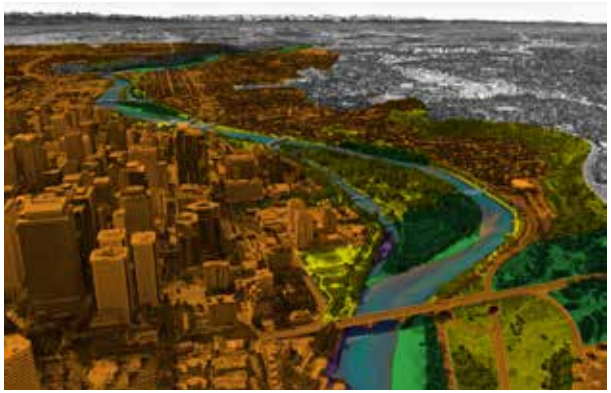
Calgary

The Riparian Action Program:
A blueprint for resilience

UCS2020-1007
Attachment 4

Table of Contents



The areas that border our creeks and rivers are highly valued landscapes and critical pieces of 'green infrastructure' that provide multiple, free, and self-sustaining services. The front cover illustration highlights the multiple uses of riparian lands located within the downtown core.

- Developed
- Conservation
- Flood and erosion control
- Restoration
- Recreation

PRINTING DATE: March 2017

WEB: www.calgary.ca

List of Figures

List of Tables

Foreword

Statement of purpose

Water utilities around the world are seeking new solutions to urban infrastructure issues and have recognized the importance of "green infrastructure" to protect, restore and mimic nature's water cycle. Green water infrastructure harnesses the power of natural design to provide multiple services, often free and self-sustaining, rather than building costly drainage and flood mitigation infrastructure.

The areas that border our creeks and rivers—riparian areas—are the foundation of The City of Calgary's integrated approach to watershed protection and management. The Riparian Action Program also takes a systems approach to program design based on the unifying vision and strategies established in the 2013 Riparian Strategy. It sets out a 10-year program focused on three areas and outcomes:

Program area	Outcome
Land use planning	Further loss of riparian areas is minimized
Health restoration	City-wide riparian health is improved
Education and outreach	Stakeholders and citizens value riparian areas

The following document characterizes riparian landscapes, organizes areas of work across The Corporation and brings emphasis to the importance of riparian landscapes as green infrastructure critical to integrated watershed management.

It is also a complementary companion piece to flood resiliency and mitigation. Many of the priority actions found here are equally critical to realizing the recommendations outlined within The City's **Report from the Expert Management Panel on River Flood Mitigation**, as well as other regional watershed management planning initiatives.

How to use this document

The Riparian Action Program is intended to be a working document and unfolds over three chapters. Chapter One discusses Calgary's riparian areas, including riparian ecosystem services, the health of Calgary's riparian areas, recent work to map and categorize these landscapes and citizen research. Chapter Two covers the main content of the program and outlines three areas of action and recommended outcomes and indicators. Chapter Three includes a series of watershed maps that provide an overview of riparian land uses in Calgary and identifies priority restoration projects.

Specific information and implementation tools designed for planners, engineers and practitioners are included in Supplements 1 to 4. Supplements include detailed information on land-use planning, restoration, monitoring protocols and engagement planning. Finally, detailed work plans for each program area are included in an Appendix.

Who should use this plan and how to make best use of it

The document should be used by planners, engineers, practitioners and watershed stewards within The Corporation and the community for direction and ideas on how to protect and restore riparian landscapes within Calgary. It is intended to help practitioners and citizens actively engage and align their work across Calgary's watersheds. It is hoped that this document will also help watershed stewards identify potential project partners.

This document may also assist with resourcing riparian protection and restoration projects, as proposals linked to this plan will be contributing to watershed goals. A number of resources, contacts and existing projects are detailed throughout.

83 per cent of Calgarians say that river areas are important to them personally.

Ipsos Public Affairs (2016b)

The legacy of Calgary's river parks and stewardship

Bowness Park: In 1912, developer John Hextall, donated Bowness Park area to The City in return for an extension of a streetcar line to his adjacent subdivision.

Lawrey Gardens: In the 1930s and 1940s, ice jam floods regularly impacted Calgary's riverside communities, including the working class neighbourhood of Lawrey Gardens, three miles west of downtown. To reduce flood risk, private residential lots in Lawrey Gardens were purchased by The City of Calgary with provincial assistance in the 1950s.

Bow Riverfront Park system near downtown: In the 1960s, the south bank of the Bow River alongside downtown Calgary was almost converted into a highway freeway and railway corridor. The public riverfront park system today that provides such an amenity next to downtown's skyscrapers was only made possible by a coalition between the organized women's movement, urban elites, philanthropists, and the planning department.

Pearce Estate Park: William Pearce, an early settler and the federal government's land commissioner, willed his property on the west bank of the Bow River in Inglewood to The City.

Sources: Armstrong, Evenden, and Nelles (2014); Nelles (2005)

"We have a clean river flowing through our city, this is so precious"

Riparian Landowner
Ipsos Public Affairs (2016a)

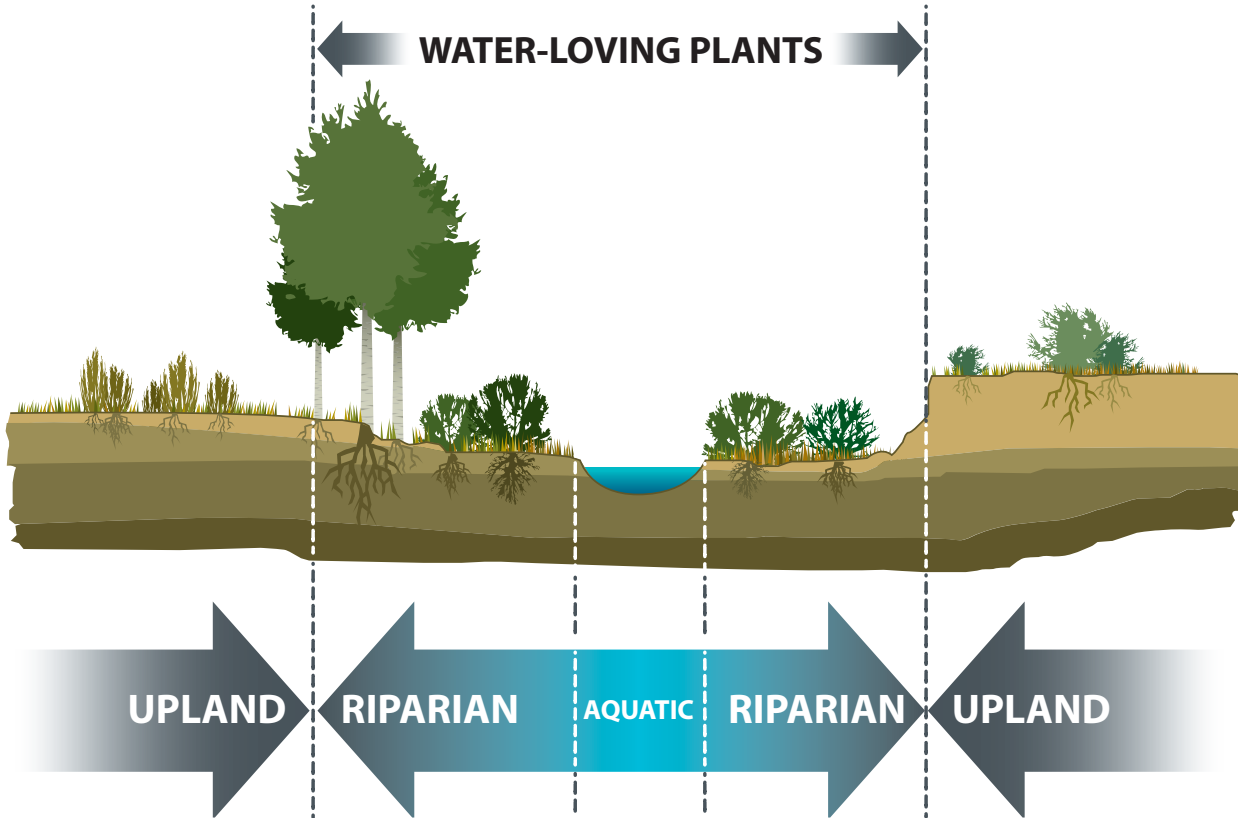
Green water infrastructure harnesses the power of natural design to provide multiple services, often free and self-sustaining, rather than building costly drainage and flood mitigation infrastructure.

Introduction: Building a blueprint for resilience

Riparian areas are central to watershed and community resilience

Riparian areas unfold like ribbons across our watershed, encompassing landscapes where land and water interact. They border rivers, creeks and wetlands and extend across the floodplain, down into the groundwater and upwards to include plants and trees (see Figure 1). These areas are unique ecosystems largely defined by the complex interactions that happen when land meets water. Along the water's edge, higher-than-average levels of nutrient exchange give rise to rich soils that store water and support a diversity of plant and animal life. This natural diversity sustains many ecological, social and economic benefits that we depend on, including clean drinking water, resilience to flood and drought, plant and animal life, recreational opportunities and experiences of nature within our urban environment.

Figure 1. Riparian areas border rivers, creeks, stream and wetlands (adapted from Fitch et al., 2001)



Resilience is the capacity to endure and recover from disruptive events. Resilience requires appropriate action before, during and after an event to minimize negative effects. A more resilient city suffers less impact when disasters occur and recovers more quickly.

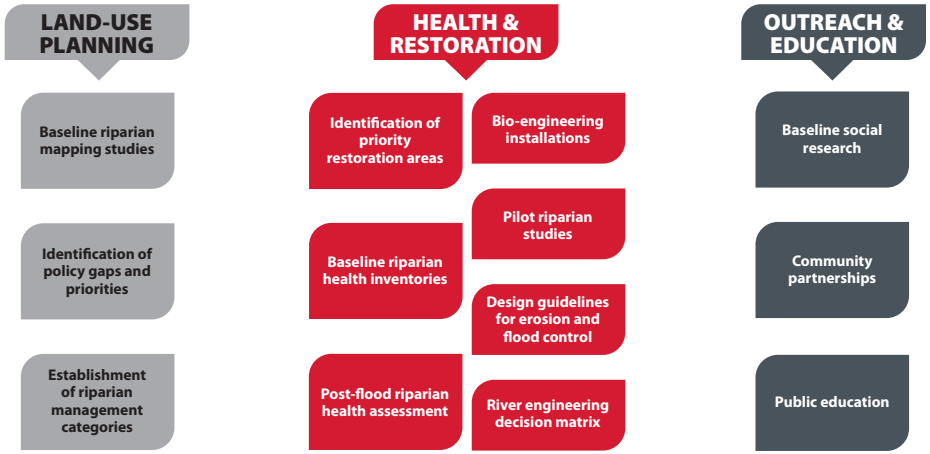
The Latin root of the word riparian is "ripa," meaning bank.

Within the past 10 years, The City of Calgary has focused on understanding the function of riparian areas within our watershed and on better understanding their connection to the resilience of our community after a flood. In particular, since the 2013 flood, our focus on better riparian management has become an urgent priority. Protecting these landscapes now will directly improve public safety in the near term and increase our watershed and community resilience in the long term. Healthy, intact riparian areas also improve overall drainage and minimize demands on our stormwater infrastructure.

Our commitment to riparian protection and management

The Riparian Action Program addresses multiple business priorities—including stormwater management, flood mitigation, biodiversity and climate change adaptation—while directly improving the quality of life for citizens and improving the resilience of our infrastructure and communities. While Water Resources has already undertaken many actions over the past decade to protect and restore riparian areas (see Figure 2). The Riparian Action Program aims to better co-ordinate and focus municipal and community efforts.

Figure 2. Actions undertaken to improve riparian areas



Program management and governance

Water is a public resource, and there is considerable legislation, policy and planning that already provides direction for riparian-area governance. In fact, the complexity of the Riparian Action Program is due to the broad number of interests that play a role in how we plan for and manage these areas. Currently, the management of riparian areas extends across federal and provincial governments, as well as across multiple municipal business units. Responsibility also extends outwards to partnering organizations, consultants, developers, private landowners and citizens.

It takes a community

Riparian protection is already an important part of how The City manages water and natural resources. The creation and implementation of the Riparian Action Program is made possible by the contributions of numerous City business units and departments., as well as community partners who have shared their expertise, guidance and support, including:

- City of Calgary: Water Utilities, Calgary Parks, Planning and Development
- Cows and Fish: The Alberta Riparian Habitat Management Society
- Calgary River Valleys
- Bow River Basin Council
- Government of Alberta

Due to the critical influence riparian landscapes play in the business of delivering and managing municipal water management priorities, Water Resources will oversee and lead riparian programming within The Corporation and Calgary's municipal boundaries. In the very near future, it is recommended that dedicated resources be established within Water Resources to oversee and deliver on programming identified within this document. It is also recommended that Water Resources provide annual Riparian Action Program progress updates to City Council.

Alignment with flood program and other corporate plans, policies and projects

The Riparian Action Program aligns with numerous provincial and municipal plans, policies and projects. Most notably, it is key to realizing the **Municipal Development Plan's** (MDP) goal of "Greening the City" and specific MDP objectives related to green infrastructure, watershed protection and ecological networks. It also provides a visible line of sight to MDP policies related to riparian protection that have long been approved, though not always consistently applied.

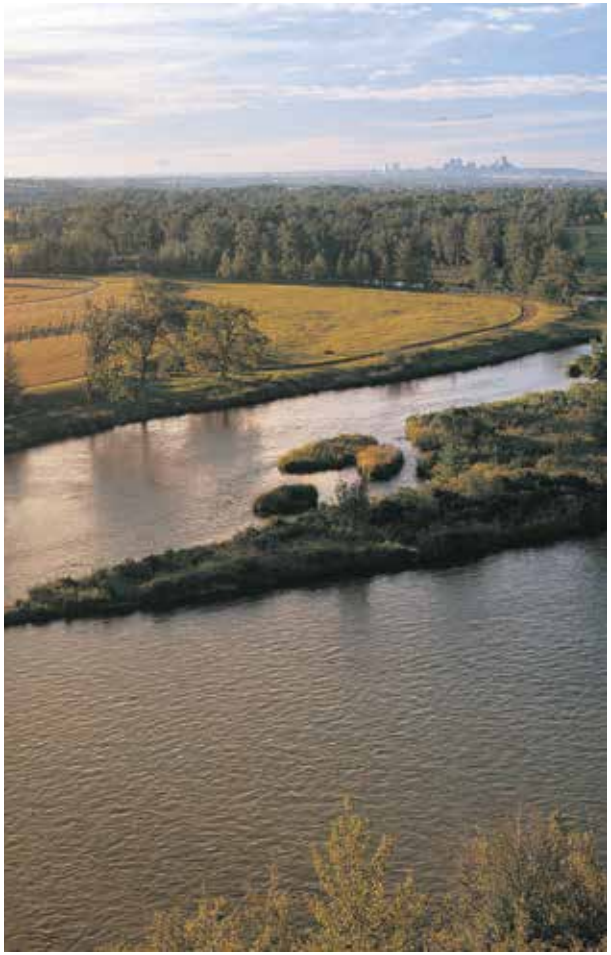
Many of the priority actions found here are equally critical to realizing the recommendations outlined in The City's **Report from the Expert Management Panel on River Flood Mitigation**. While the program focuses specifically on the natural riparian areas that border river, streams and creeks, it complements work related to wetlands and other watershed management programs. Other key areas of corporate alignment include the **Biodiversity Strategic Plan** (2015), the **Action Plan** 2015-2018 and a range of regional watershed management planning initiatives, including the provincial **Water for Life** strategy, regional and sub-regional plans like the **South Saskatchewan Regional Plan** and the **Bow River Basin Watershed Management Plan.**[1] See Figure 3.

Figure 3. Alignment of the Riparian Action Program with other corporate initiatives

1 See Supplement Two of the Riparian Strategy (City of Calgary, 2013) for a complete overview of legislation, policy and plans pertaining to Calgary's riparian areas.

Responsible planning and management of riparian areas will benefit Calgarians by providing cleaner water and improved drainage that supports recovery after climatic events, including flood and drought. As well, riparian areas improve public safety, minimize long-term costs to citizens, enhance the spatial quality of our river valleys and creek systems and protect critical environmental assets.

Riparian areas are the foundation of a new approach to integrated watershed management.



Riparian areas sustain our creeks and rivers.

Chapter 1. Riparian Areas in Calgary

Calgary's historical roots are at the confluence of the Bow and the Elbow rivers, a naturally occurring ford that has been the centre of life and activity in this region for millennia. Like many places around the world, as our city has expanded, our natural riparian landscapes have disappeared. Today, Calgary's riparian areas are marked by human intervention, and remaining natural open spaces that border our creeks and rivers often face pressures from recreation and development.

The City has undertaken significant work in partnership with riparian experts to better understand and characterize Calgary's riparian areas, including:

- Recognizing riparian ecosystem services.
- Assessing the health of riparian areas.
- Mapping riparian areas within the city.
- Creating riparian management categories.
- Conducting citizen and stakeholder research.

The work discussed within this section represents nearly 10 years of accumulated research and data focused on Calgary's riparian areas. This document provides a scientific foundation and direction for program implementation.

Calgary's creeks and rivers provide precious opportunities to experience nature in our city.

Recognizing the value of Calgary's riparian ecosystems

The benefits provided to humans by natural areas are often referred to as ecosystem goods and services. Networks of healthy, well-connected riparian areas are vital ecological infrastructure for cities and provide distinct goods and services with high environmental, social and economic values. By integrating natural and built infrastructure, water managers reduce their reliance on the latter, while at the same time realizing a host of riparian benefits, including:

Flood risk management Natural riparian floodplains act as a watershed safety valve by storing water during floods. Wide riparian buffers respect flood hazards and natural channel migration processes. Deep-rooted native plants in riparian areas reduce erosion, instability and bank failure. By retaining natural riparian areas and restoring degraded riparian areas, we will reduce infrastructure damage and risks to safety during future extreme floods.

Clean, safe water Healthy riparian areas are part of source water protection strategies that provide Calgary and downstream communities with fresh, clean water. Well-managed riparian areas can also provide natural filtration systems to help capture, store and filter a wide range of pollutants.

Biodiversity Riparian areas are among the most biologically diverse and productive places in Alberta. Networks of riparian open spaces provide critical habitat and corridors for plant, animal and fish populations.

Economic benefits Well-vegetated riparian areas provide free natural services that reduce the need for costly restoration and additional infrastructure over time. Functioning riparian ecosystems reduce the need for intervention and investment in water quality improvement, stormwater management and erosion protection. If riparian functions degrade, regulatory water quality and quantity targets may be more costly to meet, and reactive repairs or responses–like restoring stream banks and damaged property–may be required.

Quality of life Natural areas and open spaces provide a sense of place, opportunities for activities and play, tourism and education, as well as moments of quiet solitude in areas of natural beauty. High-quality recreation opportunities and scenic amenities contribute to our quality of life, improve our health and improve property values in surrounding communities.

Ecosystem service valuation method

While practitioners have yet to develop a simple, widely accepted method to calculate ecosystem service values, valuation techniques include:

- replacement costs
- avoided damage costs
- contingent valuation + willingness to pay
- choice experiment
- benefits transfer

An example of the avoided damage cost method would be the 2013 Inglewood critical erosion site. It required almost $5 million to repair and harden the bank. An intact, healthy riparian area, with deep-rooted trees and shrubs, would have slowed erosion at this site and may have eliminated the need for a major engineering intervention.

Therefore, the avoided cost of damage for a healthy riparian area at this site in Calgary is $2.5 million per hectare or $4,800 per linear metre of bank.*

*This cost value may be an underestimate, as it does not capture all types of ecosystem services (e.g., fish habitat, aesthetics, etc.)

Riparian areas are places where land meets water

Education and stewardship Riparian areas are premium outdoor classrooms. Spending time in natural riparian landscapes provides critical opportunities for Calgarians to connect with nature and helps them to develop an understanding of how Calgary's watershed functions. Increasing public awareness and understanding of how we are all connected to the river is essential to long-term environmental stewardship.

Assessing riparian conditions in Calgary: the legacy of urban planning

The condition of riparian areas in Calgary is measured using a riparian health inventory, which estimates the ability of a riparian area to provide a range of ecosystem goods and services, including the maintenance of watershed health. In Calgary's urban environment, riparian health has been reduced by a range of factors, including upstream dams, fragmentation by development, recreational activities, bank hardening, channelization and increased stormwater runoff and erosion.

The City of Calgary began conducting baseline riparian health inventories in 2007. The baseline assessments showed that more than 49 per cent of riparian areas city wide were unhealthy, and 40 per cent were healthy with problems. More recently, 2015 assessments showed considerable improvements over baseline levels, including an overall increase of four per cent in average city-wide riparian health (see Figure 7 on page 24). This trend was most pronounced in recently restored riparian areas and those areas beneficially influenced by the 2013 flood.

Mapping riparian areas

Though floodplains and riparian areas occupy the same physical space within our watersheds (see Figure 4), traditionally they have been modelled and mapped separately using different modelling methods. While flood mapping tends to focus on identifying hazards and risks to infrastructure, property and people, riparian mapping tends to focus on defining the boundaries of riparian ecosystems. Over the past years, The City has invested considerable resources in mapping riparian areas, including the application of a variable-width riparian areas model along Calgary's major rivers and, more recently, the mapping of ephemeral and intermittent streams. At the same time, The City and the Government of Alberta have continued to work closely to update flood hazard mapping.

This mapping work has highlighted that many riparian areas are either considerably larger than the current designated floodway, or are larger than the Environmental Reserve policy setback. As such, riparian and stream valley corridors are not fully protected in current land-use planning processes. Smaller headwater-drainage features that generate the majority of a river's flow and play a critical role in maintaining water quality [2] may be vulnerable to development.

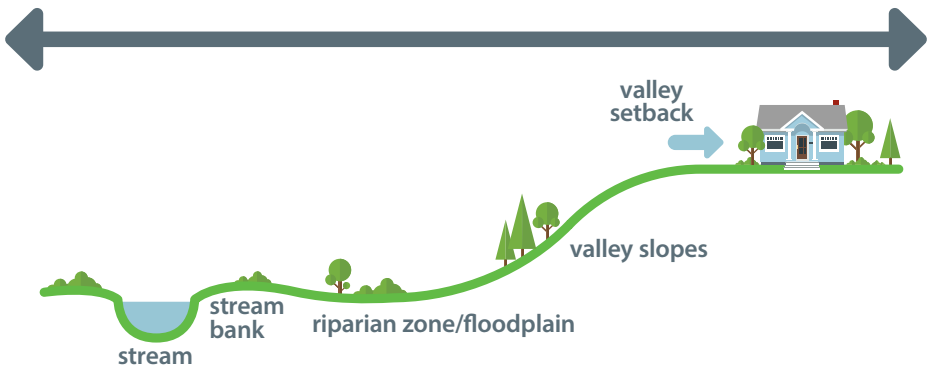
Similarly, river morphology mapping has helped to delineate channel migration zones and better account for how water channels change and migrate over time in our city. If we make room for rivers and creeks at the outset of planning, we can help prevent expensive damage to infrastructure and eliminate the need for expensive bank-hardening projects.

Overall, an important piece of work that lies ahead for The City and stakeholders is to better understand how mapping related to flood hazards and riparian areas (variable-width, morphology and ephemeral and intermittent streams) can be integrated with land-use planning systems. In doing so, we may base decision-making on best available science and adopt a more holistic approach to living with the river.

2 See (Bentrup, 2008; TRCA, 2014; USEPA, 2015).

Riparian areas in our source watershed protect and support water quality and quantity.

Figure 4. River valley corridor and setback



Classifying riparian management categories

Given their natural beauty and biodiversity, riparian areas are highly valued landscapes. To better manage these natural assets, The City developed a framework of riparian management categories that can guide river engineering approaches to restoration and bank stabilization, as well as potentially inform decisions about appropriate land uses within riparian areas.

Calgary's riparian management categories include: 1) **conservation**, 2) **restoration**, 3) **recreation**, 4) **flood/erosion control**, and 5) **developed**.

Table 1. Definition of riparian category and an example found within Calgary.

Management Category	Examples	Definition
Conservation		Riparian areas retained for natural open space.
Restoration		Riparian areas with poor health that are intended to be reclaimed or restored.
Recreation		An area of high recreational value and use.
Flood and erosion control		Riparian areas subject to flood and erosion risk. The priority is to mitigate potential flood or erosion damage using the best options available.
Developed		Riparian areas affected by development. If suitable opportunities arise (e.g., redevelopment), these areas will be assessed for restoration.

Making room for the shifting river

Provincial floodplain boundaries represent only a snapshot in time. Rivers, streams and floodplains are not fixed in place, but rather continuously shift in response to natural processes. During floods, these shifts occur particularly rapidly as swelling channels cut new banks, move out onto the floodplain and deposit gravel and debris picked up and carried from upstream areas.

Accounting for channel migration is increasingly important to sustainable land-use planning. Delineating channel migration zones and making room for the river can help prevent expensive damage to infrastructure and eliminate the need for expensive bank hardening projects to prevent flooding and erosion. Avoiding major new developments in river valley corridors makes sense.

It is predicted that the effects of climate change will alter the frequency and magnitude of floods and droughts. Scientists have recently observed changes to the jet stream that are slowing the progression of weather systems and increasing the likelihood of extreme weather. It is prudent to consider climate change risks in relation to the amount and type of new development allowed in these vulnerable areas.

The Elbow River changes over time

Riparian zones clearly correspond with flood extents

Riparian areas are dynamic, variable systems that respond to cycles of drought and deluge on time scales that range from hours to decades. It is very clear that riparian areas and flooded areas correspond highly with one another. The photos below contrast a sample riparian-zone map along the Bow River in South East Calgary with an air photo from the 2013 flood. Note: inner riparian zones typically correspond with the 1:5 year floodplain boundary; middle riparian zones tend to occupy the 1:20 year floodplain boundary; outer riparian zones tend to occupy between the 1:50 and 1:100 year floodplain boundaries; and the potential outermost riparian zone typically extends beyond the 1:100 year floodplain.

Mapped variable width riparian area (top) versus 2013 flood extent (bottom)

- Inner Riparian Zone
- Middle Riparion Zone
- Outer Riparian Zone
- Potential Outermost Riparian Zone

Implications for management practices and land uses in riparian areas

Key policy gaps related to land-use planning include a need for consistency in riparian river engineering approaches and permitted land uses. Ultimately, riparian management categories address these gaps by providing a city-wide framework and geospatial vision for the use, protection and management of riparian lands. For example, all project engineers and consultants involved with bank stabilization and erosion control are directed to use these management categories when designing bank stabilization and river engineering projects (see Riparian Decision Matrix on page 58).

It is our recommendation that, where possible, these management categories direct City of Calgary guidelines, processes, policies and bylaws related to riparian areas. Key work moving forward will be to consult with internal and external stakeholders to reconcile other land-use planning processes and policies with the proposed management categories.

Understanding citizen and stakeholder values

At the heart of the Riparian Action Program are two discreet, yet related, areas of activity: riparian protection and riparian restoration. Essential to achieving success in both areas will be the engagement of citizens and riparian landowners to understand, value and take action. To this end, The City developed a robust research plan to gain a better understanding of the audiences and potential programs that could be designed to advance riparian protection in Calgary.

Research took place over a six-month period and used a mixed-methods approach that included semi-structured and in-depth interviews, focus groups, surveys and literature review. In addition to informing program development, this research also established a baseline and indicators and has revealed the foundational citizen values and expectations that will inform subsequent stages of community engagement related to land-use planning and policy, and restoration.

The floodplain provides vital space to hold water during spring melts.

Chapter 2. Riparian Action Program: A blueprint for resilience

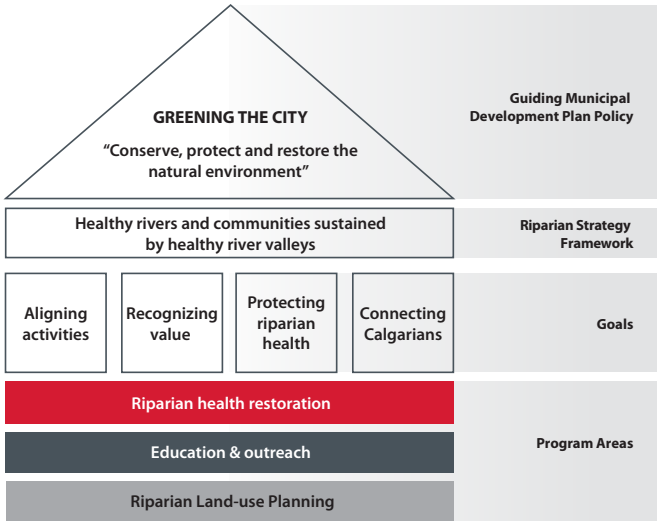
Building resilience through a systems approach to programming

The challenges facing our watershed and water management approaches cannot be understood in isolation. They are often systemic problems, interrelated and interdependent. Just as the challenges facing riparian areas are interconnected, so too are the intervention points for change. The ability of our riparian areas to provide Calgarians with ecosystem services is intimately tied to their health and to our land use planning choices. Similarly, it is also tied to the citizen and community values that influence and shape our choices. As such, the program contains three areas of focus:

1. land use planning
2. health restoration
3. education and outreach

This program has been designed purposely to deliver on the goals outlined within the **Riparian Strategy** framework (see Figure 5). It is also based on best-available science and a robust planning process. The following chapter discusses these program areas in more detail, including desired outcomes, current trends, key actions to improve our performance and how we will measure our results.

Figure 5. Alignment of Riparian Action Program with Riparian Strategy



83 per cent of Calgarians care about The City having a plan to preserve and protect river areas

Ipsos Public Affairs (2016b)

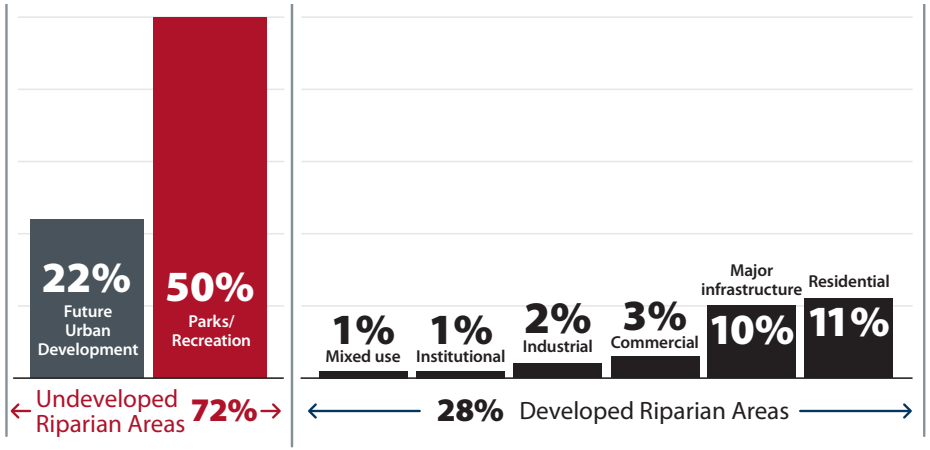
Outcome: Further loss of riparian areas is minimized.

Program area one: riparian land-use planning

Indicator #1: Retain open spaces along major perennial creeks and rivers.

Less than one third (28 per cent) of riparian areas are developed in Calgary. The vast majority (72 per cent) of these areas have been effectively conserved due to a combination of regulation, philanthropy and buyouts in the 1950s, a remarkable legacy that continues to define the lives of Calgarians today. The remaining 22 per cent awaiting planning and development is largely agricultural land in various stages of the planning process.

Figure 6. Major land uses in Calgary's riparian area (2012)



Indicator #2: Limit the conversion of riparian areas to new development along ephemeral and intermittent watercourses.

Work to inventory and map ephemeral and intermittent watercourses is ongoing. Once complete, limits of acceptable change related to the loss of ephemeral and intermittent watercourses will be defined.

Three key actions to improve performance

1. **Identify riparian areas.** While many riparian areas have been identified and protected, significant work remains. First, most river maps represent only a snapshot in time, because rivers, streams and floodplains are not fixed in place, but continuously shift in response to natural processes. As such, it is important to assess river geomorphology to better understand the changing landscape of riparian areas. Second, The City must identify ephemeral and intermittent streams. The health of our rivers and streams depends on the ephemeral and intermittent watercourses and wetlands where they begin. Yet, due to their small size, intermittent nature and lower aesthetic value, small drainage features are often lost or highly vulnerable to the impacts of urban development. Identifying these areas is an important step towards enhancing green infrastructure and working with nature.
2. **Protect riparian areas.** Riparian floodplains are just one component of river or stream corridors, which contain a mosaic of landscape types. Protection of slopes associated with valleys, ravines, gullies and coulees is also critical for watershed protection, as these slopes are often prone to erosion and sediment mobilization.

Support tools for practitioners: land-use decision trees

In response to stakeholder demand and identified gaps in process, The City has developed a series of decision-making trees to support land use planners and developers. These flow charts integrate riparian area direction policies from a wide number of documents. See Supplement Two.

Currently, Environmental Reserve (ER) is the most effective planning tool to protect riparian areas. The City's ER setback policy and guidelines [3] are based on the Municipal Government Act (MGA) and are variable widths based on a number of factors, including waterbody type, slope, vegetation cover and local groundwater influence. However, they do not go far enough to protect all riparian areas, such as ephemeral and intermittent streams, nor provide a large enough setback to ensure healthy and functioning riparian areas. Generally, best-practice provides more space to rivers and streams, so that natural processes can occur. To achieve this, the current ER setback policy and guidelines must be reviewed, and processes must be developed to ensure new guidelines are consistently interpreted and applied throughout The Corporation. It is recommended that Administration also investigate other ways to protect riparian areas. For example, once the Municipal Government Act is updated, other planning tools may become available.

3. **Manage development along riparian areas.** Allowing appropriate land uses and managing the interface between development and riparian areas in greenfield areas will help ensure that riparian areas remain healthy and continue to provide ecosystem benefits. It is recommended that Administration investigate other planning tools or approaches to manage and inform appropriate land uses along riparian areas.

Who will benefit

Current and future Calgarians will benefit from improved community safety, as these drainage features can be designed as emergency valves for extreme rainfall events. Other benefits include access to nature and increased ability to recover from climatic events, including flood and drought. As more riparian areas are protected from development, The City could lower its maintenance costs by having less engineered drainage infrastructure.

Partners who can help us

City of Calgary. Parks, Planning and Development, Water Resources.

Other. Cows and Fish, Calgary River Valleys, Federation of Calgary Communities, community associations, citizens, Urban Development Institute, Canadian Home Builders Association, consultants, planners and developers.

Performance measurement Measuring and reporting on program progress will rely on a results-based framework including indicators and targets. These provide guidance over the long term and assist with assessing our performance during the implementation period. See Table 1 below for an overview of indicators and targets.

Table 2. Riparian land-use indicators and targets

Outcome	Indicator	Area	Baseline	2026 Target
Further loss of riparian areas is minimized.	riparian open spaces along major perennial creeks and rivers*	City wide	73%	No net loss
		Bow River	75%	
		Elbow River	62%	
		Nose Creek + West Nose Creek	67%	
	riparian open spaces along ephemeral and intermittent watercourses	City wide	**Limits of acceptable change/thresholds for ephemeral and intermittent streams are to be determined.**	

See Supplement Three for detailed methodology and land-use monitoring protocols.

The health of our rivers and streams depends on the ephemeral and intermittent watercourses and wetlands where they begin.

3 See http://www.calgary.ca/CSPS/Parks/Documents/Planning-and-Operations/Natural-Areas-and-Wetlands/environmental_reserve_setback_policy.pdf

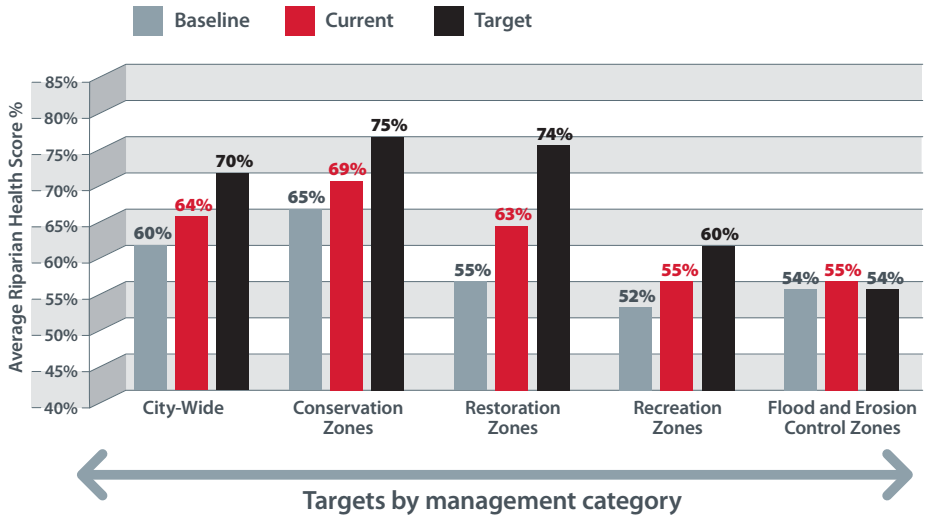
Outcome: City-wide riparian health is improved.

Program area two: riparian health restoration and monitoring

Indicator #3: City-wide riparian health index scores improve over time.

Baseline surveys of riparian health were conducted from 2007 to 2010 across 57 sites in Calgary, representing over 368 hectares of riparian habitat. All of these sites were revisited in 2014-2015. Assessments show that, overall, riparian health scores in Calgary have improved over this time period, with 25 per cent of sites showing an improving health trend and very few sites showing a declining health trend. Overall, the City-wide average riparian health score increased by approximately four per cent (from 60 per cent to 64 per cent). Key factors contributing to this trend include restoration and management improvements, natural vegetation recovery and the beneficial impacts of the 2013 flood on riparian ecology.

Figure 7. Trends and targets of riparian health



Unhealthy riparian area.

Healthy with problems riparian area.

Healthy riparian area.

Three key actions to improve performance

1) **Integrate bioengineering techniques into bank restoration.** Bioengineering [4] is more ecologically beneficial than hard riprap designs—the practice of armouring and stabilizing banks with rock. While riprap is an effective immediate answer to erosion, it impacts riparian health, and its long-term effects can be less than ideal. The hard rock surfaces tend to increase water flow, which reinforces the damaging effects of high flows downstream. The rocks also impact sensitive spawning areas, by heating the water and depriving fish and wildlife of oxygen, food and habitat. Vegetating degraded areas is a lower-maintenance and self-sustaining solution with multiple benefits, such as providing critical habitat for fish and wildlife and creating areas of natural beauty in our urban landscape. Bioengineering can also enhance hydraulic benefits, as the surface roughness associated with plants absorbs energy and reduces water velocities. Evidence shows that bioengineering can outperform riprap alone, with its higher resistance to shear stresses. [5] The City of Calgary promotes multi-functional bioengineering designs, and significant progress has been made to encourage adoption of these approaches within the community at large. See Supplement One for a discussion of the differences between structural and plant bioengineering, as well as examples of successful bioengineering projects in Calgary.
2) **Monitor riparian health and evaluate performance.** As restoration projects are conducted, systematic collection of successes and failures helps to identify trends, monitor performance and inform future improvements to procedures and specifications. The City already monitors riparian health conditions and collects data on planting survival rates in restoration sites. This data has been used to develop design recommendations to maximize survival rates and to inform choices related to installation timing, irrigation and environmental factors (TCS 2016).
3) **Build capacity for riparian restoration.** Riparian restoration requires specialized knowledge of hydrology, riparian processes, engineering, plant biology, soils and ecology. It also requires the capacity to undertake the work and the ability to monitor and evaluate site performance. Significant portions of Calgary's river and creek banks require restoration in the upcoming years. While The City has some capacity, it will need new and additional resources internally and externally. Superior results may be achieved by investing strategically in partnerships with academia, NGOs and private industry to accomplish this work and build riparian restoration capacity within the community.

Bioengineering incorporates living and non-living plant materials in combination with natural and synthetic support materials.

Many fisheries experts believe that the most critical impacts to fish and fish habitat occur, not as a result of a flood event itself, but rather from our response to the flood. Bioengineering is more ecologically beneficial than hard riprap designs—the practice of armouring and stabilizing banks with rock.

Almost all fish and wildlife depend on the areas bordering our rivers and creeks for some part of their life cycle.

4 Bioengineering is an approach that incorporates living and nonliving plant materials in combination with natural and synthetic support materials for slope stabilization, erosion reduction and vegetation establishment.

5 See Pack and Gaffney (2014).

Support tools for practitioners: bank restoration decision matrix

In response to stakeholder demand and identified gaps in process, The City developed a decision-making tool to support river bank engineers and developers choosing the type of bank stabilization design to apply to different areas. See Supplement One.

Bioengineering can outperform riprap—the practice of armouring banks with rock.

See the watershed maps in Chapter Three for an overview of planned future riparian restoration projects.

Who will benefit

As more riparian areas are restored to health, current and future Calgarians will benefit from improved water quality in our waterways, improved drainage and improved public safety due to increased ability to recover from climatic events, including flood and drought. Healthy banks are also more aesthetically pleasing, require less engineered bank infrastructure and provide critical habitat and corridors for plant, animal and fish populations.

Partners who can help us

City of Calgary. Parks, Water Resources

Other. Cows and Fish, watershed stewardship groups, external consultant planners and riverbank engineers

Performance measurement

The condition of riparian areas is a critical indicator of watershed health. Riparian areas are strongly influenced by surrounding watercourses and landscapes, including historic and current land uses and activities. Consequently, targets or indicators depend on both location and context. Riparian zones in heavily urbanized areas require targets different from those in riparian areas within intact natural open spaces. The size of a river or creek also influences target-setting.

Table 3. Riparian health indicators and targets

Outcome	Indicator	Area	Baseline	2026 Target
City-wide riparian health is improved.	riparian health index score	City wide	61%	72%
		Conservation zones	65%	77%
		Restoration zones	56%	71%
		Recreation zones	52%	60%
		Flood and erosion control zones	55%	54%

See Supplement Three for a detailed explanation of riparian health index (RHI) score methodology and monitoring protocols.

Flooding, upstream dam operations and influences on riparian health

Seasonal peak flows and occasional large floods are natural processes that renew riparian vegetation. Between the 1950s and 2000s, dam operations, combined with a lack of major natural floods, created a deficiency of new natural vegetation along the Bow River within Calgary. After the 2013 flood, many new gravel bars were deposited or expanded in Calgary, providing suitable conditions for native vegetation to colonize and grow. Observations during summer 2014 revealed extensive balsam poplar seedlings along new gravel bars and scoured floodplain surfaces.

Dr. Stuart Rood of the University of Lethbridge has been working with TransAlta to develop flow "stage ramping" criteria for the Bow River to imitate natural hydrographs and promote the establishment and growth of native balsam poplar and willow. This can be optimized with June peak spring flows of 350-375 m3/s on the Bow in downtown Calgary, followed by a gradual decrease in stage elevations of 2.5 cm per day in June/July, and 1 cm per day in August. Restoring these more natural flows can provide highly efficient restoration compared to riparian plantings, which are only locally effective and may require periodic replenishment and maintenance.

Seasonal peak flows and occasional large floods are natural processes that renew riparian vegetation.

Program area three: education and outreach

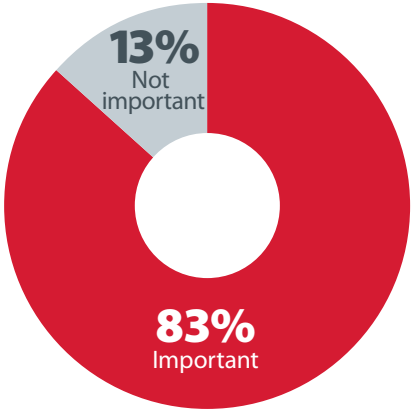
Indicator #4: Community engagement with riparian areas (awareness, attitudes and actions) increases over time.

A general population survey conducted in 2016 provided a baseline of Calgarians' awareness, attitudes and values related to riparian areas. Results show that while the majority (83 per cent) of citizens report that rivers areas are personally important to them, few Calgarians are aware of the true health of riparians areas. Also, a lack of awareness of what to do was reported as the biggest barrier to not doing more to take care of river areas. These findings will help direct long-term riparian education and outreach efforts.

Indicator #5: Community stewardship actions increase over time.

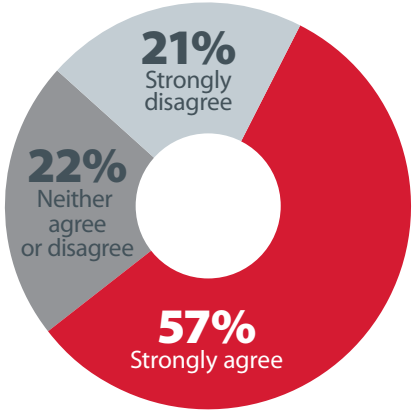
While indicator data, such as polling, give us a sense of how Calgarians are progressing in terms of their awareness, attitudes and actions, community actions bring numbers to life and provide real examples of engagement. Insights from indicator data can be bolstered by stories of community actions and by tracking stewardship activities within City programs and community partners.

Figure 8. Calgarians who say river areas are personally important to them



Source: Ipsos Public Affairs (2016b)

Figure 9. Calgarians who agree not knowing is reason for not acting



Source: Ipsos Public Affairs (2016b)

Three key actions to improve performance

1. **Tell a holistic story of living with the river.** The unique nature of riparian ecosystems provides a rich and tangible narrative to knit together water conversations that we've often had in isolation or not at all. Riparian areas also offer an important invitation into conversations about past water management decisions and the need for newer, greener solutions to infrastructure challenges and land-use planning.
2. **Create opportunities for Calgarians to connect.** The tangibility of the river's edge will help make otherwise complicated concepts of ecosystem services and natural assets more real and accessible. Connecting to the river is also a powerful way to foster environmental stewardship and civic engagement. Stakeholders must be given opportunities to be a part of the work happening within their communities from the beginning and to shape and own the success of these riparian projects. In bringing citizens along on the journey of restoration, projects become community celebrations and our civic environmental stewardship is strengthened.

Outcome:
Citizens and riparian landowners value riparian areas.

71 per cent of Calgarians agree that it is only through educating the public that we will be able to improve the health of our river areas

Ipsos Public Affairs (2016b)

Utilities and Environmental Protection's Public Art Plan: bringing water into public focus

Utilities and Environmental Protection's Public Art Plan merges ecology, art and community to bring our creeks, rivers and watershed landscapes into public focus. Integrated public art, which is open to interpretation, is designed to encourage dialogue about watershed protection and strengthen the emotional connection citizens have with their natural environment. Throughout each project, artists incorporate resident neighbourhood perspectives and insights into their work.

In 2010, approximately 20,000 Calgarians took part in The Celebration of the Bow, the plan's first major temporary project, during which illuminated spheres were floated down the Bow River. Currently, there are more than twenty public art initiatives underway. One project completed in 2014 is Bow Passage Overlook, located next to Harvie Passage at Pearce Estate Park. From a series of terraces and a grotto-like seating area, visitors can capture views of the Bow River and surrounding landscapes, while pathways and river-access points bring them to the river's edge. Visitor experiences like these enrich our urban life and help renew the public's relationship with our watershed.

Celebration of the Bow

3. **Prioritize and focus engagement and education efforts.** While we are all connected to the river, some stakeholders are more connected than others by virtue of being a landowner or living in a community close to the river's edge. Similarly, some riparian initiatives will be of greater priority than others due to restoration or protection needs. Rather than applying a one-size-fits-all approach, it will be important to prioritize landscapes and focus on those stakeholders best positioned to make change in that area. Riparian landowners, developers, civil and community planners, as well as residents and communities near riparian areas, will need to be equipped, properly supported and empowered in the protection and maintenance of their landscape. A second aspect of this key action is to identify existing riparian stewardship groups/programming and focus municipal efforts on building capacity only where needed.

Who will benefit

Current and future Calgarians will benefit from a greater connection to Calgary's rivers and creeks. Other watershed groups working within the area of riparian protection and restoration will also benefit through increased watershed literacy among citizens, increased support for their work and specific opportunities to partner with The City.

Partners who can help us

City of Calgary. Water Resources, Parks, municipal land owners, City of Calgary employees

Other. Residents, community leaders, private land owners, community associations, non-governmental organizations involved with water management, the development industry, technical consultants, golf courses and regional partners

Performance measurement

The City is currently developing baseline measures and indicators of the value of riparian areas for communities.

Table 4. Riparian education and outreach indicators, baselines and targets

Outcome	Indicator	Aspect	Baseline	2026 Target
Citizens and riparian landowners value riparian areas.	Stakeholder engagement with riparian areas	Awareness of riparian health	26%	↗ trend
		Lack of awareness of what to do	57%	↘ trend
		Personal importance of river areas	83%	→ maintain
		Behaviours taken by citizens	To come	↗ trend
	Customer satisfaction	Satisfaction with City's performance to protect and restore river areas	58%	↗ trend
	Community stewardship actions	Citizens engaged in restoration and stewardship activities	To come	↗ trend
		Riparian spaces restored or stewarded by community groups/members	To come	↗ trend

See Supplement Three for detailed explanation of education and outreach methodology and monitoring protocols.

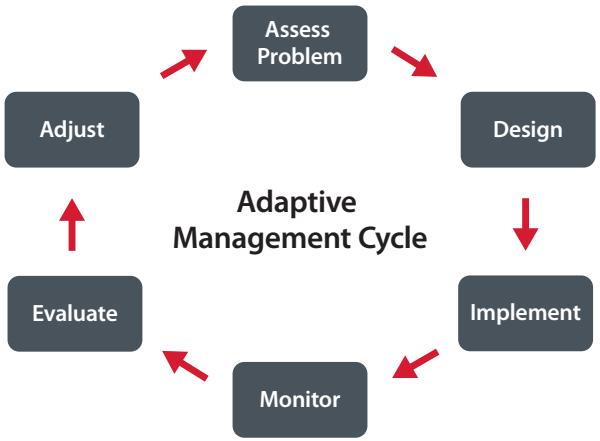
Monitoring and adaptive management

The Riparian Action Program (RAP) includes annual check-ins and adjustments. This includes two minor program reviews as part of The City's business planning and budgeting processes and a comprehensive 10-year program review in 2026. Over time, successes and failures will be documented, and the program will be updated accordingly. This adaptive management approach can deal with the uncertainty and complexity involved in resource management. It is a structured, science-based process that integrates experience and scientific information. Adaptive management also enables continual improvement, accountability and transparency, and addresses the dynamic nature of riparian systems.

The RAP adaptive-management process follows a six-step cycle:

- **Assess problem**
  At this step, knowledge is assessed and synthesized to evaluate resource conditions and establish high-level direction. All background riparian studies conducted from 2008-2013 were part of this step, including (i) baseline riparian health inventories; (ii) riparian mapping studies; and (iii) the Riparian Strategy.
- **Design.** The second step consists of program design, including the establishment of explicit outcomes, delineation of key actions and timelines, establishing methods to monitor results over time and setting appropriate indicators and targets. The Riparian Action Program represents the output of the program design process.
- **Implement** During this step, projects and actions outlined in the program plan are carried out. Riparian implementation activities began in 2014 with the release of the Riparian Decision Matrix for River Engineering Projects (see Supplement One on page 54) and through the planning and initiation of several restoration and research projects. Implementation is expected to continue throughout future business cycles.
- **Monitor.** The monitoring of indicators is undertaken to determine whether the observed effects match predictions. Post-flood monitoring of riparian health conditions and future monitoring of indicators over time fall under this step.
- **Evaluate.** Over time, successes and failures need to be documented and the program reviewed, adapted and updated as necessary. This will include a minor five-year program review in 2021.
- **Adjust.** Adjustments will be made during a 10-year program review, currently planned for 2026.

Figure 10. The Riparian Action Program follows an adaptive management approach



Restoring riparian landscape more empowering than you might think

Volunteer restoration activities involve participants in active relationships with the natural environment around them. Connecting to the land not only provides vivid examples of how our watershed works, it also kindles and fosters a desire to preserve and maintain our collective natural environment.

Studies demonstrate that:

1. Stewardship volunteering enhances civic engagement among participants.
2. Restoration activities deepen existing environmental ethics.
3. Self-identifying as a steward exerts the strongest influence on our intention to behave in pro-environmental ways.
4. Spending time with like-minded stewards is the most effective way to translate attitudes into eco-behaviour.
5. The stronger a person's emotional attachment to a place, the more they engage in pro-environmental behaviours.

As well, restoration and stewardship activities provide important outlets for action.

Connecting to the river is also a powerful way to foster environmental stewardship and civic engagement.

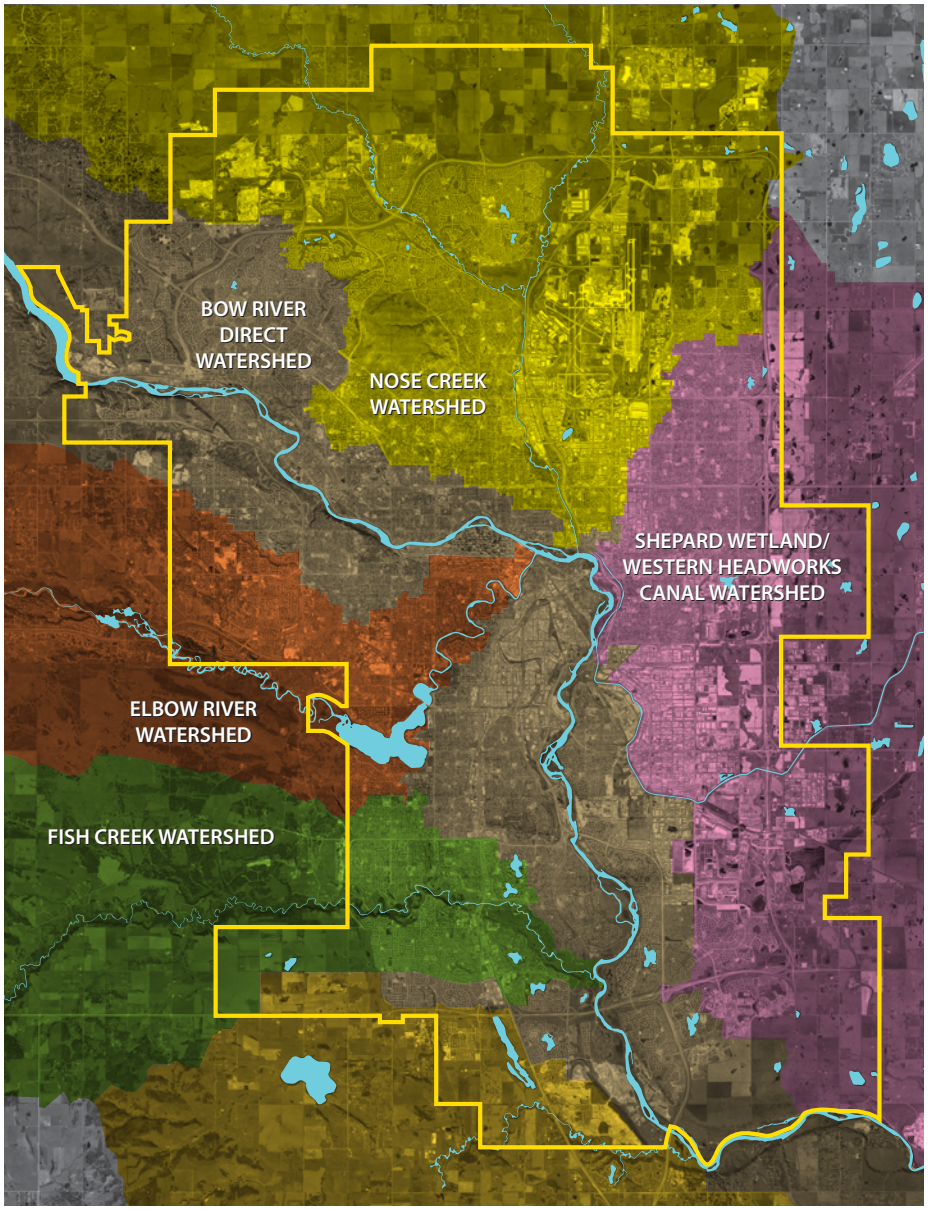
Almost all fish and wildlife depend on the areas bordering our rivers and creeks for some part of their life cycle.

Chapter 3. Calgary's commitment to our river areas

Beneath Calgary's built environment—such as roads and buildings—lies an ecological landscape defined by the flow and storage of water. The following maps tell a holistic story of how riparian areas in Calgary are used and how this program integrates with the **Flood Resiliency and Mitigation Program** and stormwater management. They knit together several collections of information, including riparian restoration priorities and restoration techniques. They are the culmination of years of research and mapping and are a defining tool in The City's commitment to the protection of riparian areas.

Within city limits, Calgary is situated within the Bow River Watershed and includes six major sub watersheds.

The information in this chapter corresponds to The City of Calgary's data as of March 2016. The information and maps are made available in good faith, but accuracy and completeness cannot be guaranteed. The City's riparian data and maps may be updated from time to time as resources allow.



- City limits
- Rivers, creeks, streams, and wetlands
- Bow River Direct
- Elbow River
- Fish Creek
- Nose Creek
- Shepard Wetland/Western Headworks Canal
- Pine Creek

Upper Bow River Direct Watershed

Watershed summary

The Bow River Basin includes over 25,000 km^2 of land, from the headwaters in Banff National Park to the confluence with the Oldman River in semi-arid southeastern Alberta. Virtually all of Calgary is within the Bow River Basin, as most land drains into one of six watersheds that are tributaries to the Bow River. Within city limits, the Bow River Direct watershed includes all areas that drain to the Bow River without passing through a major tributary first (e.g., Nose Creek).

Importantly, the Bow is the source water for the Bearspaw Water Treatment Plant, which provides approximately 60 per cent of The City's water supplies to Calgarians. Due to the extensive nature of the Bow River Direct watershed, which spans all of Calgary, it has been subdivided into upper and lower sections.

Upper Bow River direct watershed

The Upper Bow River direct watershed includes lands in Calgary draining directly to the Bow River upstream of the Elbow River confluence, as well as smaller catchments associated with Coach Creek and 12 Mile Coulee Creek.

Riparian land uses

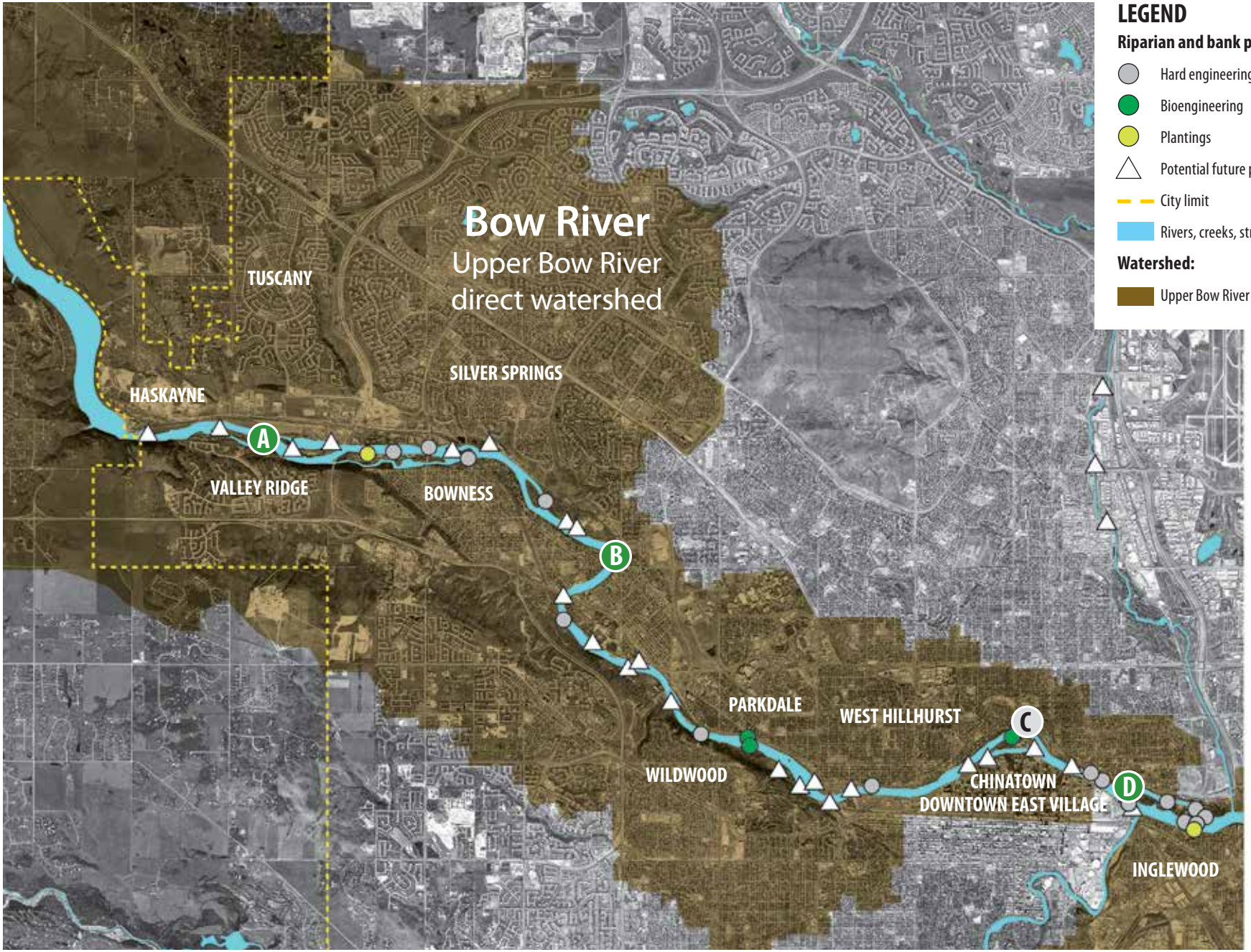
- Extensive (>2,800 ha) riparian areas fringe the Bow River in Calgary.
- Parks and recreation areas cover 52 per cent of Calgary's riparian areas along the Bow. This includes many of Calgary's defining parks, including Bowness Park (donated to the City in 1912 by a developer), Bowmont Park, Edworthy Park, Shouldice Park, Prince's Island Park, and Saint Patrick's Island.
- Residential land uses intersect 11 per cent of the Bow's riparian zones in Calgary, including the neighbourhoods of Bowness, Hillhurst, Sunnyside, and Eau Claire. The East Village mixed use development intersects about one per cent of the Bow River's riparian area.
- Railways and major highways (Stoney Trail, Crowchild Trail) occupy almost eight per cent of the riparian areas in this watershed.
- Commercial areas occupy about four per cent of the riparian zone along the Bow, concentrated in the downtown core.
- The legacy of urban development along the Upper Bow River in Calgary has created considerable flood risks to people, businesses and infrastructure, and requires careful ongoing management.
- Riparian habitats are also located along Coach Creek (18 ha) and Twelve Mile Coulee (39 ha). The majority of these have been retained as open spaces within Crestmont and Tuscany.

Vegetated rip rap – outfall B134

Home Road bank stabilization

Rip rap and groynes – Sunnyside, Memorial Drive

St. Patrick's Island – Calgary Municipal Land Corporation



Lower Bow River Direct Watershed

Watershed summary

The Bow River Basin includes over 25,000 km^2 of land, from the headwaters in Banff National Park to the confluence with the Oldman River in semi-arid southeastern Alberta. Virtually all of Calgary is within the Bow River Basin, as its lands drains to one of six watersheds that are tributaries to the Bow River. Within city limits, the Bow River Direct watershed includes all areas that drain to the Bow River without passing through a major tributary first (e.g., Nose Creek).

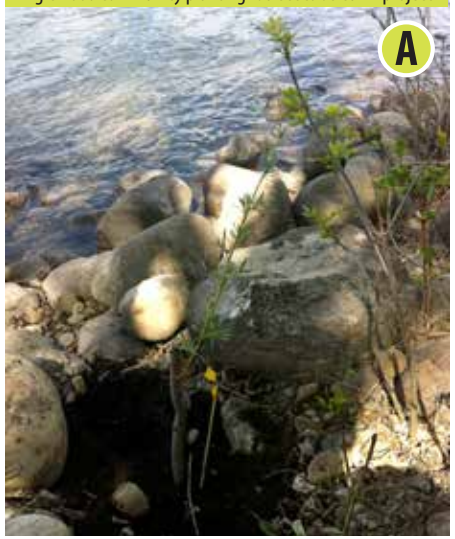
Lower Bow River direct watershed

This highly urbanized watershed includes all lands within Calgary that drain to the Bow River downstream of the Elbow River confluence. This section of the Bow River experienced severe erosion during the 2013 flood, particularly along stretches with unhealthy riparian areas.

Riparian land uses

- Extensive (>2,800 ha) riparian areas fringe the Bow River in Calgary.
- Parks and recreation areas cover 52 per cent of Calgary's riparian areas along the Bow. This includes many of Calgary's defining parks in South East Calgary, including Pearce Estate Park, the Inglewood Bird Sanctuary, Beaverdam Flats, Sue Higgins Park, Carburn Park, and Fish Creek Provincial Park. This category also includes two major golf courses: Inglewood Golf Course and McKenzie Meadows Golf Course.
- Residential land uses intersect 11 per cent of the Bow's riparian zones in Calgary, including the neighbourhoods of Inglewood, Bridgeland, Riverbend, Quarry Park, and Cranston.
- Major Infrastructure is the third most common land use category, occupying eight per cent of the Bow's riparian areas. This includes The City's three Wastewater Treatment Plants, as well as railways, railyards, and major highways (Deerfoot Trail, Stoney Trail).
- Commercial areas occupy four per cent of the riparian zone along the Bow, including the Deerfoot Meadows shopping centre.
- Significant riparian lands, particularly those downstream from Cranston within City limits, are currently unplanned, but will be under pressure for future development as the City continues to expand outwards.
- Flood risks to people and infrastructure along the Lower Bow have been reduced by: the Inglewood flood berm, which protects the community of Inglewood up to a 1:100 year flood event. Land Use Bylaw overlay regulations developed in the 1980s have also reduced flood risk to newer communities such as Douglasdale, Deer Run, Quarry Park, Chaparral and Cranston, although these areas could still be affected by extreme floods beyond the design standard.
- Some SE Calgary residential areas were developed with insufficient setbacks from the Bow River valley, creating slope stability issues and a need for expensive erosion control projects (e.g., Diamond Cove, McKenzie Lake).

Inglewood community planting "Street to Stream" project



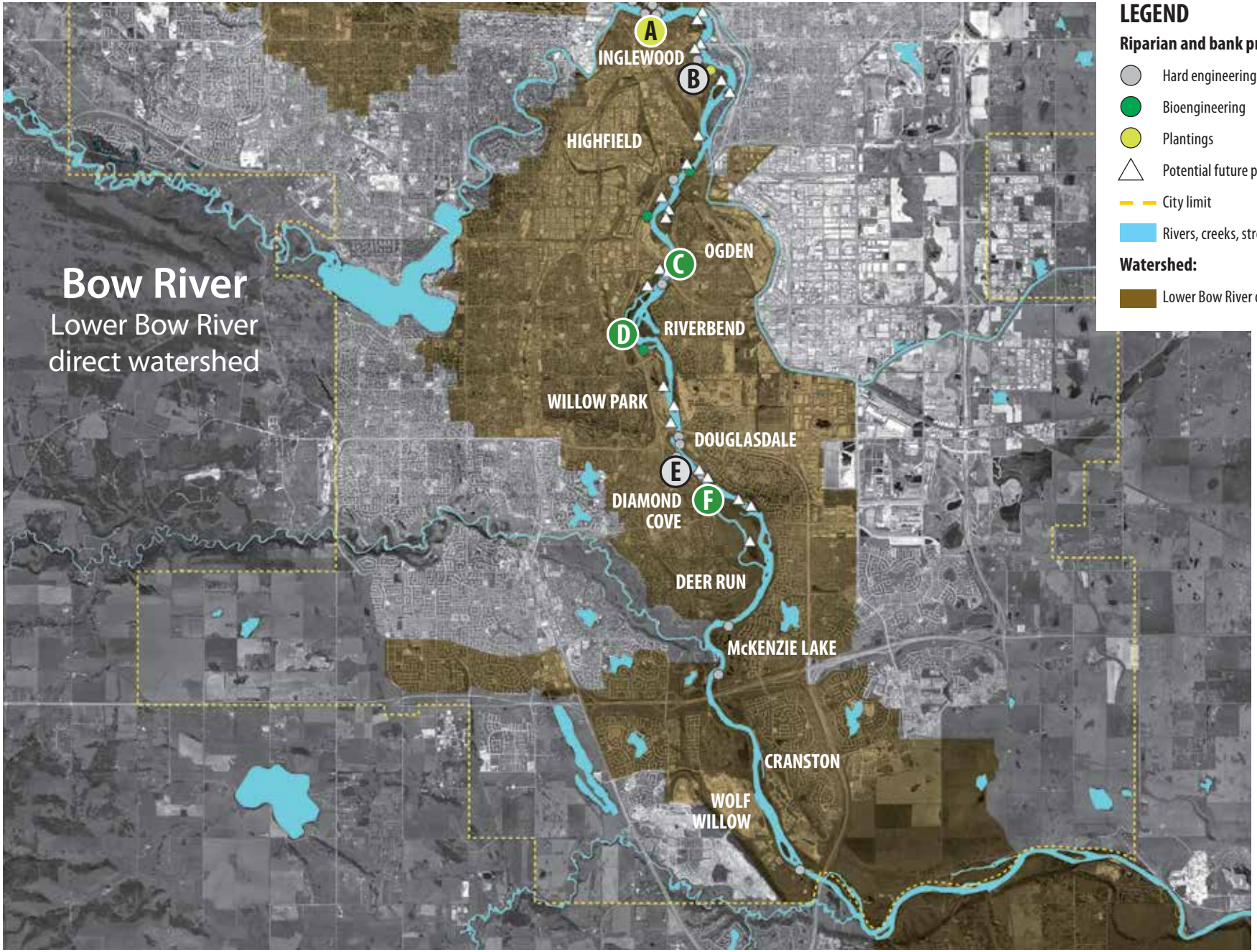
Inglewood critical erosion site – construction 2014

Timber crib wall – upstream of Glenmore Trail

Timber crib wall – Sue Higgins Park

Diamond Cove rip rap and slope toe protection

Mallard Point bioengineering project – Trout Unlimited



Elbow River Watershed

Watershed summary

The headwaters of the Elbow River watershed begin in the mountains of Kananaskis Country. Moving downstream, landscapes in the watershed gradually change from mountains to foothills, to rural agriculture and country residential in Rocky View County, then to suburban neighbourhoods and finally high-density urban areas in Calgary. Importantly, The Elbow feeds the Glenmore Reservoir and provides source water to the Glenmore Water Treatment Plant, which supplies 40 per cent of The City`s water supplies to Calgarians. Many South West Calgary communities are located in the Elbow River watershed. Communities upstream from the Glenmore raw water intake include Springbank, Rutland Park, Glamorgan, Discovery Ridge, Lakeview, and Oakridge. Further downstream, Altadore, Elbow Park, Britannia, Roxboro, and Mission, and a large portion of the downtown Beltline also drain into the Elbow River.

Riparian land uses

- Extensive riparian areas fringe the Elbow, including over 728 ha within City limits.
- About 56 per cent of these are designated parks and open spaces, such as Griffith Woods, The Weaselhead, Sandy Beach Park, The Calgary Golf and Country Club, Stanley Park, and Lindsay Park.
- In contrast, 38 per cent of this area has been developed, including residential communities (Elbow Park, Roxboro, Erlton), commercial and mixed uses (Mission), and the Calgary
  Stampede grounds.
- These land-use legacies have created significant flood risk to people and businesses along the Lower Elbow, which requires careful ongoing management. Finally, undeveloped private lands represent a small fraction of the Elbow`s riparian area along The City`s western edge.

Rip rap with root ads, Stampede Grounds

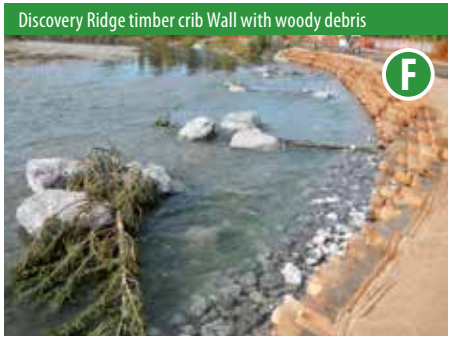
Vegetated gabion across from Stampede Grounds

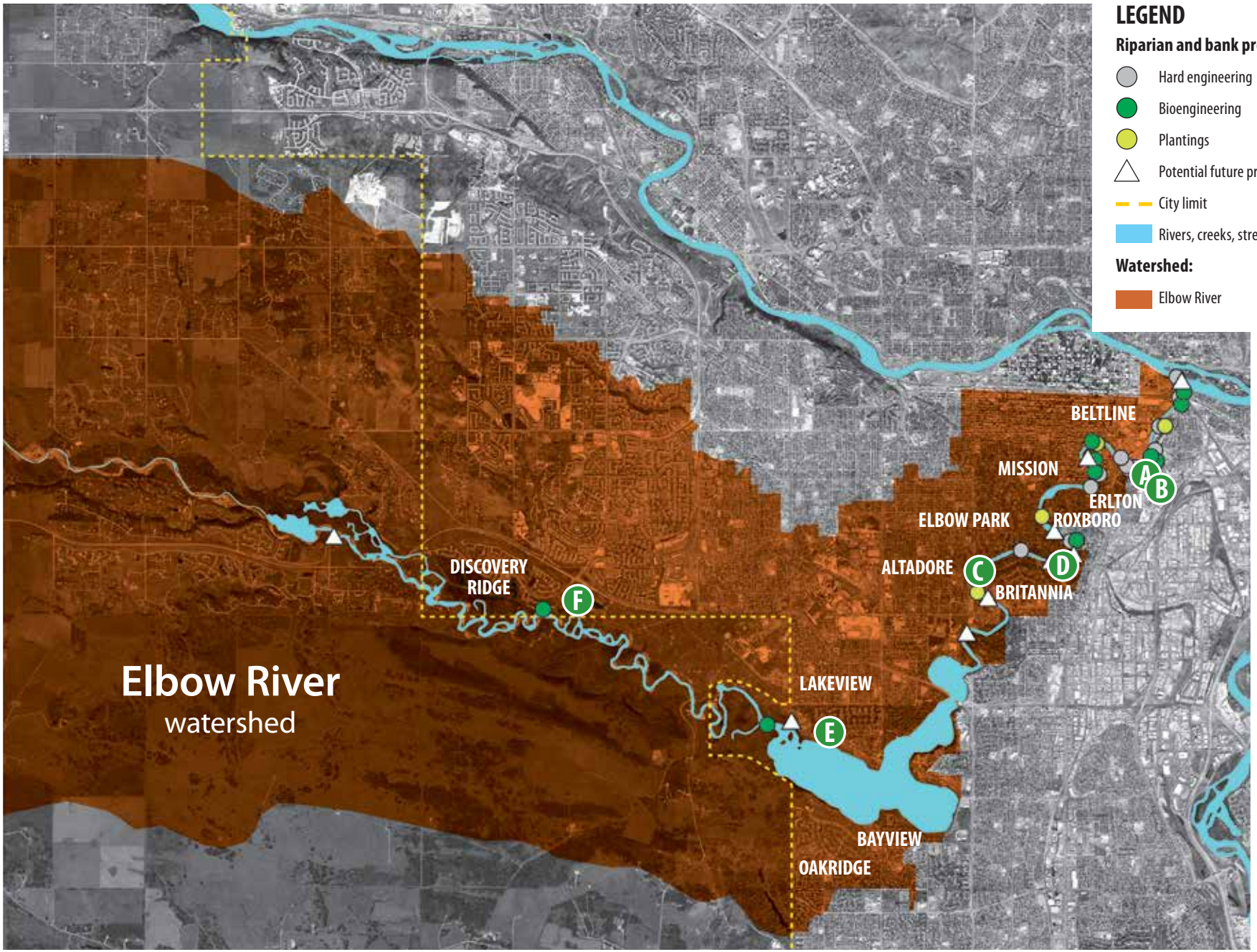
Peak stone with willow brush layering, Sandy Beach Park

Riverdale Ave. willow wattle fence

Weaselhead natural area bank stabilization project by ATCO Gas

Discovery Ridge timber crib Wall with woody debris





Fish Creek & Pine Creek Watersheds

Pine Creek

The headwaters of Pine Creek begin in forested areas just west of Calgary. Pine Creek flows east through largely rural areas in the M.D. of Foothills before entering The City of Calgary. Pine Creek eventually drains into the Bow River just east of Heritage Pointe. The Pine Creek corridor is largely undeveloped at this point. Radio Tower Creek, located in the southwest of the city, is a meandering water body that contains two separate small tributaries that feed into Pine Creek.

Fish Creek

The headwaters of Fish Creek originate in the rolling Rocky Mountain foothills southwest of Bragg Creek. West of the City it crosses the M.D. of Foothills, the Priddis area, and the Tsuu Tìna Nation. Resident beaver populations continually shift the watercourses within the watershed, creating dynamic floodplains with many oxbow wetlands.

Riparian land uses

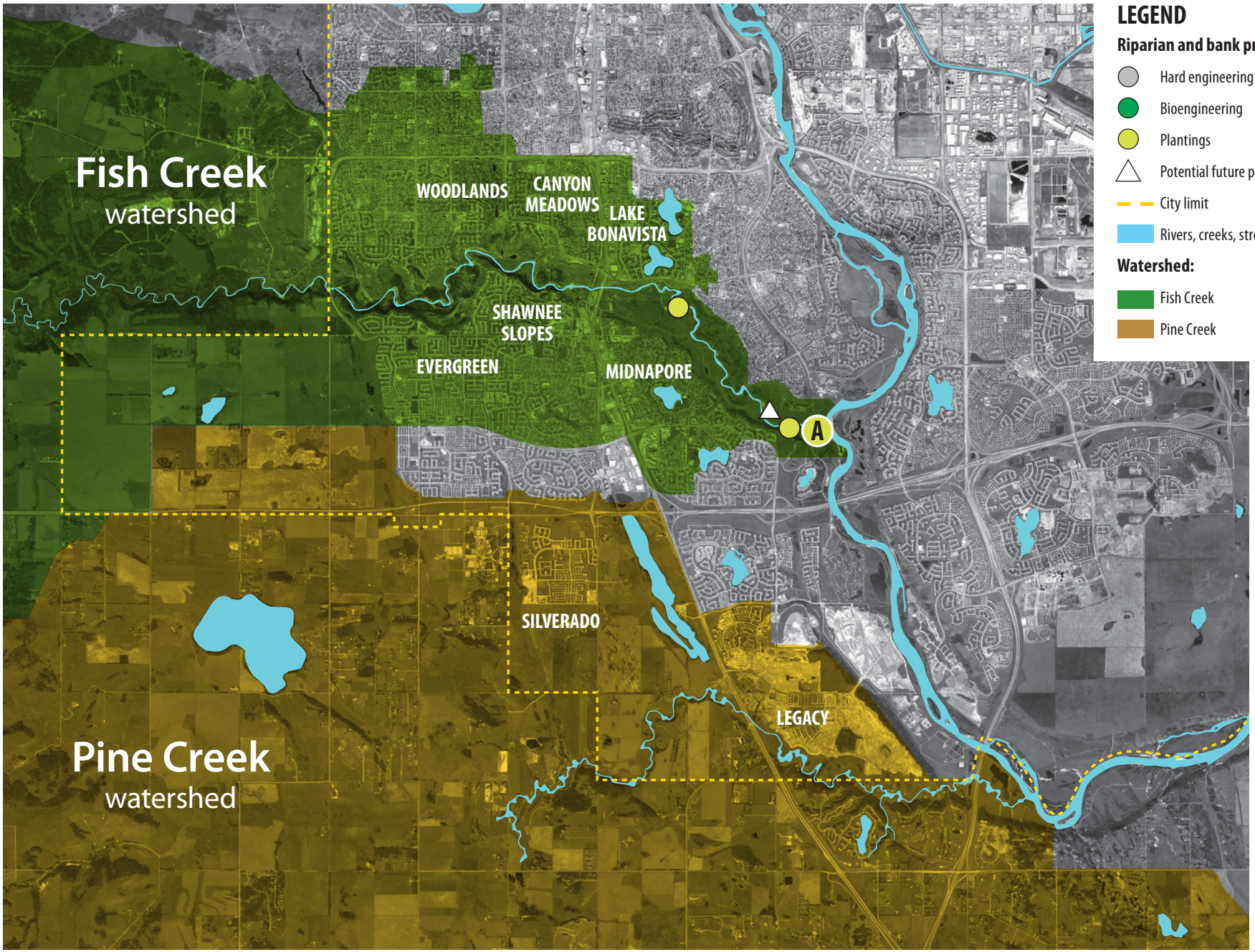
Within Calgary, Fish Creek`s riparian floodplains are entirely protected by one of the largest urban parks in North America. Fish Creek Provincial Park stretches 19 km from east to west and occupies over 13 km$^2$. As a provincial park, it was largely protected from development by Peter Lougheed`s government in 1973, and has since then become a rare wild natural riparian area within our built environment.

Pine Creek`s riparian areas are largely undeveloped within a steep ravine system, and a large portion of these areas were recently retained as open space in the recent Legacy residential subdivision.

Radio Tower Creek`s current riparian land uses in Calgary include:

- 23 per cent designated parks and recreation areas (including the Bridlewood wetland).
- 23 per cent within the Transportation and Utility Corridor.
- 17 per cent residential (largely within the communities of Bridlewood and Evergreen).
- 37 per cent currently remains unplanned (largely in agriculture), whereas the recently approved Providence Area Structure Plan (2015) flags most of this area as Environmental Open Space that may be retained as open space during future subdivision.

Friends of Fish Creek Hull's Wood restoration site



Nose Creek Watershed

Watershed summary

The Nose Creek watershed originates in Rocky View County north of Calgary. Nose Creek flows south for 75 km through Airdrie, Balzac, and Calgary, before joining the Bow River near the Calgary Zoo. The West Nose Creek and Confederation Creek drainage basins are also included in the Nose Creek watershed.

The Nose Creek watershed and its` riparian areas are heavily impacted by urban and agricultural uses, channelization, stormwater inputs, and chronic erosion and water quality concerns. Urban communities in the Nose Creek watershed include Coventry Hills, Harvest Hills, Country Hills, Huntington Hills, Winston Heights, and Renfrew. Newer communities such as Sage Hill, Evanston, Hidden Valley and Panorama Hills are located in the West Nose Creek subwatershed. Confederation Creek is bordered by the communities of Capitol Hill, Rosemont, Collingwood, and North Mount Pleasant.

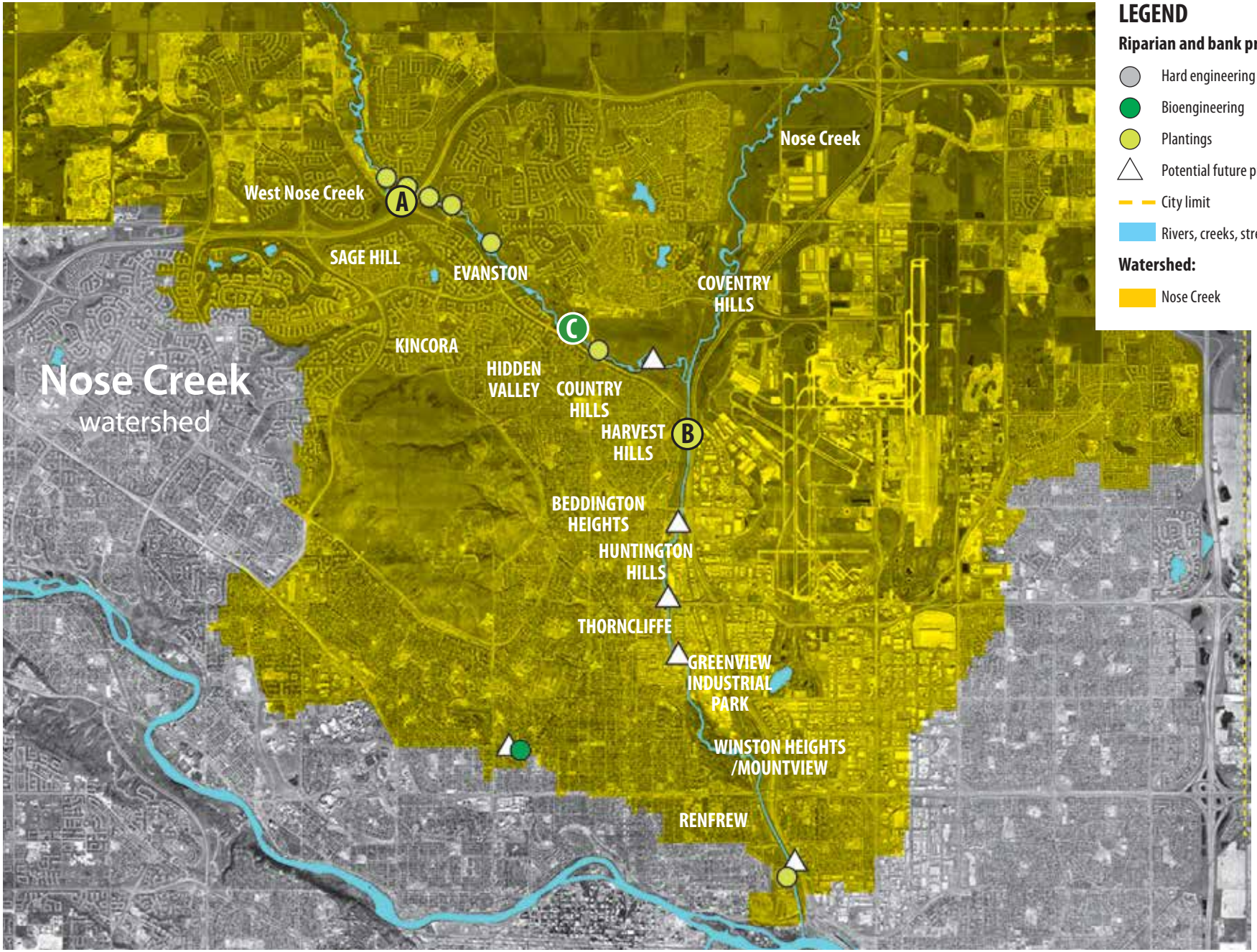
Riparian land uses

- Approximately 468 ha of riparian areas are located in this watershed within Calgary along the Nose Creek, West Nose Creek, and Confederation Creek systems.
- Most of these riparian areas (59 per cent) are designated as parks and open spaces such as:
  - Laycock Park, the Elks Golf Club, and Bottomland Park along Nose Creek.
  - A largely unbroken riparian greenway extending from Sage Hill to Confluence Park along West Nose Creek.
  - Confederation Park along Confederation Creek, before the creek disappears into a large concrete stormwater vault upstream of Highland Park.
- Major infrastructure such as highways (Stoney Trail, Deerfoot Trail, Beddington Trail) and railways intersect 14 per cent of the riparian areas in the watershed, and often restrict the meandering of Nose Creek across its' floodplain.
- Undeveloped areas also intersect 14 per cent of riparian areas in the watershed; however the approved Glacier Ridge Area Structure Plan (2015) and Nose Creek Area Structure Plan (2015) provide direction that these riparian areas are to be retained as open spaces within future communities.
- Industrial lands occupy 12 per cent of Nose Creek`s riparian area, primarily within the Greenview industrial area.
- Residential riparian land use is very sparse in the watershed, occupying less than four per cent of all mapped riparian areas.

Evanston planting site – Bow Valley habitat development

Confluence Park riparian planting site – Bow Valley habitat development

West Nose Creek meander and riffle restoration



Shepard Wetland and Western Headworks Canal Watershed

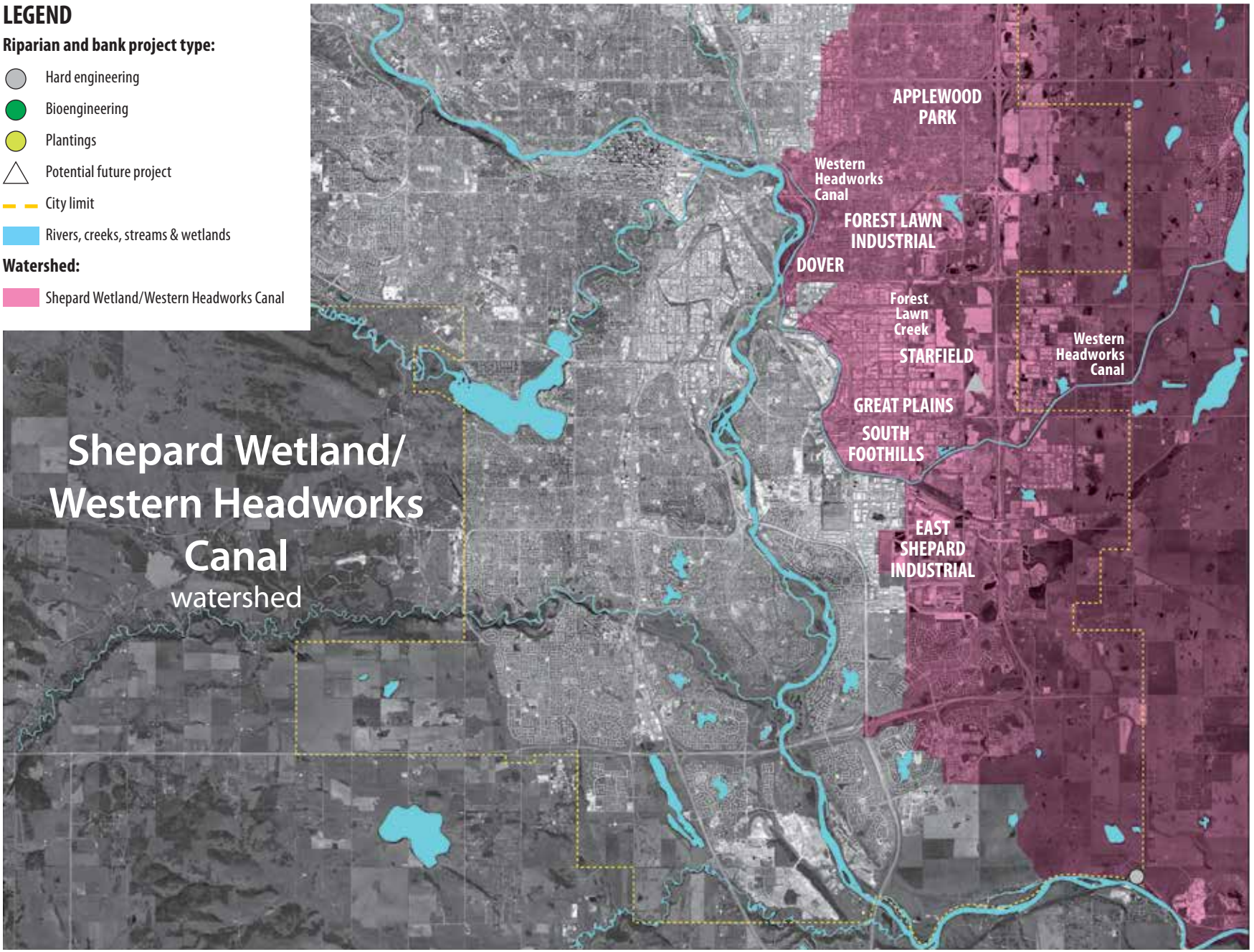
Watershed summary

This watershed, covering the eastern areas of Calgary, is notable for its high cover of wetlands in a `prairie pothole` landscape. The Western Headworks Canal, which supplies water to the Western Irrigation District, bisects the watershed. Forest Lawn Creek, as well as the large constructed Shepard Wetland and Shepard Ditch systems, are other major drainage features in the watershed.

Forest Lawn Creek, which runs through a heavily industrialized area of Southeast Calgary, is surrounded by undeveloped lands owned by The City of Calgary, although the surrounding areas will be developed to industrial lots by The City in the near future. Parts of Forest Lawn Creek were recently rerouted and restored into a series of in-stream constructed wetlands as part of the Peigan Trail expansion, completed in 2013.

Riparian land uses

Around the Forest Lawn Creek corridor, 84 per cent of the riparian areas are currently unplanned, but are intended to be incorporated as open space in the future Forest Lawn Creek industrial land development led by The City. The remaining 16 per cent of Forest Lawn Creek`s riparian areas are impacted by major infrastructure, such as Stoney Trail, a railway line, the Transportation and Utility Corridor, and Stoney Trail.



Appendix: Ten year program area workplans

The Riparian Action Program provides guidance by linking Calgary's previous riparian technical research and data collection to specific program area outcomes and actions over the next ten years. The following timeline provides a brief history of The City of Calgary's work to date followed by work plan tables, which outline specific actions in the areas of land use planning, health restoration and education and outreach.

Figure 11. Timeline of riparian research, data collection, planning and reporting

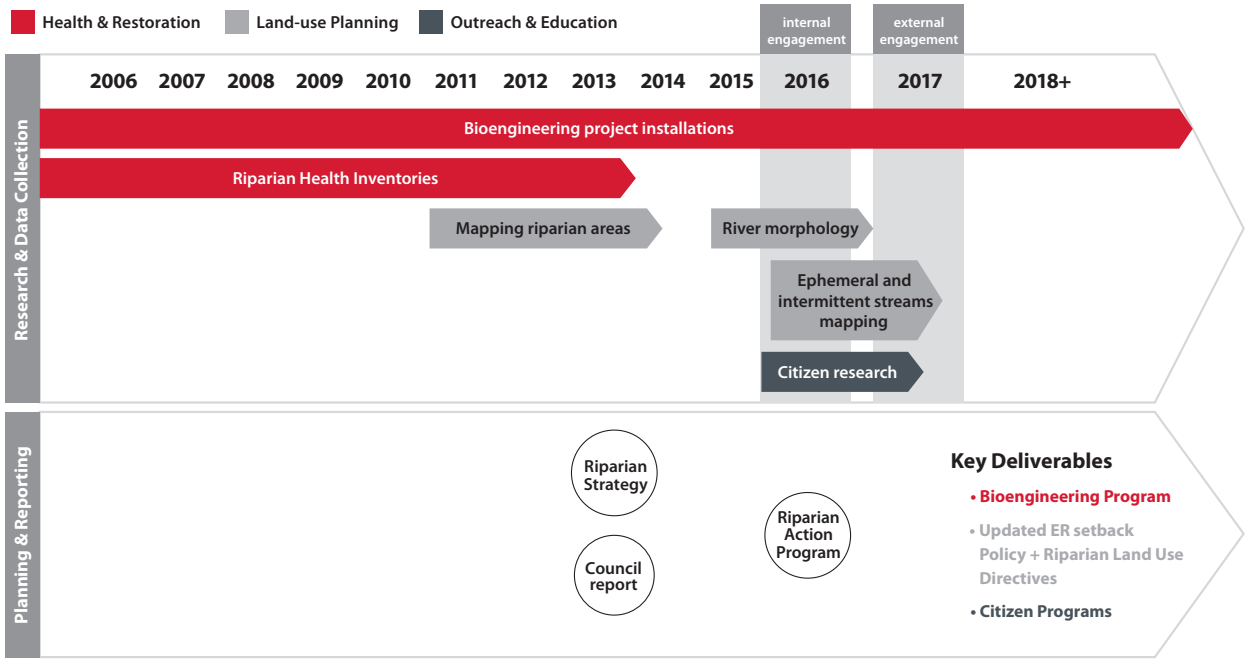


Table 5. Work plan for riparian land-use planning

Timeframe*	Project or action	Lead business unit	Stakeholders and level of engagement**		
			Collaborate	Consult	Listen & learn
Short-term	Mapping: Ephemeral and intermittent watercourses in Calgary.	Water Resources	Parks	Planning	developers, consultants, NGOs
Short-term	Research: Assess river geomorphology to better understand how the river and riparian areas will change.	Water Resources	Parks, University of Lethbridge	Planning	developers, consultants, NGOs, riparian landowners
Short-term	Policy/process: Update riparian information in the new Stormwater Management and Design Manual.	Water Resources	Other	Parks	other developers, consultants
Short-term	Process: Support internal Water Resources staff and other City business unit staff (Parks, Planning, etc.) with maps and decision support, processes, tools and policies related to land-use approvals and riparian areas.	Water Resources and Parks	Parks, Planning	developers, consultants	
Mid-term	Policy/process: Define the scope of integration of riparian and floodplain data in urban planning policies, processes, tools and bylaws.	Water Resources	Planning, Parks	developers, riparian landowners, consultants, NGOs	community associations, citizens
Mid-term	Policy/process: Update the Environmental Reserve (ER) Setback Guidelines.	Water Resources	Parks, Planning, Law	developers, riparian landowners, consultants, NGOs, Council	community associations, citizens
Mid-term	Policy/process: Investigate additional new bylaws and land use policies supporting riparian area protection.	Water Resources	Parks, Law Planning	developers, riparian landowners, consultants, NGOs Council	citizens
Mid-term	Research: Complete a detailed riparian land-acquisition study.	Water Resources	Parks, Planning, Corporate Properties, Law	developers, riparian landowners	
Mid-term	Research: Ecosystem-services valuation scoping/research studies for riparian areas.	Water Resources	post-secondary institutions	developers, Office of Sustainability, Corporate Economics	
Ongoing	Process: Continue with decision support to City staff.	Water Resources	Parks, Planning	n/a	

Notes:

*Short-term=2016-2019; mid-term=2020-2023; long-term=2023-2026.

** Levels of engagement are defined in The City's engage! policy at: http://www.calgary.ca/CA/city-clerks/Documents/Council-policy-library/CS009-engage.pdf

Outcome:
Further loss of riparian areas is minimized.

Table 6. Work plan for riparian health restoration

Timeframe*	Project or action	Lead business unit	Stakeholders and level of engagement**		
			Collaborate	Consult	Listen & learn
Project-specific	Restoration: Design and construct new projects to restore riparian health.	Water Resources or Parks	Parks, Water Resources	consultants	local communities, citizens, NGOs
Project-specific	Restoration: Integrate bioengineering designs in riverbank stabilization projects.				
Ongoing	Engagement: Support city staff, consultants and contractors with maps, information and decision support tools (e.g., riparian decision matrix for river engineering projects) to promote bioengineering designs.	Water Resources		Parks, consultants, riparian landowners	Local communities, citizens, NGOs
Ongoing	Assessment/monitoring: Monitor vegetation establishment at restoration sites.	Water Resources	Parks, consultants		
Ongoing	Research: Facilitate research projects on riparian health (e.g., post-flood riparian recruitment studies, ephemeral and intermittent water courses analysis, etc.).	Water Resources	post-secondary institutions		
Long-term	Restoration/engagement: Design and implement new tools, procedures and checklists to restore and manage riparian lands.	Water Resources	Parks		
Long-term	Policy/process: Standardize processes, tools, roles and responsibilities.		Parks		
Long-term	Assessment/monitoring: Monitor/report on riparian health improvements by 2026.	Water Resources		Parks, Council	local communities, citizens, NGOs

Notes:

*Short-term=2016-2019; mid-term=2020-2023; long-term=2023-2026.

** Levels of engagement are defined in The City's engage! policy at: http://www.calgary.ca/CA/city-clerks/Documents/Council-policy-library/CS009-engage.pdf

Outcome:
City-wide riparian health is improved.

Table 7. Work plan for riparian engagement and education

Timeframe*	Project or action	Lead business unit Collaborate	Stakeholders and level of engagement**		
			Collaborate	Consult	Listen & learn
Short-term	Research: Develop and execute mixed-methods research plan that scopes, explores and validates how citizens and riparian landowners understand and live with riparian areas.	Water Resources	research consultant	riparian landowners, Parks, gov't agencies, relevant WPACs	citizens
Short-term	Planning: Develop education-program framework, work plan and evaluation plan.	Water Resources	Consultant		
Short-term	Communications: Develop strategic-communications strategy to identify audiences, partners/messengers, key messages, programming, media and evaluation measures (including social media campaign).	Water Resources	WR communications		
Mid-term	Partnerships: Establish partnership agreements with organizations.	Water Resources			
Mid-term	Education: Develop education/ restoration site-selection criteria and identify specific riparian health restoration initiatives/sites to engage citizen-based restoration activities.	Water Resources	Parks		
Mid-term	Education: Develop program(s) to support riparian area enhancement on private landowner sites.	Water Resources		private landowners	
Mid-term	Partnerships: Identify public arts-based programming opportunities (i.e., Watershed+) that help promote the value of riparian areas.	Water Resources	UEP Public Art		
Mid-term	Education/communication: Develop and produce educational materials.	Water Resources			

Notes:

*Short-term=2016-2019; mid-term=2020-2023; long-term=2023-2026.

** Levels of engagement are defined in The City's engage! policy at: http://www.calgary.ca/CA/city-clerks/Documents/Council-policy-library/CS009-engage.pdf

Outcome: Citizens and riparian landowners value riparian areas.

Glossary

adaptive management (i) a dynamic process of task organization and execution that recognizes that the future cannot be predicted perfectly. Adaptive management applies scientific principles and methods to improve management activities incrementally as decision-makers learn from experience, collect new scientific findings and adapt to changing social expectations and demands (AESRD, 2008). (ii) a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. Its most effective form – "active" adaptive management – employs management programs designed to experimentally compare selected policies or practices by evaluating alternative hypotheses about the system being managed (BCMFR, 2014).

alluvial aquifer a non-confined aquifer comprised of groundwater under the influence of surface-water bodies, such as rivers and lakes. It typically occurs within alluvial sediments deposited by a river or other body of flowing water (BRBC, 2012).

aquifer (i) an underground water-bearing formation that is capable of yielding water (SSRP 2014); (ii) a sub-surface layer or layers of porous rock that hold water within the spaces between the rocks (interstitial spaces) (BRBC 2012).

bank the margins of a channel. Banks are called right or left as viewed when facing in the direction of the flow (USGS, 1995).

base flow the component of stream flow that can be attributed to groundwater discharge into streams.

bed and shore land covered so long by water that vegetation is either wrested from it or marked by a distinctive character where it extends into the water. In Alberta, the province owns most of the beds and shores of all naturally occurring bodies of water pursuant to s.3(1) of the Public Lands Act.

bioengineering an approach to riverbank/streambank engineering that incorporates living and nonliving plant materials in combination with natural and synthetic support materials for slope stabilization, erosion reduction and vegetation establishment (USDA, 2007).

buffer a strip of land managed to maintain desired ecological processes and provide economic and societal benefits.

channel (watercourse) an open conduit, either naturally or artificially created, that periodically or continuously contains moving water or forms a connecting link between two bodies of water (USGS, 1995).

channelization the modification of a natural river channel, which may include deepening, widening or straightening.

cost distance model a spatial modelling approach to delineate riparian areas. Inputs include stream channel locations, the rate of elevation change ("cost") as one moves away from the river, and field sampling that includes GPS delineation of riparian vegetation edges in undisturbed open spaces. Riparian extents selected are calibrated to observations along different stream and river systems (Hemstrom, 2002; O2, 2013).

coulee (i) a deep, steep-sided gulch or valley that is often dry during the summer months **(Canadian Dictionary of the English Language)**; (ii) a dry stream valley, especially a long steep-sided ravine that once carried melt water **(Alberta EAP Integrated Standards and Guidelines)**.

cumulative effects the combined effects of past, present and reasonably foreseeable future land-use activities on the environment (SSRP 2014).

drainage course See watercourse.

ecosystem function processes that are necessary for the self-maintenance of an ecosystem, such as primary production, nutrient cycling, decomposition, etc. Ecosystem "function" is primarily distinguished from "ecosystem" values (SSRP 2014).

ecosystem services ecosystem services are the benefits people obtain from nature (WRI, 2003). These include provisioning services (i.e., clean water supplies); regulating services related to disturbances (floods, droughts, pest outbreaks); supporting services (i.e., soil formation, nutrient cycling); and cultural services (i.e., recreational, spiritual, religious, etc.) (WRI, 2003).

environmental reserve (ER) land designated as Environmental Reserve by a subdivision authority under section 664 of the **Municipal Government Act**.

ephemeral watercourse (i) watercourse that flows briefly in direct response to precipitation; these channels are always above the water table (USEPA 2015). (ii) A watercourse that flows only during and immediately after snowmelt or heavy rainfall (<10% of the time) (Hedman & Osterkamp, 1982).

erosion the natural breakdown and movement of soil and rock by water, wind or ice. The process may be accelerated by human activities (AESRD, 2008).

flood, maximum probable the largest flood for which there is any reasonable expectancy in this climatic era (Leopold & Maddock, 1954; USGS, 1995).

flood fringe (i) The portion of the flood hazard area outside of the floodway; water in the flood fringe is generally shallower and flows more slowly than in the floodway (COC, 2014). (ii) Those lands abutting the floodway, the boundaries of which are indicated on the floodway/flood fringe maps, that would be inundated by floodwaters of a magnitude likely to occur once in one hundred years (City of Calgary Land Use Bylaw 1P2007).

floodplain (i) the area of land adjacent to a river that stretches to the base of the enclosing valley walls and experiences flooding during periods of high river flow (COC, 2014); (ii) an area adjoining a body of water that has been or may be covered by flood water (AESRD, 2008).

floodway (i) the portion of the flood hazard area where flows are deepest, fastest and most destructive. The floodway typically includes the main channel of a stream and a portion of the adjacent area (COC, 2014). (ii) the river channel and adjoining lands indicated on the floodway/flood fringe maps that would provide the pathway for flood waters in the event of a flood of a magnitude likely to occur once in one hundred years (City of Calgary Land Use Bylaw 1P2007).

1:100 (or 100 Year) Flood a flood level with an estimated 1per cent chance of being equalled or exceeded in any year based on historical records (COC, 2014).

green infrastructure green infrastructure uses vegetation, soils and natural processes to create healthier urban environments. On the scale of a city, green infrastructure refers to the patchwork of natural areas that provides habitat, flood protection, cleaner air and cleaner water. On the scale of a neighbourhood or site, green infrastructure refers to stormwater management systems that mimic nature by soaking up and storing water (USEPA, 2014).

gully a trench that was originally worn in the earth by running water and through which water often runs after heavy rain or snowmelt (Merriam-Webster dictionary).

hydrology the study of water on the earth and in the atmosphere, its distribution, uses and conservation.

indicator (i) a measurable surrogate for outcomes that are of value to the public (Noss, 1990); (ii) a direct or indirect measurement of some valued component or quality in a system, such as an ecosystem or organization. For example, an indicator can be used to measure the current health of the watershed or to measure progress towards meeting an organizational goal (AESRD, 2008).

integrated water resources management (IWRM) co-ordinated water and land management that achieves economic and social benefits without compromising ecosystem sustainability (Global Water Partnership 2012).

integrated watershed management focuses on retaining or enhancing natural features and hydrologic functions within the landscape.

intermittent watercourse (i) a watercourse or portion of a watercourse that flows continuously only at certain times of year. At low flow, dry segments alternating with flowing segments can be present (USEPA 2015). (ii) a watercourse that flows for part of each year (e.g., flow occurs 10 to 80 per cent of the time) (Hedman & Osterkamp, 1982).

live stakes live, woody cuttings tamped into the soil to root, grow and create a living root mat that stabilizes the soil by reinforcing and binding soil particles together and extracting excess soil moisture (UNEP 2004).

low impact development a land planning and engineering design approach to managing stormwater runoff. The approach includes land use planning and conservation, as well as engineered hydrologic controls to replicate the pre-development hydrologic regime of watersheds by infiltrating, filtering, storing, evaporating and detaining runoff close to its source.

meander belt the land area on either side of a watercourse representing the farthest potential limit of channel migration. Areas within the meander belt may someday be occupied by the watercourse; areas outside the meander belt typically will not.

outcome a desired future condition guiding the development and implementation of an organization's related programs.

perennial watercourse: (i) a watercourse or portion of a watercourse that flows year-round (USEPA 2015); (ii) a watercourse that generally flows continuously year-round (e.g., flow greater than 80 per cent of the time) (Hedman & Osterkamp, 1982); (iii) watercourses where base flow is dependably generated from the movement of groundwater into the channel (USEPA, 1998); (iv) perennial channels that convey water throughout the year (AESRD, 1998).

project a temporary activity designed to produce a unique product, service or result. A project is temporary in that it has a defined beginning and end in time and, therefore, defined scope and resources (PMI, 2014).

ravine (i) a small, narrow, steep-sided valley that is larger than a gully and smaller than a canyon, usually worn by running water (Merriam-Webster Dictionary); (ii) a deep, narrow valley or gorge in the earth's surface worn by running water (Canadian Dictionary of the English Language).

resilience (i) the ability of a social or ecological system to absorb disturbances while retaining its functions and capacity to adapt to stress and change; (ii) the capacity of a system to deal with change while continuing to develop.

riparian "riparian" is derived from the Latin word "ripa," meaning bank or shore, and refers to land adjacent to a water body.

riparian area The following definition has been developed by the Alberta Water Council Riparian Land Conservation and Management Project Team. It provides a common, science-based, ecological characterization of riparian areas for the province of Alberta and our work.

> Riparian lands are transitional areas between upland[6] and aquatic ecosystems. They have variable width, extend above and below ground, and perform various functions. These lands are influenced by, and exert an influence on, associated water bodies[7], including alluvial aquifers[8] and floodplains. Riparian lands usually have soil, biological and other physical characteristics that reflect the influence of water and hydrological processes (Alberta Water Council, 2013).

riprap a layer of stone, pre-cast blocks, bags of concrete or other suitable materials, generally placed on the upstream slopes of an embankment or along a watercourse as protection against wave action, erosion or scour (AESRD, 2008).

river a natural watercourse of fairly large size flowing in a well-defined channel or series of diverging and converging channels (Random House Kernerman Webster's College Dictionary, 2010).

setback minimum distance that must be maintained between a land use or development and a water body. The distance is measured from the legal bank of the water body to the boundary line of the adjacent development.

stream a flowing body of water, especially a small river (Canadian Oxford Dictionary, 2nd edition).

target a specific, quantitative value assigned to an indicator that reflects a desired outcome.

terrace abandoned floodplain remnants.

timber crib wall hollow, box-like interlocking arrangements of untreated logs or timber filled above base flow with alternating layers of soil material and live branch cuttings that

6 Upland is land located above the alluvial plain, stream terrace(s), or any similar area associated with a water body.
7 A water body is any location where water flows or is present, whether or not the flow or presence of water is continuous, intermittent or occurs only during a flood. It includes, but is not limited to, wetlands and aquifers.
8 Alluvial aquifers are defined as areas where groundwater is under the direct influence of surface water.

root and gradually take over the structural functions of the wood members (UNEP, 2004).

triple bottom line (i) refers to the goal of sustaining our growing economy, while considering economics with Albertans' social and environmental goals (SSRAC, 2011); (ii) fiscal responsibility, environmental responsibility and social responsibility.

vision statement an aspirational description of what an organization would like to achieve in the mid- to long-term future.

watercourse/drainage course the bed and shore of a river, stream, lake, creek, lagoon, swamp, marsh or other natural body of water, or a canal, ditch, reservoir or other artificial surface feature made by humans, whether it contains or conveys water continuously or intermittently (AESRD, 2008).

watershed all lands enclosed by a continuous hydrologic-surface drainage divide and lying upslope from a specified point on a stream (SSRP 2014).

wetland wetlands are land that is saturated with water long enough to promote wetland or aquatic processes. Wetlands are indicated by poorly drained soils, water-loving vegetation and various kinds of biological activity adapted to a wet environment (AESRD, 2008).

Almost all fish and wildlife depend on the areas bordering our rivers and creeks for some part of their life cycle.

From the river to the tap and back, we all have a connection to the watershed.

When natural systems are no longer intact, infrastructure is typically needed to provide these lost services.

Bibliography

AESRD. (2011). **Alberta Environment Library.** Retrieved 2014 27-5 from Ecosystem Services Approach Pilot on Wetlands: Integrated Assessment Report: http://environment.gov.ab.ca/info/library/8493.pdf

AESRD. (1998). **Draft Environmental Guidelines for the Review of Subdivisions in Alberta.** Alberta Environmental Protection, Standards and Guidelines Branch, Environmental Assessment Division, Edmonton, AB.

AESRD. (2011). **Ecosystem Services Approach Pilot on Wetlands: Integrated Assessment Report.** Retrieved 2014 27-5 from Alberta Environment Library: http://environment.gov.ab.ca/info/library/8493.pdf

AESRD. (2012). **Environmental Tools: Transfer of Development Rights.** Retrieved 2014 27-October from Alberta Environment and Sustainable Resource Development: http://environment.alberta.ca/documents/Transfer_of_Development_Rights.pdf

AESRD. (2008). **Glossary of terms related to water and watershed management in Alberta. 1st edition.** Partnerships and Strategies Section, Alberta environment. Available at: http://environment.gov.ab.ca/info/library/8043.pdf.

AMEC. (2012). **Design Guidelines for Erosion and Flood Control Projects for Streambank and Riparian Stability Restoration.** AMEC Environment & Infrastructure, The City of Calgary, Water Resources.

Armstrong, C., Evenden, M., & Nelles, H. V. (2009). **The River Returns: An Environmental History of the Bow.** McGill-Queen's University Press.

AWC. (2013). **Riparian Land Conservation and Management Report and Recommendations.** Alberta Water Council, Edmonton, AB.

AWS. (2014). **Room for the River Pilot in the Bow River Basin: Advice to the Government of Alberta, December 19th, 2014.** Alberta WaterSMART Solutions Ltd., Calgary, AB.

BCMFR. (2014). **Defining Adaptive Management.** Retrieved 2014 27-August from http://www.for.gov.bc.ca/hfp/amhome/Admin/index.htm

Bentrup, G. (2008). **Conservation buffers: design guidelines for buffers, corridors, and greenways.** Department of Agriculture, Forest Service, Southern Research Station. Asheville, NC: United Sates Department of Agriculture.

Bormann, B. T., Cunningham, P. G., Brookes, M. H., Manning, V. W., & Collopy, M. W. (1994). **Adaptive ecosystem management in the Pacific Northwest.** US Dept. of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR, USA.

Brauman, K. A., Daily, G. C., Duarte, T. K., & Mooney, H. A. (2007). The Nature and Value of Ecosystem Services: An Overview Highlighting Hydrologic Services. **Annual Review of Environment and Resources** , 32, 67-98.

BRBC. (2012). **Bow Basin Watershed Management Plan**. Bow River Basin Council, Calgary, AB.

Center for Community Progress. (2015). **Stream Daylighting**. Retrieved 2015 15-January from http://www.communityprogress.net/stream-daylighting-pages-358.php

Chu, A. (2015). Application of Secondary Treated Effluent onto a Shallow Alluvial Aquifer. **Bow River Basin Council Science Forum.** Calgary, AB.

Clare, S., & Sass, G. (2012). **Riparian lands in Alberta: Current state, conservation tools, and management approaches.** Edmonton, Alberta: Report prepared for Riparian Land Conservation & Management Team, Alberta Water Council. Fiera Biological Consulting Ltd. Report #1163.

COC. (2014). **Calgary's Flood Resilient Future: Report from the Expert Management Panel on River Flood Mitigation.** City of Calgary, Calgary, AB.

COC. (2011). **Stormwater Management & Design Manual.** The City of Calgary Water Resources.

COC. (2008). **The City of Calgary Land Use Bylaw 1P2007.** The City of Calgary. calgary.ca/landusebylaw.

COC. (2011). **Triple Bottom Line Policy Framework Update**. The City of Calgary, Calgary, AB.

COSA. (2014). **City of San Antonio: About the Edwards Aquifer.** Retrieved 2014 2-April from http://www.sanantonio.gov/EdwardsAquifer/About.aspx

Cows and Fish. (2015). **2014 City of Calgary Riparian Health Inventory Post-Flood Monitoring Project: Report No. 45.** Alberta Riparian Habitat Management Society (Cows and Fish).

Cows and Fish. (2012). **City of Calgary 2007-2010 Riparian Evaluation Synthesis and Riparian Restoration Recommendations.** Lethbridge, AB: Alberta Riparian Habitat Management Society (Cows and Fish).

CRP. (2014). **Calgary Metropolitan Plan**. Calgary Regional Partnership, Calgary, AB.

Cunderlik, J. M., & Ouarda, T. B. (2006). Regional flood-duration-frequency modeling in the changing environment. **Journal of Hydrology , 318** (1-4), 276-291.

Dodds, W. K., & Oakes, R. M. (2008). Headwater Influences on Downstream Water Quality. **Environmental Management , 41**, 367-377.

Francis, J. A., & Vavrus, S. J. (2012). Evidence linking Arctic amplification to extreme weather in mid-latitudes. **Geophysical Research Letters , 39**.

Fripp, J., Hoag, J. C., & Moody, T. (2008). **Streambank Soil Bioengineering: A Proposed Refinement of the Definition.** Retrieved 2014 17-November from United States Department of Agriculture: Natural Resources Conservation Service: http://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/idpmcar8294.pdf

GOA. (2011). **Economic Valuation Technical Report.** Alberta Environment, Edmonton, AB.

GOA. (2014). **South Saskatchewan Regional Plan: 2014-2024.** Government of Alberta.

GWP. (2012). **What is IWRM?** Retrieved 2014 31-December from Global Water Partnership: http://www.gwp.org/The-Challenge/What-is-IWRM/

Hedman, E. R., & Osterkamp, W. R. (1982). **Streamflow Characteristics Related to Channel Geometry of Streams in the Western United States.** United States Geological Survey Water Supply Paper 2193.

Hemstrom, M. A. (2002). **Midscale analysis of streamside characteristics in the Upper Grande Ronde Subbasin, Northeastern Oregon.** United States Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Holling, C. S., & Meffe, G. K. (1996). Command and Control and the Pathology of Natural Resource Management. **Conservation Biology , 10** (2), 328-337.

Ipsos Reid. (2014). 2014 Water Conservation Research. Prepared for The City of Calgary by Ipsos Reid.

Ipsos Public Affairs. (2016a). **Riparian Action Plan: Riparian Landowner Affinity Groups.**

Ipsos Public Affairs. (2016b). **Riparian Action Plan: General Public Survey.**

Jakob, M., & Church, M. (2011). The Trouble with Floods. **Canadian Water Resources Journal , 36** (4), 287-292.

Lane, R. (1998). **Transfer of Development Rights for Balanced Development.** Retrieved 2014 27-October from Lincoln Institute of Land Policy - Land Lines: March 1998, Volume 10, Number 2: http://www.lincolninst.edu/pubs/424_Transfer-of-Development-Rights-for-Balanced-Development-

Leopold, L. B., & Maddock, T. (1954). **The Flood Control Controversy.** New York: Ronald Press Co.

Lorenz, K., Depoe, S., & Phelan, C. (2008). **Assessment of Environmental Sustainability in Alberta's Agricultural Watersheds Project: AESA Water Quality Monitoring Project.** Lethbridge, Alberta: Alberta Agriculture and Rural Development.

Nelles, H. V. (2005). How Did Calgary Get Its River Parks? **Urban History Review , 34** (1), 28-45.

Noss, R. (1990). Indicators for Monitoring Biodiversity: A Hierarchical Approach. **Conservation Biology , 4** (4), 355-364.

NRTEE. (2011). **Charting a Course: Sustainable Water Use by Canada's Natural Resource Sectors.** Ottawa, ON: Government of Canada: National Round Table on Environment and Economy.

O2. (2013). **Riparian Areas Mapping Project.** O2 Planning + Design Inc. Prepared for The City of Calgary Water Resources, Calgary, AB.

Orme, W. (2014 21-August). **How much money is a healthy ecosystem worth?** Retrieved 2014 10-October from High Country News: http://www.hcn.org/blogs/goat/the-dollar-sign-in-nature

Pack, J., & Gaffney, D. (2014). **Protecting Streambanks and Shorelines with Integrated Erosion Control Systems.** Forester University and Tensar North American Green.

PMI. (2014). **Project Management Institute: What is Project Management?** Retrieved 2014 30-October from http://www.pmi.org/About-Us/About-Us-What-is-Project-Management.aspx

Rapp, C. F., & Abbe, T. B. (2003). **A Framework for Delineating Channel Migration Zones.** Retrieved 2014 25-July from Department of Ecology - State of Washington - Publications: https://fortress.wa.gov/ecy/publications/publications/0306027.pdf

RDRWA. (2013). **Background Technical Report on Riparian Areas, Wetlands, and Land Use.** Red Deer River Watershed Alliance, Red Deer, AB.

Rood, S. B., & Kaluthota, S. (2015). **Riparian Woodlands along the middle Bow River through Calgary: Patterns and Processes, including Plant Colonization and Succession.** Chinook Environmental Resources and University of Lethbridge, Sub-report for City of Calgary River Morphology Project, Klohn Krippen Berger and City of Calgary.

Rood, S. B., Samuelson, G. M., Braatne, J. H., Gourley, C. R., Hughes, F. M., & Mahoney, J. M. (2005). Managing river flows to restore floodplain forests. **Frontiers in Ecology and Environment , 3** (4), 193-201.

Rood, S. B., Taboulchanas, K., Bradley, C. E., & Kalischuk, A. (1999). Influence of Flow Regulation on Channel Dynamics and Riparian Cottonwood Along the Bow River, Alberta. **Rivers , 7** (1), 33-48.

SSRAC. (2011). **Advice to the Government of Alberta for the South Saskatchewan Regional Plan.**

Stanfield, L. W., Del Giudice, L., Lutscher, F., Trudeau, M., Alexander, W. F., Fagan, W. F., et al. (2014). **A Discussion Paper on: cumulative effects from alteration of headwater drainage features and the loss of ecosystem integrity of river networks.** Glenora, ON: Ontario Ministry of Natural Resources, internal publication.

Stewart, R. E., & Kantrud, H. A. (1971). **Classification of Natural Ponds and Lakes in the Glaciated Prairie Region.** Resource Publication 92, Bureau of Sport Fisheries and Wildlife, U.S. Fish and Wildlife Service, Washington, D.C.

Tang, Q., Zhang, X., & Francis, J. A. (2013). Extreme summer weather in northern mid-latitudes linked to a vanishing cryosphere. **Nature Climate Change , 4**, 45-50.

TCS. (2016). **City of Calgary Assessment of Vegetation Establishment on Bio-engineering Projects: Interim Monitoring Report: Cuttings, Live Plants, and Seed.** Prepared by Tannas Conservation Services Ltd. (TCS), Cremona, AB for The City of Calgary Water Resources, Watershed Planning, Calgary, AB.

TRCA. (2014). **Evaluation, Classification and Management of Headwater Drainage Features Guidelines.** Toronto, ON: Toronto and Region Conservation Authority (TRCA) and Credit Valley Conservation (CVC).

UNEP. (2004). **Integrated Watershed Management - Ecohydrology and Phtotechnology Manual.** United Nations Environment Programme, Division of Technology, Industry and Economics, Osaka, Japan.

USDA. (2007). **Part 654, National Engineering Handbook, Stream Restoration Design.** United States Department of Agriculture - Natural Resources Conservation Service.

USEPA. (2015). **Connectivity of Streams & Wetlands to Downstream Waters: A Review and Synthesis of the Scientific Evidence.** United States Environmental Protection Agency. Washington, D.C.: Office of Research and Development.

USEPA. (2013). **Connectivity of Streams and Wetlands to Downstream Waters: A Review and Synthesis of the Scientific Evidence.** U.S. Environmental Protection Agency, Washington, D.C.

USEPA. (2008). **Handbook for Developing Watershed Plans to Restore and Protect Our Waters.** United States Environmental Protection Agency - Office of Water, Washington, DC.

USEPA. (1998). **Stream Corridor Structure: Adapted for the Internet from Stream Corridor Restoration: Principles, Processes and Practices.** U.S. Environmental Protection Agency, Watershed Academy Web Distance Learning Modules on Watershed Management. Available online at: http://cfpub.epa.gov/watertrain/pdf/modules/new_streamcorridor.pdf.

USEPA. (2014). **What is Green Infrastructure?** Retrieved 2015 5-March from http://water.epa.gov/infrastructure/greeninfrastructure/gi_what.cfm

USGS. (1995). **Science in Your Watershed: General Introduction and Hydrologic Definitions.** Retrieved 2014 17-November from http://water.usgs.gov/wsc/glossary.html#A

Walters, C. (1997). Challenges in adaptive management of riparian and coastal ecosystems. **Conservation Ecology , 2** (1), Available from the Internet. URL: http://www.consecol.org/vol1/iss2/art1.

WRI. (2003). **Millennium Ecosystem Assessment: Ecosystems and Human Well-Being: A Framework for Assessment.** World Resources Institute, United Nations Environment Programme, and Millenium Ecosystem Assessment Secretariat. Washington, D.C.: Island Press.

The Bow supports life in many forms.

Plants help reduce the amount of sediment, pollution and nutrients reaching our rivers.

Supplement One: Bioengineering

Audience: river and civil engineers

During stakeholder engagement, participants clearly told The City of Calgary that civil and river engineers require additional guidance on where to use bioengineering structures in place of hard engineering riprap for the purpose of stream and riverbank erosion control. To better support river and civil engineers, a number of tools have been developed, including:

1. An overview of the differences between structural versus plant-based bioengineering.
2. Examples of past bioengineering projects with The City.
3. A Riparian Decision Matrix for river engineering projects.

Inventory of riparian restoration projects and priorities

Since 2008, The City of Calgary has promoted bioengineering practices for bank stabilization and riparian restoration. The erosion stabilization projects constructed immediately after the June 2013 flood were driven by the need to protect critical infrastructure and typically applied hard riprap designs. Current and future restoration sites and priorities set out by The City are based on studies conducted by AMEC Foster Wheeler, engineering consultants, ongoing flood recovery efforts and expert opinions of Water Resources and Parks staff. Priority sites are reviewed and re-established each year.

Riparian infrastructure tools

Table 8. Structural versus plant-based bioengineering techniques

Treatment features	Structural-based bioengineering	Plant-based bioengineering
Typical applications	Urban or suburban situations where high value infrastructure is adjacent to the waterway	Suburban, rural, or park situations where some movement of the bank line will not endanger life or property
Bank line	Determined by designer and defined by hard material placement	Approximated by designer and defined over time by natural processes
Dynamism	Low to none—successful project is static, with a low tolerance for movement	Moderate—successful project is as dynamic as a natural reach
Materials	Structural materials enhanced with plantings	Living riparian plants and inert materials used for temporary stabilization
Ecological benefits	Terrestrial and aquatic benefits provided by plants and placement of inert material	Terrestrial and aquatic benefits provided by plants and dynamic nature of the resulting project
Self-healing	Limited—if structural component fails, treatment is compromised	Significant—plant material can be severely impacted, yet recover
Examples	Riprap with live cuttings	Live cuttings
	Vertical bundles with a rock toe	Vertical bundles
	Log cribs	Wattle fence
	Vegetated gabions	Fascines
	Vegetated geogrid	Brush revetment
	Permanent erosion control fabric	Temporary erosion control fabric

Examples of riverbank bioengineering projects in Calgary

Since 2008, The City of Calgary has promoted bioengineering practices for bank stabilization and riparian restoration. Key examples of riverbank bioengineering projects are highlighted in Table 9.

Table 9. Examples of riverbank bioengineering projects in Calgary

Project name	Description	Illustration/photo
Riverbank rescue site, Sandy Beach	Between 2008-2010, City of Calgary "Adopt-A-Park" staff, in partnership with the Calgary Herald and Cows and Fish, restored riverbanks along the Elbow River at Sandy Beach Park. Crews and volunteers planted shrubs and installed live sandbar willow stakes. The willow and shrubs act as structural elements to stabilize soils and slow floodwaters—a two-fold approach to preventing bank erosion. Native thorny shrubs deter access to the site to allow vegetation establishment. This site survived the 2013 flood very well.	Sandy Beach Riverbank Rescue, photo taken July 2013 
Deerfoot Meadows/ Southland Park vegetated timber crib wall	In 2009, The City of Calgary installed two timber crib walls interspersed with live willow cuttings along the Bow River near Deerfoot Meadows. Rock was installed underneath the timber crib wall to ensure structural integrity. These structures survived the June 2013 flood exceptionally well, while adjacent areas experienced erosion (photo opposite). The timber crib wall provides higher ecological and aesthetic values at this site compared to more conventional engineering approaches. Furthermore, the cost to design and install this project was lower than for conventional riprap bank hardening.	The bioengineered structures survived the June 2013 flood exceptionally well, while adjacent areas experienced erosion. photo credit: Cows and Fish, July 2013  Deerfoot Meadows/Southland Park vegetated timber crib wall 

Vegetated gabion across from Stampede grounds

The vegetated Gabion Project, located on the Elbow River, sustained damage during the June 2013 flood.

Vegetated gabion project

Elbow River (right bank) across from Stampede grounds

A vegetated timber crib wall, with willow cuttings that root inside the log structure, was installed in 2014 to repair this area and protect the adjacent Elbow River pathway, which was damaged by the 2013 flood.

Live timber crib wall across from Stampede grounds during installation, summer 2014

Weaselhead ATCO gas pipeline site

Major bank engineering projects within a natural environment park are generally highly undesirable. However, in the Weaselhead Natural Environment Park, the 2013 flood exposed a section of an ATCO gas pipeline. The solution was to provide an integrated erosion control system consisting of a rock layer, geosynthetics, engineered soil media and dense, native shrub plantings and native willow cuttings from the Weaselhead Park. Impacts to bank-swallow nesting habitat were also mitigated by placing a blanket down in the spring prior to the nesting period. The result is a bank engineering project that effectively balances infrastructure protection, aesthetics and the environmental requirements of the site.

Weaselhead ATCO Gas riparian restoration site

Riparian Decision Matrix for river engineering projects. The following matrix (Figure 10. Riparian Decision Matrix for river engineering projects below) was developed by Water Resources and is intended as a decision support tool for City of Calgary projects involving bank stabilization, restoration and/or river engineering. Project engineers and consultants involved with these projects are currently being directed to use this matrix in project management, design, administration and construction. The purpose of the matrix is to ensure bioengineering practices are applied to the maximum extent possible within Calgary.

Table 10. Riparian Decision Matrix for river engineering projects

Riparian Management Zone	Hard Engineering	Bioengineering / Soft Engineering	Example Sites*
Flood and erosion control zones	**Permitted** As necessary	**Preferred** Must be evaluated during design	**Memorial + 19th St.** **Alyth Yard Bridge** **MacDonald Bridge** **Elbow Rail Bridge**
Conservation Zones	**Prohibited**	**Required** Designs should minimize environmental impacts	**Discovery Ridge** **Parkdale**
Restoration zones	**Discretionary** Highly discouraged	**Preferred** Must be evaluated during design	**Douglasdale** **South Highfield**
Recreation zones	**Discretionary** Highly discouraged	**Preferred** Designs should minimize environmental impacts	**Lindsay Park** **Inglewood Golf Course**

*Contact City of Calgary Water Resources for more information about example sites and locations.

Understanding the width of natural riparian zones is a critical step towards informed land-use planning, understanding risk and, ultimately, protecting public safety.

Supplement Two: Riparian land-use planning

Audience: land-use planners, developers, civil engineers and stormwater professionals

To better understand and protect Calgary's riparian ecosystems during planning and development, The City has undertaken considerable work to map and delineate these areas and to develop tools that better support practitioners. The following supplement provides:

1. An overview of mapping activities/methodologies and riparian management categories.
2. Land-use planning procedures for riparian areas.
3. Land-use planning decision trees for permanent, intermittent and ephemeral streams.
4. Guidance on biophysical/ecological assessments and riparian areas.
5. Guidance on master drainage plans and riparian areas.

Riparian area mapping

Variable-width modelling of riparian areas

Generally, the farther lands are from water, and the higher they are, the less likely they are to support riparian conditions. To define Calgary's riparian areas, a variable-width riparian areas model was applied along Calgary's major rivers and streams. This model was developed based on three simple variables: 1) river and streambank locations, 2) digital elevation models and 3) field data on natural riparian vegetation occurrences. Maps and digital files were then created depicting the extent of current and historical riparian areas along permanent rivers and streams. The variable-width riparian areas model defined four zones:

- Inner Riparian Zone
- Middle Riparian Zone
- Outer Riparian Zone
- Potential Outermost Riparian Zone

Inner Riparian Zones typically correspond with the 1:5 year floodplain boundary; **Middle Riparian Zones** tend to occupy the 1:20 year floodplain boundary; Outer Riparian Zones tend to occupy between the 1:50 and 1:100 year floodplain boundaries; and the **Potential Outermost Riparian Zone** typically extends beyond the 1:100 year floodplain. Given the size of the Bow and Elbow rivers, adjacent riparian areas tend to be much larger than those adjacent to the smaller creeks in the city. Table 9 on page 59 shows the typical range of riparian widths observed in Calgary.

Table 11. Range of riparian widths along major Calgary rivers and streams

River or creek	Typical range of riparian widths* (m)
Bow River	145 m – 350 m
Elbow River	105 m – 290 m
Nose Creek	35 m – 60 m
West Nose Creek	25 m – 40 m
Forest Lawn Creek	70 m –120 m
Radio Tower Creek	30 m – 50 m
Pine Creek	35 m – 50 m
12 Mile Coulee Creek	20 m – 35 m
Coach Creek	15 m – 25 m

Note: *Based on 2nd quartile to 4th quartile range of the mapped riparian edge, rounded to the nearest 5 m

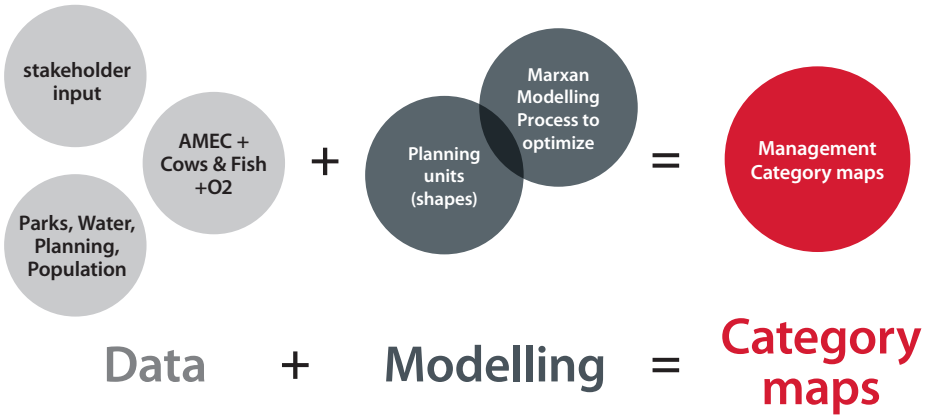
Riparian mapping data sets are available online at The City of Calgary's Open Data Catalogue.

Riparian Management Category mapping

Mapping riparian management zones is a critical step towards developing land-management categories that guide how we restore and protect riparian areas. The following section discusses the category modelling process in more detail.

Step one of the category mapping process (see Figure 11) involved a stakeholder-led process to define possible management categories for Calgary's riparian zones. The resulting recommendations placed riparian landscape categories on a continuum based on patterns of land use ranging from completely built environments (e.g., downtown commercial high rises) to completely natural open space).

Figure 12. Overview of Riparian Management Category modelling process



Step two involved a technical process of multi-criteria spatial modelling. More than 47 layers of data, representing various resource values and conditions, such as the presence of infrastructure or recreation features, were used to model and map each of the five riparian management categories along Calgary's major rivers and streams. The variable-width riparian zone data were also a key input in the modelling process, as they identified the physical area occupied by riparian areas; inner and middle riparian zones were weighted to have high conservation value.

Mapping river morphology An on-going project includes mapping river morphology to better account for how water channels change and migrate overtime. River morphology delineates channel migration zones at the outset of planning, makes room for the river and can help prevent expensive damage to infrastructure and eliminate the need for expensive bank-hardening projects used to prevent flooding and erosion. Areas of significant river morphology will be identified and future development in those areas will be considered.

Ephemeral and intermittent streams Ephemeral and intermittent streams are small headwater-drainage features that generate the majority of a river's flow and play a critical role in maintaining water quality on a cumulative, regional basis. Intact, well-vegetated riparian areas in and along ephemeral and intermittent watercourses reduce the mobilization of sediment, excessive nutrients and other pollutants downstream. Mapping of these areas is in progress and potential limits of acceptable change related to the loss of ephemeral and intermittent watercourses can and will be defined.

Land-use planning procedures for riparian areas

Growth in Calgary is co-ordinated by a series of plans within a planning hierarchy. Riparian area boundaries and setbacks should be flagged as early as possible in the planning process, so that constraints and opportunities can be made clear far in advance of development. Planning procedures to incorporate riparian values and boundaries in new developments are important at all levels in the planning hierarchy.

Part 17 of the Municipal Government Act (MGA) addresses planning and development in a municipality and gives the municipality the authority to require dedication of lands, including Environmental Reserve (ER) and Municipal Reserve (MR), at subdivision. Of particular relevance to riparian areas is Section 664(1) of the MGA [9], which states:

> "An area of land may be designated as Environmental Reserve if it consists of:
>
> a) a swamp, gully, ravine, coulee or natural drainage course,
>
> b) land that is subject to flooding or is, in the opinion of the subdivision authority, unstable, or
>
> c) a strip of land, not less than 6 metres in width, abutting the bed and shore of any lake, river, stream or other body of water for the purpose of (i) preventing pollution, or (ii) providing public access to and beside the bed and shore."

Any of the landscape features noted above can fall within the definition of potential ER and be identified as such in a planning document. However, whether dedication of potential ER lands is actually required at subdivision is left to the discretion of the Subdivision Authority.

By identifying potential ER related to riparian areas and other landscape elements (e.g., wetlands, steep slopes, etc.) in ASPs, expectations regarding environmental constraints and opportunities can be established. Subsequently, the Outline Plan will fill any remaining information gaps and provide more detail and refinement for decision-making purposes, including the actual designation of riparian-related ER.

In accordance with the MGA, there are six landscape elements that can qualify as potential ER. Table 10 below lists each of these, along with existing data sources and criteria, responsibilities for mapping and recommended timing of supporting studies. An Ecological Inventory Framework [10] is required to support ASPs, and Biophysical Impact Assessments (BIAs) are required to support Outline Plans.

Draft riparian decision-analysis trees have been created to support land-use planning applications (see Figure 13 and Figure 14). These are primarily intended for use within the ASP and Area Redevelopment Plan (ARP) processes. However, in the future, more refined criteria will be developed for the Outline Plan, Tentative Plan and Development Permit stages.

9 Anticipated changes to the Municipal Government Act may offer municipalities new tools for riparian protection.

10 http://www.calgary.ca/CSPS/Parks/Documents/Construction/Ecological-Inventory-Framework.pdf

Table 12. Potential environmental reserve, as specified in the Municipal Government Act [11]

Potential environmental reserve element	Legal basis in Municipal Government Act	Data source/criteria	Timing of mapping studies
Gully, ravine or coulee (with escarpments >15%) [12]	664(1) (a)	Landform mapping from digital elevation models	Prior to/during ASP
Wetlands	664 (1) (a) 664(1) (b)	City wetlands data, provincial merged wetlands inventory, current and historical air-photo interpretation	During ASP field confirmation during growing season prior to Outline Plan
Natural drainage course	664 (1) (a)	Mapped stream vectors Ephemeral/intermittent watercourse mapping study Field studies of areas	As available Flag at ASP Refine at Outline Plan
Land subject to flooding	664 (1) (b)	Current floodplain maps Riparian maps for streams/rivers*	Include current floodplain boundaries (not just floodway) in ASPs, incorporate updates as available
Land that is, in the opinion of the subdivision authority, unstable	664 (1) (b)	River geomorphology study Geotechnical studies	Flag at ASP Refine at Outline Plan
A strip of land, not less than 6 metres in width, abutting the bed and shore of any lake, river, stream or other body of water for the purpose of: **(i). Preventing pollution** **(ii). Providing public access to and beside the bed and shore**	664 (1) (c)	2007 Environmental Reserve (ER) Setback Guidelines-base + modifier** Ephemeral + Intermittent stream mapping study (once complete)	Current ER Setback Guidelines map tool available now Incorporate updates as available

*Available in City of Calgary Open Data Catalogue.

**Alluvial aquifer zones directly affecting surface water should be protected using tools other than ER; these have been mapped previously at a 1:50000 scale (Alberta Research Council 2010; Moran 1984).

11 Please note that the Municipal Government Act is under review and will be updated. Definitions are subject to change. For more information, please visit http://mgareview.alberta.ca.

12 AESRD (2012) – Stepping Back from the Water; UNEP (Integrated Watershed Management - Ecohydrology and Phototechnology Manual, 2004) – hill slopes with slopes greater than 15 per cent directly enclosing a stream or river are considered to be an element of a riparian area corridor.

Riparian land-use planning decision trees

The following Riparian land-use planning decision trees integrate directions and policies regarding riparian areas from a wide-range of documents, including the **South Saskatchewan Regional Plan** (2014), **Municipal Development Plan** (2009), **New Communities Planning Guidebook** (2013), **Environmental Reserve (ER) Setback Guidelines** (2007), **Riparian Areas Mapping Project** (2013), **River Flood Mitigation Panel Report** (COC, 2014), **Biophysical Impact Assessment Framework** (under review), water and watershed management plans (e.g., **Bow Basin Watershed Management Plan, Nose Creek Watershed Management Plan) and Calgary Land Use Bylaw.**

These decision trees are drafts and advisory in nature and do not preclude further changes as a result of any future federal, provincial, or municipal policy or legislation enacted to enhance flood resiliency, environmental quality or municipal authority.

Figure 13. Riparian land-use planning decision tree: step one

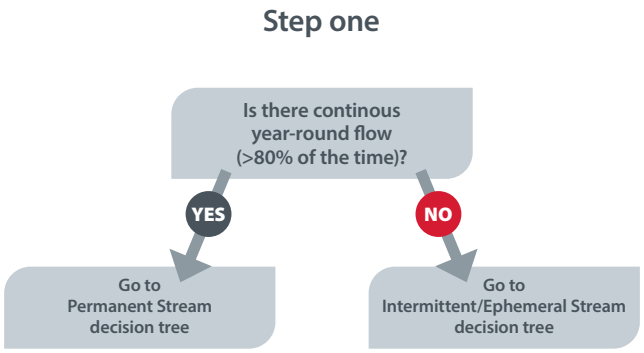


Figure 14. Riparian land-use planning decision tree: permanent streams

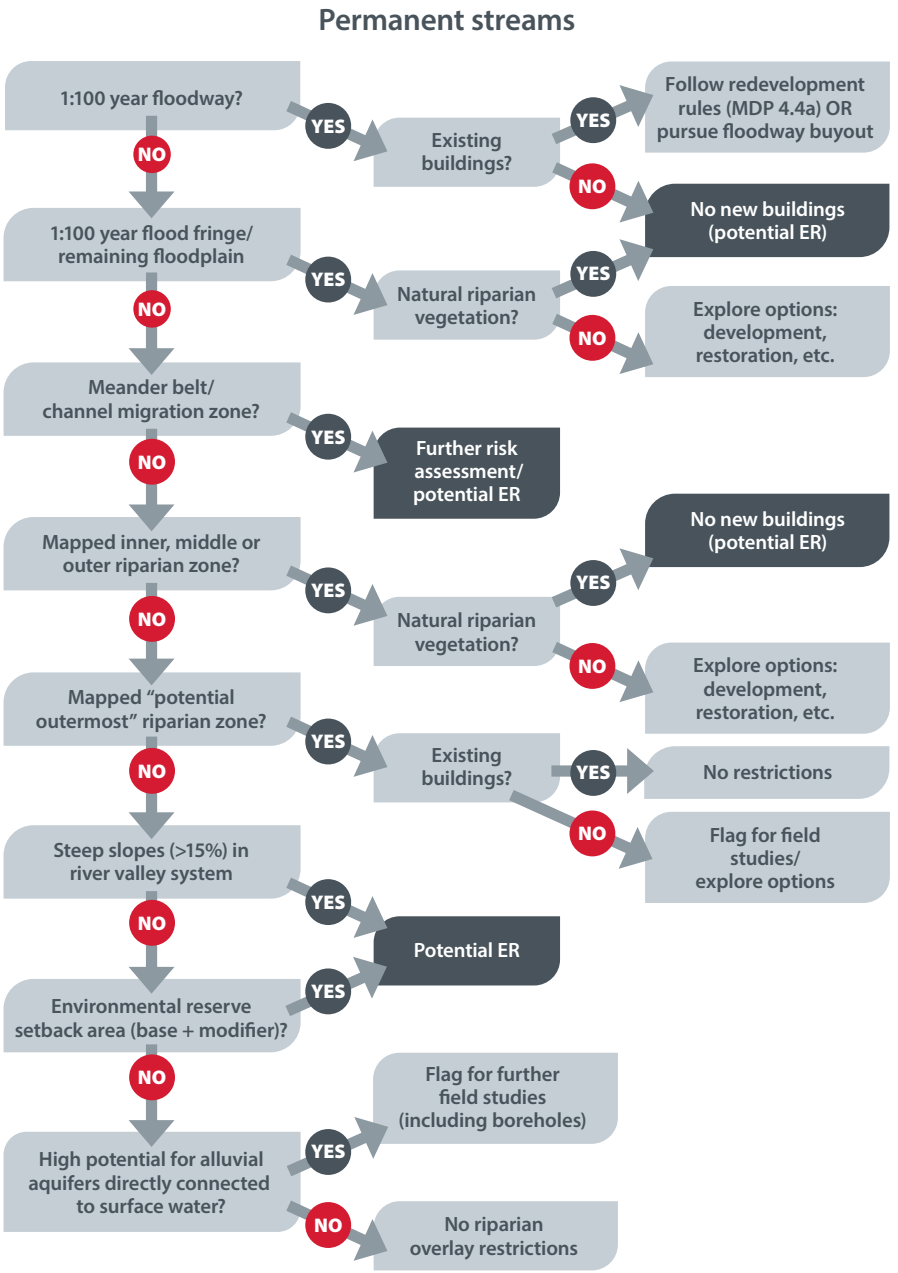
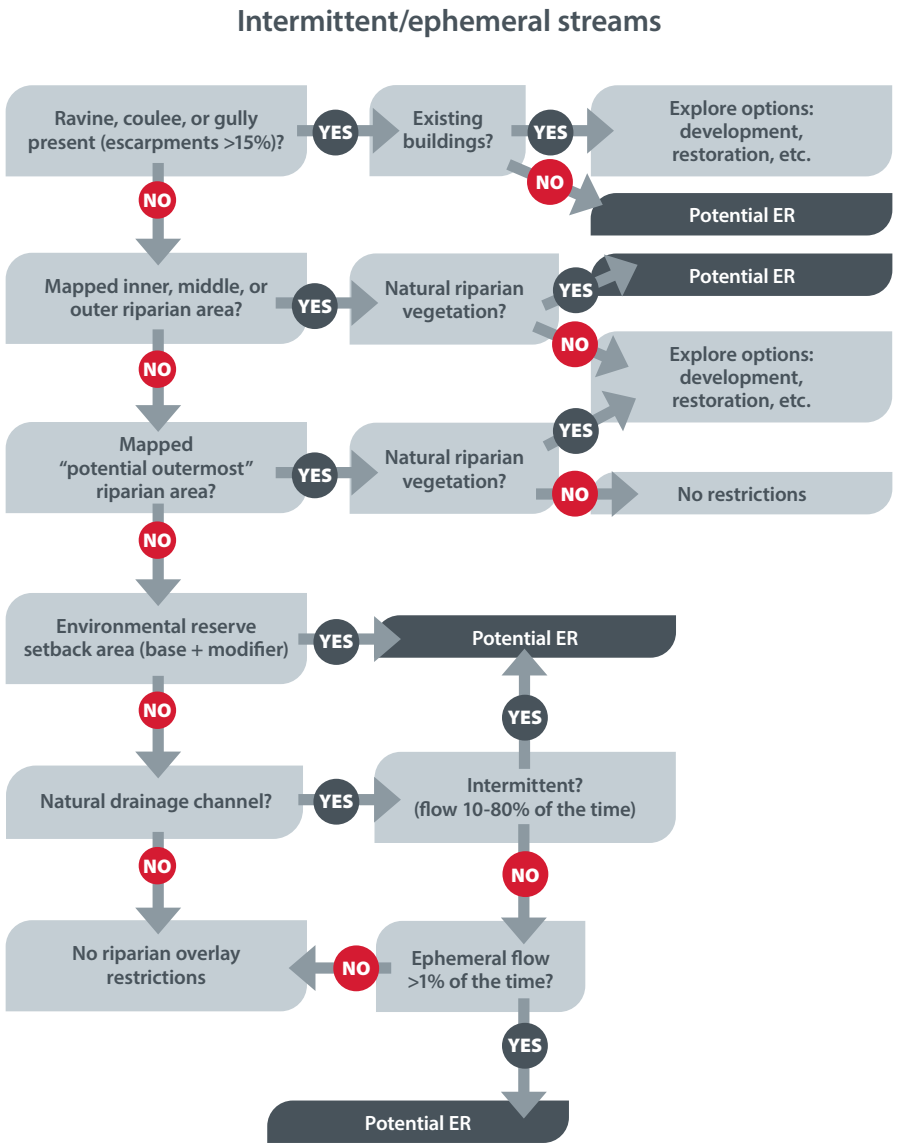


Figure 15. Riparian land-use planning decision tree: ephemeral + intermittent streams



The challenge of identifying lost or impacted riparian areas in the field

When the signature of natural riparian vegetation has been erased in the field by development or agricultural activities, care must be taken when interpreting and mapping riparian boundaries based on field data alone. If riparian restoration opportunities are being explored, broad scale riparian mapping data should complement site-specific field data. The broad scale riparian mapping data has been calibrated to include lost/developed riparian areas along major rivers and streams in Calgary.

Biophysical ecological assessments and riparian areas

Riparian area GIS mapping data and biophysical/ecological assessments Existing city-wide riparian-area mapping boundaries provide key information for initial desktop Ecological Inventory Framework or Biophysical Impact Assessment (BIA) review purposes, as required by The City of Calgary Parks. All consultants and developers should be referred to this source of reference information as early as possible in development planning processes. Any users of the data must also review the metadata, including associated data limitations (e.g., its restriction to riparian areas along major rivers and streams in Calgary). Supplementary city-wide ephemeral and intermittent stream mapping is also planned for 2016 and will be used to update data on City Online once finalized. Mapping ravine and coulee boundaries based on a systematic city-wide process is also underway.

Riparian-area field assessments Field verification of riparian-area boundaries is required, as broader-scale mapping may not capture site-specific riparian variability. In addition, many ephemeral and intermittent watercourses and associated riparian areas cannot be mapped accurately with desktop exercises alone. Field assessments combined with hydrological mapping will generally improve the accuracy of riparian-area delineation. Strong plant-taxonomy skills and hydrological knowledge, including knowledge of soils, are required to accurately delineate riparian areas in the field. Experience with identifying permanent high water, ephemeral high water (e.g., spring run-off) and high water marks associated with flood events is crucial for field delineation of riparian areas (Clare & Sass, 2012). Soil pits should be examined to determine riparian boundaries based on soil mottling or gleying, or in situations where there may be questions regarding water permanency (e.g., red indicates oxidization in areas that experience full saturation). Vegetation surveys are also critical. Where vegetation is disturbed, principles outlined in Stewart and Kantrud (Classification of Natural Ponds and Lakes in the Glaciated Prairie Region, 1971) can also be used during field assessments of riparian areas. In agricultural environments with non-native vegetation, the crop draw-down phase and presence of colonizing invasive species can also be field cues showing the presence of riparian conditions. In addition to ground-truthing the extent of the riparian area, characteristics of the site should be assessed to assign a riparian health score (Cows and Fish, 2012).

Riparian setback determination Determination of appropriate riparian setbacks should be based on the land-use planning decision trees above. Riparian setbacks must take into consideration the floodway, riparian areas, meander belts/channel migration zones, steep slopes and existing policies and guidelines, such as the ER Setback Guidelines (2007). Setbacks can also be modified and increased to preserve wildlife movement corridors, species at risk/species of conservation concern, sensitive landscape features, unstable soils, etc. Field assessments should be performed by an experienced environmental professional during the growing season, when the majority of riparian species in the proposed project site are in flower. During the design of the assessment, riparian and floodplain maps must be used to develop a sampling strategy.

Master drainage plans and riparian areas

The City of Calgary's stormwater management planning process involves the integration of plans from the watershed level down to detailed design. Watershed and water management plans provide general guidance and recommendations at the watershed level. Water management plans may include specific stormwater management and riparian-area protection requirements, including water quality and water conservation objectives, maximum allowable release rates, runoff volume-control targets, implementation of LID practices, etc.

A master drainage plan (MDP), which can be developed by The City of Calgary or the developer/consultant is prepared for a large urban drainage area and is typically serviced by a single outfall. MDPs identify the location of stormwater infrastructure (e.g., ponds, trunk sizes, servicing routes, overland drainage routes, water quality-treatment requirements).

An individual MDP must:

- Incorporate stormwater management and watershed protection requirements of the broader scale watershed or water management plan.
- Provide an acceptable level of service and meet the objectives of regional context studies, area structure plans, redevelopment plans and biophysical impact assessments. Depending on various factors, these other documents can be developed before, during or after the development of an MDP.
- Comply with The City of Calgary Stormwater Management & Design Manual and provincial requirements.

One of the technical requirements of MDPs is to confirm post-development runoff rates and volume targets. Increased stormwater runoff due to urbanization can cause channel erosion and pollution, and can have adverse impacts on aquatic species. The City has developed runoff rate volume and water quality targets for greenfield and redevelopment projects.

Technical requirements for MDP reports can be found in the Stormwater Management & Design Guidelines, as well in the Terms of Reference issued for the scope to be included in individual Master Drainage Plans. Generally, Master Drainage Plans will include the following requirements pertaining to drainage courses and associated riparian areas:

- Establish stormwater targets and objectives from relevant regional Watershed and Water Management Plans
- Refer to The City of Calgary's Riparian Action Program as well as Wetlands Management Plans and Policies for alignment and consistency purposes
- Document, including with site inspections and photos, existing wetlands and drainage pathways, as well as all perennial, intermittent, and ephemeral drainage courses, man-made drainage infrastructure, and flow directions
- Assess and align stormwater concepts with available draft or final Biophysical Impact Assessment (BIA) reports
- Evaluate the stability thresholds and conveyance characteristics of existing streams and ravines, with specific attention to those drainage courses and ravines that may convey concentrated urban runoff in the future
- Identify the extent of drainage courses deemed to be important for maintaining in a natural-like state
- As part of a planning-level hydrogeological assessment, assess groundwater impacts relevant to the preservation of existing drainage courses or wetlands in a natural-like state
- Prepare pre-development flow-duration curves for ravines and drainage courses, and verify that flow frequency curves following the introduction of controlled, treated stormwater releases do not exceed pre-development flow-frequency curves
- In consultation with Water Resources, determine requirements for sampling and monitoring of water quality (e.g., TSS, P, N, Cl, metals, hydrocarbons, PAHs, etc.) and/or water flow rate monitoring for streams within the study area
- During drainage system design, locate all stormwater infrastructure (except outfalls or perimeter rain gardens or bioswales) outside of riparian areas, floodplains, and meander belt widths
- Evaluate whether and describe how existing water bodies or potential/contested water bodies might need to be sustained by the stormwater drainage system
- Give preference to the use of native wetland and riparian vegetation in constructed wetlands and stormwater management features
- Evaluate considerations for appropriate stream setbacks addressing the following setback objectives:
  - Safe flood conveyance
  - Stream movement
  - Water quality/treatment
  - Access for maintenance
  - Habitat and wildlife movement
  - Groundwater protection
  - Geotechnical slope stability
  - The City of Calgary's existing riparian and stream mapping products, including identified riparian extents, 2007 ER Setback guideline locations, and new mapping and classification of perennial, intermittent, and ephemeral streams as they become available
  - Educational, interpretive, and recreational functions
- Identify overland drainage routes, including the use of streams as overland escape routes

Supplement Three: Riparian Monitoring Protocols

Audience: specialized technical staff and/or consultants

The Riparian Action Program (RAP) is based on an adaptive management approach that includes regular monitoring and adjustments. It is a structured, science-based process that plans for and integrates experience and research into programming along the way. Adaptive management enables continual improvement, accountability and transparency and best addresses the dynamic nature of riparian systems.

On a regular basis, for example once every five years, trained City staff and/or contractors will conduct assessments to monitor and measure indicators. City of Calgary Watershed Planning staff will assume overall responsibility for co-ordinating the monitoring of this work, as well as reporting and sharing the results more broadly.

The following supplement provides an overview of the methodologies and protocols related to each of the three program areas: riparian land-use, riparian bank health, and education and outreach.

Program area one: riparian land-use monitoring protocols

This section outlines the methodology undertaken to measure baseline (2012) land uses in riparian areas and outlines a relatively straightforward method to conduct ongoing monitoring of riparian land uses as part of future monitoring efforts. The expert conducting this work will be a senior geographic information systems (GIS) technician assigned to Water Resources (e.g., Infrastructure and Information Services – Water Design staff), under the overall direction of the assigned Watershed Planning staff.

Indicator #1: Riparian open spaces (major creeks and rivers) are mapped. The City of Calgary already has a process in place to systematically update geospatial data sets on designated land-use districts as planning and development decisions proceed, a process integrated with the Land Use Bylaw. This process is encapsulated in The City's SDE GIS layer, currently named: "CALGIS.CNTST_LANDUSE_1P2007". Although this data layer includes areas that are zoned but not yet built or developed, these areas do represent major land-use decisions and, therefore, signify the intent to allow development within them.

Therefore, for the purpose of monitoring how riparian land uses are changing along Calgary's major rivers and streams, this data layer (or future updates to it) is relatively suitable. To use this data for future monitoring purposes, the following procedure is recommended:

1. The first step in monitoring riparian land use is to clip the city land use layer to the same boundary used to measure baseline land use data. This area includes the maximum extent of those areas mapped as riparian (includes the Outer Riparian Boundary, i.e., everything classified as Inner, Middle and Outer Riparian zones) or the ER Setback buffer width, whichever is greater. This boundary is encompassed by the outer spatial extent of the O2 (2013) geodata set representing major land uses, saved on the Water Resources' server.
2. Once the land use district data has been clipped to the riparian extents as described above, the data is to be combined into the simplified categories shown in Table 12 below, based primarily on the major land use district field.

Table 14. Assumptions for grouping land uses into Developed and Undeveloped categories

Developed land use categories		
Commercial	**Residential**	**Institutional**
Includes all C- districts, and CC-COR, CC-MH, and CR-20 centre city districts.	Includes all R- districts (Low, Medium and High Density), Multi-Residential, and CC-MH and CC-MHX districts.	Includes all health, religious, educational institutions, mostly in the S-CI land use district.
Industrial	**Mixed use**	**Major infrastructure**
Includes all I- districts.	Includes all CC-East Village districts, CC-X.	Includes the ring road/transportation and utility corridor, Deerfoot Trail, major roadways, railways, Ogden Rail Yards, Stampede grounds, wastewater treatment plants.
Open space (undeveloped) land use categories (for the purposes of riparian land use monitoring)		
Parks, recreation + public education - Includes all S- districts. - Includes St. Patrick's Island + Calgary Zoo (reclassified from FUD). - Golf courses where symbolized differently on the map.	Future urban development (S-FUD) - Includes all lands on the periphery "awaiting urban development and utility servicing" (COC, 2008). It accommodates extensive agricultural uses prior to rezoning during future planning.	

1. One drawback to the CALGIS.CNTST_LANDUSE_1P2007 data layer is the large number of Direct Control (DC) land use districts, which vary greatly in terms of actual major land use type. To provide a consistent, more useful layer for interpretation and city-wide summary purposes, it is necessary to reclassify these into one of the categories noted above prior to conducting any statistical summaries. The DC_LUD data field can be consulted, but current air photo imagery should also be examined while reclassifying DC polygons within riparian areas. During baseline data analysis conducted in 2012, all of the Direct Control –DC land use districts were reclassified to a new major land-use class identity by referencing the data set and current aerial photography imagery in the GIS. The interpreter then reclassified these DC parcels to a new major land use class identity, as per the table above.
2. Once this data processing is completed, the current riparian land use data can be summarized statistically and compared to the baseline 2012 values. Current statistics by river system must also be generated, as summarized in the "ExistingLandUse%inRiparianAreas" tab in the Excel database, saved on the Water Resources server at: riparianStatsOct2014.xlsx.
3. For the purposes of indicator monitoring, the total developed area along each river/stream should be summarized and compared to baseline values from 2012 (e.g., 27 per cent developed city-wide; 25 per cent developed along the Bow River; 38 per cent developed along the Elbow River; 33 per cent developed along Nose Creek and West Nose Creek). If desired, more detailed land use categories can be created, to track and summarize trends, but it is not necessary to address the intent of the established indicator.

Indicator #2: Conversion of riparian areas to new development along ephemeral and intermittent watercourses are monitored. This indicator methodology will require further development once an inventory and map of ephemeral and intermittent watercourses has been completed and potential limits of acceptable change related to the loss of ephemeral and intermittent watercourses are appropriately defined.

Program area two: riparian and bank-health monitoring protocols

Within Calgary, different methods have been developed and applied to assess riparian health versus bank health. The riparian health assessment is a more detailed method that includes field surveys of the entire riparian area. Bank health assessment is a rapid tool applying only to banks, using observations from
river floats.

Indicator #3: City-wide riparian health index is scored by management zone Riparian health and bank health are different indicators with their own assessment methods, and they address different components of the riparian system. The differences between these two indicators are summarized in Table 13 below.

Table 15. Riparian-health versus bank-health methodologies

	Riparian health	Bank health
Area of assessment	Focused on the entire riparian area	Focused only on banks
Method of transport	Conducted on foot across the site	Conducted from the river during river floats
Level of detail	More detailed field assessments	Reconnaissance-level, simplified field assessments
Time	More time-intensive	Less time-intensive
Cost	Higher cost	Lower cost

To date, targets have been based on the riparian health metric, as it captures the full-extent of the riparian zone and not just the bank. The riparian health metric reflects program outcomes and intent. Based on extensive discussions held during 2014, it was decided that the riparian health indicator was more appropriate for ongoing monitoring and reporting. Although it is generally advised against changing this decision for purposes of consistency, future targets for bank health could also be considered and monitored, particularly if budget or time is a limiting factor. Further explanation of bank-health monitoring protocols is available in Cows and Fish (2012).

The following section summarizes monitoring protocols, including site-specific protocols, and methods for statistically summarizing riparian health sets at city-wide scales using geographic information systems (GIS).

Riparian health monitoring Riparian health was assessed within Calgary by the Alberta Riparian Habitat Management Society (more commonly known as Cows and Fish) between 2007 and 2010. In total, 31 sites along the Bow River were assessed between 2008 and 2010; 16 sites along the Elbow River were assessed from 2007 to 2010, and 13 sites within the Nose Creek watershed were assessed between 2007 and 2009, including sites along Nose Creek (six sites), West Nose Creek (six sites) and Beddington Creek (one site). These riparian-health surveys were focused along publicly owned open spaces, including 23 city parks and several golf courses. Additionally, four sites were assessed on OLSH property along Forest Lawn Creek in 2008 and again in 2013. An additional 36 privately owned residential riverfront properties were also assessed in 2009, based on the voluntary participation of private landowners. [13] It is important to stress that this effort was not an inventory of all riparian areas within the city, but rather a sampling of a subset of riparian areas.

The methodology applied to site-level riparian-health assessments was the Riparian Health Inventory (RHI). This method was developed by Cows and Fish in collaboration with Dr. Paul Hansen and William Thompson. For stream and small river systems, RHI scores are derived from an evaluation of 11 key vegetation and soil/hydrology health parameters assessed in the field. For the Bow River, RHI scores are based on an evaluation of eight of these parameters in addition to seven others mainly related to tree cover and hydrology (see Table 14 and Table 15). The parameters assessed are largely based on visual estimates made in the field by trained observers, supplemented by measurements. The riparian health scores (ratings) are expressed both as a percentage score and in terms of one of three health categories: healthy, healthy with problems and unhealthy.

13 However, due to confidentiality agreements with landowners at the time these surveys were conducted, the private-lands data collected can neither be used to develop riparian targets, nor integrated into a long-term monitoring program.

Table 16. Riparian health scores

Health category	Score range	Description
Healthy	80 to 100%	Little to no impairment to any riparian functions
Healthy, but with problems	60 to 79%	Some impairment to riparian functions due to human or natural causes
Unhealthy	<60%	Severe impairment to riparian functions due to human or natural causes

Table 17. Riparian health parameters assessed in the RHI methodology

Riparian health parameter assessed		Streams and small rivers	Large rivers
Vegetation	Vegetation cover	✓	
	Cottonwood and poplar regeneration		✓
	Regeneration of other tree species		✓
	Preferred shrub regeneration		✓
	Preferred tree/shrub regeneration	✓	
	Preferred tree/shrub utilisation and woody vegetation removal by other than browsing	✓	✓
	Dead/decadent woody material	✓	✓
	Total canopy cover of woody plants		✓
	Invasive plants	✓	✓
	Disturbance plants	✓	✓
Physical	Root mass protection	✓	✓
	Human-caused alteration to banks	✓	✓
	Human-caused bare ground	✓	✓
	Human-caused alteration to rest of site	✓	✓
	Floodplain accessibility		✓
	Channel incisement	✓	
	Removal or addition of water from/to river system		✓
	Control of flood peak and timing by upstream dam		✓

GPS receivers are used by surveyors to record the locations of upstream and downstream ends of the riparian polygon (site). For monitoring purposes, benchmark photographs facing upstream and downstream are taken at each end of the site.

Additional photographs are taken where warranted to document features of interest or concern (e.g., weed infestations, bank erosion). Where possible, the upstream and downstream site boundaries are placed at distinct locations or landmarks, such as a bridge or stream confluence, for ease of future monitoring. The lateral extent (outer boundary) of the riparian area was previously determined in the field by Cows and Fish, and mapped onto a 2009 orthophoto (1:3000 to 1:8000 scale). Boundaries were based on the presence of hydrophytic vegetation, hydric soils and other signs of the presence of water, seasonally or regularly, on the surface or close to it. Due to human-caused disturbance of riparian-vegetation indicators in Calgary, the lateral boundary of RHI sites were often delineated based on topographic breaks or land use/management boundaries (e.g., fence lines, paved trails, roadways). In future surveys, consideration should be given to using the mapped City of Calgary riparian boundary (outer riparian boundary) to determine the edge of the riparian area prior to conducting field surveys.

Riparian health index: baseline statistical summaries While the RHI indicator is often reported in terms of the three health categories (see Table 14 on page 75), health categories reduce data resolution and therefore can pose difficulties in effectively tracking changes over time. For example, an RHI health score of 11 per cent is clearly much worse than an RHI health score of 57 per cent, yet both would be reported as **"unhealthy."** Therefore, **average** RHI scores were the key variable selected for reporting on riparian health and its change/trend over time. Average scores allow for a more thorough integration of numbers into a single indicator and a more comprehensive understanding of the data and trends behind the resulting summaries, while reducing the number of data points for reporting and communication purposes.

The city-wide baseline average RHI riparian health score was calculated as **area-weighted** average geostatistics, where larger riparian polygons have a stronger proportional influence on the average compared to smaller polygons. The basic formula applied was:

$$(\Sigma[((\%\ \text{RHI Score of polygon(a)})x\ (\text{polygon area (a)(ha)}))+((\%\ \text{RHI Score of polygon(b)})x\ (\text{polygon area (b)(ha)})),\ldots.])/(\text{Total Area of All RHI polygons (ha)})$$

Average RHI scores for the different river systems (Bow, Elbow, Nose/West Nose Creeks, Forest Lawn Creek) were also calculated using a similar process and reported on separately [14]:

$$(\Sigma[((\%\ \text{RHI Score Bow River polygon(a)})x(\text{polygon area(a) (ha)})])+\cdots)/(\text{Total Area of RHI Identity Intersection for all Bow River Polygons (ha)})$$

Next, to summarize riparian health scores by mapped riparian management categories, the following process was applied:

1. Cows and Fish Riparian Health polygons were intersected with the Riparian Management Category Polygons in GIS (identity function).
2. Any data artefacts with no management category allocations due to small polygon mismatches on edges within the GIS, were removed from the statistical analysis.
3. For each individual management category (conservation, restoration, recreation, flood + erosion control, developed), the area-weighted average was calculated with a similar process, separated by management category:

   $$(\Sigma[((\%\ \text{RHI Score Conservation polygon(m)})x(\text{polygon area(m) (ha)})])+\cdots)/(\text{Total Area of RHI Identity Intersection for all Conservation Polygons (ha)})$$

   $$(\Sigma[(\%\ \text{RHI Score in each Restoration polygon(x)})x(\text{polygon area(x)(ha)})+\ldots..])/(\text{Total Area of Identity Intersection for all Restoration Polygons (ha)})$$

   etc.

14 Again, it should be stressed that the results of this method represent only areas actually surveyed during the baseline time period, and these surveyed areas are only a sample of all riparian areas in the city, not a complete inventory.

Riparian health index: future targets To establish future riparian health targets, the following process was applied:

Baseline data were summarized city-wide, as well as for each riparian management zone and river system.

Observed changes/trends in riparian health, based on post-flood surveys conducted in 2014-2015, were calculated both city-wide and for each riparian management zone established (see table below).

Table 18. Observed changes/trends in riparian health

Riparian health index (RHI) monitoring variable	CITY WIDE	Conservation	Restoration	Recreation	Flood and erosion control
Total area assessed to date (ha)**	368	212	43	85	8
Baseline 2007-2010 riparian health inventories*					
Baseline area-weighted average RHI Score (%)	60%	65%	55%	52%	54%
2014-2015 Re-visit riparian health inventories					
2014-2015 area-weighted average RHI Score (%)	64%	69%	63%	55%	55%
Change in RHI scores from baseline	+4%	+4%	+8%	+3%	+1%
2026 Future target (based on extrapolation of trend)					
2026 future target (%)	70%	75%	74%	60%	54%
Change in RHI scores from baseline	+10%	+10%	+7%	+8%	0

*Excludes private residential sites and ELB25 (actively under renovation in 2015), ELB53 (nested within ELB26) and BOW75 (eroded entirely by the 2013 flood).

**As of Spring 2016

1. Observed improvements in riparian health scores and the reasons for those improvements, as documented in Cows and Fish (2016), were analyzed and summarized as follows:
   - City-wide, the area-weighted riparian health score improved by approximately four per cent over baseline.
   - 25 per cent of the 57 sites re-visited showed "improving" health scores (i.e., >5 per cent increase), including:
     - Several sites where recent restoration projects/plantings have improved riparian health.
     - Sites where the 2013 flood beneficially impacted riparian areas by stimulating new vegetation and/or depositing fresh sediment.
     - One site along West Nose Creek in what is now the Evanston Urban Reserve showed an improvement of the health score from 65 per cent in 2007 to 85 per cent in 2014, primarily due to a shift from in-land agricultural use to urban open space, which removed livestock trampling as a disturbance.
   - 72 per cent of re-visited sites showed a relatively static health trend (less than 5 per cent change in scores).
   - Only 2 sites (4 per cent of all sites) registered a "declining" health trend, with a greater than 5 per cent decrease in scores.
2. Building on observations, continued improving trends were predicted based on the following assumptions:
   - Post-flood natural riparian-vegetation recruitment is expected to continue.
   - Preferential targeting of priority areas for riparian health restoration projects will occur.
   - Community and public stewardship actions are expected.
   - Some flow ramping criteria applied to dam operations may be applied to help enhance recruitment.
   - Future construction and riverbank engineering projects will aim to minimize impacts and maximize bioengineering designs. However, flood protection berms and riprap installed in flood and erosion control zones are likely to have some impact on riparian health scores.

Plants slow water down and their roots grab soil, helping to reduce erosion and stabilize banks.

A sprouting willow.

Caveat on scale mismatches: RHI polygons versus management category polygons Riparian health surveys were generated based on field specialist assessments of average representative health conditions in relatively large field-surveyed polygons. When large polygons are subdivided into smaller areas based on the location of management categories, conditions in the smaller sub-areas may not necessarily represent average health scores assigned to the larger riparian polygon. Therefore, the riparian health scores assigned to the smaller polygons introduce mismatches between site-specific health conditions and the broader riparian health scores from field data. For the purposes of a city-wide assessment, this is not necessarily a major issue, and various site-specific errors will likely cancel one another out when city-wide averages are calculated, as long as the variance between polygon sizes is not large. However, the smaller the management category polygons are, the greater the likelihood that the value assigned by the field database does not accurately represent actual site conditions. This is an issue for categories represented almost entirely by small polygons, including the Flood + Erosion Control and Developed management categories. However, the total area of these polygons represents only 3.9 per cent of all riparian areas in Calgary. As such, the overall city-wide average is still considered to be a valid estimate.

Program area three: education and outreach monitoring protocols.

Indicator #4: Community is engaged with riparian areas (awareness, attitudes and actions) In partnership with a third-party research vendor, The City of Calgary conducted an online survey with a randomly selected sample of 750 adult Calgarians in 2016. The margin of error for a sample of n=750 is +/-3.6 percentage points, 19 times out of 20, and a credibility interval of +/3.7 percentage points. Quotas were set by quadrant, age and gender, and the final data was weighted to ensure it is representative of adult Calgarians based on census data. Questions will be measured bi-annually to track engagement trends within the general population.

The overall outcome of the education and outreach program is that stakeholders and citizens value riparian areas. A reasonable proxy measure for values are attitudes and actions related to riparian areas, as research shows that values underlie both (Stern, 2000; Stern, Dietz, Abel,

A healthy river depends on healthy riverbanks.

Plants help reduce the amount of sediment, pollution and nutrients reaching our rivers.

The Bow supports life in many forms.

Guagnano, & Kalof, 1999). Attitudes and actions are also derived from an awareness of the beneficial or harmful consequences to valued riparian spaces and, as such, are appropriate measures of the effectiveness of environmental education programming.

In total, three to four "ballot" questions form a baseline measure of community engagement with riparian areas. These include three questions related to awareness of healthy riparian areas and benefits, care for riparian areas and one question related to stewardship actions taken with the intent to benefit these areas. Citizen satisfaction related to The City's performance to protect and restore river areas will also be measured.

Programmers and community partners will also be asked to include these ballot questions (and a suite of standardized questions) in pre- and post-program evaluations to gauge progress before and after participating in education activities. This information will enable standardized program reporting and inform specific and broad-scale adaptations. It will also allow programmers to measure how participants trend against the general population.

Indicator #5: Community stewardship actions increase over time. While indicator data, such as polling, give us a sense of how Calgarians are progressing in terms of their levels of awareness and actions, actual community actions bring polling numbers to life and provide real examples of levels of engagement. As part of the conditions of agreement between The City of Calgary and community partners, organizations will be asked to annually report the number of stewardship events, actions and people who took part in their activities. The City will also track and report on its own stewardship programming. Partners will also be asked to report on the riparian spaces restored or stewarded by community groups or members. Similar program information is already tracked and compiled by the Water Resources education and outreach team.

Supplement Four: Riparian engagement planning

Audience: Water Resources Management, City Council, key stakeholders

To date, the project team and consultants have engaged dozens of key stakeholders both internal and external to The City of Calgary. This work has helped to identify the priorities and plans outlined within the Riparian Action Program and supported the development of new tools and frameworks related to riparian programming. Future engagement work will follow The City of Calgary's official Engage! [15] process and focus on raising awareness of the riparian program, defining roles and responsibilities and collaborating with internal and external stakeholders to develop the tools, processes and policy required to better support riparian
land-use planning, maintaining or improving riparian health and education.

The following supplement provides 1) a summary of key riparian policy gaps, 2) an overview of key engagement activities and 3) an overview of proposed future engagement.

Past stakeholder engagement

In 2013, a riparian areas workshop was held at The City of Calgary Water Centre. More than 45 attendees were present, including municipal planners and staff, regulators, watershed stewardship groups and partners. One of the workshop topics included the identification and discussion of riparian policy gaps for protection and management. Based on further consultations, key gaps were summarized, as shown in Table 17.

15 The City's engage! policy is available at: http://www.calgary.ca/CA/city-clerks/Documents/Council-policy-library/CS009-engage.pdf

Table 19. Summary of key riparian policy gaps

Identified policy gaps	Planned policy responses/actions	
River and bank engineering design process		
Not enough guidance provided to civil and river engineers on appropriate locations for hard engineering riprap vs. bioengineering structures for stream/riverbank erosion control.	Riparian Decision Matrix for River Engineering Projects decision support tool was completed and released in October 2014. Intended to help promote more bioengineering projects by informing the scope of work for consultants designing riverbank engineering works.	✓
Land-use planning and policy		
Riparian and stream valley corridors are not fully protected in land-use planning processes.	Align plans, policies and regulations to ensure consistent, clear protection of critical riparian areas.	
The Municipal Government Act is open to interpretation on Environmental Reserve (ER) dedication for riparian areas, and ER Setback Guidelines (2007) do not protect all riparian areas.	Review the ER Setback Policy to provide greater clarity, including permitted and prohibited uses within different riparian zones.	
Multiple overlapping plans, policies and regulations create complexity and lack of clarity.*	Develop and apply clear guiding documents, flow charts and maps to ensure consistent interpretation and integration.	✓
Land Use Bylaw 1P2007 only prohibits new development in the mapped 1:100 year floodway and allows filling and development in the flood fringe and other riparian areas.	Identify riparian boundaries and adjacent setbacks in all new regional context studies, area structure plans, area redevelopment plans, outline plans, biophysical impact assessments (BIAs), master drainage plans, etc.	
Understanding riparian areas		
Long-term river landscape changes.	Identify meander belts/channel migration zones and add them to land use planning documents.	
Ephemeral and intermittent drainages: Disagreements between administration and development proponents on stream order mapping criteria and protection of ephemeral and intermittent watercourses.	Study and map ephemeral and intermittent watercourses and appropriate setbacks. Review the ER Setback Guidelines to increase clarity, using up-to-date information and data.	
No strong measures in place to consider and protect alluvial aquifer zones with strong connections to surface watercourses.	Where possible, use Environmental and Municipal Reserve dedications to protect alluvial aquifers in Local Area Plans.	

* See Supplement One of the Riparian Strategy for a full list of plans, policies and regulations related to riparian areas.

Key engagement activities

- December 2013: 23 experts engaged in a web survey.
- February 2013: 45 experts engaged in a World Café workshop.
- Spring 2014: Presentations by Water Resources at the Alberta Society of Professional Biologists conference (Edmonton, AB) and the Canadian Water Resources Association conference (Calgary, AB), as well as to Calgary River Valleys.
- 2014: More than 100 City of Calgary staff were consulted in various riparian-specific meetings and draft-document circulations. Participating departments/offices included:
  - Water Resources
  - Parks
  - Planning, Development and Assessment
  - Office of Sustainability
- 2015: More than 25 City of Calgary staff were consulted in Riparian Action Program engagement meetings to summarize program contents and report back on how their feedback was used.
- April 2015: Presentation by Water Resources at the Bow River Basin Council Science Forum, Mount Royal University, Calgary, AB.
- March 2016: 85 City staff attended presentations and workshop communicating program implementation plan to City staff
- June 2016: General citizen survey
- June - August 2016: Semi-structured interviews with watershed community groups
- September 2016: Stakeholder workshop with watershed community groups to present research and interview findings

Future engagement priorities

Future engagement work will focus on raising awareness of the riparian program, defining roles and responsibilities and collaborating with internal stakeholders to develop the internal tools, processes and policy required to support better riparian land-use planning, health and education. It is anticipated that specific work plan activities (i.e., review of the ER setback policy) will require extensive engagement with both internal and external stakeholders.