and forests, causing landscape-level changes in the Columbia and Kootenay river valleys. Lake/reservoir habitat increased from 414 km^2 to 1,108 km^2 as numerous lakes were replaced by reservoirs. Natural flow patterns, flood dynamics and the ecological function of historic valley bottom ecosystems were also altered.

While most tributaries to the Kootenay and Columbia rivers remain naturally flowing, their hydrology may be affected by land uses such as forestry, mining, hydropower, range, agriculture and recreation. Land use effects on Basin water resources vary according to the nature of the activity. Drainage diversions, changes in snow accumulation, changes in runoff patterns due to alterations in surface cover, and increased sedimentation are the most common effects. Human settlements, industry, mining and agriculture are the main sources of contamination to Basin water bodies, the levels of which have declined significantly over the decades as a result of improved pollution control and stricter regulations.


Aerial view of Golden and Kicking Horse River

Snapshot of the Basin's Water Resources



Illecillewaet Glacier in Glacier National Park

Glaciers and Snow

Snow and ice provide natural water storage and contribute to the Basin's water supply during warmer periods. This cycle is important for ecosystem health and community water supply.

Approximately 65 per cent of the Basin's annual precipitation falls as snow, which later melts and drives annual spring runoff. Up to 35 per cent of late summer stream flow in the Basin's glaciated watersheds can come from glacial meltwater.

Current Trends

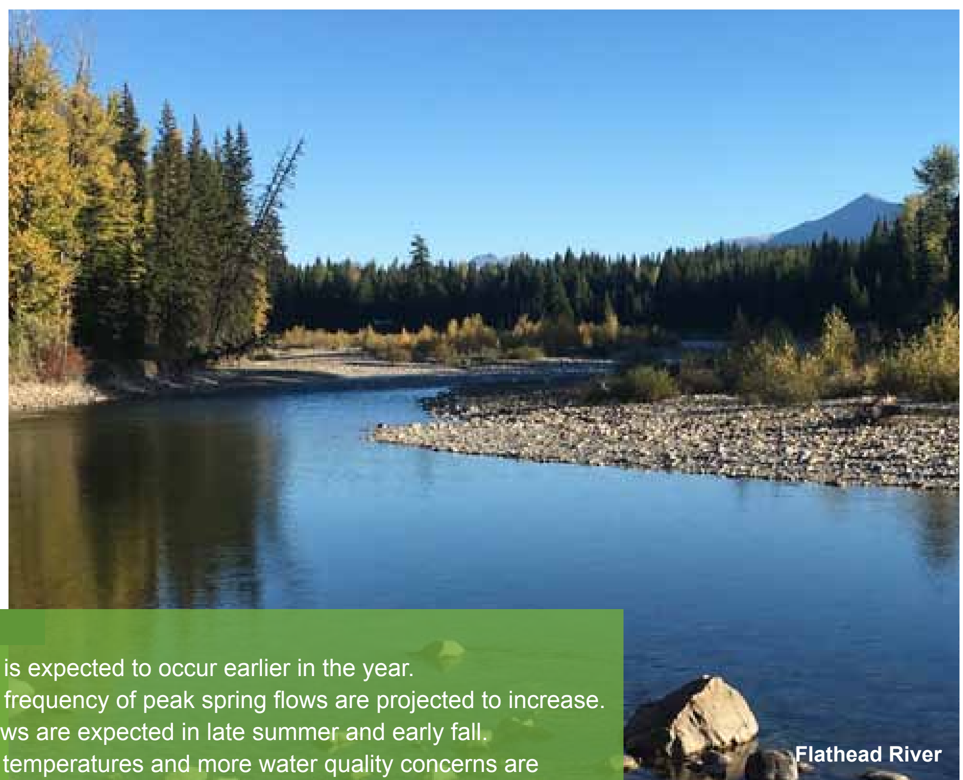
- Between 1950 and 2005, average snowpack declined by five to six per cent, taking into account climate modes.
- Less snow is falling and accumulating at low elevations, and snowpack is disappearing earlier in spring.
- As of 2013, glaciers covered 2.06 per cent of the Basin, down from 2.67 per cent in 1985.

Future Projections

- Some scientists are projecting a total loss of the Basin's glaciers by 2100.

Rivers and Streams

The Upper Columbia Basin is comprised of the Kootenay and Columbia rivers and their many tributary streams and rivers. These two major river valleys are further defined by 19 dams built between 1922 and 1982 for flood control and hydropower development. Their major tributary watersheds include the Upper Kootenay, St. Mary, Slocan and Elk rivers. Almost all Basin communities are situated along one of these six rivers and their associated lakes and reservoirs.



Flathead River

Credit: Living Lakes Canada

Future Projections

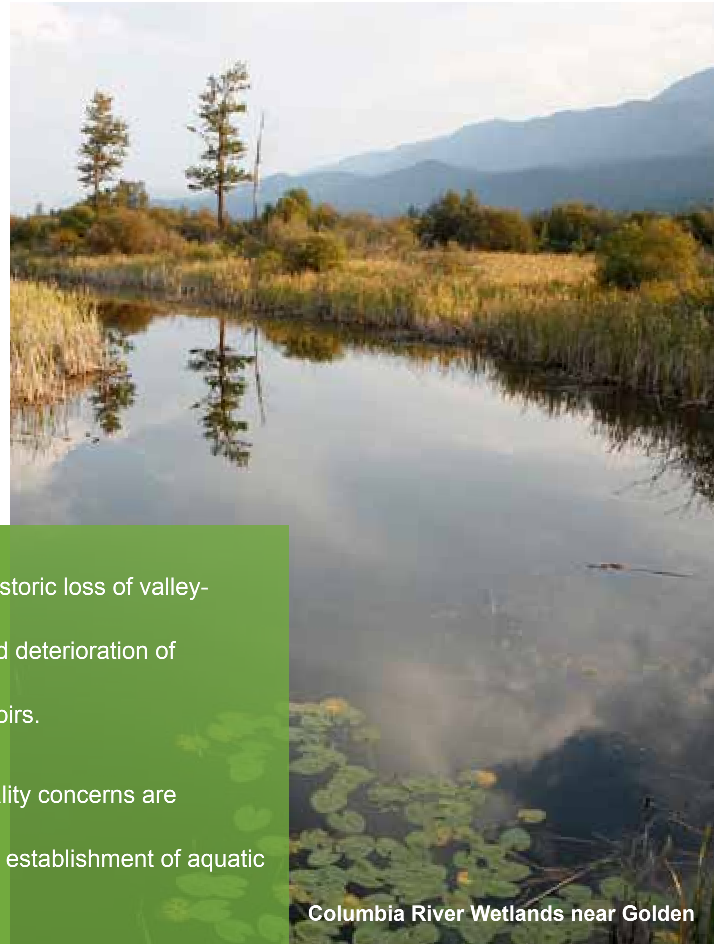
- Spring runoff is expected to occur earlier in the year.
- The size and frequency of peak spring flows are projected to increase.
- Lower low flows are expected in late summer and early fall.
- Higher water temperatures and more water quality concerns are anticipated.

Reservoirs, Lakes and Wetlands

Dams constructed for flood control and hydropower generation between 1922 and 1982 created numerous reservoirs. The eight largest reservoirs inundate 1,216 km^2, an area almost the size of Yoho National Park.

The Basin has many natural lakes and wetlands. Kootenay Lake is the fourth largest body of standing water in British Columbia, spanning 104 km from south to north. Other large lakes include Trout Lake, Slocan Lake, Lake Windermere, Columbia Lake and Moyie Lake.

Both the Columbia River Wetlands and Creston Valley Wetlands are internationally recognized as important wetland ecosystems.



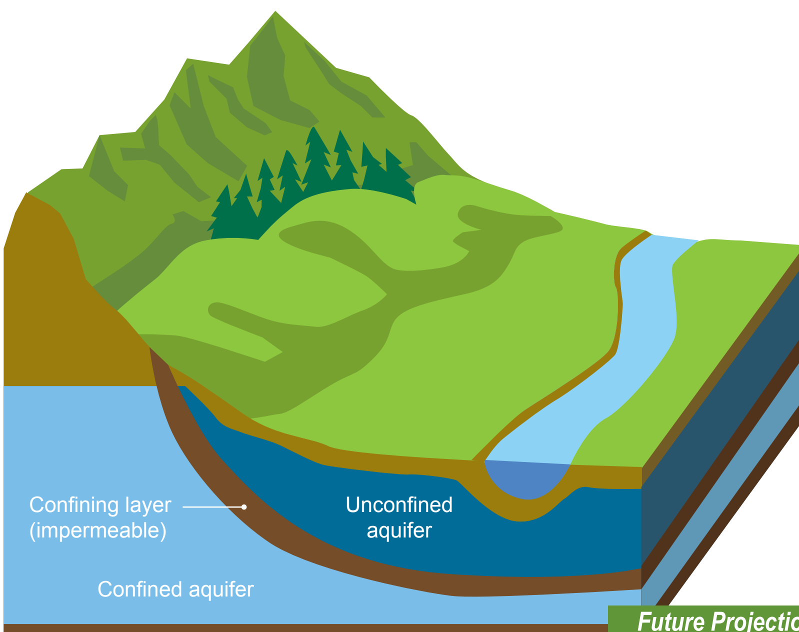
Columbia River Wetlands near Golden

Current Trends

- Hydropower and flood control have caused a historic loss of valley-bottom wetland and riparian ecosystems.
- Shoreline development has caused the loss and deterioration of foreshores in some areas.
- Nutrient depletion has occurred in some reservoirs.

Future Projections

- Higher water temperatures and more water quality concerns are expected.
- Changing water conditions may result in further establishment of aquatic invasive species.



Groundwater

Groundwater is found underground in the soil and in pores and crevices in rock. An aquifer is a layer of rock or sand that can hold water. Under BC's system of aquifer classification, 157 Basin aquifers have been mapped to provide important information related to groundwater quantity. The majority of Basin aquifers are unmapped.

Groundwater may play an increasing role in supplementing water supply during summer low-flow periods, especially as contributions from snowpack and glacial ice diminish in coming decades.

Future Projections

- Increased demand for groundwater is expected where surface water supplies become limited due to climate change.

Water Monitoring in the Basin

Since the hydrological system is interconnected, a more complete understanding of the current status and trends in Basin hydrology requires monitoring of various types of water resources, including snow and glaciers, rivers and creeks, lakes and reservoirs, wetlands and groundwater. Water monitoring can provide valuable data to inform scientific understanding and stewardship of water resources, including the availability, quality and appropriate use for community water supplies, fish habitat, hydropower, food production, fire protection and recreation.

Credit: Living Lakes Canada

Building on a shared interest in local water resources, about two dozen community groups around the Basin conduct community-based monitoring programs in their local watersheds. The data from these efforts can complement data gathered by larger monitoring programs.

Water monitoring data can be collected to:

- determine the current status and health of water resources
- identify long-term trends in watersheds and aquatic ecosystems
- detect emerging hazards and assess associated risks
- establish baseline and reference conditions
- inform water quality objectives
- evaluate regulatory compliance and performance
- calibrate and validate scientific projections about future water conditions
- guide water stewardship and land management efforts
- inform community water-supply planning
- highlight opportunities for and limitations to economic development.

A mix of government, academic and research institutions, industry and community groups are involved in monitoring the Basin's water resources, collecting data from over 550 sites in the region.[4] Each water monitoring initiative has distinct objectives focused on improving knowledge about water quantity or water quality. Efforts range in size and sophistication from community groups monitoring water quality in local watersheds to largescale, long-term, government-led water monitoring networks.

Due to the Basin's hydrological diversity, the current network of stations monitoring water quantity represent only a small fraction of the sites that could be monitored to provide a well-rounded understanding of water quantity. Additional data and related scientific understanding could support a range of activities including ecosystem stewardship, land-use planning, helping communities adapt to a changing climate, optimizing use of municipal funds available for provision of water supply and facilitating sustainable economic development.

4 This number does not include monitoring conducted by Water Improvement Districts, which is mandated and overseen by the Interior Health Authority.

Gold River stream flow measurement.

Credit: Ryan Seibel, Water Survey of Canada

Planning for the Future

The current scientific understanding of Basin water resources highlights how they can be affected by land use and climate change. Addressing gaps in knowledge through improved water monitoring would help Basin communities and land managers to plan for and adapt to current and future water-related challenges.

Numerous opportunities exist to strengthen understanding and stewardship of Basin water resources in a changing climate. These include the following:

- Expand monitoring of the rate of melting and loss of Basin glaciers
- Increase tracking of changes in high elevation snow and rain, snowpack and snowmelt patterns
- Identify current trends in mid-to-high elevation stream flow
- Integrate existing water quality data into a comprehensive “report card” on smaller surface streams
- Increase monitoring of smaller streams used for community water supplies
- Improve tracking of changes to wetlands and natural lake levels
- Enhance groundwater mapping, monitoring and analysis, especially in the drier, warmer parts of the Basin
- Develop a long-term “backbone” monitoring network to provide consistent baseline information across all hydrologic regions, land attributes and climates in the Basin.

For more information about the Trust’s Environment Initiatives and to read the full report, *Water Monitoring and Climate Change in the Upper Columbia Basin*, visit www.ourtrust.org.

Head Office, Southwest Basin
300–445 13 Avenue
Castlegar, BC V1N 1G1

1.800.505.8998
250.365.6633
info@cbt.org

Northeast Basin Office
512 8 Avenue North, PO Box 393
Golden, BC V0A 1H0

1.800.505.8998
250.344.7065
info@cbt.org

Northwest Basin Office
220 Broadway, PO Box 220
Nakusp, BC V0G 1R0

1.800.505.8998
250.265.9936
info@cbt.org

Southeast Basin Office
201–828 Baker Street
Cranbrook, BC V1C 1A2

1.800.505.8998
250.426.8810
info@cbt.org