

Calgary



Source Water Protection Plan

Protecting our source watershed through proactive collaboration



Executive summary

The City of Calgary is committed to delivering high quality, safe drinking water to the communities we serve, which include over 1.3 million citizens. Our exceptional drinking water is due in part to the high quality of our **source water** – the natural waters of the Bow and Elbow rivers prior to treatment and distribution to our customers. In turn, the quality of our source water depends on the condition of the land that collects and drains water downstream to our drinking water treatment facilities. Also known as our **source watershed**, this 9,000 km² area generates and filters water through a vast network of glaciers, mountains, forests, grasslands, rivers, streams, wetlands, aquifers, agricultural landscapes and communities.

Safeguarding our high quality source water requires a proactive approach to comprehensively address current and future risks to source water.

Source water protection is a coordinated risk management approach that provides the first line of defence in a multi-barrier approach to providing safe, clean drinking water.

Our Source Water Protection Plan (Plan) was developed over the course of three years (2015-2018), and is based on the culmination of:

- Provincial direction and guidance
- Water quality monitoring data
- Technical risk assessments
- Internal and external engagement
- Best practice guidelines and standards

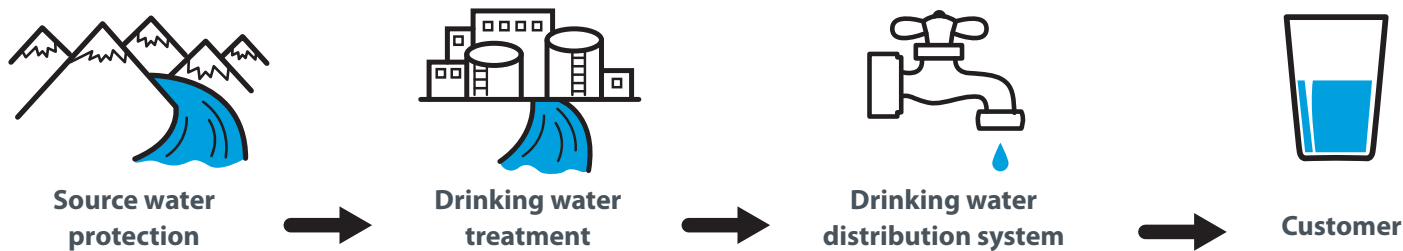


Figure 1: The City of Calgary’s multi-barrier approach to safe drinking water

The vision, goals and actions to protect source water quality are the foundation of this Plan (Figure 2). These flow from documented best practices in other jurisdictions, as well as provincial direction and key policy drivers, including public health, environmental stewardship and cost-effective service delivery. The Plan provides a common direction and priorities, while synthesizing and building on existing data and initiatives. Although the Plan is focused on The City's source water, it can also be used as a foundation for more regional source water protection initiatives as well.

Priority actions under each of the four goals are also described in the Plan, including targeted timelines and key stakeholders. Implementation intends to leverage resources across a wide range of jurisdictions and knowledge domains.

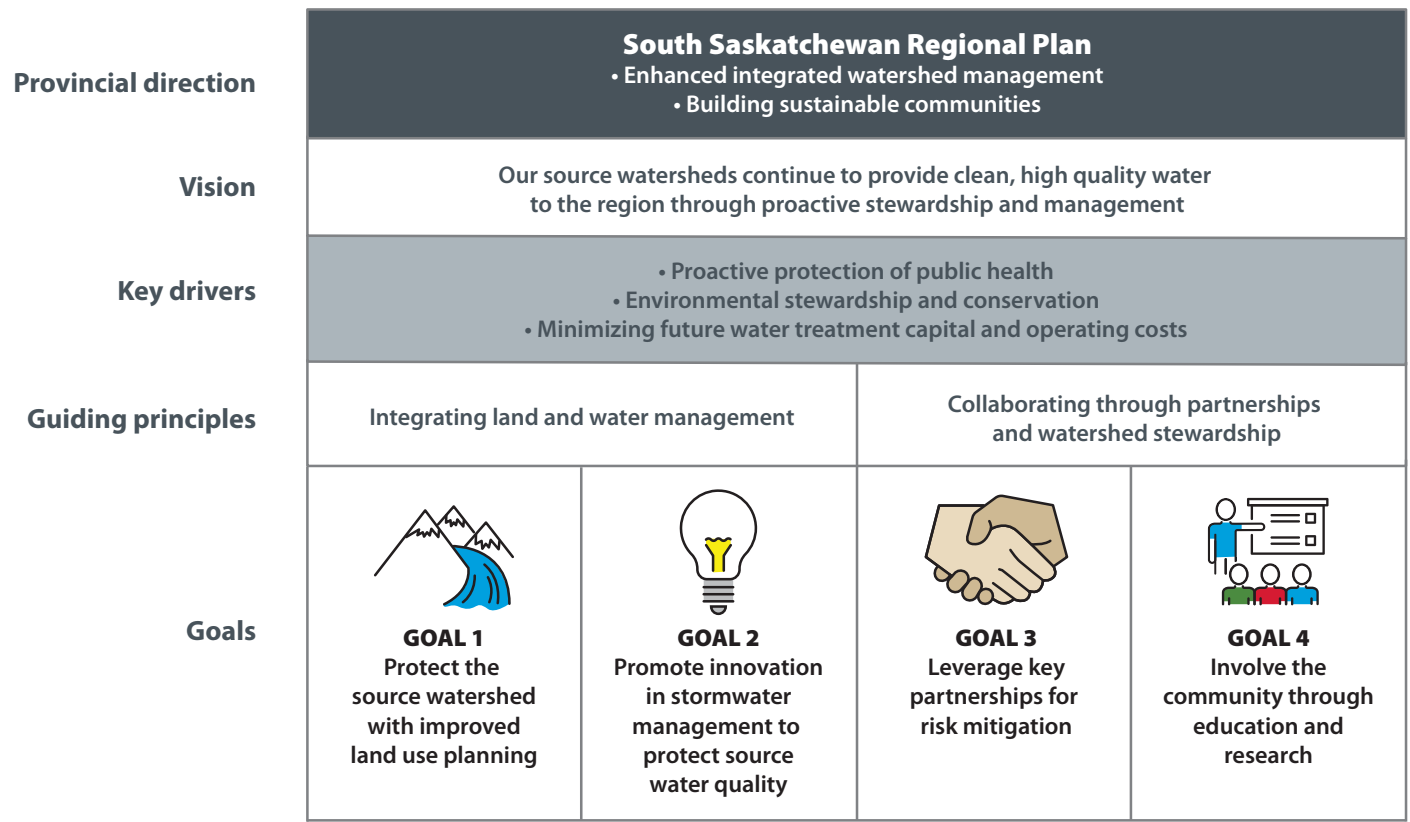


Figure 2: From vision to goals: A strategic framework for source water protection

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What is source water protection?

Source water protection is the first line of defence to minimize the risk of drinking water contamination. Together with drinking water treatment and risk mitigation within the water distribution system, source water protection is part of a multi-barrier approach to providing clean, safe drinking water to our customers (Figure 3). Source water protection reflects the inherent diversity and unique attributes of natural waters, watershed landscapes, local governance and institutions.

Source water

Water in its natural or raw state, prior to being withdrawn for treatment and distribution as a drinking water supply. The City of Calgary's source water is associated with the Bow and Elbow watersheds upstream from the Bearspaw and Glenmore water treatment plants.

Documented best practices show that successful source water protection plans and programs share the following six basic elements [1,2]:

- A program **vision**
- Source water **characterization**
- Source water protection **goals**
- A source water protection **action plan**
- **Implementation** of the action plan
- Periodic **evaluation and revision**

In accordance with these best practices, the contents of this Plan reflect the above elements.

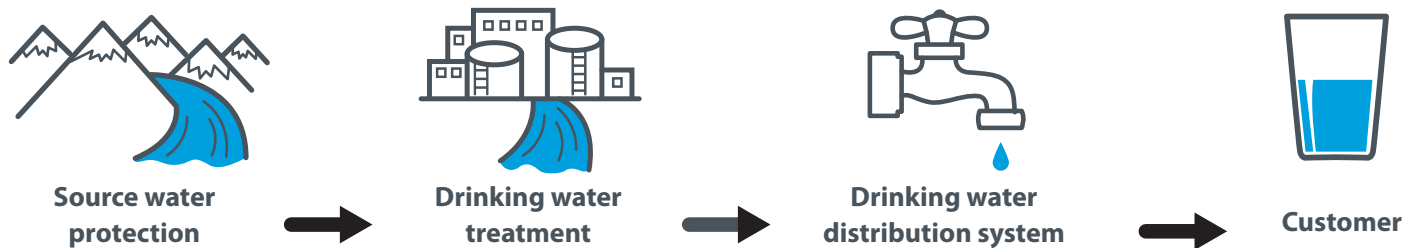


Figure 3: The City of Calgary's multi-barrier approach to safe drinking water

A focus on source water quality

This Plan focuses primarily on source water quality issues, although interactions between water quality and quantity are recognized throughout. Approaches to manage water quantity and scarcity issues are addressed more thoroughly in The City's Water Efficiency Plan, Drought Management Planning and other related work.

Key **drivers** for undertaking the development of a Source Water Protection Plan for Calgary include:

- **Proactive protection of public health** for current and future generations.
- **Greater awareness of the need for environmental stewardship and conservation**, including cumulative effects management addressing multiple stressors, such as land use change and climate change.
- **Potential to minimize costs**, including operational costs for water treatment, or deferred capital costs for future upgrades to treatment infrastructure.
- **Increasing development and land use change** throughout our source watersheds, both within and upstream of Calgary.

Relationships to other regulations and planning processes

Source water protection is related to many other processes at provincial, regional and local scales. This Plan complements existing governance frameworks and does not duplicate existing roles and responsibilities.

Integration with other planning and regulatory frameworks

A wide range of regulations, policies, plans and strategies relate either directly or indirectly to watershed protection in Alberta and the Calgary region (Figure 4). Legislation, regulations and standards are in place for many land use planning procedures, and for regulating water-related environmental risks associated with various industries. Water utilities in Alberta are also required to prepare Drinking Water Safety Plans (DWSP), which include qualitative risk evaluations and mitigation actions in a source-to-tap framework. This Source Water Protection Plan builds on the foundation provided by The City's Drinking Water Safety Plan.

The Plan also integrates and coordinates with the South Saskatchewan Regional Plan, the Calgary Municipal Development Plan, the Bow Basin Watershed Management Plan, various subwatershed plans and evolving regional planning requirements. The City of Calgary is also a leader in minimizing the impacts of our wastewater and stormwater on the broader Bow River Basin watershed, in order to help protect the environment and the source water of other users located downstream from Calgary.

The City of Calgary's stewardship of downstream environments

The scope of this Plan focuses on source watersheds upstream from Calgary. However, The City of Calgary is also a leader in minimizing the impacts of wastewater and stormwater on the broader Bow River Basin watershed, to help protect the environment and the source water of other users downstream from Calgary. As a reflection of success to date, the amount of sediment pollution loading to the Bow River from Calgary remains under 2005 levels, despite rapid growth.

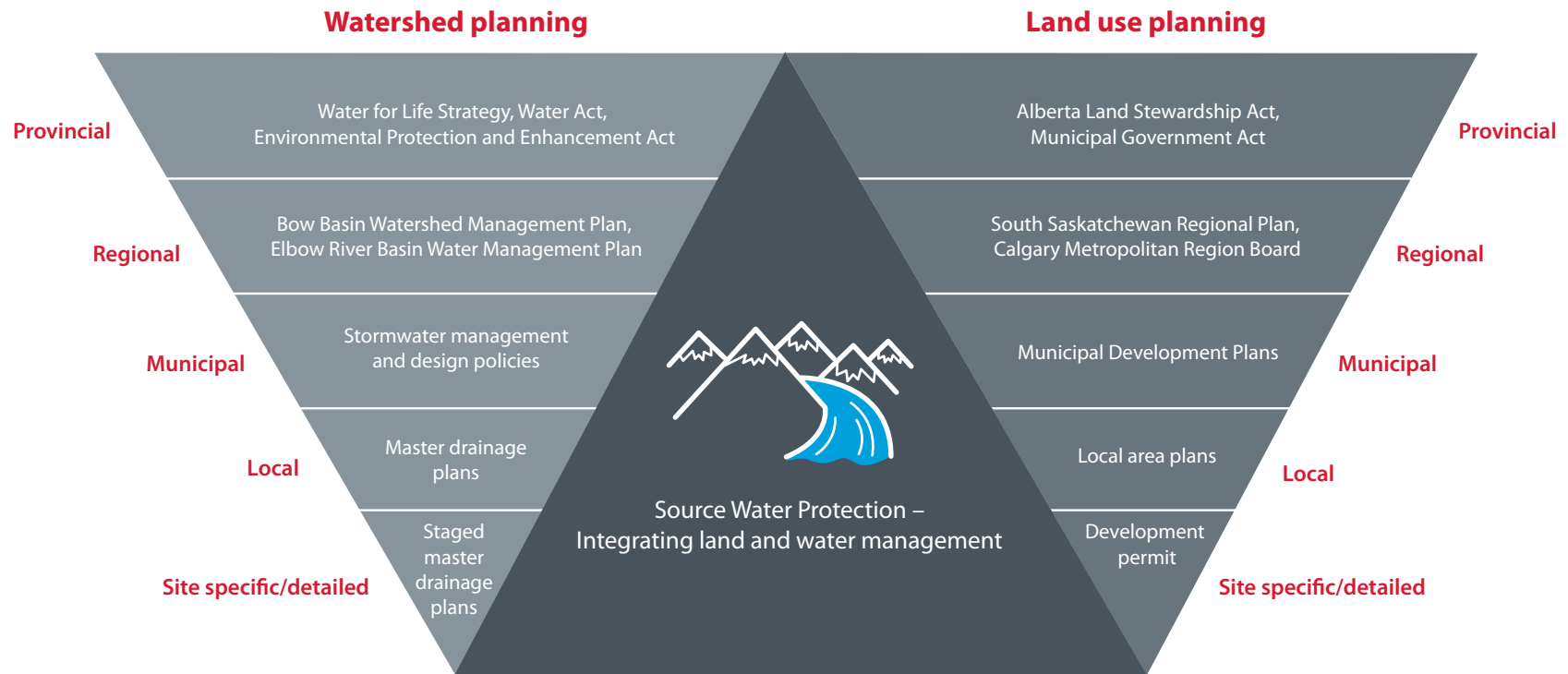


Figure 4: Source water protection and integrated watershed management

“Clean water and a healthy watershed are integral to our ability to protect public health.” ~ Internal City stakeholder



Watershed values and program vision

Calgary's source watersheds include a wide range of landscapes, with diverse functions and values that must be balanced. These include First Nations' cultural values, ecological values and ecosystem services, development values, working landscapes and industrial activities.

First Nations' values

Since time immemorial, land and water resources in the Bow and Elbow watersheds have been used for traditional purposes by indigenous peoples. Calgary's source watersheds overlap the traditional territories of the Treaty 7 First Nations, including:

- The Niitsitapi or Blackfoot, which includes the Siksika, Kainai and Piikani nations.
- The Nakota Sioux (Stoney) Nation, comprising the Chiniki, Bearspaw and Wesley bands, who also have substantial reserve lands in the Bow River source watershed.
- The Tsuut'ina or Beaver people, who also have substantial reserve lands in the Elbow River source watershed.

Calgary's Source Water Protection Plan honours and acknowledges indigenous values, and encourages ongoing dialogue and collaboration with First Nations and Metis during implementation. First Nations' engagement has been undertaken to better understand indigenous cultural values related to our watershed, and to build deeper relationships between City staff and First Nations. This is consistent with the spirit and intent of The City's Indigenous Policy. During Plan implementation, The City intends to implement actions that provide mutual benefits to both The City and indigenous peoples.

"Water is the most sacred source of life...it is one of the greatest medicines given to living things and beings...nature cannot survive without water, not even humans." ~ Mike Oka, Kainai Nation

"We believe the Creator put us here for stewardship and to ensure the environment is protected."

"In our community, literacy is about understanding that everything is connected and acknowledging that sacred kinship."

"Wetlands and rivers are part of that sacred connection and (this) needs recognition."

~ Treaty 7 First Nations Traditional Knowledge Keepers,
City of Calgary Indigenous Policy Framework (2017)



Vision

Our source watersheds continue to provide **clean, high quality water** to the region, through proactive stewardship and management.

Ecological values and ecosystem services

Our shared source watersheds contain many ecological values and ecosystem services. Ecosystem services are the benefits people obtain from nature [3]. Generating and filtering clean source water for downstream users is a key service provided by a vast network of ecological infrastructure in our source watershed, including mountains, forests, rivers, streams, riparian areas, wetlands, aquifers and grasslands. This network of ecological infrastructure also supports biodiversity, provides recreation and tourism opportunities and a sense of place, and generates a wide range of other ecosystem services.

Working landscapes

Calgary's source watersheds also play host to working landscapes involving agriculture, forestry, hydroelectricity generation and mining – activities which generate food, forest products, electricity, minerals, revenue and jobs. The watershed also includes diverse communities that people call home. These various resources and values must be respected and integrated with the goal of maintaining high quality source water supplies for downstream users. Municipalities, private landowners and industries within our source watersheds also have various rights that go along with their responsibilities.

Stakeholder engagement highlights

Extensive stakeholder engagement targeting various industries, non-government organizations and other government agencies was undertaken as an input to this Plan. Key points emphasized by many diverse stakeholders included:

- Links between public health and environmental stewardship in source water protection.
- A need for collaborative approaches and coordination among groups and agencies.
- A proactive management approach, rather than a reactive or crisis management approach.

Importance of water quality to Calgarians

In addition to the more in depth stakeholder and First Nations engagement, this Plan was also informed by previous surveys of Calgarians on water and watersheds, to reflect the perspectives of our customers and citizens. Surveys consistently show strong support for the importance of high quality drinking water. A 2017 Ipsos Reid poll showed that over 95 per cent of Calgarians rate the quality of drinking water as “very important” [4].

Our source water vision

A formal vision has been established to provide focus and direction for source water protection activities. The vision statement was developed using stakeholder input and reflects:

- Public values, confirmed through citizen surveys.
- Treaty 7 First Nations' perspectives.
- Stakeholder input gathered from government, industry and non-government organizations.

Land stewardship, holistic thinking and connection to place were important themes heard during First Nations' engagement, and very similar themes were also echoed by stakeholders in industry, government and non-government organizations.

“Source water protection is a process to turn discussions and plans related to water into on the ground actions to protect water.” ~ External stakeholder

Characterizing Calgary's source watersheds

Calgary has two source watersheds, associated with each of its two drinking water plants:

- **Bow River source watershed:** A 7,768 km² area upstream from the Bearspaw water treatment plant.
- **Elbow River source watershed:** A 1,227 km² area upstream from the Glenmore water treatment plant.

Jurisdictions

The majority of Calgary's source watershed is owned by the Crown, and administered by the provincial or federal government. Almost two thirds of the source watershed area is designated as parks, primarily in Banff National Park (39 per cent) and provincial parks and protected areas (24 per cent).

The City of Calgary has jurisdiction over only a very small proportion (0.7 per cent) of the total area. Rocky View County's jurisdiction extends over 12 per cent of the source watershed, with most of these lands in private ownership in close proximity to City limits. First Nations reserves make up about eight per cent of the source watersheds in total.

Source watershed

A source watershed includes all land from which water drains downstream to provide untreated water supplies for a municipal drinking water treatment plant. Boundaries for Calgary's source watersheds were delineated based on topography and water infrastructure.

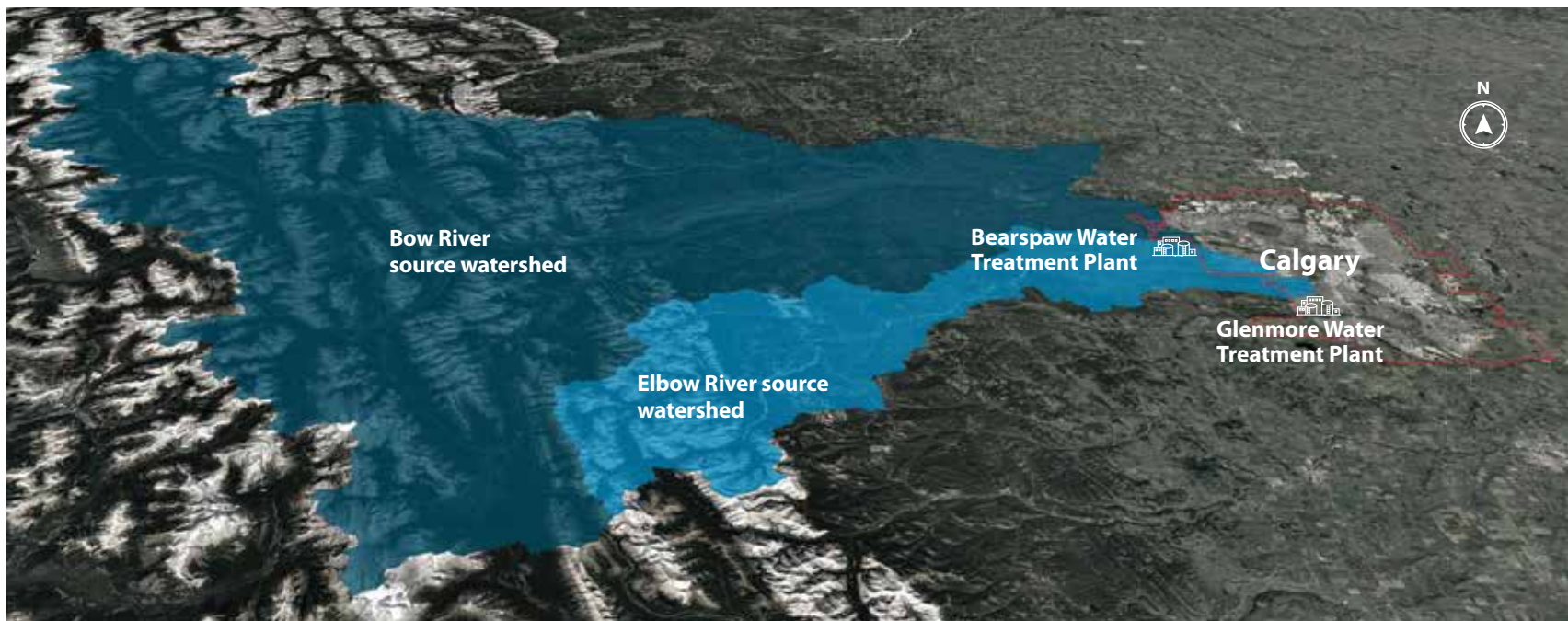


Figure 5: The City of Calgary's source watersheds

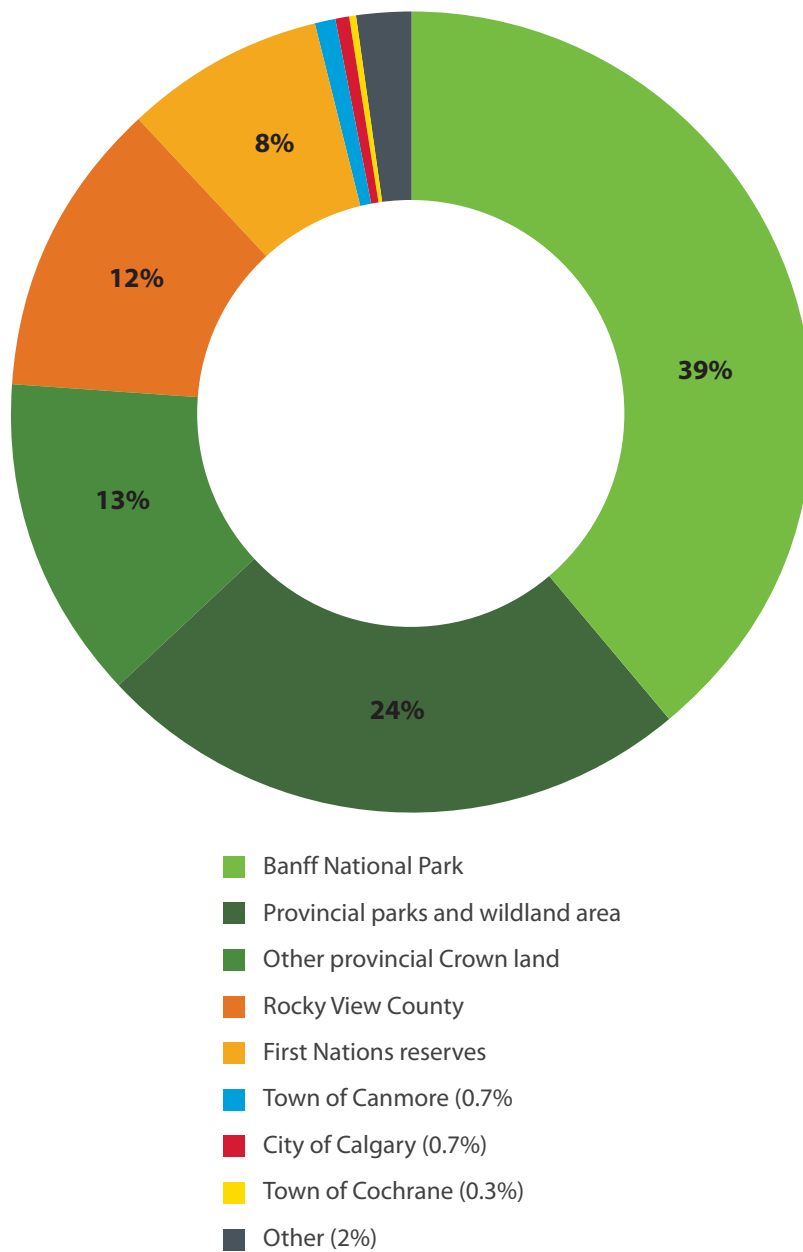


Figure 6: Jurisdictions in Calgary's two source watersheds

Bow River source watershed

The City's Bow River source watershed includes 7,768 km² of the Bow River Basin upstream from the Bearspaw Water Treatment Plant. There are two intake locations for this plant: (i) directly in the Bearspaw Reservoir dam site operated by TransAlta Utilities, and (ii) directly in the Bow River near Stoney Trail.

The Bow River currently supplies about 60 per cent of the water supplied to Calgary and its customers. Many other communities draw their source water from the Bow River, including but not limited to Canmore, Cochrane and several communities in Rocky View County, as well as other communities downstream from Calgary.

Jurisdictions in the Bow River source watershed

The mountainous headwaters upstream from the Bearspaw treatment plant are mostly within Banff National Park, which makes up 46 per cent of this source watershed. Provincial parks and wildland areas are also prominent in our Bow source watershed, particularly in the Kananaskis Country area (Figure 7). Glenbow Ranch Provincial Park located between Cochrane and Calgary along the Bow River is another important provincial park.

Rural municipal districts in the Bow River source watershed include Rocky View County (nine per cent of the Bow source watershed), as well as the Municipal District of Bighorn and the Kananaskis Improvement District. Cochrane is the largest major settlement outside of Calgary, followed by Canmore, Banff and Lake Louise. The Stoney Nakoda Reserve (including the community of Morley) and a small portion of the Tsuut'ina Reserve lands are also located in the Bow source watershed. Approximately 19 km² or just 0.2 per cent of this source watershed lies within Calgary city limits. Lands owned by Calgary Parks in the Bow source watershed include the Haskayne and Bearspaw Legacy parks.

Elbow River source watershed

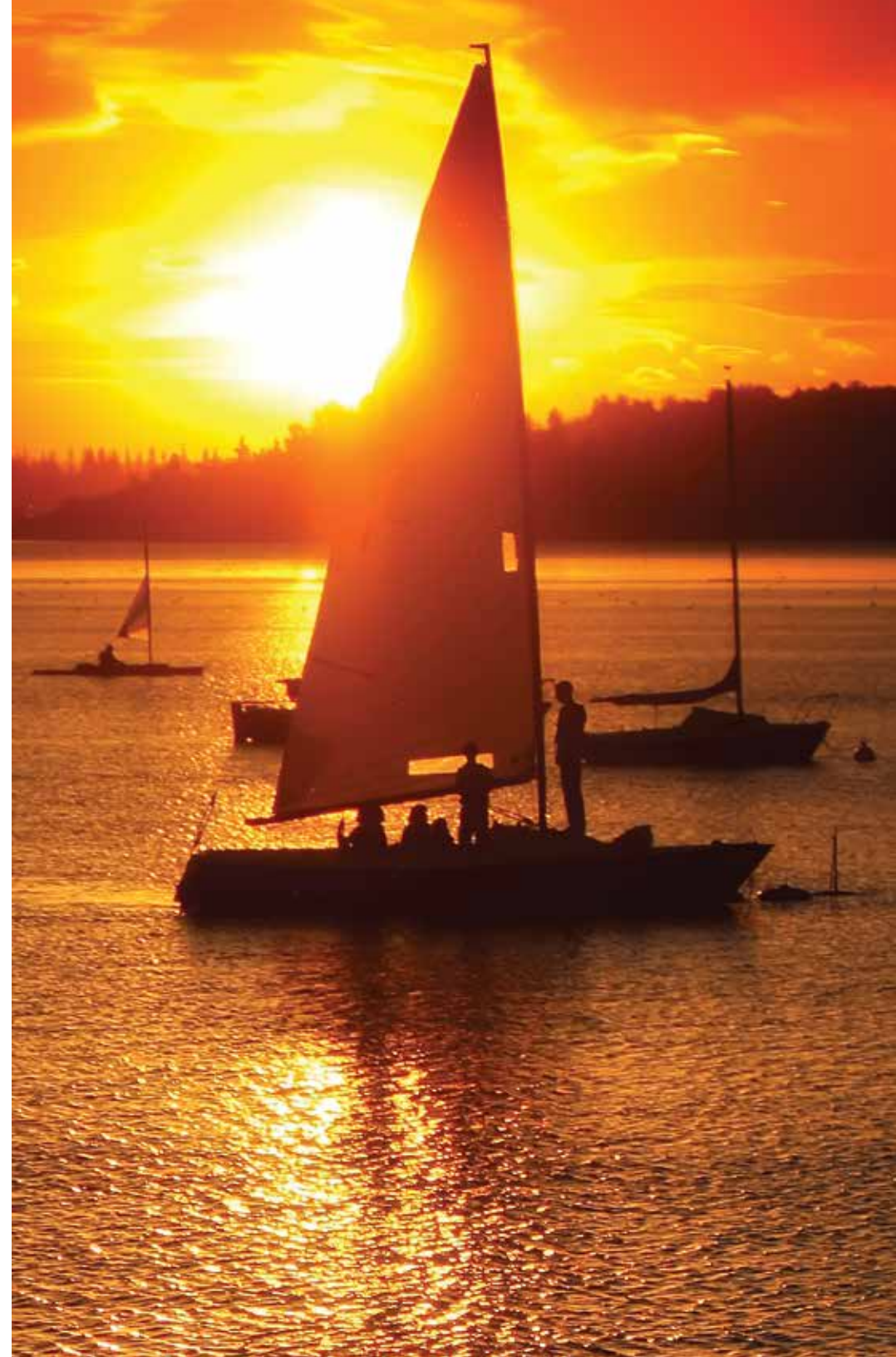
The City's Elbow River source watershed includes 1,227 km² of the Elbow River basin upstream from the Glenmore Water Treatment Plant. The plant's intakes are located in the Glenmore Reservoir at the dam. The Glenmore Reservoir is within City of Calgary limits, and the Glenmore Dam is owned and operated by The City. In addition to water supply, the Glenmore Reservoir also provides flood protection and is a popular site for non-motorized boating and recreation. The Elbow River currently supplies about 40 per cent of the water needs of Calgary and its customers. Maintaining the Elbow River's source water quality is of particular importance since it has been identified as more vulnerable to water quality deterioration.

The Elbow River also supplies water to many other communities, including but not limited to Bragg Creek, Redwood Meadows and several communities in Rocky View County along the Highway 8 corridor. The Elbow is also a tributary to the Bow River, which is used as a water supply by many other communities located further downstream from Calgary.

Jurisdictions in the Elbow River source watershed

The upper headwaters of the Elbow River source watershed include extensive provincial parks and public recreation areas in Kananaskis Country, including the Don Getty and Elbow-Sheep Wildland provincial parks. Rocky View County, including the hamlet of Bragg Creek, has jurisdiction over 20 per cent of the Elbow source watershed, followed by the Tsuut'ina Nation at 14 per cent.

Almost 45 km² of SW Calgary lies upstream from the Glenmore Reservoir, representing 3.6 per cent of the Elbow River source watershed. Almost half of this area has been protected over the years by The City in large municipal parks, including South and North Glenmore Park, Weaselhead Flats and the Clearwater Legacy Park. The other half of this area includes many Calgary communities both north and south of the reservoir that drains stormwater into the Glenmore Reservoir.



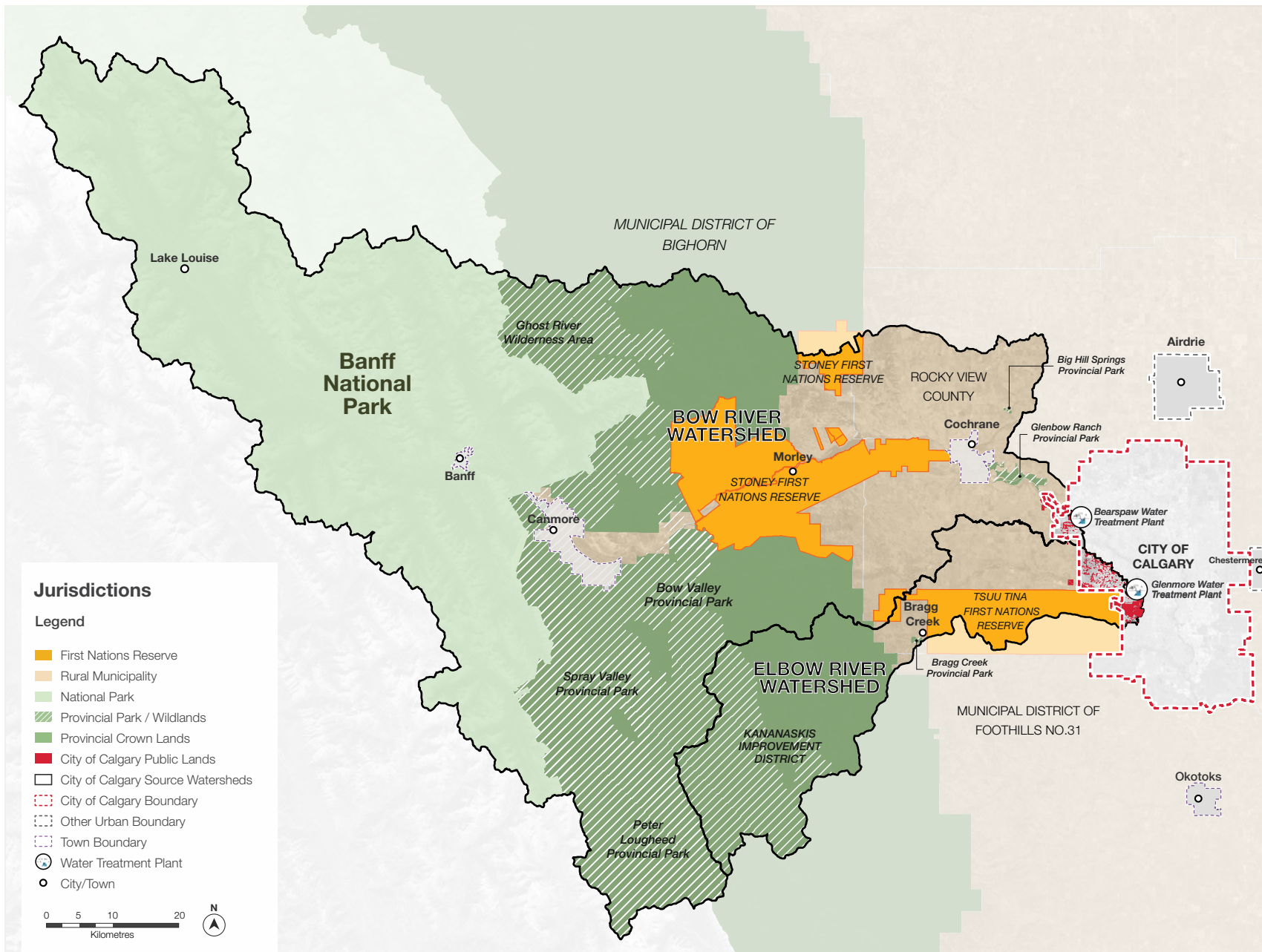


Figure 7: Map of jurisdictions in Calgary's source watersheds

Land cover

Land cover strongly influences water quality in watersheds and treatment costs for water utilities [5, 6]. Calgary is fortunate that almost half of the total source watershed area is in forested land cover (Figure 8). Exposed mountainous areas are also a very common land cover type, occupying over a quarter of the source watershed. Glaciers make up only one per cent of the two source watersheds, with most of these located at high elevations in the headwaters of the Bow River basin. Grasslands and shrublands combined cover about 17 per cent of the area, followed by cultivated agriculture at five per cent. Developed lands currently occupy about four per cent of the source watershed, and are concentrated within Calgary, with significant contributions from Cochrane, Rocky View County and Canmore as well. Open water – including lakes, rivers and streams – occupy three per cent of our source watershed area. Figure 9 shows a map of land cover in the study area.

The importance of land cover in river valleys

Shallow groundwater aquifers connected to our rivers are also known as “river-connected alluvial aquifers”. These areas of sand and gravel contain water that flows freely between the underground aquifer and the river. These subsurface aquifers can extend up to a few kilometres out from the river. Maintaining natural land cover along these river valley corridors is important for source water protection and preventing sources of contamination from entering rivers.

On average, the cost to treat water in watersheds with 10 per cent forested land cover is double the cost of treatment for higher quality watersheds with 40 per cent forested land cover [6].



Figure 8: Major land cover types in Calgary's two source watersheds

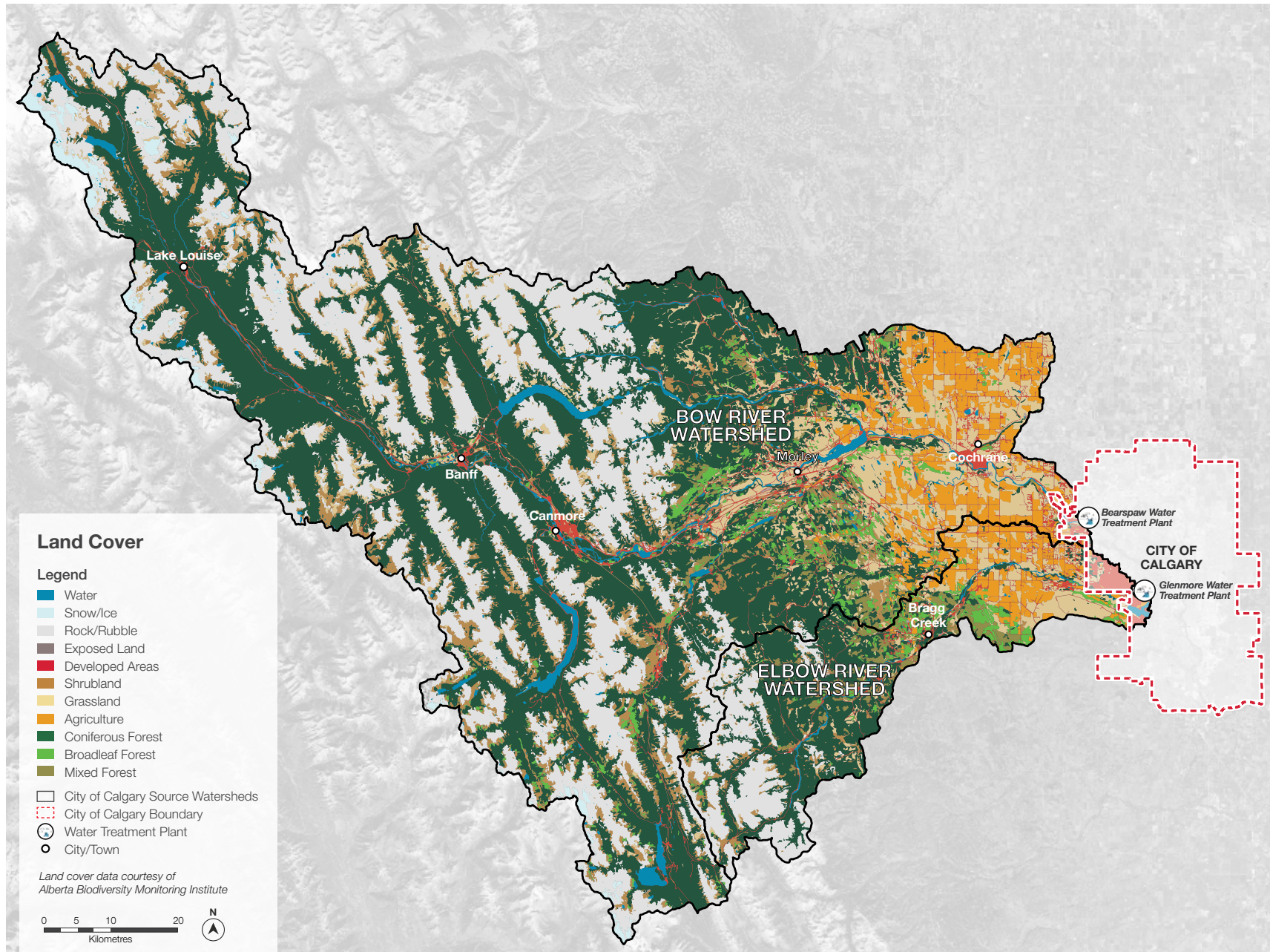


Figure 9: Map of land cover in Calgary's source watersheds

Source water quantity

The majority (greater than 90 per cent) of Calgary's source water originates as rain and snow in the Rocky Mountains and Foothills west of Calgary. Typical flows on the Bow and Elbow rivers are shown in Figure 10. In addition to strong seasonal variation, periodic wet and dry cycles also affect southern Alberta. Major droughts in the past have included droughts in the 1400s, 1700s, 1800s and early 19th century [7]. In addition, climate change is increasing the frequency and magnitude of extreme events such as drought and flash flooding [8, 9].

Water quantity and quality synergies

Although this Plan focuses primarily on water quality issues, there are synergies between water quality and water quantity issues. For example, high flows are usually accompanied by high turbidity. In contrast, low flows result in less dilution of wastewater effluent and stormwater runoff, resulting in higher concentrations of contaminants in our rivers.

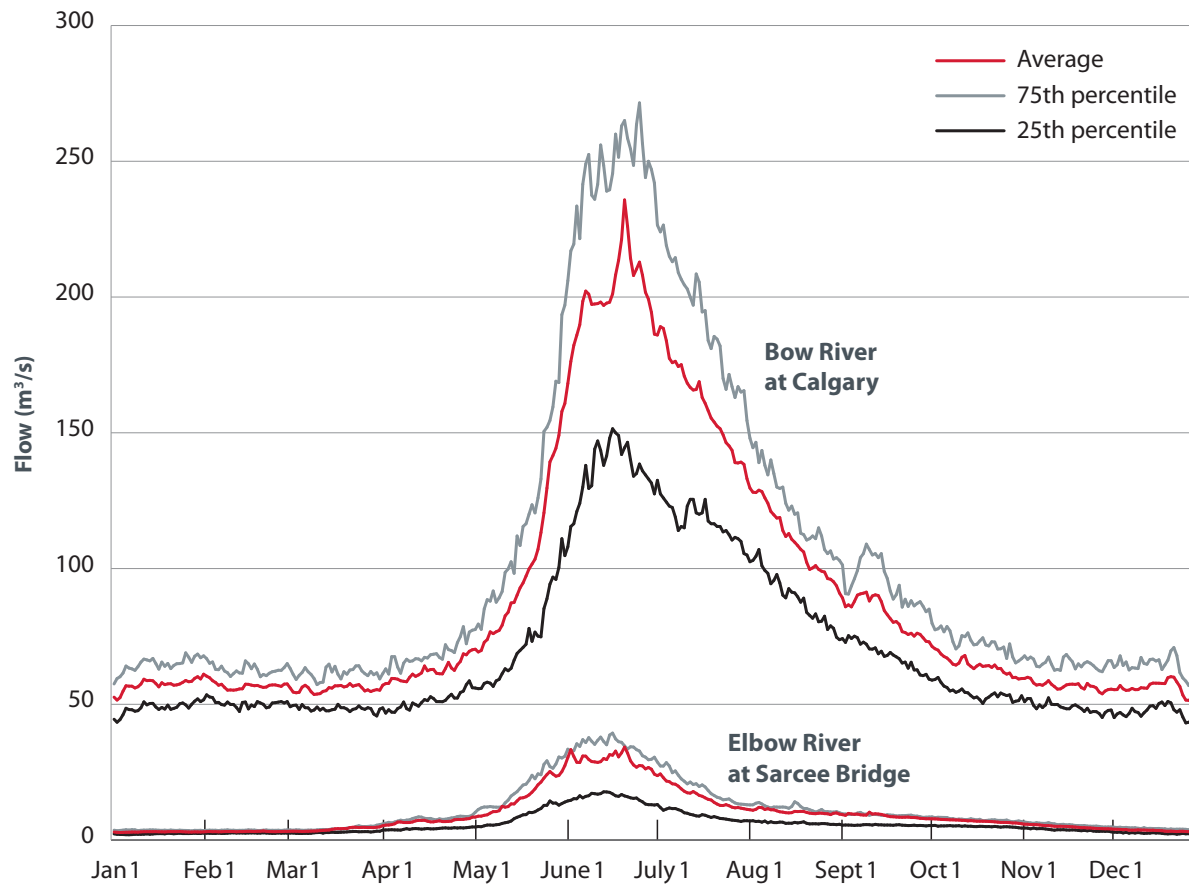


Figure 10: Typical flows of the Bow and Elbow river source water supplies (1955-2015 records)

Source water quality

Understanding source water quality is key to ensuring the protection of public health. The City conducts extensive source water quality sampling at our drinking water treatment facilities and throughout the source watershed. Water quality parameters monitored include:

- Turbidity as a measure of water clarity.
- Microbiological contaminants from human and/or animal faeces, including enteric protozoa (*Cryptosporidium* and *Giardia*).
- Nutrients, including the various different forms of phosphorus and nitrogen.
- Nuisance organic compounds produced by naturally occurring bacteria, algae and fungi, that can create taste and odour issues and in some cases have toxic properties.
- Total organic carbon (TOC), which originates from the decomposition of plant materials.
- Metals, including naturally occurring metals and those associated with human land use or industry.
- Pesticides that may be applied in residential areas or on agricultural lands.
- Organic contaminants commonly associated with industrial processes and waste disposal sites.
- Radiological parameters.
- Other physical-chemical parameters, including pH, temperature, and ions.

Of the 164 water quality parameters monitored, 65 have regulated Maximum Acceptable Concentrations (MAC) for finished drinking water under the Guidelines for Canadian Drinking Water Quality [10].

Public health regulations for drinking water control the quality of treated water entering the distribution system. Source water quality generally determines the level of treatment required to make water safe to drink.

Turbidity, total organic carbon and enteric protozoa are the most important source water quality parameters driving current water treatment operations. These parameters affect the day to day operation and optimization of the water treatment plants, and are the key factors influencing future infrastructure planning. Organic compounds associated with taste and odour issues and a range of other organic chemicals are also key to consider for source water protection, as discussed below.



Turbidity is a term used to describe water clarity. High turbidity is caused by particles of clay, silt and fine organic and inorganic matter suspended in water. Turbidity in our rivers is strongly influenced by high river flows and related processes of erosion, although land use in the watershed is also important. Calgary's source waters demonstrate seasonal changes in turbidity, with peak levels coinciding with the mountain snowpack melt in late spring and early summer. Turbidity also shows strong variation from year to year. Depending on the nature of the suspended matter, implications for water quality and treatment differ. Over the last decade, significant upgrades have been made to both water treatment plants to improve their ability to treat water during high turbidity events. The success of these upgrades was illustrated during the June 2013 flood. During the flood, maximum turbidity values of 4196 NTU and 3754 NTU were recorded at the raw water intakes for the Glenmore and Bearspaw treatment plants, respectively. Despite these extremely high turbidity values, The City continued to produce clean water without any service interruptions.

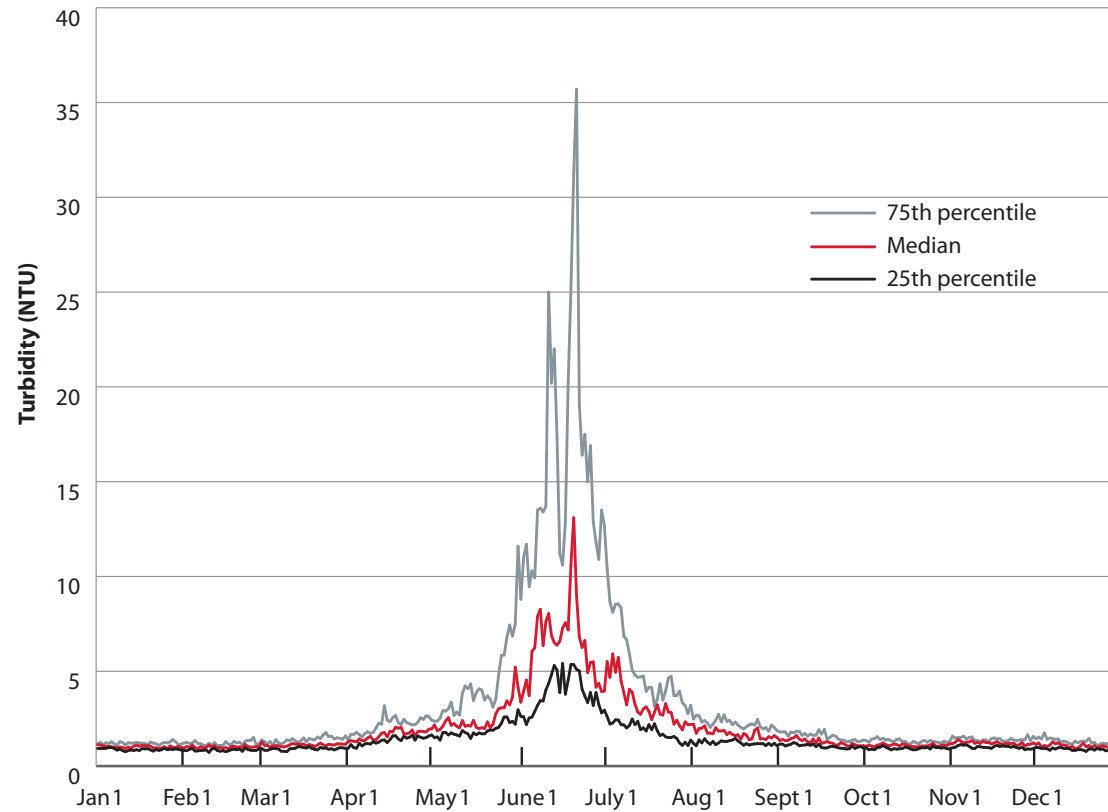


Figure 11: Seasonal turbidity at the Bearspaw Treatment Plant (2000-2016 records)

Water quality changes due to runoff

Spring runoff often causes dramatic, mostly natural changes to water quality. October through March show consistently low values, but there is typically high variability during May, June and July due to high runoff and associated erosion. Microbes, total organic carbon and nutrients also show similar seasonal patterns. Although The City's water treatment system is designed for turbidity spikes, costs for water treatment chemicals can increase by three to five times during runoff events. High flows can also have the benefit of diluting many low concentration contaminants that cannot be treated at The City's plants. Therefore, based on existing treatment capacities, source water quality protection could be even more important during low flow drought conditions.

Microbiological enteric protozoa, such as *Cryptosporidium* and *Giardia*, are the main pathogens of concern for drinking water. Their occurrence in source water is due to contamination by human or animal feces. Calgary is fortunate that their occurrence in our source water is very low by North American standards. Currently, extensive evidence shows that Calgary drinking water treatment processes are sufficient to treat current and historic protozoa levels found in Calgary's source water. However, significant increases of protozoa in source waters could trigger the need for additional disinfection in the future.

Nutrients, taste, odour and algal toxins are not a major problem for Calgary's source water, although taste and odour complaints have occurred in some past years. Tastes and odours can be imparted to water by a number of different chemicals. Some of the most potent are volatile organic compounds (VOCs) produced by naturally occurring algae and bacteria. Although algal blooms can happen under natural conditions, nutrient inputs such as phosphorus and nitrogen from upstream sources tend to increase their frequency and magnitude. Some algae are known to produce toxins; however, monitoring indicates that such algal species are identified infrequently and at low abundances.



Total organic carbon (TOC) is important to water treatment, as increases in TOC can lead to increased treatment costs. Increased TOC that is not accompanied by increased turbidity can increase operational complexities and reduce efficiencies, since dissolved organic carbon is more difficult to remove than solids. TOC is also a precursor to the formation of Disinfection By-Products (DBP) during chlorine disinfection. DBPs can result from chemical reactions between disinfectants and natural organic matter. DBPs are regulated in a precautionary manner to prevent them from causing public health risks and current water treatment practices and monitoring indicates that Calgary's treated water remains within all regulatory limits for DBPs.

Other organic compounds (pesticides, hydrocarbons, volatile organic compounds, PAHs) Calgary's source waters are routinely monitored for synthetic and naturally-occurring organic compounds, including pesticides, polycyclic aromatic hydrocarbons (PAHs), hydrocarbons and volatile organic compounds (VOCs). Since 2007, 103 different compounds have been tested, 53 of which have Canadian Drinking Water Quality Guidelines because of their potential public health risks. Over 1,800 samples from The City's raw water intakes were analyzed for organics between 2007 and 2016, and less than one per cent of these samples had detections. Levels detected in both the raw and finished drinking water were below drinking water guidelines in all cases. Maintaining high quality source water with respect to organics is important, since some of these compounds are not effectively removed by standard drinking water treatment processes.



Emerging substances of concern (ESOCs) are found in products people use on a daily basis, and include pharmaceuticals, hormones, detergents, plasticizers and flame retardants. ESOCs can make their way into surface waters via domestic and industrial waste, and urban and agricultural runoff. As technology continues to advance, it is easier to detect these substances at minute concentrations in water (i.e. parts per trillion or lower); however, our ability to detect these substances at such low concentrations vastly exceeds our capability to accurately determine whether there are any risks of human health effects at these very low concentrations. The World Health Organization conducted a review of pharmaceuticals in drinking water in 2012 and came to the conclusion that *appreciable adverse impacts on human health are very unlikely at current levels of exposure* [11].

Monitoring for ESOCs in Calgary's watersheds has been ongoing since 2007, and an ESOC Strategy was created in 2016. Since then, monthly monitoring has been conducted for 14 indicator compounds at the intakes of both water treatment plants, and semi-annual testing has been conducted for an additional 116 ESOCs. In total, 202 different ESOCs have been tested in Calgary's source water since 2007, and only six of these substances have been detected, all of which are indicators of wastewater impacts from

upstream communities. Of the indicator compounds tested on a monthly basis, the most frequently detected is caffeine, which has been observed in 18 per cent and 5 per cent of samples from the Glenmore and Bearspaw raw intakes, respectively. However, it must be emphasized that the concentrations detected are minute at 32 parts per trillion or lower. This is comparable or lower than concentrations found in other surface waters across North America [12]. The City is also working with government and University partners to gather information and conduct research on ESOCs to proactively advance the state of the science, inform regulatory agencies, and protect public health and the environment both upstream and downstream from Calgary.

Parts per trillion in perspective

The maximum concentration of caffeine detected in our surface water to date was 32 parts per trillion. To equal the amount of caffeine found in a single cup of coffee would require 12.5 million glasses of water at this concentration.



Calgary's watershed monitoring program

Established in the 1980s and expanded over time, The City of Calgary's Watershed Monitoring Program conducts monthly sampling of rivers, tributaries and reservoirs in the region, including 22 sites in Calgary's source watershed. This program complements the detailed daily monitoring of source water at the treatment plants. Historical records of water quality help monitor changing watershed conditions over time and implications for source water protection. Changes in water quality in smaller tributaries or specific reaches can serve as early warnings of deteriorating water quality, and can help pinpoint the locations of contamination sources.

Bow River source watershed

Overall, the Bow River and the Bearspaw Reservoir provide excellent, high quality source water to the Bearspaw Water Treatment Plant (Table 1). The Jumpingpound Creek tributary site shows the greatest departures of water quality from guidelines, although water quality is still considered 'Good' in this creek (Table 1). Jumpingpound Creek generally has higher nutrients, higher TOC, and higher turbidity compared to the Bow River.

In addition, the province maintains a monitoring site at Cochrane where a variety of pesticides are monitored. Between 2009 and 2015, only the herbicides 2,4-D and Mecoprop (MCPP) were detected, at frequencies of 18 per cent and 7 per cent of samples, respectively. However, maximum concentrations detected remained much lower than federal and provincial guidelines for aquatic health and drinking water.

Water quality index

The federal water quality index (WQI) represents overall general water quality conditions for rivers and streams. The index translates detailed data on multiple water quality parameters into a score from 0-100 along with a descriptor (e.g., 'Excellent', 'Good', 'Marginal', 'Poor'). The Bow River typically has 'Excellent' water quality, while the Elbow River typically has 'Good' water quality.

Elbow River source watershed

There are 14 City monitoring sites in the Elbow River source watershed (Table 2). A gradual deterioration of water quality has been observed from upstream to downstream through the watershed, ranging from the most upstream site (Cobble Flats), which has a perfect Water Quality Index (WQI) score of 100 (Excellent), to an overall rating of 87 (Good) at the Weaselhead footbridge. The changes are primarily due to gradual increases in Total Suspended Solids (TSS) and total phosphorus associated with more developed land uses and associated stormwater inputs. The largest increase in sediment and total phosphorus is observed between the Twin Bridges site and Sarcee Bridge, which reflects the transition from rural to urban land uses and increasing stormwater inputs. Other parameters, such as TOC, metals, *E. coli* and protozoa also demonstrate similar increases as the Elbow River approaches the Glenmore Reservoir. Studies have also shown a gradual deterioration of water quality in the Elbow River over time [13, 14].

Pesticides have been monitored in the Elbow River at the upstream end of the Glenmore Reservoir for over 10 years. Of the 72 pesticides investigated, only six have been detected, with the herbicides 2,4-D and MCPP detected most frequently. Their presence is due to the cumulative impacts from upstream sources, including urban stormwater inputs and diffuse overland drainage from various land uses in the watershed. However, maximum concentrations of pesticides still remain significantly lower than federal and provincial guidelines for aquatic health and drinking water.

Table 1: Summary of Calgary's watershed monitoring program: Bow River source watershed (2014-2016)

Bow River source watershed		
Monitoring site	Sampling frequency	Summary of water quality
Bow River below Ghost Dam	Monthly, year round	Excellent (100)
Bow River at Highway 22		Excellent (97)
Bow River below Bearspaw Dam		Excellent (100)
Tributaries		
Ghost River at Benchlands	Monthly, year round	Excellent (100)
Jumpingpound Creek at the mouth		Good (82)
Bearspaw Reservoir		
Bearspaw Reservoir west	Monthly, May to September	Oligotrophic*
Bearspaw Reservoir centre		
Bearspaw Reservoir east		

* River values based on Water Quality Index (WQI); reservoir value based on trophic status (oligotrophic represents a desirable low nutrient status).

Trophic state index

The Carlson Trophic State Index for chlorophyll a is used to measure algal productivity, as an indicator of the nutrient status for reservoirs. It is typically used to classify water bodies into three categories: oligotrophic, mesotrophic, or eutrophic. For drinking water and recreational uses, oligotrophic conditions are desirable as they have the lowest potential for harmful algal blooms to occur.

Table 2: Summary of Calgary’s watershed monitoring program: Elbow River source watershed (2014-2016)

Bow River Source Watershed		
Monitoring Site	Sampling frequency	Summary of water quality
Elbow River above Cobble Flats	Monthly, May to October	Excellent (100)
Elbow River above Bragg Creek	Monthly, year round	Good (90)
Elbow River at Highway 22 bridge		Good (92)
Elbow River at Twin Bridges		Good (87)
Elbow River at Sarcee Bridge		Good (86)
Elbow River at Weaselhead foot bridge		Good (87)
Tributaries		
Prairie Creek near mouth	Monthly, May to October	Excellent (100)
McLean Creek near mouth		Good (88)
Lott Creek near the mouth		Good (88)
Bragg Creek at the mouth	Monthly, year round	Good (88)
Bearspaw Reservoir		
Glenmore Reservoir – head pond	Monthly, May to September	Oligotrophic*
Glenmore Reservoir – mid-lake		
Glenmore Reservoir – Heritage Cove		
Glenmore Reservoir – Weaselhead		

*River values based on WQI; reservoir value based on trophic status, where oligotrophic represents a desirable low nutrient status.

“Our watershed is vital for communities; better source water means treatment is more cost effective.”

~ Internal City stakeholder

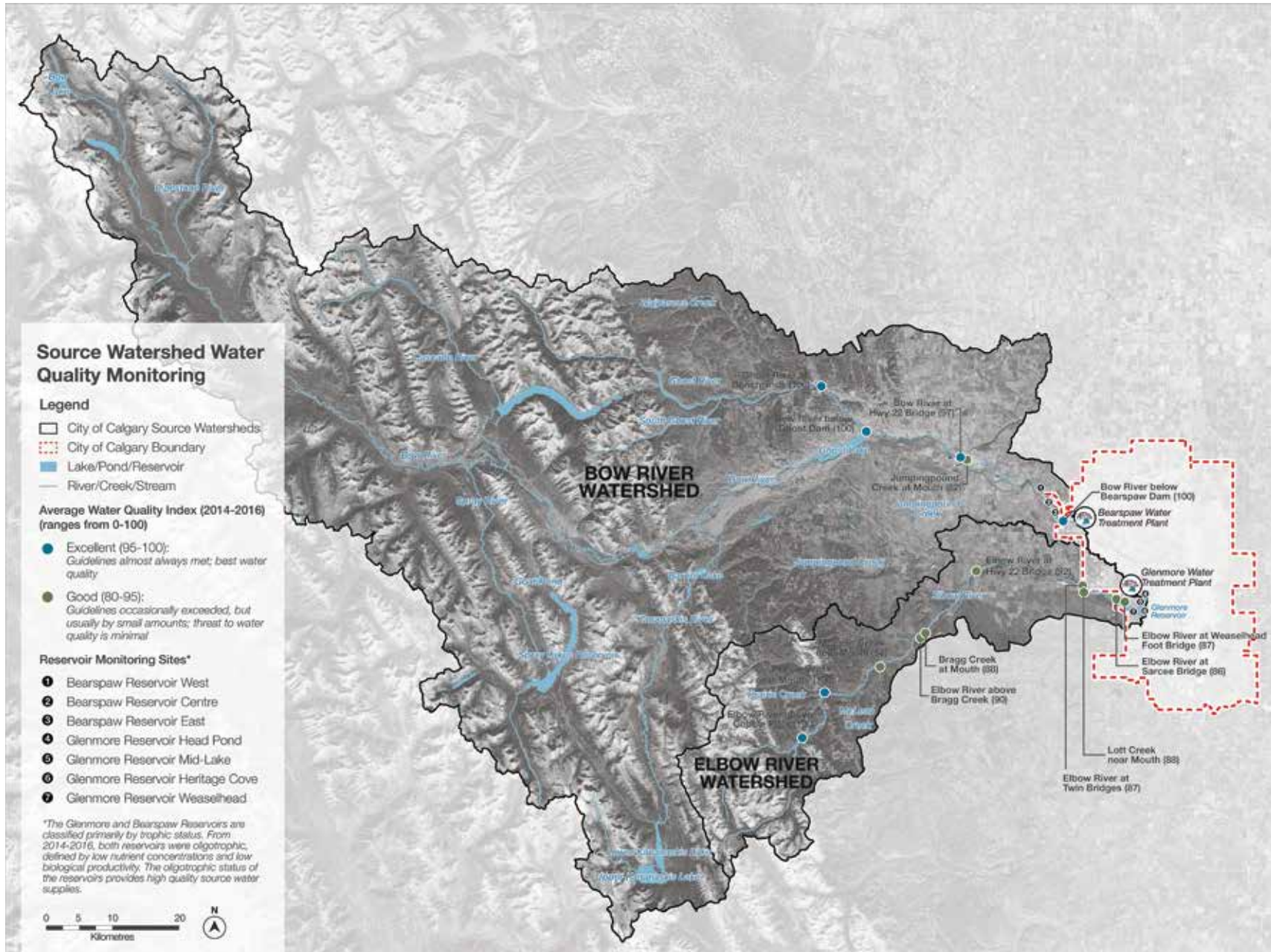


Figure 12: Source watershed water quality monitoring sites

The Glenmore Reservoir

Generally, the Glenmore Reservoir currently provides high quality source water. Water quality in the Glenmore Reservoir also tends to improve as water moves from the Weaselhead Natural Area through the reservoir to The City's source water intake. This occurs because natural processes in the reservoir facilitate the removal of particulate matter, nutrients, metals and protozoa from water as it passes through the reservoir. The reservoir tends to maintain low algal productivity – classified as 'oligotrophic' – which is ideal for source water (Figure 13). However, there is a risk that this delicate balance could be disturbed by land use change in the watershed combined with climate change. If nutrient inputs cause the reservoir to increase in productivity to mesotrophic or eutrophic conditions, source water quality will degrade, leading to a range of management issues.

Summary of source water quality issues

The City's extensive water quality monitoring shows that the Bow River generally provides excellent source water to The City. In contrast, the Elbow River generally provides good source water quality, but with some deterioration observed in recent decades. The cumulative effects of land use change and climate change may result in future issues such as more taste and odour issues due to algal blooms, or an increase in real or perceived public health risks due to ESOCs. These risks are likely higher for the Elbow River source compared to the Bow River source, due to existing and future land uses and lower dilution capacity of the Elbow.

Sediment, nutrients and flood dynamics in the Glenmore Reservoir

Most of the fine sediments that are deposited in the Glenmore Reservoir are washed or scoured past the dam during high flow events. The trophic index also tends to decrease in the Glenmore Reservoir the first few years following a flood (e.g., 2005, 2013) (Figure 13). This indicates that natural removal of sediment from the reservoir during high flow events may also be contributing to its desirable low-nutrient status.

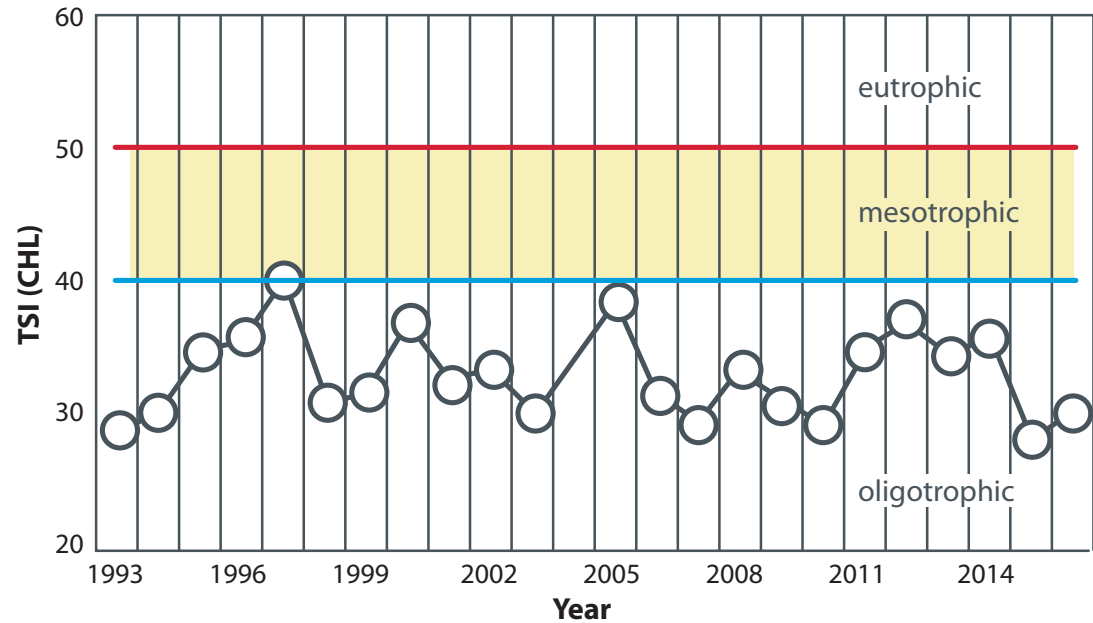


Figure 13: Trophic state index (average of monthly May-Sept values) in the Glenmore Reservoir over time

Source watershed risks

Assessing source water risks is a critical precursor to source water protection planning. To achieve this, The City worked with a multidisciplinary consulting team to complete a Source Watershed Assessment and Risk Characterization (SWARC) study. This study drew from and integrated with provincial direction including the Drinking Water Safety Plan process, as well as the American Water Works Association's Source Water Protection Standard [2] and the federal government's Source-to-Tap guidelines [15]. The methodology included mapping and spatial analyses, and a synthesis of information to assess and prioritize risks. Risks were prioritized in relation to one another based on the likelihood of risks occurring, and the consequence of risks should they occur. Vulnerable areas in the source watershed were also identified and mapped using a Geographic Information System (GIS).

Risk does not imply impact

Identified risks do not imply that actual impacts to source water are occurring. Risks have the potential to contaminate source waters if something goes wrong (e.g., a spill, major wildfires). Small impacts from multiple activities can also have cumulative impacts that gradually degrades water quality over time.

Key risk: Stormwater

One of the highest risks to Calgary's source water was identified as stormwater pollution from current and future land developments in the source watershed. Currently, almost 200,000 people live in Calgary's source watershed in several municipal jurisdictions. The vast majority of these reside within 30 km of Calgary's intakes. This population is projected to more than double to almost 400,000 people over the next 50-70 years. Stormwater quality is highly variable and shows significant spikes in pollutants in an unpredictable manner, and has the potential to degrade Calgary's source water. This could include either chronic impacts from ongoing loadings of low concentrations of pollutants or nutrients, or acute impacts due to spill events or runoff after severe storms. Hydrocarbons, pesticides and a variety of other organic compounds in stormwater cannot be treated effectively in our water treatment plants, and current regulations and best practices do not address these contaminants effectively. Nutrients and pathogens found in stormwater also present significant concerns. Temporary impacts to water quality during construction were also identified as a secondary concern. A secondary but relatively moderate concern associated with land development are increasing volumes of treated wastewater discharges associated with populations upstream from city limits not serviced by Calgary.



Key risk: Wildfire

Widespread, high intensity wildfires are also a key risk for Calgary's source watershed. Fires are known to impact water quality in several ways that could pose significant challenges. After fires, water chemistry changes in burned watersheds include higher concentrations of nutrients, sediment, metals, dissolved organic carbon and other organics, which can pose significant challenges for treatment [16, 17, 18]. Large, widespread wildfires are also likely to become more frequent due to climate change in the future [19].

The dry summer and fall of 2017 resulted in widespread fires in the region, including the Verdant Creek wildfire in Kootenay National Park, the Kenow wildfire in and around Waterton National Park, and the Bob Creek Wildland fire. Fortunately, the dry conditions of summer 2017 did not cause any large wildfires in Calgary's source watershed, in part due to the excellent proactive and reactive measures taken by provincial and federal land management and fire management agencies. However, these large wildfires do serve as a reminder of the potential for severe wildfires throughout Calgary's source watersheds.

Other risks

In addition to the top two source water risks described above, moderate risks identified include: contamination introduced from transportation corridors, wastewater, recreation, industrial discharges, livestock, use of pesticides on crops and country residential areas, oil pipeline spills, a rail line spill near Bearspaw and algal blooms. Many other risks were ranked as lower risks overall, based on biophysical factors, location in the watershed, existing regulations and management practices and current water treatment capabilities. It should also be noted that lower priority risks do not necessarily imply no management concern, as the cumulative effects of multiple stressors can also degrade water quality.

Time of travel

It can be difficult for treatment plant operators to receive notice and react to spills if travel times are short from upstream areas. Consequently, the time of travel for contaminants moving through a watershed is very important to prioritize locations for source water protection initiatives. This issue was carefully considered during source water risk evaluations.



Investing in source water protection makes good business sense

Investments in source water protection not only protect public health and help The City of Calgary maintain the high quality of drinking water citizens have grown accustomed to, but will also help to avoid expensive infrastructure investments required to treat water. Many other municipalities have found that proactive expenditures to protect source water can be more cost effective than building and operating more advanced treatment facilities.

Currently, the most frequent challenge faced by Calgary's water treatment plant operators is the need to remove high levels of suspended solids associated with turbidity events. Treatment processes have been selected and designed to deal with this challenge. In contrast, current infrastructure and operations are not designed to treat hydrocarbons, pesticides, ESOCs or other organics. Although to date these have largely been absent from our source waters, if source water quality degrades, more advanced treatment processes would be required.

The costs of upgrading both the Glenmore and Bears paw water treatment plants with more advanced treatment processes could reach **\$350 million of capital costs** for construction, and an additional **\$5.5 million/year annual operating costs** for ongoing operations and maintenance. The benefits in avoided costs that we derive from the high quality of our watershed and rivers is known as an ecosystem service – or a benefit that people obtain from nature.

Current drinking water treatment infrastructure

Water treatment processes at Calgary's two plants include:

- Pre-treatment utilizing a ballasted clarification process
- Clarified water basins
- Filtration with gravity flow and multi-media filters
- Chemical disinfection with sodium hypochlorite
- Clearwell for disinfection contact time and storage

Other ecosystem services in our source watersheds

In addition to clean source water for drinking water utilities, our high quality source watershed also provides many other ecosystem services to people. For example, recreational fishing contributes approximately \$25 million/year to Calgary businesses and the regional contribution of fishing-related activities is approximately \$114 million/year annually. Regional recreational paddling activities also contribute over \$50 million per year to the local economy. *Source: Calgary River Users Alliance [21]*



Source water protection goals

Strategic source water protection goals provide focus for a source water protection program. The City of Calgary’s goals for its long-term Source Water Protection Program are based on proactively preventing, reducing, or mitigating key source water quality risks, as part of a multi-barrier approach to providing safe, clean, high quality drinking water. The following goals have been carefully selected based on risk priorities, customer commitments and stakeholder engagement.

GOAL 1: Protect the source watershed with improved land use planning



Why is improved land use planning important?

Our source watersheds face significant future population growth and land use changes, and stormwater impacts associated with land development in our source watershed have been identified as a key risk. Additional guidance and tools for planning decisions will be needed to more proactively balance community growth with source water risk mitigation. Maintaining source water quality over the long-term requires careful attention in land use planning systems – both within and outside of Calgary city limits – to improve integration with source water protection. Highly vulnerable areas –

including water bodies, floodplains, riparian areas, river-connected alluvial aquifers, steep slopes and erodible soils – are areas that ideally should be left as open spaces during land use planning to reduce the risks of source water deterioration due to land development.

GOAL 2: Promote innovation in stormwater management to protect source water quality



Why is stormwater management important?

One of the highest risks to Calgary’s source water is stormwater pollution from current and future developments. To mitigate these impacts and prevent source water quality deterioration, careful attention to innovative stormwater management techniques will be required for both new and existing developments.

“Goals for a source water protection plan should focus on prevention vs. cure” ~ External stakeholder



GOAL 3: Leverage key partnerships for risk mitigation



Why is leveraging key partnerships important?

Partnerships are critical to address our source water risks, since most of the source watershed is outside of the jurisdiction of The City of Calgary. Experience and case studies from around the world demonstrate that effective partnerships are a requirement for an effective source water protection program. By leveraging key partnerships, additional funding can be obtained, while source water protection “champions” can be developed in multiple communities of practice. For Calgary, partnerships are particularly important to help protect and manage vulnerable source watershed lands in upstream jurisdictions.

GOAL 4: Involve the community through education and research



Why is stakeholder and citizen involvement important?

Many industries, stakeholders, and citizens work, live, and play throughout Calgary’s source watersheds. Ultimately, The City aims to create trusting, long-term relationships with decision-makers and communities in the watershed to achieve common goals. Best practice case studies show that by effectively involving people through education and research, municipal utilities can better achieve their source water protection goals through:

- Leveraging expertise from multiple knowledge domains
- Promoting learning and understanding by all parties
- Improving community relations



“A source water protection plan should provide long-term vision but concrete steps in the short and medium term, identify key actors and stakeholders, tools and actions, and should be easy to share, understand and communicate.”

~ External stakeholder

Source water protection action plan priorities

This section identifies and describes actions required to mitigate existing and future threats to source water quality, and establishes priorities and a timetable for Plan implementation.

Past source water protection actions

This Plan is just the latest chapter in a long history of source water protection in the Calgary region. Many agencies, industries, individual citizens and other stakeholders have executed actions that have influenced the high quality source water that we enjoy today. These actions go back well over a hundred years and are far too numerous to list here. However, key source water protection actions implemented by The City of Calgary in the past are summarized in Figure 14. In addition, selected examples of key actions that have been taken by other agencies are profiled below.

Today, The City continues to undertake ongoing operational actions for source water protection. Examples include:

- Extensive water quality monitoring programs.
- Integrating water quality enhancements into infrastructure projects.
- Mitigating source water risks throughout the development application review process.

The Bow River Basin Council: A key partner in source water protection

The Bow River Basin Council (BRBC) is a collaborative, multi-stakeholder charitable organization dedicated to conducting activities for the improvement and protection of the waters of the Bow River Basin. The BRBC is a Watershed Planning and Advisory Council (WPAC) under the province's *Water for Life* strategy. They maintain a forum for all members to share perspectives, exchange information, prioritize water management issues and develop reports including State of the Watershed reports and the Bow Basin Watershed Management Plan. The BRBC is a key partner in our efforts to raise awareness, promote source water protection, network with decision-makers and professionals, and help design sound, multi-stakeholder governance strategies, processes and pilot projects for improved watershed management.

Federal and provincial Crown land management agencies: Key partners in source water protection

Federal and provincial agencies in our source watershed play a key role in maintaining the quality of our source watershed. Two key roles are profiled below: the establishment and management of parks and protected areas, and wildfire risk management.

Parks and protected areas: Originally established in 1885, Banff National Park covers the majority of the Bow River watershed's headwaters, and their current mandate of ecological integrity is highly consistent with source water protection. Provincial parks and wildland areas - established through provincial leadership over a period of decades - also cover a large proportion of our source watershed. The South Saskatchewan Regional Plan (SSRP) recently expanded several provincial parks, wildland provincial parks and public recreation areas, with over 364 km² of new protected areas that will be established in Calgary's source watersheds.

Wildfire risk management: Alberta Agriculture and Forestry maintains rapid response capabilities for wildfires on provincial Crown lands and conducts wildfire risk management planning and modelling. Parks Canada also maintains rapid response capabilities for wildfires in the National Parks and also run an extensive prescribed burn program, which help lower fuel loads and reduce the risk of large, uncontrollable wildfires. During the dry summer of 2017, very effective firefighting responses were observed throughout and adjacent to Calgary's source watersheds. Tools such as fire bans and temporary motorized recreation bans on provincial Crown lands were also applied in 2017 to manage wildfire risk.





Figure 14: A history of source water protection actions implemented in Calgary

Source water protection action plan

To enable proactive approaches to source water protection, targeted priorities for future actions have been developed and grouped under each of the four goals (Figure 15). Implementation is anticipated to involve many partnerships, to leverage resources across a wide range of jurisdictions, domains, and disciplines. Collaboration and innovation will be promoted throughout Plan implementation. Although additional details will need to be built out further in the future, anticipated implementation strategies for each of the priority actions are outlined below, along with key stakeholders and proposed timelines.





 GOAL 1 Protect the source watershed with improved land use planning	 GOAL 2 Promote innovation in stormwater management to protect source water quality	 GOAL 3 Leverage key partnerships for risk mitigation	 GOAL 4 Involve the community through education and research
1.1 Develop and implement recreation management strategies and actions for the Bearspaw Reservoir	2.1 Prioritize erosion and sediment control inspections and enforcement within The City's source watersheds	3.1 Refine wildfire management strategies with fire management agencies	4.1 Conduct a traditional use study to explore First Nations' traditional knowledge on water and watersheds
1.2 Develop drinking water protection zone overlays and integrate with The City's statutory and regulatory instruments	2.2 Evaluate and implement stormwater management requirements to meet source water quality objectives	3.2 Conduct a watershed investment study to evaluate options to protect vulnerable source watershed lands	4.2 Provide guidance to university research projects in Calgary's source watersheds
1.3 Integrate source water protection priorities in regional land use and servicing plans and provincial regulations	2.3 Prioritize riparian, wetlands and green infrastructure projects within The City's source watersheds	3.3 Update emergency response plans for spills and increase co-ordination with industry	4.3 Develop a source water education plan to promote community and regional actions to reduce risks

Figure 15: From goals to actions: A summary of Calgary's source water protection program priorities



Goal 1: Protect the source watershed with improved land use planning



Action 1-1: Develop and implement recreation management strategies for the Bearspaw Reservoir

Recreational activities have been identified as a moderate risk to Calgary's source water, and planned new developments in the Haskayne area near the Bearspaw Reservoir are likely to significantly increase demand for recreation on the Bearspaw Reservoir, which is currently largely unmanaged. Source water quality risks, emergency response and public safety issues at the Bearspaw Reservoir require more proactive strategies. However, the governance of the Bearspaw Reservoir poses unique challenges. The City of Calgary's boundary ends at the reservoir's eastern shoreline. The reservoir itself, as well as the western and southern shorelines, are under the jurisdiction of Rocky View County. TransAlta Utilities is also a key stakeholder, as it has title to the Bearspaw Dam, reservoir and a right-of-way surrounding the water body.

Key stakeholders: City of Calgary (Water Resources, Fire, Recreation, Parks), Rocky View County, TransAlta Utilities, CP Rail

Timeline: Short-term (2018-2020)

Action 1-2: Develop drinking water protection zone overlays and integrate with The City's statutory and regulatory instruments

Development upstream from Calgary's intakes has been identified as a key risk to Calgary's source water, due primarily to the cumulative impacts of stormwater pollution associated with land development. A key tool to prevent or mitigate these contamination risks is the establishment of Drinking Water Protection Zone Overlays around source water intakes. Policies in these zones typically prohibit or restrict specific activities or land uses, such as industrial land uses, storage facilities for hazardous materials, gas stations and car repair garages, and dry cleaning facilities. Risk management plans can also be developed with business and property owners located in the overlay.

This tool has been established in many jurisdictions, including:

- Ontario (Intake Protection Zones - IPZ)
- Nova Scotia (Watershed Protection Areas)
- New York State (Watershed Protection Overlay Districts)
- North Carolina (Watershed Critical Areas)
- Western Australia (Public Drinking Water Source Areas)



Some municipalities restrict maximum site imperviousness of land uses in the watershed protection overlay to reduce stormwater pollution (e.g., San Antonio, Texas; Austin, Texas). Other municipalities (e.g., Whatcom County, Washington) have watershed overlays that require cluster housing development, very high standards of stormwater management, and mandatory retention of trees and native vegetation.

Key stakeholders: City of Calgary (Water Resources, Planning and Development), development industry, landowners in proposed overlay zones

Timeline: Short-term (2018-2020): Develop overlays and draft regulations and policies. Medium-term (2020-2023): Integrate with The City's statutory and regulatory instruments

Action 1-3: Integrate source water protection priorities in regional land use and servicing plans and provincial regulations

Development upstream from Calgary's intakes is one of the top two highest risks to Calgary's source water, due to the cumulative effects of stormwater pollution, as well as secondary risks related to treated wastewater discharge. This issue is an input to the decisions and deliberations on growth and servicing by the Calgary Metropolitan Region Board (CMRB). The CMRB is a new regional governing body, established in January 2018, with membership from the 10 municipalities in the Calgary region. Its mandate is to develop regional growth and servicing plans that promote the long-term sustainability of the region and ensure environmentally responsible land-use planning, growth management, and efficient use of land. All of these mandates are directly related to regional source water protection issues. This provides unique opportunities for source water protection priorities, risks and vulnerability maps to be used as inputs for the new regional growth and servicing plans.

Key stakeholders: CMRB members)

Timeline: Medium-term (2020-2023)

Provincial regulations and source water protection

In addition to the CMRB regional planning process, The City of Calgary supports provincial implementation of the South Saskatchewan Regional Plan (SSRP), including improved management of Crown lands in our source watershed. The City also strongly supports the application and enforcement of provincial legislation and regulations governing various industries and activities related to water and the environment. Provincial regulations or their interpretation could evolve in the future to further address source water protection priorities.



Goal 2: Promote innovation in stormwater management to protect source water quality



Action 2-1: Prioritize erosion and sediment control inspections and enforcement in The City's source watersheds

Erosion and sediment mobilization during construction is one of the risks associated with land development. In the absence of proper management, large volumes of sediment can be released from construction sites, as well as other pollutants such as nutrients or hydrocarbons. In 2017, The City of Calgary revised their Erosion and Sediment Control (ESC) guidelines, field manual, specifications and review processes. The City's source watershed priorities were integrated into this review. Starting in 2018, construction sites in Calgary's Bearspaw or Glenmore source watersheds will receive higher rates of monitoring and inspection compared to other parts of The City. Although this will be implemented in Calgary first, upstream municipalities have also expressed an interest in this idea for the future.

Key stakeholders: City of Calgary Water Resources (Water Quality Services), development industry, consultants, construction industry

Timeline: Short-term (2018-2020)

Action 2-2: Evaluate and implement stormwater management requirements to meet source water quality objectives

Increasing stormwater pollution was identified as one of the top two risks to Calgary's source water, due primarily to contaminants of concern such

Source water trend analysis update

In part to help inform future stormwater management, The City will also update statistical trend analyses of source water quality data in 2019.

as hydrocarbons, pesticides, organic compounds, nutrients associated with algal blooms and pathogens. Determining optimal stormwater management solutions for the source watershed requires further evaluation.

Additional requirements to meet source water quality objectives might include: diverting stormwater around The City's water intakes where feasible, oil and grit separators, enhanced stormwater pond designs, or low impact development/green stormwater infrastructure facilities. In the interim, The City is taking a precautionary approach, with any new stormwater outfalls in city limits required to discharge downstream of our source water intakes as feasible. Stormwater evaluations and recommendations should also be conducted in a collaborative manner involving upstream jurisdictions, to gain broader regional support for innovative stormwater management.

Key stakeholders: City of Calgary Water Resources, Alberta Environment and Parks, Alberta Transportation, Rocky View County, Town of Cochrane, and potentially Town of Canmore, Town of Banff and the M.D. of Bighorn

Timeline: Short-term (2018-2020): Evaluations and data analysis
Medium-term (2020-2023): Implement new requirements (pending resourcing)

37th St. S.W. stormwater trunk project: Water quality enhancements for source water protection

In 2018, as part of the relocation of the 37th St. S.W. stormwater trunk, The City is improving the quality of stormwater draining to the Glenmore Reservoir by installing an oil-grit separator to capture hydrocarbons and sediment and improve water quality. Water Resources is also investigating the opportunity to install an additional storm pond facility associated with this project to further polish stormwater quality, including nutrient removal.



Action 2-3: Prioritize riparian, wetlands, and green infrastructure projects in The City's source watersheds

The loss and conversion of riparian areas, wetlands, forests and pervious soils on the landscape is associated with watershed degradation and reduced water quality. By conserving and restoring these green infrastructure features and associated watershed functions, impacts of land use change on watershed health and water quality can be reduced or mitigated.

The City of Calgary has developed several strategic watershed-focused plans and policies that are being implemented, including:

- **The City of Calgary's Riparian Action Program** (2017) emphasizes the importance of riparian landscapes as natural infrastructure, and identifies actions to minimize further loss of riparian areas, restore degraded riparian areas, and develop outreach and education that encourages stewardship.
- **The Wetland Conservation Plan** (2004) was developed to help balance wetlands conservation in the context of urban development. The plan highlighted the important roles wetlands often play in maintaining or improving watershed health and water quality.
- **Green Stormwater Infrastructure:** The City continues to promote the integration of Green Stormwater Infrastructure or Low Impact Development as a key component of sustainable urban development throughout Calgary, including within our source watersheds. The Oakridge rain garden, installed in 2016, was selected in part to help improve the quality of stormwater discharging to the Glenmore Reservoir from this community.

There are perhaps even greater opportunities for projects to restore, enhance or build green infrastructure upstream from Calgary than within city limits. For example, land trust organizations and watershed stewardship groups have been working with landowners upstream of the city on a wide range of riparian health restoration and wetlands initiatives. There are strategic plans and policies for watershed management and green infrastructure beyond The City's borders as well, which are strongly encouraged and supported by The City. For example, Rocky View County has implemented a Riparian Land Conservation and Management policy.

Key stakeholders: Within The City of Calgary: City of Calgary Water Resources, City of Calgary Parks, development industry, consultants

Key stakeholders upstream from The City of Calgary: Rocky View County, City of Cochrane, Town of Canmore, Alberta Environment and Parks, Watershed Stewardship Groups, Land Trust organizations (Western Sky Land Trust, The Nature Conservancy of Canada, Southern Alberta Land Trust), Alternative Land Use Services (ALUS), private landowners

Timeline: Short-term and medium-term (ongoing)

"A source water protection plan should empower land users to make good management decisions."

~ External stakeholder





Goal 3: Leverage key partnerships for risk mitigation



Action 3-1: Refine wildfire management strategies with fire management agencies

The risk of large, uncontrollable wildfires was identified as one of the top two risks to Calgary's source water quality. In fact, this is the only risk that could cause a major change in source water quality over a relatively short time period. Although wildfire risk management and emergency planning is very well developed among provincial, federal and municipal fire management agencies, there remains a need to probe the question of wildfire risks further within the context of source water protection and multi-agency dialogue.

Although further scoping with provincial and federal agencies is required, a regional wildfire task force will be pursued to help enhance regional collaboration on wildfire risk management. The task force would discuss and determine options for improved land use management to help mitigate wildfire potential and impacts within high-risk subwatersheds identified as important to Calgary's source water. Potential actions and outcomes to be considered by the task force include:

- Reducing the likelihood of human-caused fires, using various enforcement options under high fire danger conditions.
- Reducing the potential spread and severity of an escape fire in high-risk watersheds, using prescribed burns and other silvicultural and/or forest management practices.
- Conducting mock fire scenario exercises to improve multi-agency communication, understanding, and response strategies.
- Clarifying fire suppression considerations if a fire escapes control in a high-risk watershed.
- Exploring additional synergies and future collaborations on wildfire management within the region.

Key stakeholders: Alberta Agriculture and Forestry – Wildfire Management Branch, Parks Canada, City of Calgary Water Resources, City of Calgary Fire Department, Rocky View County, City of Cochrane, Town of Canmore, Spray Lake Sawmills, Alberta Wilderness Association, Ghost Watershed Alliance Society, University of Alberta, University of Waterloo

Timeline: Short-term (2018-2020)

Action 3-2: Conduct a watershed investment study to evaluate options to protect vulnerable source watershed lands

Most of the headwaters of the Bow and Elbow watersheds are already protected by national and provincial parks. As a result, targeted investments to improve best management practices on vulnerable privately owned lands may provide significant benefits to maintain The City's source water quality over the long-term.

A model for watershed investments is to use market-based payments from downstream beneficiaries to upstream stewards and providers of watershed services. In this manner, The City could incentivize upstream stewardship actions that go above and beyond current legislation and regulations. The main challenges with moving this forward lies in navigating various institutional, administrative, economic, legal, and political issues. Although it is clear that Calgary and the region value water quality and clean drinking water, how much customers might be willing to pay in additional utility fees to help take care of our source watershed over the long term is a question that remains unresolved.

To help move forward in this direction, The City intends to undertake a Watershed Investment Study to examine and evaluate options and administrative processes that would be required to make this a reality. The existing expertise and innovation of land trust organizations and other non-government organizations is intended to be leveraged during execution of the study.

Key stakeholders: The City of Calgary Water Resources, The City of Calgary Parks, Western Sky Land Trust, The Nature Conservancy of Canada, Southern Alberta Land Trust, Alternative Land Use Services (ALUS), private landowners, Rocky View County, Miistakis Institute

Timeline: Short-term (2018-2020)

"We don't have to undertake further planning exercises to protect land, we simply need resources to action existing opportunities." ~ Dustin Pate, Western Sky Land Trust

"I think in the long run, conserving these lands could be a cost-saving measure for Calgary, good for tourism and good for the environment too."

~ Larry Simpson, Nature Conservancy of Canada





Action 3-3: Update emergency response plans for spills and increase coordination with industry

The risk of a rail line spill or oil pipeline spill upstream from our intakes was ranked as moderate overall. However, concerns over potential spills of hydrocarbons or toxic chemicals were expressed during engagement events, and this concern was heightened by recent oil pipeline spills affecting both Saskatchewan and Alberta. The CP rail line adjacent to the Bears paw Reservoir in particular is a concern, due to extremely short travel times to our intake if a derailment of hazardous materials were to occur. Additional concerns exist further upstream in the Bow River source watershed. For example, under typical conditions, the travel time from the Bow River in Cochrane to The City's intake at the Bears paw Dam is less than 24 hours, but can be shortened to under 2 hours during high flows. Improving emergency response planning within the Elbow River watershed is also important, despite a longer average residence time in the Glenmore Reservoir.

Key Stakeholders: City of Calgary Water Resources, Calgary Emergency Management Agency, Calgary Fire Department, Alberta Environment and Parks (Compliance and Drinking Water Operations Specialist), ASERT, Alberta Energy Regulator (Environment and Operational Performance Branch), Alberta Transportation, CP Rail, Husky, Shell, Plains Midstream, Western Canada Spill Services, Springbank Airport

Timelines: Short term (2018-2020)

Utilities are increasingly recognizing a strong need to connect the public's desire for high-quality water with an understanding of the costs involved in its delivery and the implications of underinvestment.

Canadian Water Network (2018): Balancing the Books: Financial Sustainability for Canadian Water Systems

Goal 4: Involve the community through education and research



Action 4-1: Conduct a traditional use study to explore First Nations' traditional knowledge on water and watersheds

During consultations with Treaty 7 First Nations, the idea emerged on the need for a traditional use study to better understand First Nations' ways of knowing and ways of seeing with respect to water, watersheds and land management in the Bow and Elbow watersheds. The purpose will be to obtain a deeper understanding and mutual respect of First Nations' viewpoints and values regarding watershed management, while also aiming to create more meaningful relationships between The City and Treaty 7 First Nations.

Key stakeholders: Siksika Nation, Tsuut'ina Nation, Stoney Nakoda Nation, Kainai Nation, Piikani Nation, Metis Region 3, City of Calgary Neighbourhood Services, City of Calgary Water Resources

Timeline: TBD: Short term (2018-2020) or medium-term (2020-2023) pending resourcing

Action 4-2: Provide guidance to university research projects in Calgary's source watersheds

The City of Calgary maintains active research partnerships and provides guidance to many university research projects within Calgary's source watersheds, and plans to continue to do so into the future. Existing partnerships related to source water protection include but are not limited to:

- **The Southern Rockies Watershed Project**, led by the University of Alberta with input from the University of Waterloo, focused on the impacts of wildfire on watersheds and source water quality along the eastern slopes of the Rockies within Alberta.
- **Global Water Futures**, led by the Global Institute for Water Security at the University of Saskatchewan, in partnership with the University of Waterloo, McMaster University and Wilfrid Laurier University.
- **The Advancing Canadian Wastewater Assets** partnership with the University of Calgary, where a controlled research environment has been integrated with The City's Pine Creek wastewater treatment plant to examine novel wastewater treatment technologies

Key stakeholders: Universities, academics, City of Calgary Water Resources

Timeline: Ongoing

Action 4-3: Develop a source water education plan to promote community and regional actions to reduce risks

It is crucial that the connection between raw water from source water areas and people's drinking water is conveyed to the public, landowners and recreationists alike. To achieve this, existing citizen education programs should be leveraged, expanded or shifted to address source water protection priorities, both within and outside of City limits.

Key stakeholders: City of Calgary, Bow River Basin Council, Rocky View County, Alternative Land Use Services (ALUS), TransAlta Utilities

Timeline: Long-term (2023-2026), pending resourcing

Trout Unlimited Yellow Fish Road program

Trout Unlimited's Yellow Fish Road program is a successful example of a public education program to raise awareness and promote watershed stewardship. It emphasizes the importance of people not pouring used oil, paint, fertilizers, pharmaceuticals or other contaminants down storm sewer drains in urban areas.



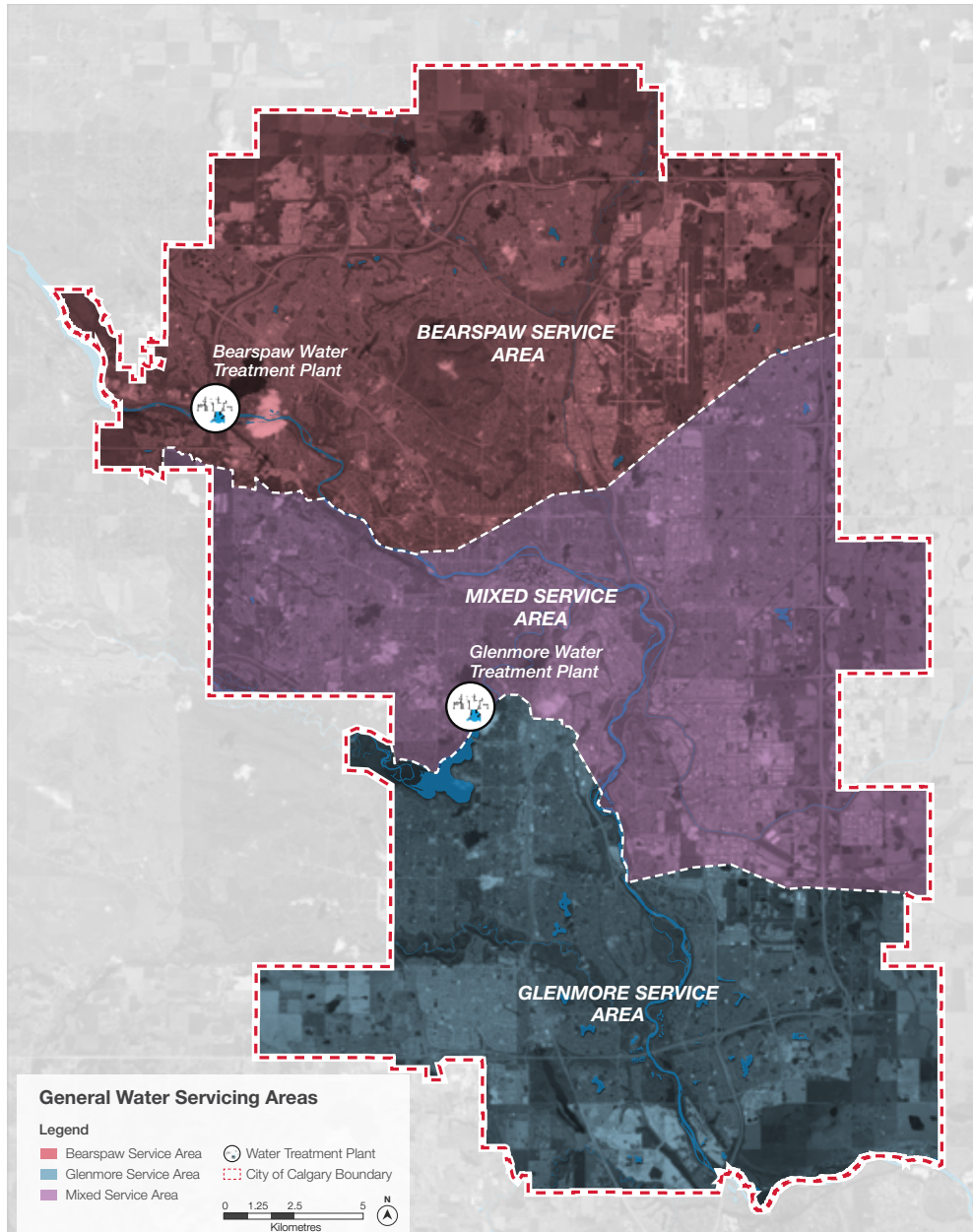


Figure 16: Typical potable water service areas in Calgary

Which river does your water come from?

Typically, the Bears paw plant supplies treated Bow River water to the northern half of Calgary and the Glenmore Plant provides treated Elbow River water to the southern half of Calgary. There is a wide swath through the middle of Calgary – including downtown and many inner city communities – that is typically a mix of water sources from both the Bow and Elbow rivers.

Typical conditions are shown in Figure 16. However, all of Calgary's water mains are connected to one another. As a result, water sources at different locations in Calgary change regularly in response to production and pumping volumes, operational strategies, or situations in the rivers and reservoirs.



Plan evaluation and revision procedures

This Plan was completed in 2018. The Plan will be reviewed and evaluated every five years to update water quality trends and document progress and issues. The formal review will take a results-based approach and should include an evaluation of:

- Source water quality monitoring data and updated trend analysis.
- Any significant incidents in the source watersheds.
- New scientific or technical research findings.
- New regulatory or planning initiatives.
- Evaluation of successful source water protection actions implemented.
- Challenges and obstacles encountered during implementation of the Plan, and lessons learned.

A wholesale revision of the Plan should occur every 10 years to ensure it is relevant and up-to-date with respect to goals, actions, outcomes, documented progress and potential need for more quantitative indicators. Additional formal stakeholder and public engagement is anticipated to occur prior to 10-year plan revisions. The review will feed into an adaptive management approach, addressing results in the context of our dynamic source watersheds. In a spirit of continual improvement, Plan revisions may require modifications or additions to the vision and goals, risks, action priorities, timelines, key stakeholders or program resourcing.

“A source water protection plan should empower land users to make good management decisions.”

~ External stakeholder



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List of acronyms

AEP – Alberta Environment and Parks

BRBC – Bow River Basin Council

CMRB – Calgary Metropolitan Region Board

DBP – Disinfection By-Products

DWSP – Drinking Water Safety Plan

ERWP – Elbow River Watershed Partnership

ESC – Erosion and Sediment Control

ESOC – Emerging Substance of Concern

GIS – Geographic Information System

IPZ – Intake Protection Zone

MAC – Maximum Acceptable Concentration

SSRP – South Saskatchewan Regional Plan

SWARC – Source Watershed Assessment and Risk Characterization

SWPP – Source Water Protection Plan

TOC – Total Organic Carbon

VOC – Volatile Organic Compound

WQI – Water Quality Index

Glossary

Bioretention area: A landscaped plant bed that captures and filters stormwater. They can differ in design and size from small residential rain gardens to large engineered bioretention areas.

Disinfection byproducts: Chemicals produced during the water treatment process, caused by reactions between disinfection agents and organic materials or ions naturally occurring in water.

Drinking water protection zone: The land and water areas surrounding municipal source water intake pipes, which are managed to prevent or mitigate contamination risks.

Drinking Water Safety Plan: A proactive method of assessing risk to drinking water quality, which better protects public health [20].

Ecosystem services: The benefits people obtain from nature. These include provisioning services such as clean water supplies, regulating services such as flood and disease control, and cultural services such as spiritual, recreational and cultural benefits [3].

Green Stormwater Infrastructure: An approach to use urban stormwater as a resource and manage it at (or as close to) the source of its creation, using vegetation, soils and other elements [22].

Low impact development: An approach to land development that uses various land planning and design practices and technologies to simultaneously conserve and protect natural resource systems and reduce infrastructure costs [23].

Multi-barrier approach: An integrated system of procedures, processes and tools that collectively prevent or reduce contamination of drinking water from source to tap to reduce risks to public health [15].

Riparian area: Transitional lands between upland and aquatic ecosystems. Riparian lands usually have soil, biological and other physical characteristics that reflect the influence of water and hydrological processes.

River-connected alluvial aquifer: Sand and gravel deposits containing water located beside and below rivers, where groundwater flows freely between the shallow aquifer and the river. It can extend for a few kilometres out from the river and typically ends at a relatively steep escarpment.

Source water: Water in its natural or raw state, prior to withdrawal for treatment and distribution as a drinking water supply.

Source water protection: (i) Taking action to prevent contaminants from reaching water sources; (ii) A site-specific process designed to maintain or improve the condition of water sources through a proactive, multi-barrier approach for managing risks.

Source water protection plan: A plan identifying required actions (management practices, statutory or regulatory changes, etc.) needed to mitigate existing and future threats to source water quality, which establishes priorities and a timetable for the plan's implementation [2].

Source water risk: The chance or possibility of a threat causing harm to the functioning of the drinking water system or to human health [15].

Source watershed: The land areas from which water drains downstream and provides raw water supplies for a drinking water utility.

Source watershed assessment: A study that defines the land area contributing to a public water system, identifies the major potential sources of contamination that could affect the drinking water supply and determines how susceptible the public water supply is to this potential contamination [2].

Watershed vulnerability: Reflects the ease with which contaminants, if present, could be mobilized downstream based on the intrinsic properties of the land and subsurface in different areas.



Engagement summary

Stakeholder engagement was undertaken to obtain input for developing this Plan. The purpose of engagement was to obtain input on source water protection goals and priorities, in keeping with documented best practice and The City of Calgary’s engagement policy. Stakeholder engagement results are summarized in “What We Heard”¹ reports summarizing internal City staff engagement events held in February 2017, and external stakeholder engagement events held in April 2017. Further engagement occurred during circulation of the draft document. Input was received from over 60 staff within City administration, and over 75 people representing more than 50 stakeholder groups in industry, other orders of government and non-profit organizations (Table 3). The Plan was also reviewed by four leading experts in source water protection and public health issues, including two within Alberta and two in the United States. Additional targeted engagement will also occur during future implementation efforts.

Table 3: List of industries, organizations or agencies consulted during external engagement

Industry groups	Non-government organizations	Watershed management groups	Government	Other
BILD Calgary Region	Action for Agriculture	Elbow River Watershed Partnership	Parks Canada	University of Calgary
Lafarge Canada Inc.	Canadian Parks and Wilderness Society	Ghost Watershed Alliance Society	Alberta Environment and Parks	University of Alberta
Husky Energy	Alberta Wilderness Association	Bow River Basin Council	Alberta Agriculture and Forestry	Calgary Regional Partnership
Volker Stevin Canada	Alternative Land Use Services (ALUS) Canada	Calgary River Valleys	Alberta Energy Regulator	Technical Services Advisory Group (TSAG)
Canadian Pacific Railway	Western Sky Land Trust	Oldman Watershed Council	Alberta Health Services	EPCOR (peer review)
TransAlta Corporation	Southern Alberta Land Trust	Bighill Creek Preservation Society	Rocky View County	Dr. Steve Hrudehy (peer review)
Spray Lake Sawmills	Nature Conservancy of Canada	Jumpingpound Creek Watershed Partnership	Town of Cochrane	Dr. Chi Ho Sham (international peer review)
Play Golf Calgary Facilities	Alberta Low Impact Development Partnership Society		Town of Banff (Wastewater Treatment Plant)	Julie Ventaloro, North Carolina Water Supply Watershed Protection Coordinator (international peer review)
River Spirit Golf Course	Alberta Riparian Habitat Mgmt. Society (Cows and Fish)		Town of Canmore	
Earl Grey Golf Club	Yellowstone to Yukon Conservation Initiative		M.D. of Bighorn	
			Town of Airdrie	

¹ What We Heard reports are available at calgary.ca or upon request

First Nations Engagement

Communications and engagement with First Nations was conducted throughout 2016 and 2017, for the following purposes:

- Informing First Nations on the scope of The City’s source water protection studies and plans.
- Listening and learning through conversations to understand First Nations’ perspectives on water and watersheds.
- Building relationships to help enable ongoing dialogue during future implementation activities.

This type of engagement is consistent with the spirit and intent of The City’s Indigenous Policy, and is separate from regulatory Duty to Consult obligations related to provincial legislation and legal requirements. A list of key engagement and communications with Treaty 7 First Nations undertaken during Plan development is summarized in Table 4 below.

Table 4 First Nations’ communications and engagement activities on City of Calgary source water protection to date

Date	Activity
January 2016	Letters to all Treaty 7 First Nations delivered
February 2016	Presentation at the Treaty 7 Water Sub-Table* Calgary, AB
May 2016	Follow-up meeting with Stoney Nation
September 2016	Presentation at Full Circle Gathering as part of City Indigenous Policy development, Jon Dutton Theatre, Calgary, AB
April 2017	Presentation at the Treaty 7 Water Sub-Table*, Calgary, AB
September 2017	Meeting with Tsuut’ina Nation representatives, Public Works Building, Tsuut’ina Reserve

* The Treaty 7 Water Sub-Table is organized by the Government of Alberta and includes participation from the Siksika, Kainai, Piikani and Stoney Nations.



