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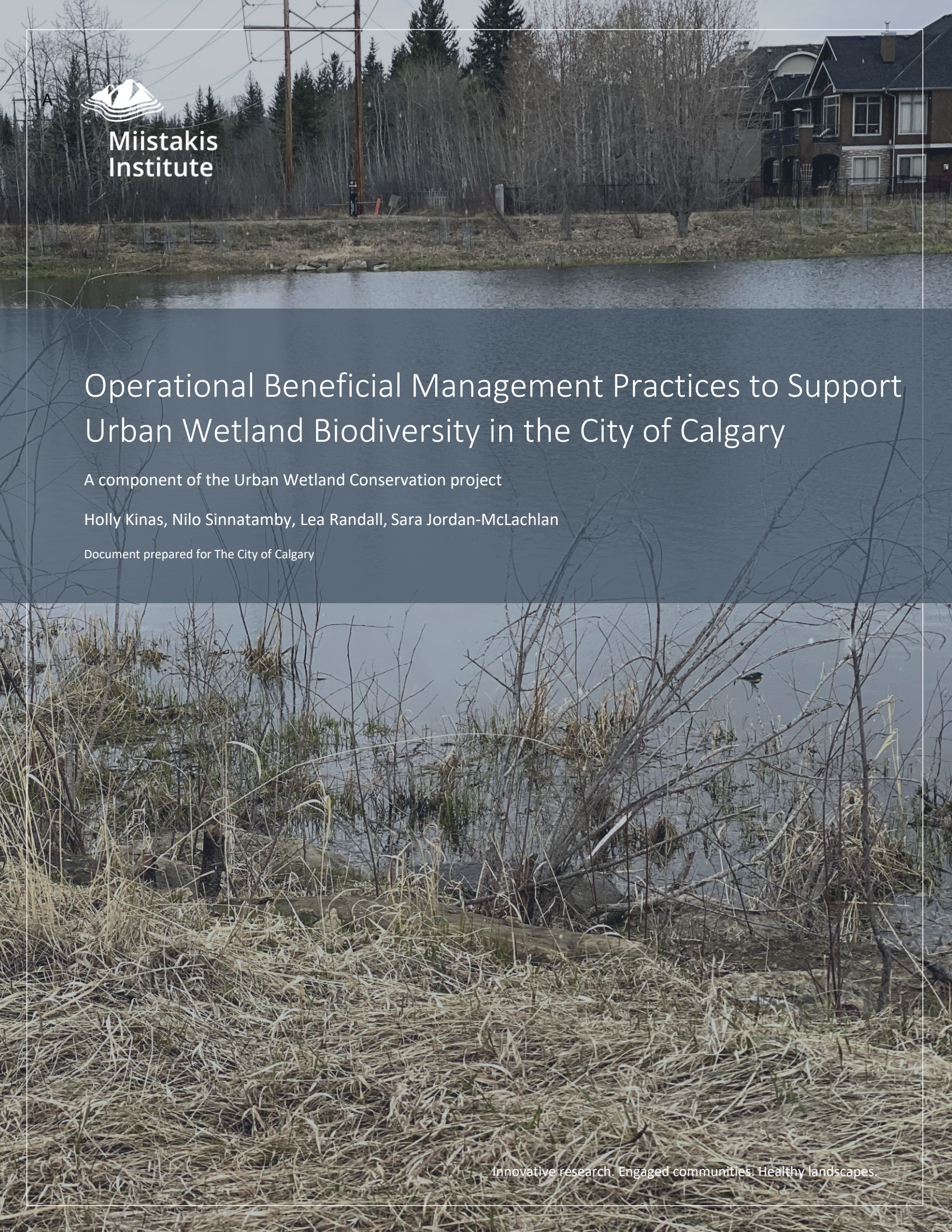
Miistakis Institute

Operational Beneficial Management Practices to Support Urban Wetland Biodiversity in the City of Calgary

A component of the Urban Wetland Conservation project

Holly Kinas, Nilo Sinnatamby, Lea Randall, Sara Jordan-McLachlan

Document prepared for The City of Calgary



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December 2023

Miistakis Institute
EB3013, Mount Royal University
4825 Mount Royal Gate SW
Calgary, Alberta T3E 6K6

Phone: (403) 440-8444
Email: institute@rockies.ca
Web: www.rockies.ca

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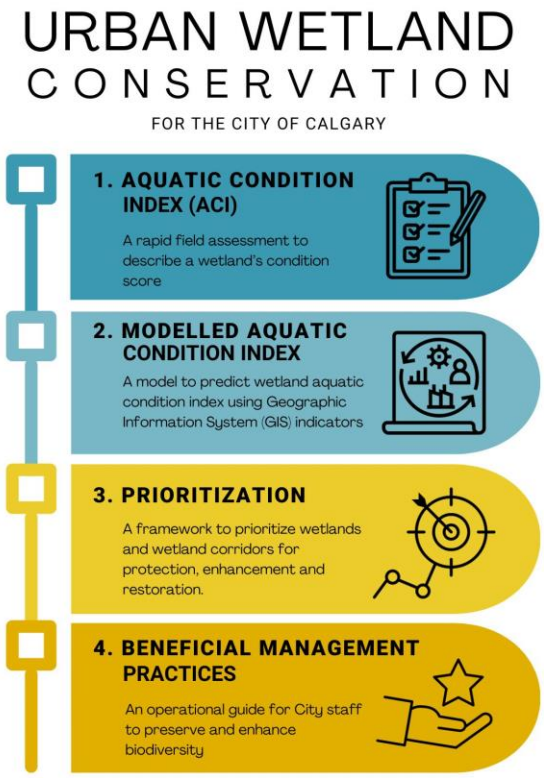

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Introduction

Wetlands are hotspots for biodiversity, providing habitat and breeding grounds for numerous plant and animal species. But wetlands continue to disappear from the landscape in response to land use demands in urban areas. By 2004, an estimated 90% of Calgary's wetlands had already been lost (City of Calgary, 2004). It is important that The City of Calgary manage its remaining wetlands to protect and improve general wetland health and promote biodiversity, in addition to managing for stormwater function.

Beneficial management practices (BMPs) are management practices that reduce environmental risk and can provide an important resource to a municipality's daily operations. The urban wetland BMPs outlined in this document support biodiversity conservation within wetlands in The City of Calgary, specifically focused on operational mitigations and not large capital projects such as new construction or development. The goal of this document is to set a standard of excellence for municipal wetland management practices that exceed regulatory requirements. The BMPs focus on amphibians and birds as proxies for wetland health and biodiversity conservation within the urban environment. These BMPs are focused on wetlands that are currently stewarded by The City of Calgary's Parks and Open Spaces department, herein called Parks; these include some storm ponds managed by the Water Services department, as well as some wetlands within the Province of Alberta's jurisdiction in transportation utility corridors. Wetlands in city parks include a range of wetland modification ranging from fully natural wetlands to fully engineered storm ponds.

"As a city we need to better understand the complex interactions between growth, our day-to-day life and conserving nature. We need to understand how urban development and management aid or restrict what nature provides us. We need to carefully consider how to best develop Calgary, how to conserve and manage functional natural areas, how to bring nature into what we build and how to work with Calgarians and experts to address these questions to meet the needs of citizens."

-Our BiodiverCity, Calgary's 10-year Biodiversity Strategy Plan

In these BMPs, we strive to achieve a balance between sometimes competing goals to manage services while promoting biodiversity. We provide transparent information on weighing the cost-benefit from both a biodiversity and management perspective and provide an Operational Priority rating for each BMP.

Review Process

To inform the BMPs we conducted a broad literature search, interviews, hosted two in-person workshops, and one survey with subject matter experts and City of Calgary staff from the Urban Conservation, Natural Areas, Environment Planning and Policy, Water Services, Regulatory Affairs and Compliance, and Utilities Infrastructure Planning portfolios.

We conducted a search for unpublished (grey) literature using Google search engine and reviewed relevant resources from other jurisdictions. We also conducted a search for peer-reviewed literature for studies in Alberta, Canada, and globally using Mount Royal University Library's academic search engine.

On June 26th, 2023, Miistakis facilitated a workshop to understand the various operational activities that The City conducts that could impact biodiversity and wetland health. The second workshop was held on October 11, 2023 where Miistakis presented the draft BMPs and the format for which they'll be presented, requesting feedback from City staff and experts.

Wetlands in the City of Calgary

Wetlands are unique ecosystems, occupying only a small percentage of the landscape but contributing a significant proportion of ecosystem services, such as improving water quality and quantity, reducing flooding and soil erosion, promoting biodiversity, and moderating climate conditions. Despite these benefits, urbanization impacts a wetland's ability to provide ecosystem services by altering its hydrology, ecology and water quality functions. Calgary has over 2,700 wetlands that span a gradient from natural wetlands to constructed storm ponds.

City of Calgary Wetland Typologies

The City of Calgary has developed a typology system to define its wetlands based on the City's management regime and permits a focus on wetland function. For example, if a wetland is typed as a natural wetland (with a primary purpose of supporting biodiversity) it can be managed differently than a constructed wetland with a primary function of storm water management.

A typology based on the management regime of wet ponds and wetlands within the city describes types of aquatic features that range from low to high human-modification. In this BMP document, we consider a simplified version of The City's typology that was used in the field-based Aquatic Condition Index (Nwaishi et al., 2023) as follows:

Existing Retained Wetland: Natural wetlands that are in a relatively undisturbed state based on historical imagery but may, or may not, have piped infrastructure. These wetlands are often "fed" by an inlet pipe to ensure their continuity in a fragmented or otherwise disturbed landscape. These aquatic features have a full wetland compensatory value.

Existing Modified Wetland: A wetland in a location where one existed previously, based on historical imagery, but has been modified to a noticeable extent (beyond just a pipe, often including the construction of a forebay or some level of grading). The characteristics of the previous wetland have been at least partly preserved and stormwater functions have been enhanced. The wetland compensatory value ranges from medium to high. The extent to which modifications were able to effectively retain natural wetland characteristics and function varies within this category.

Constructed Stormwater Wetland: A wetland constructed in a location where there was no wetland or pond previously. These wetlands were designed to mimic at least some aspects of natural wetlands and reflect greater balance in the prioritization of ecological, social, and stormwater management benefits. A medium to full wetland compensatory value is associated with this feature; but note that the extent to which natural wetland properties were mimicked through design varies widely.

Naturalized Wet Pond: Impoundment areas designed to hold excess stormwater, promote settling, and reduce downstream discharge. Vegetation is expected to reduce maintenance of the pond edge and covers < 30% of the emergent zone and may or may not be comprised of native vegetation. These wetlands prioritize hydrological function, and no wetland compensatory value is associated with them.

Utility Wet Pond: Impoundment areas primarily designed to hold excess stormwater and encourage settling of sediment, limiting the discharge of pollutants downstream. There are minimal naturalization and habitat provisions as these ponds prioritize hydrological functions and have no wetland compensatory value.

Urban wetlands kept during development might be well buffered by natural parks, as is the case for many existing retained wetlands, or integrated into community design so that their riparian habitat borders residential property. Wetlands provide a unique ecological service in cities by providing habitat to

amphibians in a landscape that may not otherwise have a large amount of high-quality habitat (Gallagher et al., 2014). However, not all urban wetlands are ideal habitats for amphibians or other forms of biodiversity and consideration should be given to limiting connectivity to sites that are less than ideal because these can be sink habitats (Gallagher et al., 2014), see BMP number 13 for more information on sinks.

Biodiversity

In 2015 the City of Calgary completed *Our BiodiverCity*, a 10-year biodiversity strategic plan to support their vision where Calgarians value our city's diversity and richness in wildlife, vegetation and landscapes, and where The City and residents work to integrate our actions and the built environment with an ecological network that is healthy, connected and well managed. (The City of Calgary, 2015). The International Union for Conservation of Nature defines biological diversity (biodiversity) as follows (SSC Invasive Species Specialist Group, 2000):

> The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems.

Conservation of biodiversity is important because it supports the life functions of our planet. A healthy and functional ecosystem provides ecosystem services such as water purification, flood reduction, drought mitigation, recreational opportunities, habitat provision to name a few (Millennium Ecosystem Assessment, 2005). Wetlands are hotspots for biodiversity. It is believed that up to 40% of the world's plant and animal species live and breed in wetlands.

To better understand the health of Calgary's wetlands, The City of Calgary, Miistakis Institute, Enbridge, Parks Foundation Calgary, Alberta Conservation Association and the Calgary Zoo developed "Call of the Wetland", a citizen science program that enabled the public to monitor amphibians in the city as an important indicator of wetland health. There were 6 amphibian species that have historically been found in Calgary, however, prior to Call of the Wetland, it was unknown which persisted in our urban environment.

Call of the Wetland ran from 2017-2019 and engaged Calgarians in understanding the health of wetlands through monitoring of amphibians and enabling a connection to nature in the City. The long-term outcome of Call of the Wetland is to build on the knowledge gained around amphibian presence to understand the health of wetlands within the City of Calgary, as well as to continue to foster a community of knowledgeable citizens to champion wetland protection and restoration. Since completion of the project, the results have been used to develop occupancy modelling for Calgary, a framework for urban amphibian conservation, and have been included in several City of Calgary policies (Lee et al., 2022). Once Call of the Wetland was completed and incorporated into some of the City's policies, considerations for management of the existing amphibians and their habitats needed more attention.

Building on the work resulting from Call of the Wetland, these BMPs were developed using amphibians and birds as a proxy for wetland health. Birds are a good additional proxy for wetland health as the diversity in species and the ways in which they use wetlands ensures the development of the BMPs will be applicable to a wide range of biodiversity and activities within the City.

Alberta Wetland Classes within Calgary

Approximately 20% of Alberta's surface is covered with wetlands, consisting of five different classes: marsh, bog, fen, swamp, and open water (Environment and Sustainable Resource Development, 2013), of which Calgary is home to three of these classes: swamp, marsh, and open water (both freshwater and saline) (C. Manderson pers. comm.).

Marshes in Calgary have variable permanence including temporary, seasonal, or semi-permanent (C. Manderson pers. comm). Water in these wetlands come from surface flows, groundwater and precipitation and can be fresh to brackish. Typical vegetation in marsh wetlands is emergent, floating, and leaved trees and shrubs along the margins. Their soil type is mineral, hydric soils (gleysols) (Alberta Environment and Sustainable Resource Development (ESRD), 2015).

Shallow **open water** wetlands in Calgary could be intermittent, seasonal, semi-permanent, and permanent (C. Manderson pers. comm.). Their water regime consists of permanent to seasonal flooding, groundwater, surface water and precipitation, and can often fluctuate significantly. These wetlands can range from freshwater to saline within the City (C. Manderson pers. comm.). Vegetation is submergent, floating and/or emergent, but these wetlands can also be unvegetated. Their soils are mineral, hydric (gleysols) (Alberta Environment and Sustainable Resource Development (ESRD), 2015).

Swamps in Calgary are nutrient rich and have a predominant vegetation that is wooded, typically shrubs (e.g., willow, dogwood), balsam poplar and river birch and may include riparian and perched forest systems (C. Manderson pers. comm.). The water regime in swamps is controlled by precipitation, groundwater, surface water, and often has significant fluctuations. The water chemistry is fresh-sub-saline and the soil is mineral, hydric (gleyed to mottled) (Alberta Environment and Sustainable Resource Development (ESRD), 2015).

Although Calgary's wetlands are classified as marsh, open water, or swamp, many of them have been significantly altered, impacting their function and suitability as amphibian and bird habitat. These wetlands contribute to other ecosystem services such as stormwater management for example, and those purposes determine their management goals, which may contradict BMPs for amphibian and bird habitat.

Wetlands in the urban environment face threats from intensive human use such as pollution and increased nutrients from runoff (e.g., nitrates and phosphates), altered hydrology, reduced connectivity to other wetlands within the drainage, and altered water chemistry such as pH and dissolved oxygen. To address these threats, The City of Calgary has policies and plans in place which seek to protect, enhance and restore wetlands and corridors between wetlands in Calgary. The development of this BMP document will support these efforts by providing guidance for activities undertaken by operations staff in and around wetlands. To enhance the use of these BMPs, we recommend incorporating them into existing City Policies, Plans, Standard Operating Procedures, Ecoplans, and Biophysical Impact Assessments where possible.

Amphibians

Amphibians are a group of tetrapod vertebrate animals (i.e., they have four legs and a backbone) comprised of three orders. The most specious is the Anura (frogs and toads), followed by Caudata (salamanders and newts), and Gymnophiona (caecilians). Globally, there are over 8,000 species; however, only 47 species are found in Canada (Environment and Climate Change Canada, 2017), all belonging to the orders Anura and Caudata.

There are ten species of amphibians in Alberta, and historically, Calgary was home to six of these species. However, *Call of the Wetland* revealed only three species remain: boreal chorus frog (*Pseudacris maculata*), wood frog (*Lithobates sylvaticus),* and tiger salamander (*Ambystoma mavortium)*. Most of Calgary's amphibians occur on the outskirts of the city, where there are more remaining intact wetlands (Lee et al., 2022). Wood frogs and boreal chorus frogs are relatively common species in Canada. Neither has been assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), but they are not presumed to be at risk. In contrast, the Prairie / Boreal populations of western tiger salamander found in Alberta, Saskatchewan, and Manitoba and are designated as "Special Concern" under the *Species at Risk Act* (COSEWIC, 2012). These populations are largely threatened due to habitat loss, degradation, fragmentation, fish stocking, and emerging diseases.

The geographic range of amphibians in Canada is limited mainly to southern regions where it tends to be less cold. This is because amphibians are exothermic and unable to generate their own internal body heat. Although amphibians cannot generate their own body heat, these species can control their internal temperature to some extent through behaviors such as basking in the sun or burrowing, or through evolved specialized physiological traits that help them survive cold Calgary winters.

Species Descriptions

Wood Frog

Wood frogs are a medium sized frog (adult 3-6 cm snout-vent length) with a distinctive dark facial mask (Russell & Bauer, 2000). Their dorsal colouration is typically a uniform tan, reddish-brown, or dark brown but they may have some darker mottling on the side and have a white to off-white underbelly (Dodd, 2013). They have a light stripe on their upper lip running from their eye to their jaw. They may also have a light stripe that runs down the back {about 20% of individuals in the Prairies; (Schueler & Cook, 1980)} and darker bars on their hind legs. Unlike boreal chorus frogs, they have subtle dorsolateral folds that run from behind the eyes to their hind region. During the breeding season, a female may lay a single egg mass, typically 4-10 cm in diameter with an average of 2,000-3,000 eggs (Russell & Bauer, 2000). Eggs are black on the top and white underneath, and females typically lay eggs in shallow water near other wood frog egg masses. Tadpoles are about 0.7-1 cm at hatching, reaching up to 5 cm just prior to metamorphosis. They are brown or greenish, with a cream-coloured underside and a light stripe along the upper jaw; the gut is not usually visible.

Wood Frog. Image Credit: Lea Randall

Boreal Chorus Frog

Boreal chorus frogs are the smallest of the amphibians in Calgary; adults have a slender body ranging in length from 2-4 cm snout-vent length (Russell & Bauer, 2000). Their background dorsal coloration can vary widely, ranging from gray, brown, and green and their belly can range from white, yellow, to olive coloured. They typically have three darker irregular, broken stripes running down their back and a dark stripe running through their eye towards their hind legs. Their skin has a granular appearance in comparison to the smooth skin of the other two species of amphibians. In comparison to wood frogs, they also have less webbing between their hind toes. Eggs range in colour from creamy tan to black (Dodd, 2013). During the breeding season, a female may deposit several egg masses, each containing from 15-190 eggs. Upon hatching, tadpoles are about 0.5 cm, reaching 3-4 cm prior to metamorphosis. Tadpoles are typically gray and speckled with bronze and their gut is often visible (Dodd, 2013).

Boreal chorus frog. Image credit: Lea Randall

Tiger Salamander

Adult tiger salamanders typically range from 14-18 cm in total length (Russell & Bauer, 2000). Adult color may vary but is generally described as having a dark blotched, barred or reticulate dorsal background pattern (Black, grey, dark brown or olive green) with yellow or white with a sooty grey underside (COSEWIC, 2012). Females lay single or small clusters of eggs on twig, plant stems, or other objects at a depth of about 30 cm below the water surface (Matsuda et al., 2006; Russell & Bauer, 2000). Larvae range from a dull yellow to dark brown or olive green dorsal colour with a pale coloured underside and have prominent external gills (Russell & Bauer, 2000). Larvae are about 1.5 cm at hatching and reach up to 7.5-8 cm prior to metamorphosis.

Neotenic adult tiger salamander (left), image credit: Nicole Kahal; Adult tiger salamander (right), image credit: Kris Kendell

Habitat and Movement

Habitat requirements of amphibians within the city of Calgary vary by species, season, and life stage (summarized in Table 1 and described in detail below).

Within Calgary and other parts of their range, wood frogs are found in association with open ponds, along shallow water lake margins with tall sedges, herbs, shrubs or grass cover or, as their name suggests, closely associated with forest cover such as closed- canopy deciduous and boreal forests (Dodd, 2013; Lee et al., 2021). Outside of the breeding season, this species is primarily terrestrial, often foraging for food at considerable distance from water. As summarized in Dodd (2013), wood frogs will breed in a wide variety of shallow waterbodies such as temporary ditches, road ruts, potholes, woodland pools, open ponds, bogs, fens, lakes, as well as stormwater and other artificial ponds in the urban environment. Females typically attach egg masses to woody or emergent vegetation, such as sedges, in shallow water (mean 45 cm) near the water surface; however, occasionally, egg masses may be free floating.

In the prairie portion of its range, the boreal chorus frog is an upland grassland species (Dodd, 2013), but in Alberta they are also commonly associated with willows and poplars (Roberts & Lewin, 1979). Within Calgary, boreal chorus frogs are likely to be found in urban areas of manicured grassland (usually non-native grasses that are mowed) (Lee et al., 2021). During the nonbreeding season, this species will often seek cover in small

mammal burrows, in clumps of grass or vegetation, or under debris (Dodd, 2013). Due to their small size, cryptic coloration, and secretive habits they are rarely observed outside of the breeding season.

Boreal chorus frogs are adaptable and can breed in shallow or deep water of wetlands ranging from temporary to permanent but usually lacking fish (Kolozsvary & Swihart, 1999; Russell & Bauer, 2000). They can breed in wetlands of almost every type including man-made wetlands such as roadside ditches, agricultural ponds, borrow pits, and ponds in agricultural settings, making them a common resident in urban and rural areas.

Western tiger salamanders occupy semi-permanent to permanent water bodies surrounded by a variety of open habitats such as grassland or open woodlands with loose, sandy, or crumbly soils suitable for digging burrows (COSEWIC, 2012). Breeding habitat is typically lacking fish and must hold water long enough for salamanders to complete larval development (3-7 months) or must be permanent in order to support populations of neotenic adults or overwintering larvae. Outside of the breeding season, adults spend much of their time inhabiting small mammal burrows or underneath debris or rocks.

Overwintering habitat depends on the species' overwintering strategy. Both wood frogs and boreal chorus frogs are considered freeze tolerant, able to survive temperatures dipping below freezing for extended periods of time (Dodd, 2013; Storey, 1990). As winter approaches, some amphibians can accumulate cryoprotectants which can help prevent the formation of ice crystals which can cause damage to cells leading to death (Storey, 1990). Wood frogs typically spend the winter in upland areas under leaves and other detritus (Dodd, 2013). Areas with abundant plant litter, high groundwater levels and snow accumulation may also be essential for winter survival. Although considered freeze-tolerant, boreal chorus frogs are also known to overwinter below the frost line in animal burrows or root channels (Dodd, 2013).

Tiger salamanders on the other hand, cannot withstand temperatures below freezing for an extended period. They can employ one of two strategies to prevent freezing in the winter. Most commonly they spend the winter in burrows located below the frost line. Although tiger salamanders can actively dig their own burrows, they will also use the burrows of small mammals or cavities formed by the roots of rotting trees to access these deep frost-free spaces (COSEWIC, 2012). These burrows are often located in upland areas that are not prone to flooding. Rarely, tiger salamanders may overwinter as larvae or as neotenic adults (animals that retain larval form after sexual maturity) in waterbodies with sufficient dissolved oxygen, lacking predatory fish, that don't freeze to the bottom (COSEWIC, 2012). Both these life stages possess external gills which allow them to obtain oxygen from water and remain active all winter.

Movement

As summarized in Dodd (2013), these amphibian species often don't move far from breeding ponds during the summer season; however, they may make longer seasonal dispersal movements, often returning to breeding ponds between years. For example, most boreal chorus frogs remain within 20–50 m of their breeding site (Spencer, 1964 as cited in Dodd, 2013). These species also often return to these same areas between years, for example, wood frogs were typically found within 27-88 m of the previous year's capture location (Bellis, 1965). Amphibians will occasionally make longer distance movements depending on the species and time of year. Tiger salamanders and boreal chorus frog don't usually move more than 250 m from the breeding habitat (COSEWIC, 2012; Dodd, 2013); however, they have been known to disperse up to 600 m (Smith & Green, 2005) or rarely up to 1000 m for tiger salamanders (Sarell & Robertson, 1994 as cited in COSEWIC, 2012). Similarly, wood frogs often make short distance movements (median 2.8 m, range 61 m) during the summer (Baldwin et al., 2006), but longer distance dispersal movements (approximately 2,500 m) have been noted (Smith & Green, 2005).

Table 1: Seasonal habitat requirements for amphibians in Calgary (See text for references)

Seasonal habitat Requirements	Tiger Salamander	Wood Frog	Boreal Chorus Frog
Aquatic	-Semi-permanent (3-7 months) to permanent water bodies -Free of predatory fish -Rocks, logs, and vegetation available for shelter and for egg-laying	-Usually breeding non-flowing semi-permanent wetlands -Free of predatory fish -Shallow waterbodies such as: temporary ditches, road ruts, potholes, woodland pools, ponds, bogs, fens, lakes as well as stormwater and other artificial ponds in the urban environment	-Breed in shallow or deep water of wetlands ranging from temporary to permanent -Free of predatory fish -Wetlands of almost every type including man-made wetlands such as roadside ditches, agricultural ponds, borrow pits, and ponds in agricultural settings
Terrestrial	-Open habitats such as grassland or open woodlands -loose, sandy, or crumbly soils suitable for digging burrows -Small mammal burrows or debris or rocks to act as daily refuges	-Along shallow water lake margins with tall sedges, herbs, shrubs or grass cover -Wooded areas -Closed- canopy deciduous and boreal forests -Moist soil conditions and deep deciduous leaf cover	-Upland grassland -Associated with willows and poplars -Urban areas of manicured non-native grassland -Seek cover in small mammal burrows, in clumps of grass or vegetation, or under debris
Hibernation/ Overwintering	*Larval or neotenic adult salamanders* -Permanent waterbodies -Lacking predatory fish -Sufficient dissolved O_2 -Don't freeze to bottom *Terrestrial adults* -Loose, sandy, or crumbly soils suitable for digging burrows -Small mammals burrows or cavities formed by the	-Overwinter under logs, near- surface leaf litter, soil, and other surface debris insulated under snow	-Small mammals burrows or cavities formed by the roots of rotting trees below frost line

Seasonal habitat Requirements	Tiger Salamander	Wood Frog	Boreal Chorus Frog
	roots of rotting trees below frost line		
Movement	Do not usually move more than 250 m but occasionally move up to 1000 m	Frequently make short distance movements (median 2.8 m, range 61 m) during the summer but occasionally make longer distance dispersal movements (2,500 m)	Usually remain within 20–50 m of the breeding site, not usually moving more than 250 m but occasionally move up to 600 m

General Amphibian Needs and Sensitivities

Amphibians are particularly sensitive to chemicals and poor water quality because of their permeable skin and distinct life history. All amphibians in Calgary spend at least a portion of their life in water and may be affected by an array of natural and anthropogenic chemicals and physical characteristics such as dissolved oxygen or salinity, which can affect survival, growth, and physical development (Dodd, 2010).

Dissolved Oxygen

Dissolved oxygen is important for aquatic amphibian life stages such as tadpoles, larval and neotenic salamanders and aquatic hibernators that must absorb oxygen through their skin or gills (Dodd, 2010). Dissolved oxygen content can vary greatly depending on the time of day, depth, nutrient availability, time of year, and flow characteristics of the wetland. In warm, nutrient rich waterbodies, algae and other green plants are a major source of oxygen through photosynthesis. Dissolved oxygen tends to be lowest at dawn, increasing throughout the daylight hours and declining overnight. However, in extreme nutrient-rich waters, plant decay can result in depleted dissolved oxygen levels. In water bodies that have flow, dissolved oxygen tends to be relatively uniform throughout the water column due to mixing, whereas in still waterbodies dissolved oxygen often declines with depth. Under hypoxic conditions, larval amphibians with lungs can gulp air at the surface of wetlands to obtain oxygen but this can also incur physical costs and increase exposure to predators. Low dissolved oxygen in winter can result in significant mortality events for overwintering aquatic hibernators.

Salinity

Many wetlands in Alberta are naturally saline (Alberta Environment and Sustainable Resource Development (ESRD), 2015) or salinity can result from runoff from substances such as road salts in the urban environment. Wood frog tadpoles are particularly sensitive to sodium and chloride and are typically found in wetlands with low concentrations of these ions (Dodd, 2013; Donald, 2021). However, tiger salamanders are tolerant of alkaline or slightly saline and nutrient rich waterbodies (Matsuda et al., 2006; Miller & Larsen Jr., 1986). The effects of salinity on boreal chorus frogs have received little attention, but contamination of brine from oil production has been shown to reduce the survival of tadpoles in the prairie pothole region of northeastern Montana (Hossack et al., 2017).

Pollutants

Pollutants such as fertilizers, pesticides, and some metals can have negative effects on many species of amphibian resulting in both lethal and sublethal effects on individuals (Dodd, 2010). Examples of pesticides

include insecticides, herbicides, rodenticides, and fungicides. Insecticides tend to be the most toxic to amphibians but there is much variation in the toxicity depending on the class of pollutant. Metals such as zinc, copper, and others can be naturally occurring or released by other means and can reach levels that are toxic to amphibians. There is a wide body of literature on the negative effects of organic pollutants such as Polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) on amphibians which can cause genetic damage, cancer, and endocrine disruption.

Why are We Concerned about Amphibians?

Although amphibians are declining globally, amphibians within the urban environment may experience specific threats to their survival. For example, amphibians in urban areas frequently experience loss or degradation of habitat due to development, habitat fragmentation, and pollution.

Not surprisingly, roads are common within the built environment of Calgary and can cause both direct and indirect mortality (Beebee, 2013). Roads may bisect important habitats needed by an amphibian to complete its life cycle, for example, separating breeding and foraging or overwintering habitat. Furthermore, amphibians may be attracted to roads for basking because they may be warmer than the surrounding environment. For these reasons, amphibians may experience direct mortality by being struck by vehicles while crossing or basking on roads. Additionally, habitat fragmentation due to roads can decrease connectivity among populations, reducing gene flow and leading to inbreeding and decreased genetic variation which can render populations less able to adapt to environmental change. Moreover, roads may be treated with various substances or have spills of toxic chemicals which can have lethal or sublethal effects on amphibians, such as road salts, dust control agents, fuels, lubricants, and other contaminants from road surface runoff.

In addition to pollution caused by roads, industrial activities in urban areas and application of biocides such as herbicides, pesticides and fertilizers to lawns or other vegetation can negatively affect amphibians (Dodd, 2010). Activities such as mowing to maintain parks or other green spaces, can cause direct mortality to amphibians if they are in the path of equipment. The mowed area itself could have beneficial or detrimental effects on the habitat depending on the species and life stage. For example, reducing the height of vegetation may allow for easier adult amphibian movement and dispersal but could also affect prey abundance and increase exposure to predators. Other maintenance activities within or near wetlands can alter the composition of emergent and riparian vegetation or affect water quality if activities occur within the waterbody or otherwise lead to an increase of siltation or runoff.

It is difficult to predict the effect that climate change will have on amphibians within the city of Calgary. In general, an earlier and longer growing season may benefit amphibians allowing them to grow faster and larger, thus increasing size at overwintering and increasing survival (Altwegg & Reyer H.U., 2003). However, climate change is also predicted to increase the number of days with extreme heat (The City of Calgary, 2022), which could cause heat stress or in extreme situations death if temperatures exceed an amphibian's thermal maximum. Furthermore, increased temperature could cause wetlands to dry sooner during the year stranding tadpoles if wetlands dry prior to metamorphosis.

Although precipitation is predicted to increase slightly with climate change, which could increase the prevalence or hydroperiod of wetlands in Calgary, it is also predicted that seasonal droughts will become more frequent and intense (The City of Calgary, 2022). Moreover, climate change could lead to unpredictable changes in phenology such as altered timing of breeding and duration of overwintering period. It is also difficult to predict what affect climate change may have on prey availability or diseases such as chytridiomycosis or Ranaviruses.

In addition to the threats mentioned above, the presence of predatory fish is generally not compatible with amphibian presence. Although many species of fish in Calgary are native, within the urban environment it

isn’t uncommon for people to release pet fish such as goldfish (CBC News, 2023) which can become established and prey on amphibians. The City estimates that over 200 stormwater wetlands have invasive fish in them, such as goldfish and Prussian carp (CBC News, 2023). Illegal collection of amphibians may also occur to a limited degree in Calgary but isn’t likely to be a major threat. Lastly, although there have been few studies looking at this in the urban context, noise or vibration from traffic, aircraft, or other anthropogenic sources can drown out breeding calls reducing reproductive success, cause increased stress and suppressed immune function (Zaffaroni-Caorsi et al., 2022).

Birds

The City of Calgary has a rich diversity of bird species, with over 290 different species of birds documented in Calgary since 2010. Of those, at least 144 species use wetlands at some point in their lifecycle, including waterfowl, songbirds, shorebirds, wading birds, and raptors. This number may be an underestimate as it does not account for other bird species that use bordering habitat such as grasslands and riparian forests that will visit wetlands but are not necessarily reliant on them. Of the bird species that are likely to reside or pass through Calgary, 45 species are species of concern (AECOM, n.d.).

In 2021, Calgary became one of Canada's first certified Nature Canada Bird Friendly Cities. This certification aims to raise awareness and mitigate threats to birds and to reduce the negative impacts the urban environment can have on bird populations (Bird Friendly Calgary, 2022a). Through this certification, The City of Calgary along with various partners, committed to making our urban environment safer for birds by addressing common threats such as window strikes, cat predation, light pollution, pesticide use, vehicle collisions, plastics, and habitat disturbance (Bird Friendly Calgary, 2022c).

Use of Wetlands in Calgary

Many birds use Calgary's wetlands in a variety of ways including for feeding, breeding and nesting, and as stopover sites during spring and fall migration. The large number of bird species in Calgary can make management recommendations challenging as each species may have specific BMPs. How birds are affected by human activities varies where some species are highly adaptable to human disturbance while others are easily driven away from an area by the presence of people. For instance, shorebirds are highly sensitive to the presence of humans and dogs while pelicans are relatively tolerant.

Feeding

Wetlands provide important foraging habitat for many bird species. Birds from all families will use wetlands to forage for vegetation, aquatic invertebrates, insects, amphibians, mammals or other birds. Great blue herons are commonly seen foraging along the margins of wetlands, whereas harriers can be seen hovering low over the whole wetland foraging for fish, amphibians and even mice! Waterfowl such as coots are often seen eating pond vegetation while shorebirds such as killdeer can be found around the edges eating insects and aquatic invertebrates.

There are also aerial insectivores such as swallows whose flying insect diet includes mosquitoes, mayflies and stoneflies which primarily breed in wetlands. Other birds such as ducks that breed or bring their young to wetlands shortly after hatching are important winter food sources for eagles or other raptors.

Red-necked grebes bringing a fish to young (grebette) in a Calgary wetland. Image Credit: Sara Jordan-McLachlan

Breeding and Nesting

A variety of birds use wetlands for nesting including waterfowl such as grebes and mallards as well as songbirds such as red-winged and yellow-headed blackbirds and marsh wrens and swamp sparrows. Even raptors such as Northern Harriers nest in wetlands. In Calgary, most of these birds will nest in wetland areas where tall grasses and bulrushes offer nesting material and protective cover. For blackbirds, cattails also provide a food source for adults allowing them forage and protect their nest at the same time.

Some duck species including goldeneyes, mergansers and wood ducks will nest in tree cavities near wetlands and bring their ducklings to the water once hatched.

Eared grebe feeding young (grebette). Image Credit: Sara Jordan-McLachlan

Migration Stopover

Beginning in late August and into October, migratory birds are moving through Calgary with many using our wetlands as stopover sites. Stopover sites are essential resting spots that provide a safe space to rest and refuel with food before continuing their migration south. Waterfowl including northern shovelers, pelicans, cormorants, and snow geese as well as shorebirds such as willets and greater yellowlegs can be seen frequently using stopover sites between their summer and winter habitats. Spring migration, beginning in April and going until the middle of June, is another important migration period where birds will be using wetlands as stopover sites. Fall migration usually includes a higher number of individuals due to breeding than spring migration therefore activities in the fall may be more impactful to birds than during spring migration. Additionally, it is important to preserve as many wetlands as possible as many birds flock together during migration. Having more wetlands available will prevent overcrowding and can prevent the spread of disease such as avian flu.

American white pelicans and double-crested cormorants stopping-over in a Calgary wetland. Image Credit: Sara Jordan-McLachlan

General Bird Needs and Sensitivities

Many species of birds are sensitive to the presence of humans and associated disturbances such as noise, scent, light pollution, and ground vibration. Some species are highly adaptable to human disturbance while others are easily driven away from an area by the presence of people. In general, the louder or longer

duration of activity, the more likely a bird will be disturbed (Environment and Climate Change Canada, 2023b; Stantec Consulting Ltd., n.d.). Any sound that exceeds 10 decibels (dB) above ambient noise in a natural area, or greater than 50 decibels (dB) is considered to be a high-risk activity (Environment and Climate Change Canada, 2023b). Time of year also changes the acceptable level of disturbance with birds being more easily disturbed during the breeding season (mid-April to mid-August) (Environment and Climate Change Canada, 2023c).

Regulatory Protection

In Calgary, there are two primary pieces of legislation that apply to protect birds: the federal *Migratory Birds Convention Act* (*Migratory Birds Convention Act*, 1994) and the provincial *Alberta Wildlife Act* (Alberta King's Printer, 2022).

The *Migratory Birds Convention Act* (*Migratory Birds Convention Act*, 1994) was originally enacted in 1917 after bird populations began to dwindle with the rise of feathers for fashion, harvesting for food, and the capture of wild birds for the pet trade. The Act's purpose is to protect and conserve migratory birds at both the population and individual level along with their nests. The Act protects birds, eggs and nests from trafficking, hunting and commercialization. It does not, however, protect habitat. The Act also allows for the establishment of Migratory Bird Sanctuaries, which in Calgary includes the Inglewood Bird Sanctuary. Permits must be obtained by anyone undertaking an activity that may disturb, harm or kill protected birds, their eggs or their nests. Without a permit, activities that may harm birds during the nesting season or incidental killing of birds through anthropogenic activities can result in fines between $5,000 - $4 million and up to 3 years of jail. Enforcement of the Act is through the Canadian Wildlife Service and the RCMP. A useful resource in addition to the Act is the *Guidelines to avoid harm to migratory birds* (Environment and Climate Change Canada, 2023b).

The *Alberta Wildlife Act* (Alberta King's Printer, 2022) protects most species not covered under the *Migratory Birds Convention Act, 1994.* This includes raptors, kingfishers, grouse and ptarmigans. Similar to the *Migratory Birds Convention Act, 1994*, the *Alberta Wildlife Act* protects birds at both the population and individual level along with their nests. Wildlife sanctuaries and other protected areas can be established under the Act. Enforcement of the Act is by Alberta Fish and Wildlife with penalties up to $1 million and 2 years in prison. Birds not protected by either legislation include crows and magpies, brown-headed cowbirds and blackbirds, common grackles and introduced species.

Why are We Concerned about Birds?

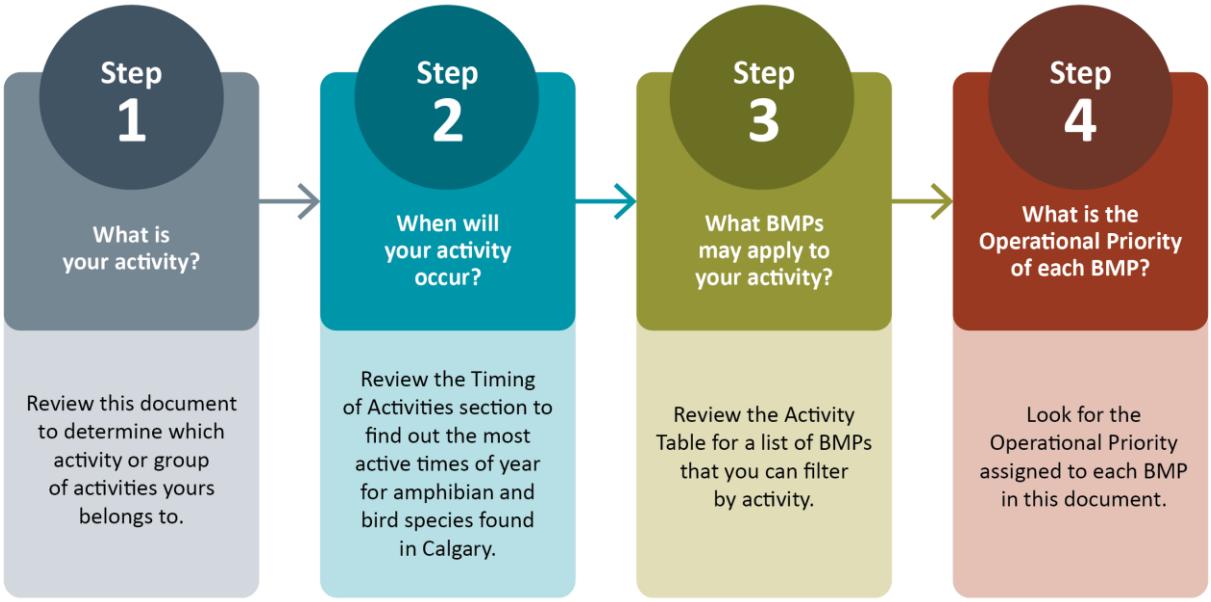
Birds are the largest group of vertebrates in Canada with species occupying a variety of ecological roles including predators, prey, scavengers, seed dispersers and pest control. Due to their wide range of ecosystem functions, they interconnect with many other organisms and their presence or absence on the landscape provides key information about the structure and health of our ecosystems. With significant losses of birds on the landscape over the last fifty years and Calgary's designation as a Bird Friendly City, taking into consideration how anthropogenic activities affect birds has recently taken on a more prominent role (Bird Friendly Calgary, 2022a; Rosenberg et al., 2019). As an umbrella group for ecosystem health, considering their reactions to change and supporting their presence throughout their life cycle can help guide beneficial management practices across guilds.

Beneficial Management Practices

Beneficial management practices (BMPs) are practices, methods, or techniques that consistently show results superior to those achieved by other means (Randall et al., 2018). This document outlines BMPs to enhance conservation of amphibian and avian populations as a proxy for wetland health within The City of Calgary to better support urban biodiversity. The BMPs are organized into three general categories: timing of activities, general BMPs organized by threat, and BMPs specific to activities. These are displayed in a series of tables below that include a BMP number that corresponds to the BMP number in the Activities Table, applicable biota (amphibians {amp.} and birds) and operational priority (opp. priority).

This document focuses on BMPs that can be applied to maintain and enhance wetland habitat for biodiversity and mitigate impacts of operational activities on target indicator groups. The City must adhere to all applicable provincial and federal laws and regulations when undertaking activities that impact amphibian and bird species.

The process to use these BMPs is as follows:



Due to the variety of operational activities conducted by The City, not all activities will appear in this guidance document or the associated activity table. Staff should identify a similar activity or conduct a scan of the general BMPs to assess which may apply.

Timing of Activities

When conducting operational activities there are general timing considerations that will benefit amphibian and bird species. These include seasonal and daily timing considerations based on amphibian and bird activity levels and critical life cycle windows.

Seasonal Timing

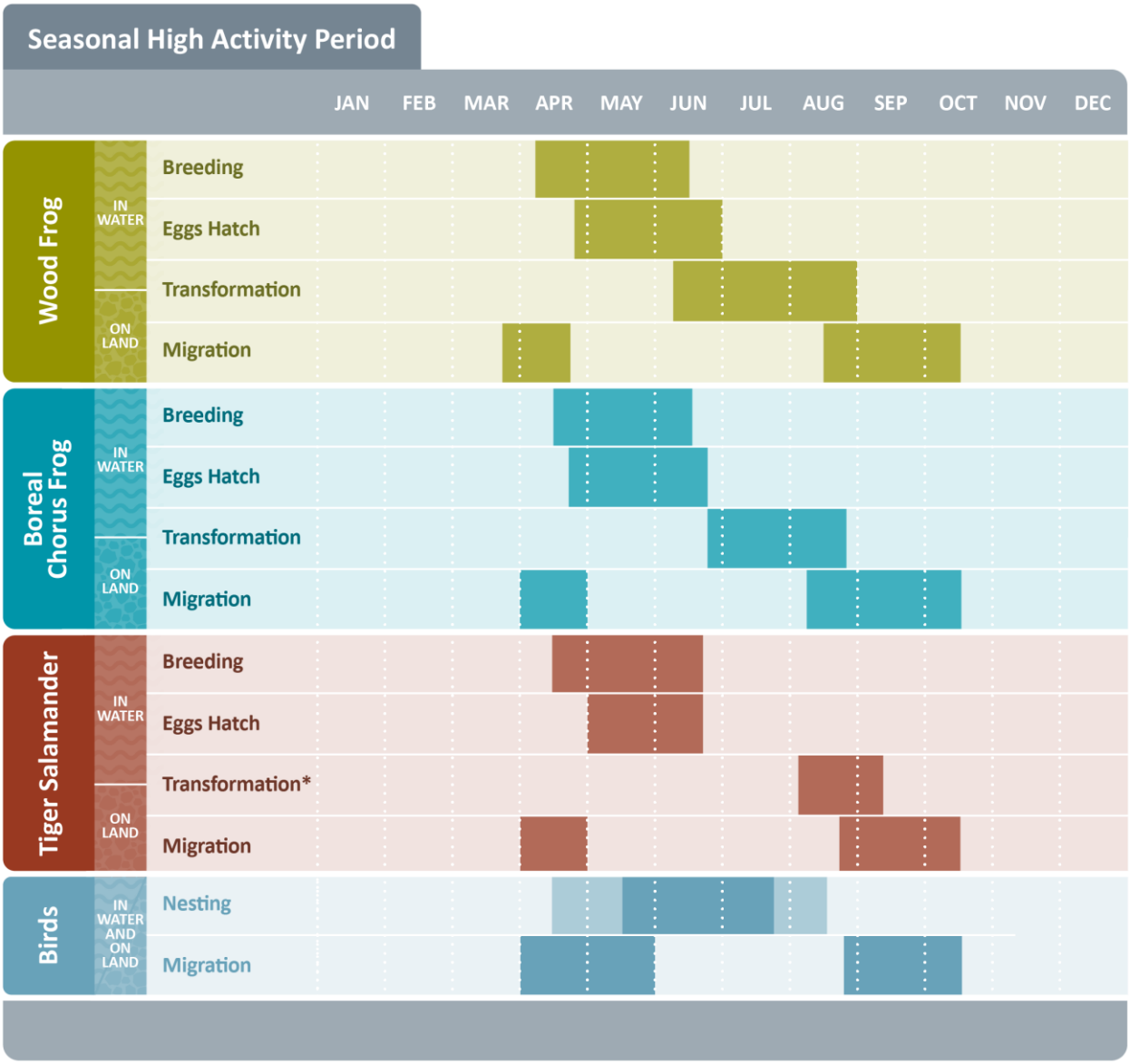


*Figure 1: Seasonal High Activity Period of amphibian and bird species in Calgary, AB. Amphibians are present in the water during breeding, egg hatch, and part of transformation stages. As eggs and until the end of transformation, they are unable to move out of the water. Transformation is a period when individuals are metatmorposizng from aqautic to terrestrial life stages and may be located on land. *Although most tiger salamanders transform into terrestrial adults, rarely, some overwinter as larvae or as neotenic adults (animals that retain larval form after sexual maturity) in waterbodies during the winter months. Amphibian migration is a period when adults are moving out of the wetland to their overwintering habitats on land. The darker shading within the bird nesting period indicates the time when there is the highest percentage of species nesting, with the lighter shading indicating birds are still within the nesting period but there is a lower percentage of species nesting.*

Amphibians

Amphibians are ectothermic and ambient temperature can influence activity and behavior. Furthermore, most amphibians have thin, moist skin that is prone to evaporative water loss (Hillman et al. 2009). For these reasons, amphibians in Calgary tend to be **most active in the spring, summer, and fall, especially when it is warm and wet**.

During the spring and fall amphibians will migrate to and from breeding ponds from their overwintering habitat, respectively. Typically, this is not a far distance (<100 m), however during this migration period and during transformation (from aquatic life stages to terrestrial life stages) it is more likely to encounter an amphibian on land, away from the water. For more information on movement distances please see Table 1.

Amphibian encounters are rare during the winter, but wetland drainage, excavation, or repositioning construction materials or other objects, may expose overwintering amphibians. During winter amphibians are especially vulnerable to disturbance, as they are inactive or only capable of minimal movement and therefore unable to relocate to suitable overwintering habitat. However, neotenic or wintering larval salamanders, which are rare in Calgary, may still be active in waterbodies during the winter.

Birds

Environment and Climate Change Canada states that the regional nesting period for wetland bird species in Calgary is mid-April to mid-August with the highest percentage of species nesting between approximately mid-May to late-July (nesting zone B4) (Environment and Climate Change Canada, 2023c).

Spring and fall migrations are periods of time where there are more individuals and species of birds present in and around wetlands, especially during fall migration (Dokter et al., 2018). These periods can shift depending on the weather but typically spring migration starts at the beginning of April to the end of May, and fall migration is from late August into October (Birds Canada, 2023; Crewe et al., 2008).

Daily Timing

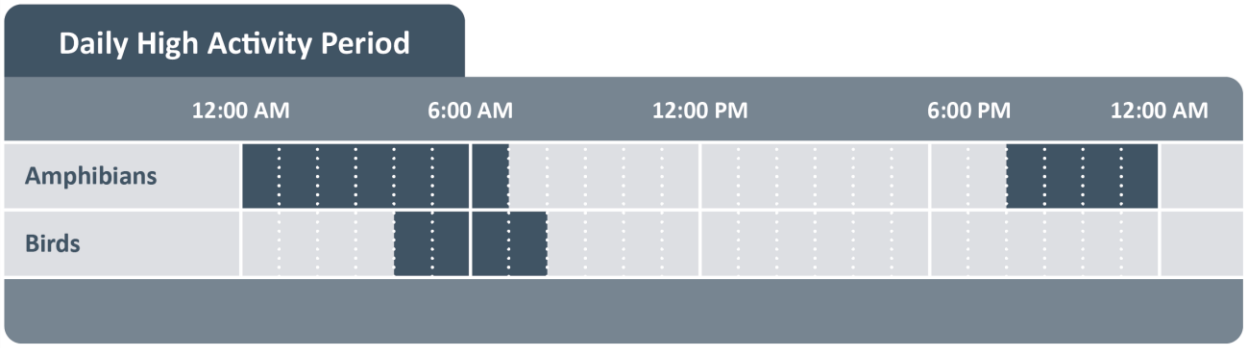


Figure 2: Daily high activity periods for birds and amphibians is based on a typical spring day, which is the most active season for amphibians and bird species in Calgary, AB.

Amphibians

Wood frogs and boreal chorus frogs are diurnal and calling can be easily detected in spring during the breeding season. Tiger salamanders, however, are much more difficult to detect because they don't vocalize, are primarily nocturnal, and spend much of their adult life in burrows or under cover objects such as debris or rocks (COSEWIC, 2012).

Although amphibians may be active day or night, they tend to migrate and breed at night during periods of warm, wet weather (The Ecology and Behavior of Amphibians, 2007). Amphibians are more likely to be encountered at a distance from waterbodies under these conditions or in moist or humid environments. Amphibian activity including breeding and movement may also vary with lunar cycle and intensity of moonlight, but whether this increases or decreases activity depends on the species and is poorly understood (Grant et al., 2013).

Amphibian activity on land tends to be lowest during hot, cool, windy and dry conditions. Activity in waterbodies tends to be lowest when temperatures are cool.

Birds

The daily activity levels of birds in Calgary are highly variable between species, however most wetland bird species are active during the daytime, with dawn being particularly active during the breeding season as songbirds call out and waterfowl perform displays to find a mate. Although daytime is when most birds are active, there are many species that are crepuscular (active during dawn and dusk) such as nighthawks, or nocturnal (active at night) such as great horned owls. Due to these variations between bird species, activities at any time should be reviewed for impacts. Birds can be found foraging at all times but like amphibians, activity levels vary with environmental conditions. During hot, dry spells birds can be found resting in higher numbers at cool waterbodies including wetlands.

Beneficial Management Practices related to Timing

No.	BMP	Amp.	Bird	Opp. Priority
1	Conduct activities where or when amphibians and birds are not present or are less active and encounters are unlikely.			High
2	Avoid scheduling activities when amphibians are present in habitats but unable to move to avoid disturbances (this will effect breeding, and egg hatch stages). Examples: • Avoid conducting in-water work when aquatic life stages of amphibians are present (i.e., eggs, tadpoles, larvae, neonatal adults) • Avoid conducting work near overwintering habitat when animals are hibernating (Randall et al., 2018).			Medium
3	Avoid scheduling activities when birds are present in habitats but unable to move to avoid disturbances (S. Jordan-MacLachlan, Pers. Comm.) Example: • Avoid conducting work when eggs and chicks are in the nest or when chicks or goslings cannot fly			Very high
4	If work must be conducted during active periods, schedule work when species have dispersed from the zone where the activity is occurring (S. Jordan-MacLachlan, Pers. Comm.; K. Kendell, Pers. Comm.). Examples: • Water level decrease should only occur during the late fall or winter when amphibians and birds are no longer in the egg or larval/hatchling stages and are mobile enough to move within or outside of the wetland			Medium

No.	BMP	Amp.	Bird	Opp. Priority
	• Repair trails in the summer because amphibians will likely in the wetland and therefore away from trails or able to move during repairs if they are already metamorphosized; and birds will be past the peak breeding period however nest sweeps would still be required in the local area • Avoid operational activities and/or permitting events with numerous participants near wetland edges (or within several metres of wetland edge) when the salamander larvae are completing their metamorphosis and emerging from the wetland resulting in concentrations of salamander near the wetland edge (Beginning of August to mid-September) (K. Kendell, Pers. Comm.)			
5	Conduct work using heavy equipment during cool, dry seasons or when the ground is frozen (Pilliod & Wind, 2008) • A Parks & Open Spaces greenspace application will be required for all disturbance to wetlands located in a city park. Ecologists and other Parks staff review the permit application and identify conditions that are required to be met by internal project managers and non-City entities responsible for projects with heavy equipment to protect habitats.			Medium

General BMPs

Habitat Alteration

No.	BMP	Amp.	Bird	Opp. Priority
6	Retain existing quality wetland habitat, features, and function (B.C. Ministry of Forests Lands and Natural Resource Operations, 2014; Demarchi et al., 2005; Pilliod & Wind, 2008; Randall et al., 2018) Examples: • For birds, maintain trees used for nesting and perching (Demarchi et al., 2005). Create a minimum buffer of undisturbed vegetation, 1.5 tree lengths around nest sites. For some sensitive species including raptors and great blue herons, disturbance buffers of 100 m are preferable. A noise and human disturbance buffer of at least 100 m for eagles and 200 m for other raptors is recommended (relying on legislation direction as a minimum) (Demarchi et al., 2005).			Very high

No.	BMP	Amp.	Bird	Opp. Priority
	• For amphibians, this means retaining woody debris and rock outcrops where amphibians may take cover, and exposed soils of leaf litter used for burrowing (B.C. Ministry of Forests Lands and Natural Resource Operations, 2014)			
7	Restore natural hydrology (hydroperiod, flow rate, and flow paths) (Pilliod & Wind, 2008; Randall et al., 2018; Van Oort et al., 2015; Wrubleski & Ross, 2011)			High
8	Maintain healthy riparian zones (S. Jordan-MacLachlan, Pers. Comm.; Randall et al., 2018) Example: • Use construction equipment on land, ice, or floating barges in ways that reduce disturbance to the vegetation on the banks of the wetland (S. Jordan-MacLachlan, Pers. Comm.; Randall et al., 2018)			High
8a	Protect sensitive riparian habitats by encouraging staff to stay on roads and trails (S. Jordan-MacLachlan, Pers. Comm.; K. Kendell, Pers. Comm.).			Very high
9	Avoid crossing the wetland, including but not limited to personnel, equipment, boats, etc. (S. Jordan-MacLachlan, Pers. Comm.; Randall et al., 2018)			Medium
10	Adhere to setback distances (Randall et al., 2018) outlined in regulations and City policies and plans (S. Jordan-MacLachlan, Pers. Comm.)			Very high
11	Consider translocation if habitat will be destroyed beyond repair, especially during a lifestage where the amphibian cannot relocate on its own (e.g. tadpoles during wetland drainage). Rely on Guidelines for Mitigation Translocations of Amphibians: Applications for Canada's Prairie Provinces. Version 1.0 to help determine if mitigation translocation is an option and to conduct the translocation appropriately (Randall et al., 2018). Be sure to adhere to relevant regulations and consult a suitable biologist.			Medium
12	Develop a broad translocation plan for winter activities that could disturb overwintering amphibians. (Randall et al., 2018)			Low
13	Avoid creating habitat attractive to amphibians or birds within the worksite or work staging area by altering methods of work, timing or using barrier fencing when habitat creation is unavoidable (S. Jordan-MacLachlan, Pers. Comm.; Randall et al., 2018). See BMPs 13a and b below for examples of sink habitat.			Medium

No.	BMP	Amp.	Bird	Opp. Priority
13a	Wetland sink habitat for birds is dependent on the time of year and the life history of specific species. Because there are so many different types of birds that use Calgary's wetlands, it is difficult to predict all the environmental characteristics that may create a sink habitat but there are a few blanket characteristics (S. Jordan-MacLachlan, Pers. Comm.). For nesting: • Wetlands adjacent to roads may increase the likelihood of vehicle strikes for birds that nest in the wetland and for birds that nest elsewhere and bring their young after hatching. • This includes species such as Mallards, Canada geese, Goldeneye ducks, Wood ducks and Mergansers. • For these birds, providing safe passage to the wetland, e.g., a culvert, may help prevent vehicle deaths. • Dirt piles and gravel areas adjacent to wetlands may draw birds like Cliff Swallows and Killdeer, respectively. For migration: • Sink habitat may be created by artificial lights at night which may draw birds off course and into areas where they become susceptible to window strikes, urban predators and roads. • Roads next to a wetland that are lit by artificial lights may look like water and birds like Loons, Coots and Grebes may accidentally land on it and become stuck. Turning off lights at night in areas near wetlands where construction is taking place can prevent accidents. (S. Jordan-MacLachlan, Pers. Comm.)			Medium
13b	Sink habitat is habitat that may attract amphibians leading to increased mortality. Sink habitat examples: • Wetlands created by anthropogenic activities may not hold water for long enough for tadpoles to reach metamorphosis (and move onto land) or may contain chemicals that can have lethal effects on aquatic life stages (L. Randall, Pers. Comm.). Wetlands near large road can have high pollutant levels (Gallagher et al., 2014). • Snow removal that accumulates in a low-lying area. See BMP number 35 for more details (Ministry of Environment and Climate Change Strategy, 2020) • Terrestrial sink habitat may include landscape features such as roads that attract thermoregulating amphibians to their warm			Medium

No.	BMP	Amp.	Bird	Opp. Priority
	surfaces but increase the risk of mortality from vehicle collision (L. Randall, Pers. Comm.). • Activities may also result in features such as loose soil which may attract burrowing species. This can be a problem if soils subsequently become compacted and amphibians are crushed or unable to move at times of inactivity (e.g., overwinter) (L. Randall, Pers. Comm.). • Piles of construction materials or brush (e.g., tree pruning), may also attract amphibians as they provide refuge from the environment and predators. This can be a problem if materials are removed and amphibians are unable to move at times of inactivity (e.g., overwinter). (L. Randall, Pers. Comm.)			

Sediment Release

No.	BMP	Amp.	Bird	Opp. Priority
14	Avoid releasing sediment into the wetland (S. Jordan-MacLachlan, Pers. Comm.; K. Kendell, Pers. Comm.; Randall et al., 2018). Unauthorized sediment release is not permitted. For guidance on erosion and sediment control please consult the "Related City Documents" in the Activity Table.			Very High

Chemical and Waste Increase

No.	BMP	Amp.	Bird	Opp. Priority
15	Minimize the use of chemicals on or along roadways (S. Jordan-MacLachlan, Pers. Comm.; Pilliod & E. Wind (editors), 2008).			High
16	Create an emergency spill response plan according to SDS regulations to quickly contain and clean spills. Spills can occur while handling chemicals, accidents, refueling or servicing vehicles and equipment (S. Jordan-MacLachlan, Pers. Comm.; Randall et al., 2018)			Very high
17	Contain and stabilize waste materials such as construction waste and debris outside of the wetland boundary (S. Jordan-MacLachlan, Pers. Comm.; Randall et al., 2018)			High

Direct Mortality

No.	BMP	Amp.	Bird	Opp. Priority
18	Maintain a sufficient distance to avoid disturbing or flushing nesting birds. Monitor bird's response and implement mitigation if disturbance or flushing occurs (Stantec Consulting Ltd., n.d.). Train operations staff how to identify and document nesting activity prior to routine tasks near wetlands, especially when a formal nest sweep may not be required (Stantec Consulting Ltd., n.d.). Signs of disturbance include: adults sitting upright on nest, increased vocalizations, adults leaving (flushing) from nest (Environment and Climate Change Canada, 2023a).			High
19	Minimize soil compaction: • Use a work staging area (S. Jordan-MacLachlan, Pers. Comm.; K. Kendell, Pers. Comm.). • Don't park vehicles close to site (S. Jordan-MacLachlan, Pers. Comm.; K. Kendell, Pers. Comm.). • Avoid travelling across pocket gopher mounds, wet areas, and softer soils (K. Kendell, Pers. Comm.) • Mitigate risk by using rig mats or other tools (K. Kendell, Pers. Comm.)			Medium
20	When using a vehicle or travelling by foot move slowly to allow amphibians and birds to move out of your path (Bird Friendly Calgary, 2022c). Use available pathways and avoid permeable surfaces as much as possible (L. Randall, Pers. Comm.). Schedule visits with vehicles during daily time periods when amphibians and birds are less active, see Daily Timing section.			Medium
21	If you find an amphibian or bird in distress or injured, contact 311 for contact information for wildlife rehabilitation agencies.			Medium

Invasive Species or Disease Presence

No.	BMP	Amp.	Bird	Opp. Priority
22	Avoid transporting invasive species or disease. Movement of water, mud, vehicles or other equipment, or animals can spread invasive species or diseases from site to site (S. Jordan-MacLachlan, Pers. Comm.; K. Kendell, Pers. Comm.; Randall et al., 2018). For proper disinfection and cleaning protocols please visit Appendix 4 of Randall et al. (2018).			High

Noise and Light Pollution

No.	BMP	Amp.	Bird	Opp. Priority
23	Limit operational activities that occur in the dark as these would require lighting of site, increasing light pollution which disturbs and disorients both birds and amphibians by brightening the night sky (Bird Friendly Calgary, 2022b; Downie, 2019; Randall et al., 2018)			Medium
24	If nighttime activity is necessary, choose warm coloured light and only illuminate the target area (Bird Friendly Calgary, 2022b; Downie, 2019).			Medium
25	Avoid replacing lighting within 50m of a natural area park unless under exceptional circumstances (e.g., non-routine safety concern), in which case, minimal and warm lighting should be considered			High
26	Avoid unnecessary ground vibration (S. Jordan-MacLachlan, Pers. Comm.; Randall et al., 2018).			Medium
27	Minimize sensory disturbances by: • Avoiding sharp or loud noises such as horns and whistles (Environment and Climate Change Canada, 2023a) • Muffling sound (Stantec Consulting Ltd., n.d.) • Using equipment with lower noise emissions (Stantec Consulting Ltd., n.d.) • Restricting equipment size (Stantec Consulting Ltd., n.d.) • Restricting crew size (Stantec Consulting Ltd., n.d.) • Limiting the duration of noise (Environment and Climate Change Canada, 2023b) • Maintaining constant engine noise levels (Environment and Climate Change Canada, 2023a)			Medium
28	Maintain a buffer of at least 1 km from bird colonies (e.g., terns, pelicans, herons, etc.) for high-disturbance activities (e.g., drilling, blasting, fireworks, etc.) (Environment and Climate Change Canada, 2023a)			Medium

BMPs Specific to Activities

Dredging

Dredging is the act of removing sediment from the bottom of wetlands and other water bodies (National Oceanic and Atmospheric Administration, 2023). Many of the wetlands within the city function as part of the stormwater infrastructure system. Over time, wetlands naturally begin to accumulate sediment as particles sink to the bottom. As sediment levels increase, water quality decreases as does the water storage capacity of the wetland therefore dredging is used to remedy this situation. Dredging in Calgary usually occurs between September and April, when the ground is frozen, reducing the risk of soil compaction. Access roads are used as much as possible. The Dredging process includes dewatering and then excavation of the sediment by machinery.

Dredging can have a negative impact on wetlands as it disrupts the natural function of wetlands by altering the depth of the wetland and removing emergent and submergent vegetation but it can be necessary to improve water quality and a functional stormwater management system. In Calgary, some wetlands may never be dredged, whereas others may require it every 10-30 years. BMPs specific to dredging include:

No.	BMP	Amp.	Bird	Opp. Priority
29	Avoid dredging wetlands unless necessary as this can create a sink habitat for amphibians (B.C. Ministry of Forests Lands and Natural Resource Operations, 2014). If dredging is necessary:			High
29a	Avoid creating steep slopes on shoreline, amphibians need shallow shoreline habitat (B.C. Ministry of Forests Lands and Natural Resource Operations, 2014)			High
29b	Dredge in the winter (after a few consecutive negative temperatures, frost days) (K. Kendell, Pers. Comm.)			Medium

Infrastructure

Operational activities conducted by City of Calgary personnel to maintain infrastructure near wetlands can vary greatly. These include maintenance of pathways, bridges, boardwalks and viewing platforms, retaining walls, culverts, pumps, monitoring panels, intake pipes, and clay liners. These activities may require the use of heavy equipment, access using trucks or on foot, and may result in compaction of soils, increased sedimentation, drawdown of water level, potential transport of invasive species, increased noise, reduction of habitat or cover, artificial lights at night, generation of waste materials, and use of chemicals.

Some categories of infrastructure activity have additional beneficial management practices that are expanded upon below.

No.	BMP	Amp.	Bird	Opp. Priority
30	Cover open vertical pipes to prevent amphibians and fledgling birds from falling in and being trapped (often used for signage, fencing or gates) (Partners in Amphibian and Reptile Conservation, n.d.)			High

No.	BMP	Amp.	Bird	Opp. Priority
31	Install wildlife escape ramps from stormwater infrastructure where amphibians will not be able to crawl out on their own (Partners in Amphibian and Reptile Conservation, n.d.)			High

Road or Pathway Maintenance

Calgary experiences many snow events and slippery conditions that necessitate the use of salt/brine, aggregates, and de-icer on road and pathway surfaces. Additionally, dust control agents may be applied to roads or in construction areas. These applications eventually make it into the stormwater system and many of the wetlands in the City, especially for wetlands proximate to roads and pathways.

These activity-specific beneficial management practices are taken directly from the *Guidelines for Amphibian and Reptile Conservation during Road Building and Management Activities in British Columbia. Version 1.0* (Ministry of Environment and Climate Change Strategy, 2020)

No.	BMP	Amp.	Bird	Opp. Priority
32	Consider using alternative, non-chloride/"green" forms of dust control and de-icing agents, especially near sensitive habitats (e.g., adjacent to aquatic breeding sites) (Ministry of Environment and Climate Change Strategy, 2020)			High
33	Minimize runoff of dust control agents into adjacent habitats, especially wetlands. Techniques might include pre-wetting surfaces to ensure proper adhesion, not applying dust control agents before, during, or immediately after rain, and minimizing spraying on the shoulder (Ministry of Environment and Climate Change Strategy, 2020)			High
34	Install silt fencing adjacent to wetlands to prevent treated dust and sediment from washing into the wetlands (Ministry of Environment and Climate Change Strategy, 2020)			Very high
35	Where possible, avoid depositing large accumulations of snow and ice that have been removed from roads into or immediately adjacent to roadside ponds, wetlands, and ditch habitats (where amphibians may breed). Mark locations of known ditch pond habitats with tall coloured stakes so that they can be avoided during snow removal (Ministry of Environment and Climate Change Strategy, 2020)			Very high
36	Consult the salt management plans outlined in the Transportation Association of Canada's (2013) Syntheses of Best Practices - Road Salt Management (https://www.tac-atc.ca/sites/tac-atc.ca/files/site/doc/resources/roadsalt-1.pdf) (Ministry of Environment and Climate Change Strategy, 2020)			Very high

Water Level Change

Some level of water fluctuation is natural in wetlands, but artificially changing the water level of storm ponds (increase or decrease) can be detrimental to wetland health. However, there are situations where a wetland may need to be partially or completely drained temporarily or permanently (e.g., dredging, eradication of non-native fish, reduce disease transmission, H2S control, etc.). There may also be times when wetlands may need to be replenished (water levels increased). To minimize impacts to biodiversity, the following beneficial management practices should be applied.

No.	BMP	Amp.	Bird	Opp. Priority
37	Time waterbody drainage for when amphibians and waterfowl young are not present or least likely to be encountered (Randall et al., 2018; Van Oort et al., 2015; Wrubleski & Ross, 2011), see Timing of Activities section.			Very high
38	Identify the wetlands that have neotenic or larval overwintering salamanders and avoid dredging and dewatering in the winter.			Medium
39	Avoid deliberately altering water levels until birds have raised their young and amphibians are finished the transformation life stage. Water level drawdown or drainage may dry out nests and make young susceptible to predation (Environment and Climate Change Canada, 2023b; Van Oort et al., 2015; Wrubleski & Ross, 2011); Water level increase may flood bird nests and drown young; see Timing of Activities section.			Very high
40	If there is alternate available habitat in the area, install barrier fencing before seasonal movements to breeding or overwintering habitats begin, to prevent amphibians from colonizing waterbodies that will be drained (Randall et al., 2018)			Very high
41	To avoid injuring or killing aquatic amphibians during waterbody drainage (Randall et al., 2018): • Be sure to cover the opening to the intake hose with a mesh screen (0.25cm in spring when tadpoles are present, larger mesh can be used later in summer-winter) to prevent crushing or sucking aquatic species or life stages into pumps. • Ensure that the screen is far enough from the intake to reduce suction. • Place the pump inside a sump container. • Use active net sweeps to remove amphibians before they reach the sump. • Monitor pumps regularly to ensure that amphibians do not become trapped on the screen			High

Vegetation Management

Vegetation management by The City is conducted for a variety of purposes including: controlling invasive and non-native plant species (e.g., weed control), maintaining recreational areas such as golf courses and open space aesthetics (e.g., mowing), enhancing human safety on pathways by increasing sightlines (e.g., vegetation removal or pruning), protecting plant health (e.g., fertilizer applications, mulching), limiting algae growth (e.g., algaecide application), and more. Vegetation management can be a challenge in the urban environment, especially around wetlands as it can pose risks to wetland health and must be undertaken with care as it can directly and indirectly harm or kill amphibians and birds (Stantec Consulting Ltd., n.d.). Removing or mowing vegetation can have a negative impact as it eliminates cover and overwintering habitat and decrease prey availability (insects) and can lead to direct mortality (Kendell, 2022; Stantec Consulting Ltd., n.d.).

No.	BMP	Amp.	Bird	Opp. Priority
42	Maintain native vegetation structure and composition (Demarchi et al., 2005; Pilliod & Wind, 2008).			High
43	Maintain tree and deadwood used for nesting by birds such as raptors and cavity nesters (Demarchi et al., 2005)			Very high

Weed Control

As defined in the City's Integrated Pest Management Policy, a pest is "an organism or organic function of an organism whose presence, introduction, establishment or spread in a particular time and place is causing or has the potential to cause ecological, economic, legal, aesthetic or social harm, or harm to human health and safety, if left unmanaged, including but not limited to invasive species" (The City of Calgary: Parks, 2020). Weeds are considered pests and there are a variety of mechanical and chemical methods for their removal available to City staff.

No.	BMP	Amp.	Bird	Opp. Priority
44	Consider using manual removal where possible including volunteer weed pulls (Demarchi et al., 2005; Pilliod & Wind, 2008)			High
45	When it is necessary to use herbicide or pesticide (S. Jordan-MacLachlan, Pers. Comm.; Pilliod & E. Wind (editors), 2008): • Follow instructions carefully and ensure the product is approved for the habitat type (use near wetlands) • Create an appropriate buffer distance from application area to wetland • Spot spray to target the smallest area possible • Avoid potential drift			Very high

Mowing

Vegetation is an important habitat feature for amphibians and bird species as it provides cover and food supply for birds and amphibians as well as overwintering habitat for amphibians (Kendell, 2022) and nesting areas for birds (Environment and Climate Change Canada, 2023a). Vegetation height is an important factor in providing quality habitat for amphibians and birds therefore grass height by mowing may impact wetland health. Mowing can lead to direct mortality and destruction of bird nests by movement of equipment (Stantec Consulting Ltd., n.d.). The beneficial management practices below aim to mitigate those risks as well as risks of habitat alteration and sensory disturbance.

No.	BMP	Amp.	Bird	Opp. Priority
46	Avoid mowing during the breeding period, see Timing of Activities section (Randall et al., 2018; Stantec Consulting Ltd., n.d.).			Very high
47	When mowing is necessary, do it infrequently following guidelines in the Timing of Activities section (S. Jordan-MacLachlan, Pers. Comm.; Randall et al., 2018)			Very high
48	Avoid mowing and brushing within 10m from the water's edge (S. Jordan-MacLachlan, Pers. Comm.; Randall et al., 2018). Avoid mowing entirely if wetland is within 30m of an Environmental Reserve.			Very high
49	Not all 311 calls may warrant a mowing action. When 311 receives a complaint about 'untidy' areas that are unmowed, staff should provide a response to the complainant about the naturalization of the area and the benefit for amphibian and species as well as wetland health in general.			Medium
50	In sites where activities are planned that will disturb habitat, continuous mowing can be used to discourage bird nesting. In this situation, mowing must start before breeding season, and occur regularly until the activity is completed (Stantec Consulting Ltd., n.d.). ***Note** – this BMP could be detrimental to amphibians as it could increase the chances of direct mortality.			Very high

Mulching

No.	BMP	Amp.	Bird	Opp. Priority
51	Avoid mulching during breeding season as it is a high-risk activity that can result in ground nests being damaged or destroyed (Stantec Consulting Ltd., n.d.)			High

Wildlife Management

A diverse range of wildlife use Calgary's wetlands and their management can impact wetland health therefore the BMPs in this section serve to mitigate impacts.

Controlling Non-native Species

Management of invasive and non-native species is critical to maintaining a healthy and biodiverse ecosystem but can be a challenge in the urban environment. Terrestrial invasive and non-native species (e.g., ring-necked pheasant, domestic rabbits, domestic cats, domestic dogs, etc.) can lead to direct mortality through predation, but also indirect negative impacts due to consumption of prey species or habitat that is required for birds and amphibians.

Removal of non-native fish species is beneficial for wetland health overall as they can impact the natural ecosystem and out compete native species. The most common aquatic non-native species that The City manages in their wetlands are Prussian carp and released goldfish. Although carp and goldfish may benefit bird species as a food resource, they have a detrimental effect on amphibians, as do most fish species, because they are predators of amphibians.

No.	BMP	Amp.	Bird	Opp. Priority
52	Develop and maintain an IPM plan that considers amphibians (Pilliod & Wind, 2008)			Very high
53	Remove or eradicate non-native species, especially those that predate amphibians or birds (S. Jordan-MacLachlan, Pers. Comm.; Pilliod & E. Wind (editors), 2008), such as Prussian carp and goldfish			High
54	Public education discouraging the release invasive species such as Prussian carp, goldfish, reptiles, and other 'pets' (CBC News, 2023)			Very high
55	Public education, signage, and enforcement of responsible pet ownership bylaw to ensure dogs are kept on leash and cats are not free roaming (Pilliod & Wind, 2008). Both domestic dogs and cats can predate and disturb amphibians and birds (Bird Friendly Calgary, 2022c).			Very high

Rodent management

While they are an important part of wetland ecosystems, rodents such as muskrats and beavers can potentially cause damage to stormwater infrastructure such as clay liners and plugging of stormwater outfalls.

No.	BMP	Amp	Bird	Opp. Priority
56	Beneficial species for Calgary's amphibians include Northern Pocket Gopher (*Thomomys talpoides*) (Welsh, 2015), ground squirrel spp. (e.g., *Urocitellus richardsonii)*, and Red Squirrel (*Sciurus vulgaris*). The burrows and middens produced by these species provide important over-wintering sites and refugia for some species of amphibian, such as tiger salamanders (K. Kendell, Pers. Comm.). Encourage and maintain			Medium

No.	BMP	Amp	Bird	Opp. Priority
	populations of these species especially within the dispersal distance of tiger salamanders, from a wetland (100 - 1000 m (Lee et al., 2020)). If any of these species are present at a site, ensure that habitat alterations do not push them out of the area (K. Kendell, Pers. Comm.).			
57	Coexist with rodents where possible as small and medium sized rodents are prey species of birds such as raptors (Demarchi et al., 2005)			Medium
58	If a beaver conflict occurs resulting in problematic flooding of infrastructure, use non-lethal coexistence tools such as a pond leveller or culvert protector to mitigate the flooding while allowing beavers to remain a part of the wetland ecosystem. Removing beavers will alter the wetland habitat and impact amphibian and bird species (Working with Beavers, 2022). Pond levellers drop the depth of the wetland therefore the section on Water Level Drawdown or Dewatering will also apply.			Medium
59	Use traps instead of poison when managing rodents to avoid secondary poisoning of raptors and other predators through ingestion of contaminated prey (Demarchi et al., 2005)			High

Bird Deterrents

Bird deterrents are used at some wetlands in the city to increase human and bird safety. Two examples of this are grid wires installed at wetlands along the flight path of the Calgary Airport, and the use of noise cannons at various water treatment facilities to deter birds from using wastewater holding ponds. Although these wetlands discourage bird use, these wetlands can be managed to support amphibians and other biodiversity.

Operations Access

Wetlands need to be accessed for a wide range of activities, therefore many of the General BMPs cover concerns regarding access to the wetland by foot, vehicle, boat, or other means. There are times when access will not be in addition to other activities but the access itself is the only operational activity, for example field trip visits to observe the wetland, small sample water collection for monitoring, passive monitoring, etc.

Public Use

Public use is balanced around wetlands, with the public being discouraged from entering the wetland itself except for lagoons used as skating rinks in the winter. Most public-use BMPs involve public outreach, signage, and enforcement of bylaws.

No.	BMP	Amp.	Bird	Opp. Priority
60	Balance wildlife and recreation needs by restricting access to important natural areas and/or important features within. Restricted access can mean not providing roads or trails, limiting time of day of access, etc. Examples of important features include breeding ponds,			Medium

No.	BMP	Amp.	Bird	Opp. Priority
	basking sites, upland overwintering habitat (S. Jordan-MacLachlan, Pers. Comm.; Pilliod & E. Wind (editors), 2008).			
61	Public education, signage, and enforcement of responsible pet ownership bylaw to ensure dogs are kept on leash and cats are not free roaming (Pilliod & Wind, 2008). Both domestic dogs and cats can predate and disturb amphibians and birds (Bird Friendly Calgary, 2022c).			Very high
62	Restrict access to important breeding ponds at City golf courses (e.g., not retrieving balls in golf course wetlands) during times of year when amphibians and birds are most active (Pilliod & Wind, 2008). See the Timing of Activities section to determine when amphibians and birds are least active and therefore it will be least impactful to remove balls from wetlands during those time periods.			Medium
63	Litter and garbage do not belong in wetlands or parks, where they can damage habitat and injure or kill plants and wildlife (Bird Friendly Calgary, 2022c). • Remove old cars, fridges, electrical appliances and other items that could leak toxic chemicals into wetlands (Pilliod & Wind, 2008) • Remove litter from wetlands and increase litter enforcement and education where needed			Medium

Restoration

Restoration of wetlands, riparian areas, and upland habitats can have a benefit to amphibians and birds so long as the restoration considers their habitat requirements. As a result, many of the same benefits provided to these species may also benefit biodiversity in general.

Thick beds of shrubs and associated leaf-litter can provide important cover for amphibians and increase prey abundance, plus they provide the benefits of snow capture (increased moisture retention and insulation for plants and wildlife). As the shrubs and trees age, downed woody debris can provide further refugia for the salamanders and other wildlife; also, the roots of the woody plants can provide nooks and crannies over time, or even become hollowed out and utilized by amphibians. That said, it is important to maintain a variety of open or semi-open areas around the pond with vegetation varying in structure, density and height (K. Kendell, Pers. Comm.).

Like amphibians, natural vegetation including tall grasses and willows provides not only refugia and suitable nesting habitat but also fosters aquatic invertebrates that provide food for a variety of birds including shorebirds, waterfowl and songbirds (Wrubleski & Ross, 2011). Supporting riparian vegetation restoration can maximize benefits to birds as well as amphibians.

Specific restoration activities may include seeding, restoration riparian planting, submerged aquatic planting, upland vegetation planting, willow staking, etc. The following table includes recommendations for restoration goals as well as specific considerations while conducting the restoration activity.

No.	BMP	Amp.	Bird	Opp. Priority
64	Maintain or restore native vegetation structure and composition (Demarchi et al., 2005; S. Jordan-MacLachlan, Pers. Comm.; Pilliod & E. Wind (editors), 2008)			High
65	Restore shallow shoreline areas with native, emergent and submerged vegetation to restore natural ecosystem processes (B.C. Ministry of Forests Lands and Natural Resource Operations, 2014; S. Jordan-MacLachlan, Pers. Comm.; Pilliod & E. Wind (editors), 2008)			High
66	Create a variety of open or semi-open areas around the pond with vegetation varying in structure, density and height (S. Jordan-MacLachlan, Pers. Comm.; K. Kendell, Pers. Comm.).			High
67	Native plants, selected for specific site requirements and zone should be used whenever possible (S. Jordan-MacLachlan, Pers. Comm.; K. Kendell, Pers. Comm.).			High
68	Use rocks, stumps, dead-wood, and other species appropriate materials to create different habitat elements for: basking, hunting, and escape/cover (S. Jordan-MacLachlan, Pers. Comm.; Pilliod & E. Wind (editors), 2008)			High
69	Cluster plantings to increase leaf litter density in localized area (K. Kendell, Pers. Comm.)			High
70	Avoiding shading of preferred breeding habitat (areas of shallow water that receive direct sunlight in early morning and afternoon, such as on the north side of the wetland) (K. Kendell, Pers. Comm.) • Consider mature size (height and width) of selected plants • Consider plant cluster density			Medium
71	Encourage and maintain populations of mammals such as Northern Pocket Gopher (*Thomomys talpoides*), ground squirrel spp. (e.g., *Urocitellus richardsonii*), and Red Squirrel (*Sciurus vulgaris*), especially within the dispersal distance of tiger salamanders, from a wetland (100 - 1000 m (Lee et al., 2020)). If any of these species are present at a site, ensure that habitat alterations do not push them out of the area (K. Kendell, Pers. Comm.)			High
72	Avoid digging and general activity (e.g., staging) in areas of pocket gopher activity as the burrows and general area may harbour salamanders (K. Kendell, Pers. Comm.).			Medium
73	Protect or create ephemeral wetlands in residential and recreation areas – studies have shown these can have greater species diversity than permanent as predators such as fish are not able to survive there (Pilliod & Wind, 2008)			Medium
74	Provide artificial nesting sites and perches if natural ones have been lost or damaged (Demarchi et al., 2005). Follow all applicable			Low

No.	BMP	Amp.	Bird	Opp. Priority
	regulations and submit a Parks & Open Spaces' Greenspace Permit Application prior to creating artificial nesting sites and perches.			
75	Snow accumulation benefits amphibian species by increasing insulation to overwintering habitat as well as increasing soil moisture. Snow accumulation can be enhanced by (K. Kendell, Pers. Comm.): • Considering the direction of the prevailing winds. Snow will accumulate on the leeward side of plantings, where wind speed is reduced (the side where wind is not directly hitting, the downwind side of the plant) (K. Kendell, Pers. Comm.) • Plant trees and shrubs a suitable distance from the edge of the wetland to encourage more snow accumulation in upland overwintering habitat instead of on the wetland itself (K. Kendell, Pers. Comm.) • Cluster plantings in localized area (K. Kendell, Pers. Comm.) • Increase mature size (height and width) of selected plants			High

Climate Change Resilience

As our changing climate continues to intensify, the threats that amphibian and bird species currently face in Calgary are likely to be exacerbated. In part because of the small movement range of amphibians, there are considerations can be made for amphibians and their habitat to help mitigate the impacts of climate change. These BMPs can range from monitoring and habitat restoration to artificially creating ideal habitat. These BMPs were not rated for Operational Feasibility at this time but should be considered in the future.

No.	BMP	Amp.	Bird
76	Manage predicted habitats you will have in the next 20 years as the climate changes and habitats shift and change (S. Jordan-MacLachlan, Pers. Comm.; Pilliod & E. Wind (editors), 2008).		
77	Install microclimates and micro habitat refuges e.g., supplementing large woody debris resources or planting additional cover in high temperature ponds (S. Jordan-MacLachlan, Pers. Comm.; Shoo et al., 2011)		
78	Enhancement and restoration of breeding sites (S. Jordan-MacLachlan, Pers. Comm.; Shoo et al., 2011)		
79	Manipulate hydroperiod or water levels at breeding sites (S. Jordan-MacLachlan, Pers. Comm.; Shoo et al., 2011)		
80	Examples of cases of climate mitigations (Partners in Amphibian and Reptile Conservation, n.d.): • Pump installed to maintain water levels in breeding ponds, New Mexico		

	• Log directional felling into breeding ponds – this appears to benefit some pond-breeding species, Washington • Support breeding site with portable irrigation sprayers to keep area moist, South Australia		
81	Translocation of species from imperiled to suitable habitat (Randall et al., 2018)		

Operational Prioritization

The operational priority rating for each BMP was determined by combining both ecological importance and operational feasibility ratings (Figure 3: Defining Operational Priority matrix for rating BMPs).

Ecological importance was rated as low, medium, or high by our biota experts for their respective biota using a survey for activity-specific BMPs. The rating was guided by considering the length of the term of recovery: short-, medium-, or long-term; as well as the level of impact: individual organism, many within one area of wetland, and wetland-wide population-level impact. Two experts contributed ratings for ecological importance to reflect amphibians and birds. Where deviation in ratings occurred, we selected the more conservative response (i.e., higher ecological priority).

Operational feasibility was rated as low, medium, or high by select City of Calgary staff from the Urban Conservation, Natural Areas, Environment Planning and Policy, Water Services, Regulatory Affairs and Compliance, and Utilities Infrastructure Planning portfolios. The ratings were gathered during workshop two for general BMPs and using a survey for activity-specific BMPs. In the survey, we asked staff to rate feasibility based on what they feel is the most common scenario. If they are very unsure or the BMP is not applicable to their area of expertise we asked them to select the "I don't know" option. Guiding questions were:

- What is the cost associated with implementing this BMP? (expensive, no additional cost, etc.)
- Is the BMP easily implemented? i.e., is this something we are already undertaking or could easily do with minor effort?
- Is there support within The City to implement this BMP?

Ten City staff contributed ratings for operational feasibility. If there was deviation in ratings, we selected the rating with most responses (the majority rating). If there was a tie for ratings with most responses, we rounded the average of all responses to the closest rating. If the average was exactly between two ratings, then the more conservative score was selected (i.e., lower feasibility).

The operational priority rating for each BMP was determined by combining both ecological importance and operational feasibility ratings and then using the matrix in Figure 3 to determine the operation priority rating. This rating is displayed alongside each BMP above.

Defining Operational Priority		Ecological Importance		
		Low	Medium	High
Operational Feassibility	Low	Very Low	Low	Medium
	Medium	Low	Medium	High
	High	Medium	High	Very High

Figure 3: Defining Operational Priority matrix for rating BMPs

Considerations and Recommendations

Throughout the development of the BMPs, additional considerations and recommendations arose and are documented here.

Teamwork

There is overlap in the management of many wetlands within the City. For instance, storm ponds that occur in City parks are managed by Water Services but also the Natural Areas group as boundaries are shared. In order to facilitate implementation of these BMPs there needs to be clear communication and cooperation to ensure we're working together to minimize impacts and protect wetland health and stormwater infrastructure. A situation that highlights the opportunity for this teamwork is when dredging needs to occur, which only happens at select wetlands every 10-30 years depending on the wetland.

City of Calgary Wetland Typologies

The City of Calgary Wetland Typologies, which are in development, can be applied with the BMPs to help refine how the BMPs and management goals are applied to each wetland. This would make the information in each BMP more specific and place-based and should increase operational feasibility as management and operational activities will be more refined.

Development

Although these BMPs are created specifically for operational activities, many of them can be applied to new developments and large capital projects. Slight modifications to text can be used to refine the BMPs through this lens and they can also be expanded upon to target activities that specific to development and large capital projects.

Species-specific or Habitat-specific BMPs

The BMPs outlined in this document are specific to operational activities that occur in or around wetlands within the City of Calgary. Many of the BMPs could be further refined based on specific species, including species at risk, and for additional habitats other than wetlands.

Other Wetland Habitat Management Goals

BMPs in this document are specific to conserving wetland health and function using amphibians and birds as proxies. This document does not attempt to resolve additional or competing wetland habitat management goals, for example:

- Wetlands managed to foster stable and diverse native fish populations (predators to amphibians)
- Enhance water and contaminant filtration through enhanced upland and riparian vegetation cover, possibly contrary to some amphibian or nesting bird outcomes such as creating open areas/sunning locations for amphibians
- Other stormwater management assets such as dry ponds for temporary water retention/storage

Resources

The resources below provided many of the BMPs used to create this document and can further help guide the City of Calgary and other urban municipalities to better manage and restore amphibians within the urban environment.

Name	Description
Guidelines for Mitigation Translocations of Amphibians: Applications for Canada's Prairie Provinces. Version 1.0 (Randall et al., 2018)	This document outlines beneficial management practices, standards, and protocols for mitigation translocation of amphibians within Canada's Prairie Provinces. These guidelines may also serve as a useful resource for other regions in Canada, or beyond. Many of the BMPs outlined in this document also apply to operational BMPs for amphibians and their habitat in the City of Calgary.
Habitat management guidelines for amphibians and reptiles of the northwestern United States and western Canada (Pilliod & Wind, 2008)	Partners in Amphibian and retile Conservation (PARC) is a partnership dedicated to the conservation of amphibians, retiles, and their habitat. This resource is one of their easy to understand and practical regional amphibian and reptile management guidelines for landowners and managers in Canada and the United States.
Protecting Nesting Birds: Best Management Practices for Vegetation and Construction Projects (City of Portland Bureau of Environmental Services, 2022)	Developed by the City of Portland Bureau of Environmental Services, this document provides information about nesting bird species in Portland and guidance to inform habitat management decisions, project timing, selection, and design, and miscellaneous maintenance activities. Although it's developed for Portland, many of the same BMPs are applicable to wetlands in Calgary.
Bird Beneficial Management Practices Guide for Utilities (Stantec Consulting Ltd., n.d.)	This Beneficial Management Practice (BMP) Guide was created to meet the requirements set out in the Migratory Birds Convention Act but will benefit all bird species. The BMP has been consciously developed based on extensive, first-hand experience of electricity facility construction and operation across Canada.
Protecting Nesting Birds: Best Management Practices for Vegetation and Construction Projects (City of Portland Bureau of Environmental Services, 2022)	This document provides information about nesting bird species in Portland and guidance that can inform habitat management decisions, project timing, selection, and design, and miscellaneous maintenance activities. Although Portland-specific, many of the species listed occur in Calgary.

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Miistakis Institute
EB3013, Mount Royal University
4825 Mount Royal Gate SW
Calgary, Alberta T3E 6K6

www.rockies.ca

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