Attachment A

FACET

Formerly DCG/Watershed

Best Available Science Review

Critical Areas Ordinance Update

CITY OF BELLEVUE

MAY 2, 2025

Prepared for:

City of Bellevue
450 110th Ave, NE
Bellevue, WA 98004

Facet Number: 2411.0456

Prepared by:

Dan Nickel – Principal of Planning
B.S. in Biology at Pacific Lutheran University
M.S. in Environmental Science at the University of Washington

Katy Crandall – Ecologist
B.S. in Environmental Science at Western Washington University
P.C. Wetland Science & Management at University of Washington
SWS Certified Professional Wetland Scientist and ISA Certified Arborist

Nell Lund - Senior Ecologist & Principal of Natural Resources
B.S. in Biology at Arizona State University,
P.C. in Wetland Science & Management at the University of Washington
SWS Certified Professional Wetland Scientist

Sam Payne - Ecologist
B.S. in Environmental Science at Western Washington University
P.S.M. in Fish and Wildlife Administration at Oregon State University
P.C. Wetland Science & Management at University of Washington
SWS Certified Professional Wetland Scientist and ISA Certified Arborist

Michael Place – Senior Geotechnical Engineer
B.S. Geological Engineering, Colorado School of Mines
Professional Engineer (Civil), Washington State
HWA GeoSciences, Inc.

JoLyn Gillie – Geotechnical Engineer, Principal
M.S. and B.S. Civil Engineering, Washington State University
Professional Engineer (Civil), Washington State
HWA GeoSciences, Inc.

FACET

Kirkland Office
750 6th Street S
Kirkland, WA 98033

425.822.5242

The information contained in this report is based on the application of technical guidelines currently accepted as the best available science. All discussions, conclusions and recommendations reflect the best professional judgment of the author(s) and are based upon information available at the time the study was conducted. All work was completed within the constraints of budget, scope, and timing. The findings of this report are subject to verification and agreement by the appropriate local, state and federal regulatory authorities. No other warranty, expressed or implied, is made.

Table of Contents

Appendices

Tables

Figures

Acronyms and Abbreviations

BAS	Best Available Science
BMP	Best Management Practices
CAO	Critical Areas Ordinance
CARA	Critical Aquifer Recharge Area
Commerce	Washington State Department of Commerce
Corps	U.S. Army Corps of Engineers
CMZ	Channel Migration Zone
DNR	Washington State Department of Natural Resources
DOH	Washington State Department of Health
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FFA	Frequently Flooded Area
FIRM	Flood Insurance Rate Map
FWHCA	Fish and Wildlife Habitat Conservation Area
GIS	Geographic Information System
GMA	Growth Management Act
HUC	Hydrologic Unit Code
LID	Low Impact Development
LUC	Bellevue Land Use Code
OHWM	Ordinary High Water Mark
NFIP	National Flood Insurance Program
NMFS	National Marine Fisheries Service
PHS	Priority Habitats and Species
RMZ	Riparian Management Zone
RCW	Revised Code of Washington
SPTH	Site Potential Tree Height
SPU	Seattle Public Utilities
USFWS	U.S. Fish and Wildlife Service
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WHPA	Wellhead Protection Areas

1. INTRODUCTION

This review of the best available science (BAS) was compiled to support Bellevue's Critical Areas Ordinance (CAO) update. As a requirement of the Washington State Growth Management Act (GMA) cities and counties must complete periodic updates to their comprehensive plans and development regulations. Bellevue's Comprehensive Plan underwent a full update in 2024. This document sets the framework for planned CAO updates in Bellevue. It serves as the basis for a gap analysis to identify where updates to current critical area regulations should be prioritized for consistency with BAS.

Under the GMA, Bellevue must "include the 'best available science' (BAS) when developing policies and development regulations to protect the functions and values of critical areas and must give 'special consideration' to conservation or protection measures necessary to preserve or enhance anadromous fisheries[1]" (WAC 365-195-900). Regulated critical areas include wetlands, areas with a critical recharging effect on aquifers used for potable water, fish and wildlife habitat conservation areas, frequently flooded areas, and geologically hazardous areas (RCW 36.70A.030).

While the BAS review is a resource for critical area management, it is not intended to provide definitive answers for all policy and regulatory decisions. Policy and regulations should incorporate BAS but also necessitate decision-making processes based on societal values. Additionally, ecological systems are highly complex and the scientific body of knowledge is constantly evolving with the advancement of new research and technology. Despite these advancements, there are limits to the current state of science and certain topics may not be fully understood. Where there is scientific uncertainty in the literature about a particular subject, this review presents a range of potential ideas, theories, or findings. In accordance with WAC 365-195-920, decision-makers may opt for a precautionary, or no-risk approach, when scientific information is incomplete.

1.1 Best Available Science

BAS means the current and best available information that follows a valid scientific process as specified in WAC 365-195-900 through WAC 365-195-925. Characteristics of a valid scientific process include peer review, standardized methods, logical conclusions and reasonable inferences, quantitative analysis, proper context, and references. Common sources of scientific information include research, monitoring, inventory, modeling, assessment, and synthesis (WAC 365-195-905). BAS literature reviews are a synthesis of the current scientific body of knowledge, and only resources that meet these requirements are included as reference materials for this BAS.

Bellevue's last comprehensive update to its CAO was in 2006; targeted CAO updates occurred in 2009, 2018, and 2020. In 2016, The Watershed Company prepared the report, *City of Bellevue Critical Areas*

---

[1] Anadromous refers to fish or fish species that spend portions of their life cycle in both fresh and salt waters, entering fresh water from the ocean to spawn.

Regulations Technical Report—Part 1: Update to Best Available Science and Existing Conditions (hereafter "2016 BAS Review," included as Appendix A (The Watershed Company 2016). Much of the science foundational to critical areas has not changed during this period and is still largely valid.

The 2016 BAS Review built upon the information presented in the *2005 BAS Review* (Herrera 2005a) and various 2003 critical areas inventory reports (listed below). The 2016 review focused on the scientific research, findings, and new agency guidance since 2005. Similarly, this BAS review does not intend to repeat information that has been comprehensively addressed elsewhere. Rather, established science or previous study findings are summarized or referenced where applicable in this document. Previously referenced studies are listed below:

<u>2016 BAS Review</u>

- *City of Bellevue Critical Area Regulations Technical Report—Part 1: Update to Best Available Science and Existing Conditions* (The Watershed Company 2016)
    - This document is referenced regularly throughout this BAS Review. It is included as **Appendix A** for easy reference; hereafter it will be referred to as "2016 BAS Review."

<u>2005 BAS Review Resources</u>

- *City of Bellevue's Critical Areas Update: 2005 Best Available Science (BAS) Review* (Herrera 2005a)
- *City of Bellevue's Critical Areas Update: Risk Analysis of No Action, Regulatory, City Programs, and Best Available Science Alternatives for Improving Critical Areas Protection* (Herrera 2005b)
- *Addendum to City of Bellevue Critical Areas Update: Risk Analysis of Council-Modified Alternative for Improving Critical Areas Protection* (Herrera 2006)

<u>2003 BAS and Critical Areas Inventory Resources</u>

- *Bellevue Critical Areas Update Best Available Science Paper: Streams* (City of Bellevue 2003a)
- *Bellevue Critical Areas Update Best Available Science Paper: Wetlands* (City of Bellevue 2003b)
- *Bellevue Critical Areas Update Best Available Science Paper: Wildlife* (City of Bellevue 2003c)
- *Bellevue Critical Areas Update Geologically Hazardous Areas Inventory* (City of Bellevue 2003d)
- *Bellevue Critical Areas Update Stream Inventory* (City of Bellevue 2003e)
- *Bellevue Critical Areas Update Wetland Inventory* (City of Bellevue 2003f)

1.2 Climate Change

As of July 2023, with passage of Washington House Bill 1181: Climate Change in Local Comprehensive Planning, the GMA requires jurisdictions to incorporate and evaluate the effects of climate change in long-range planning. Climate change is anticipated to have a profound influence on natural systems. Addressing anticipated climate change effects on critical areas allows for decision-makers to incorporate climate resilience into policy and regulations. This section provides an overview of predicted climate change effects in Washington State, focused on the Puget Sound region, that have the potential to alter the critical area functions and values in Bellevue. These predicted effects are referenced and expanded upon throughout the document.

Increasing air temperatures and more extreme heat

- Long-term warming, a lengthening of the frost-free season, and more frequent nighttime heat waves have been observed (Mauger, Casola, et al. 2015).
- Models predict more "hot days" each year (Ecology 2024).
- Global warming of about 1°C has already occurred. Warming may exceed 1.5°C (2.7°F) by 2030 (Snover, et al. 2019).

Changes to precipitation patterns

- Increases in both the frequency and intensity of heavy rainfall events have been documented in western Washington (Mauger, Casola, et al. 2015). Models predict more heavy rainfall events in the future (Ecology 2024) (Mauger and Won 2019).
- In the Puget Sound region, models initially showed a trend for a slight decrease in summer precipitation (Mauger, Casola, et al. 2015, Snover, Whitely Binder, et al. 2007, Mauger, Won and Hegewisch, et al. 2018). However, the latest projections suggest that an increase is more likely (Mauger and Won 2019).
- An observed and projected decrease in snowpack is anticipated to result in reduced stream flows later in the year (Ecology 2024).[2]
- Increasingly larger and more frequent floods are predicted with less snow and heavier, more frequent precipitation events (Ecology 2024).
- A likely reduction in groundwater availability is anticipated due to changes in precipitation patterns and intensity and timing of snowmelt combined with increased summer demand from people and ecosystems (Ecology 2024).

Rising sea levels and changing Puget Sound[2] conditions

- Sea levels have risen across Washington's coastline and are expected to continue to rise at an accelerated pace (Ecology 2024).
- Projected future sea level rise estimates include:
  - An increase of 1.5-2.5 feet for all coastal areas of the state by 2100 (Ecology 2024).
- With higher sea levels, coastal flooding and damage from storm surges are predicted to increase (Mauger, Casola, et al. 2015).
- Washington's coastal water temperatures have increased by 1.2°F since 1900 and warming is expected to continue (Ecology 2024).
- The acidity of the Puget Sound is increasing (i.e., pH values are decreasing) due to the absorption of carbon dioxide from the atmosphere into Puget Sound waters (Ecology 2024) (Mauger, Casola, et al. 2015).

---

[2] This summary is included for general informational purposes. Bellevue streams are generally not considered snow-fed. The City of Bellevue is not immediately adjacent to the Puget Sound.

Increasing risk of wildfire and smoke

- State-wide, hotter, drier summers and snowpack loss are projected to result in conditions that increase the likelihood of wildfires west of the Cascades (Mauger, Casola, et al. 2015, Raymond, et al. 2022); although the greatest wildfire risk increases occur outside of the Puget Sound region (Ecology 2024).
- While overall risk from wildfires in Bellevue may not be as extreme as in other parts of the state, smoke from wildfires elsewhere often moves into the Puget Sound basin. Projections for future changes in frequency or intensity of wildfire smoke are not available (Ecology 2024). The impact of wildfire smoke on natural systems is not fully understood (Voisin, et al. 2023).

Changing environmental conditions for flora, fauna and pathogens

- Climate change effects are anticipated to alter the timing of biological events, species' geographic distributions, productivity, and resilience of terrestrial ecosystems (Mauger, Casola, et al. 2015, Shirk, et al. 2021).
- The prevalence and location of certain pests and pathogens will likely shift. Responses are likely to be species- and host-specific (Mauger, Casola, et al. 2015).
- Introduced, adaptable species may experience greater opportunity to become established and spread after disturbance while locally evolved flora and fauna may experience stress from environmental changes that exceed historic ranges/thresholds. Plant and animal adaptability and resilience to climate change is variable by species.

2. FISH AND WILDLIFE HABITAT CONSERVATION AREAS

2.1 Definitions

Washington State defines fish and wildlife conservation areas (FWHCAs) in WAC 365-190-030(6) as follows:

(a) "Fish and wildlife habitat conservation areas" are areas that serve a critical role in sustaining needed habitats and species for the functional integrity of the ecosystem, and which, if altered, may reduce the likelihood that the species will persist over the long term. These areas may include, but are not limited to, rare or vulnerable ecological systems, communities, and habitat or habitat elements including seasonal ranges, breeding habitat, winter range, and movement corridors; and areas with high relative population density or species richness. Counties and cities may also designate locally important habitats and species.

(b) "Habitats of local importance" designated as fish and wildlife habitat conservation areas include those areas found to be locally important by counties and cities.

(c) "Fish and wildlife habitat conservation areas" does not include such artificial features or constructs as irrigation delivery systems, irrigation infrastructure, irrigation canals, or drainage ditches that lie within the boundaries of, and are maintained by, a port district or an irrigation district or company.

The following FWHCAs must be considered for classification and designation (WAC 365-190-130):

- *(a) Areas where endangered, threatened, and sensitive species have a primary association;*
- *(b) Habitats and species of local importance, as determined locally;*
- *(c) Commercial and recreational shellfish areas;*
- *(d) Kelp and eelgrass beds; herring, smelt, and other forage fish spawning areas;*
- *(e) Naturally occurring ponds under 20 acres and their submerged aquatic beds that provide fish or wildlife habitat;*
- *(f) Waters of the state;*
- *(g) Lakes, ponds, streams, and rivers planted with game fish by a governmental or tribal entity; and*
- *(h) State natural area preserves, natural resource conservation areas, and state wildlife areas.*

Bellevue regulates certain FWCHAs in the Bellevue Land Use Code (LUC), although under alternative terminology and structure. Streams and habitat associated with species of local importance, which includes naturally occurring ponds, are the two main categories. Streams are defined under LUC 20.25H.075.A as:

An aquatic area where surface water produces a channel, not including a wholly artificial channel, unless the artificial channel is:

1. used by salmonids; or
2. used to convey a stream that occurred naturally before construction of the artificial channel.

Habitats for designated species of local importance are defined as follows under LUC 20.50.024:

"Habitat" is the place, including physical and biotic conditions, where a plant or animal usually occurs and is fundamentally linked to the distribution and abundance of species. Species may depend on a Habitat or structural characteristics for part or all of its life history or may exhibit a high degree of adaptability using more than one Habitat. The relationship of species to Habitat is scale-dependent and varies from geographic range, home range, to local or site-specific Habitat components. "Habitat" includes areas of high relative density or species richness, breeding Habitat, winter range, and movement corridors. These areas may also include Habitats that are of limited availability or high vulnerability to alteration. Other examples include: remnant patches of mature mixed Puget Sound lowland forest, caves and cliffs, snag-rich areas and downed logs, riparian areas, lakes and ponds, wetlands and their buffers, and heron rookeries" (LUC 20.50.024). Ponds are designated as a type of habitat associated with species of local importance (LUC 20.25H.150.C).

2.2 FWHCAs in Bellevue

FWHCAs in Bellevue are categorized as "Streams, Lakes and Ponds, and Riparian Areas" and "Species and Habitats of Conservation Concern" for discussion in this section. There are no commercial or recreational shellfish areas, forage fish spawning, seagrass or kelp beds, state natural area preserves, natural resource conservation areas, or state wildlife areas which are inventoried or mapped within Bellevue.

2.2.1 Streams, Lakes and Ponds, and Riparian Areas

Bellevue is situated in the Cedar-Sammamish Water Resource Inventory Area (WRIA 8) and comprises three sub-watersheds: Lake Washington-Sammamish River Watershed (Hydrologic Unit Code [HUC] 171100120400), Lake Sammamish-Sammamish River Watershed (HUC 171100120202), and Bear Creek-Sammamish River Watershed (HUC 171100120304) (Figure 1) Additionally, the City defines 25 drainage basins (Figure 2) for characterization and management. Bellevue-defined basins and associated aquatic resources are shown in Table 1.

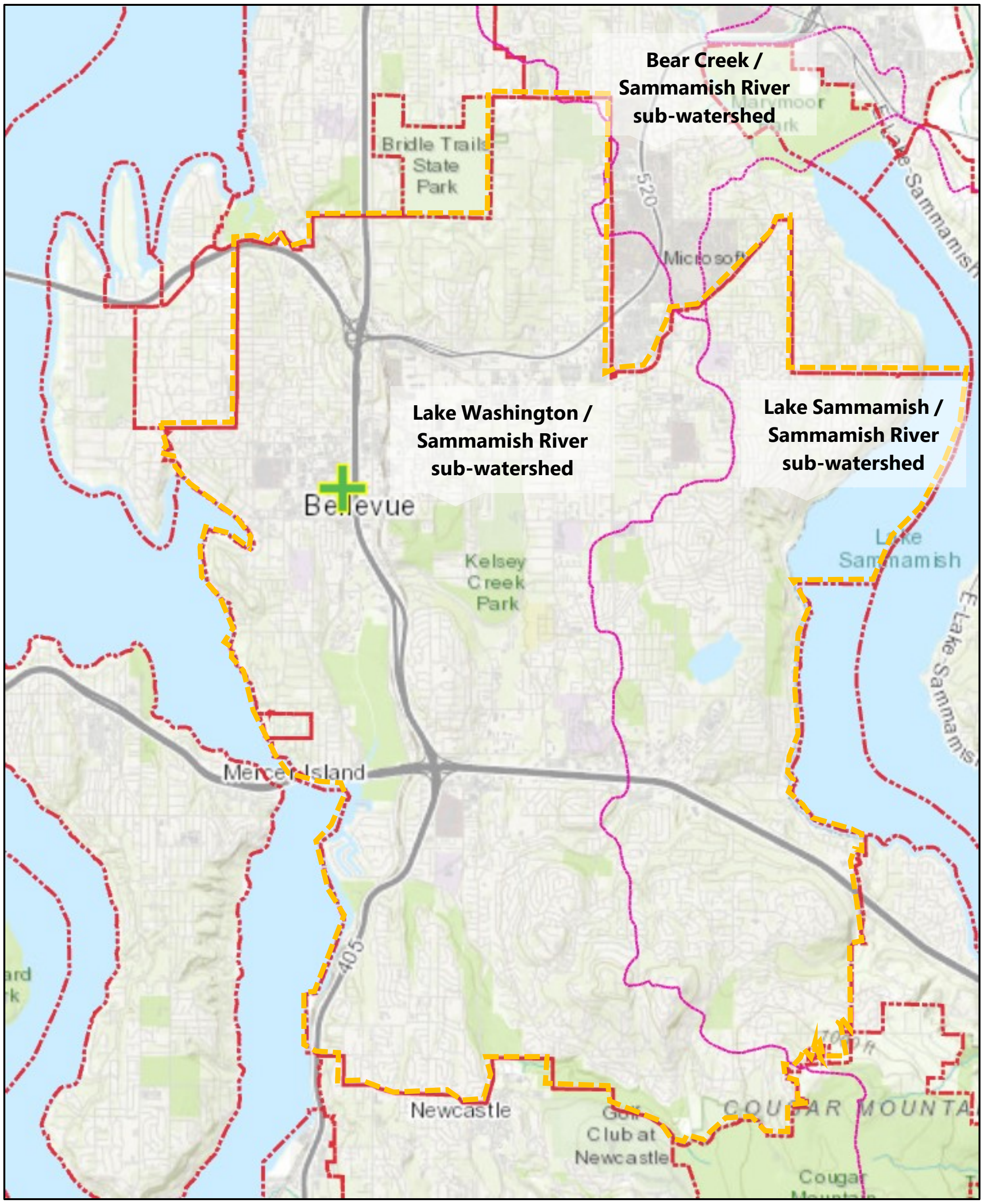

Figure 1. Sub-watersheds in City of Bellevue (Source: Ecology Water Quality Atlas)

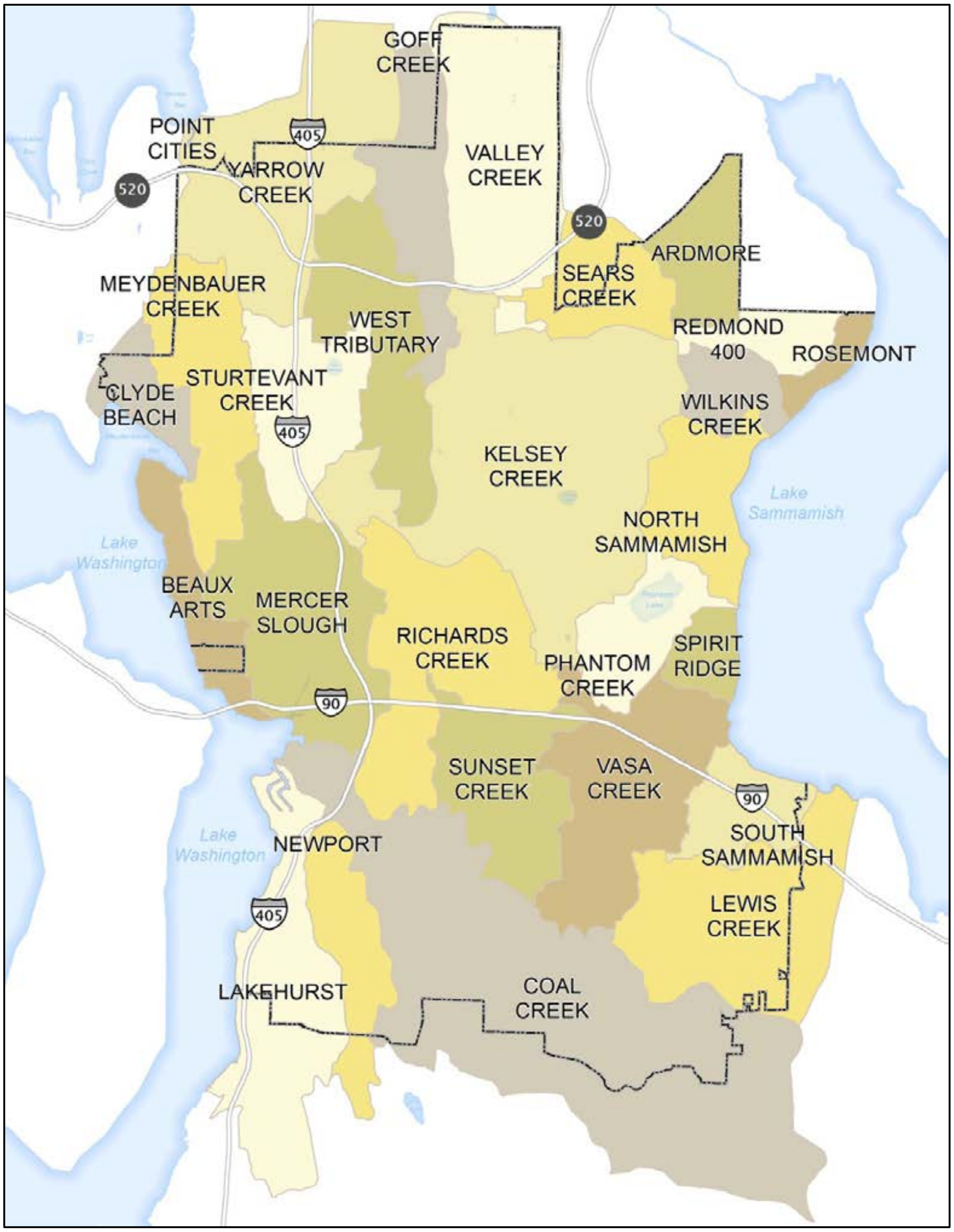

Figure 2. Map of 25 Bellevue-defined drainage basins used for planning and management.

Table 1. List of basins and streams in Bellevue, excluding unnamed and numbered tributaries to named streams.

Basin	Stream	Lakes and Large Ponds
Other	n/a	Lake Washington Lake Sammamish
Ardmore/Idylwood	Idylwood Creek	
Beaux Arts Area	n/a	
Clyde Beach	Meydenbauer Creek	
Coal Creek	Coal Creek	
Goff Creek	Goff Creek Unnamed streams	
Kelsey Creek	Kelsey Creek Unnamed streams	Larsen Lake
Lakehurst Area	Lakehurst Creek Stream 0281C Stream 0281B Unnamed streams	
Lewis Creek	Lewis Creek	
Mercer Slough	Mercer Slough (West and East)	
Meydenbauer Creek	Meydenbauer Creek	
Newport Area	Newport Creek Stream 0268Z	
North Sammamish	Stream 0151 Unnamed streams	
Phantom Creek	Phantom Creek	Phantom Lake
Richards Creek	Richards Creek East Creek	
Rosemont Area	n/a	
Sears Creek	Sears Creek	
South Sammamish Area	Stream 0161 Stream 0162 Unnames streams	
Spirit Ridge Area	Unnamed stream	
Sturtevant Creek Basin	Sturtevant Creek	Lake Bellevue
Sunset Creek	Sunset Creek	
Valley Creek	Valley Creek	Swan Lake
Vasa Creek	Vasa Creek East Tributary Vasa Creek Stream 0160 Unnamed stream	
West Tributary	West Tributary Unnamed streams	
Wilkins Creek	Wilkins Creek	
Yarrow Creek	Yarrow Creek	

Bellevue has been working on a *Watershed Management Plan* since 2020. As part of that effort, watershed assessments have been conducted for the Coal Creek Watershed, Kelsey Creek Watershed, Lake Sammamish Watershed, and Small Lake Washington Tributaries Watershed. These watershed units represent combined drainage basins (from Figure 2). The watershed assessment reports provide detailed summaries of existing conditions in each respective watershed, evaluate limiting factors, review past and present investments, list opportunities for enhancement, and identify data gaps. Information about the Watershed Management Plan and links to each of the watershed assessment reports are available online: https://bellevuewa.gov/city-government/departments/utilities/utilities-projects-plans-standards/capital-projects/watershed-management.

2.2.2 Species and Habitats of Conservation Concern

2.2.2.1 Terrestrial Habitats

Most of the land in Bellevue was historically lowland conifer-hardwood forests, wetland, and lacustrine habitat (Johnson and O'Neil 2001). Urbanization has significantly altered available habitat and habitat conditions in the City over time. The general characterization provided in the *2005 BAS Review* (Herrera 2005a) remains applicable.

The 2016 BAS Review (Appendix A) reported a decrease in tree canopy of 20 percent between 1986 and 2006. Tree canopy was 36 percent in 2016. Tree canopy reached 40 percent cover in 2021 (PlanIT Geo, Inc. 2023).

Some important terrestrial habitats in Bellevue are classified as WDFW Biodiversity and Corridor, located along slopes and/or in riparian corridors, including relatively large tracts of undisturbed vegetation. The Coal Creek corridor is identified as part of King County's wildlife habitat network, meaning that this is an important wildlife corridor at the landscape scale.

2.2.2.2 Listed Species

WDFW lists priority habitats and species (PHS) by county. Table 2 includes a summary of the King County PHS list, which also includes all state and federally listed species, current as of the date of this report. Many of the species included in this list are unlikely to be present in an urban area such as Bellevue, though, even rare species may be found infrequently. As WDFW notes, habitats and species can change over time as distributions expand or contract.

The 2016 BAS Review (Appendix A) notes that Bellevue's 23 designated Species of Local Importance (LUC 20.25H.150) represent "all state and federally listed sensitive, threatened, and endangered species, as well as priority species likely to occur in the city and some species that do not have state or federal status." While this remains generally true, the western bumble bee (*Bombus occidentalis*) is now a candidate for both state and federal listing and may occur in Bellevue.

According to the Statewide Integrated Fish Distribution map, four basins have documented presence of salmon including Coal Creek, Kelsey Creek (and tributaries), Phantom Creek, and Yarrow Creek.

Bellevue has been monitoring spawning abundance since 1999 in select streams and reports variable returns over the last decade (Heller 2023).

Table 2. List of WDFW-designated priority habitats and species which occur in King County. Not all species have range overlap with Bellevue city limits. Species and habitats associated with marine environments have been excluded from this table.

	Species and Habitats	State Status	Federal Status
Habitats	Biodiversity Areas and Corridors		
	Herbaceous Balds		
	Old-Growth/Mature Forest		
	Oregon White Oak Woodlands		
	West Side Prairie		
	Riparian		
	Freshwater Wetlands and Fresh Deepwater		
	Instream		
	Caves		
	Cliffs		
	Snags and Logs		
	Talus		
Fishes	Pacific Lamprey		
	River Lamprey	Candidate	
	White Sturgeon		
	Olympic Mudminnow	Sensitive	
	Bull Trout/ Dolly Varden	Candidate	Threatened
	Chinook Salmon		Threatened
	Chum Salmon		Threatened
	Coastal Res./ Searun Cutthroat		
	Coho Salmon		Threatened–Lower Columbia
	Kokanee		
	Pink Salmon		
	Pygmy Whitefish	Sensitive	
	Rainbow Trout/ Steelhead/ Inland Redband Trout	Candidate	Threatened
	Sockeye Salmon		Threatened–Ozette Lake
Amphibians	Larch Mountain Salamander	Sensitive	
	Oregon Spotted Frog	Endangered	Threatened
	Western Toad	Candidate	
Reptiles	Northwestern Pond Turtle	Endangered	Proposed Threatened
Birds	Common Loon	Sensitive	
	Marbled Murrelet	Endangered	Threatened
	Western Grebe	Candidate	
	W WA nonbreeding concentrations of: Loons, Grebes, Cormorants, Fulmar, Shearwaters, Storm-petrels, Alcids		
	W WA breeding concentrations of: Cormorants, Storm-petrels, Terns, Alcids		

	Species and Habitats	State Status	Federal Status
	Great Blue Heron		
	Western High Arctic Brandt		
	Cavity-nesting ducks: Wood Duck, Barrow's Goldeneye, Common Goldeneye, Bufflehead, Hooded Merganser		
	Western Washington nonbreeding concentrations of: Barrow's Goldeneye, Common Goldeneye, Bufflehead		
	Harlequin Duck		
	Trumpeter Swan		
	Tundra Swan		
	Waterfowl Concentrations		
	Golden Eagle	Candidate	
	Northern Goshawk	Candidate	
	Sooty Grouse		
	W WA nonbreeding concentrations of: Charadriidae, Scolopacidae, Phalaropodidae		
	Band-tailed Pigeon		
	Yellow-billed Cuckoo	Endangered	Threatened
	Northern Spotted Owl	Endangered	Threatened
	Vaux's Swift		
	Black-backed Woodpecker	Candidate	
	Oregon Vesper Sparrow	Endangered	
Mammals	Roosting Concentrations of: Big-brown Bat, Myotis bats, Pallid Bat		
	Townsend's Big-eared Bat	Candidate	
	Cascade Red Fox	Endangered	
	Fisher	Endangered	
	Marten		
	Wolverine	Candidate	Threatened
	Columbian Black-tailed Deer		
	Mountain Goat		
	Elk		
Invertebrates	Blue-gray Taildropper	Candidate	
	Pacific Clubtail	Candidate	
	Beller's Ground Beetle	Candidate	
	Hatch's Click Beetle	Candidate	
	Western Bumble Bee	Candidate	Candidate
	Johnson's Hairstreak	Candidate	
	Valley Silverspot	Candidate	

2.3 Functions and Values

FWHCA functions include the biological, chemical, and physical habitat conditions and processes that affect wildlife. Since wildlife may include all species, from the largest megafauna to microorganisms, these functions encompass a complex web of interacting ecological processes. At the highest level, FWHCAs function to provide wildlife with suitable habitat. They also provide communities with sources of food and materials for consumptive and productive uses. Additionally, they are valued for a range of non-consumptive cultural, social, and economic benefits (Chardonnet, et al. 2002).

2.3.1 Streams, Lakes and Ponds, and Riparian Areas

Streams, lakes, ponds, and their associated riparian areas provide critical habitat for a diverse array of wildlife species. They also provide various landscape and ecosystem functions. Commonly recognized functions and processes that influence the habitat conditions within aquatic FWHCA types are outlined below.

Water Quality

- Fish and other wildlife like amphibians require cool, clean water to meet their life history needs.
    - Riparian vegetation influences stream temperatures and microclimate conditions such as air temperature, wind, light, and moisture. Factors affecting water temperature and microclimate include shade, orientation, relative humidity, ambient air temperature, wind, channel dimensions, groundwater, hyporheic exchange, and overhead cover (Quinn, Wilhere and Krueger 2020).
    - Salmonids have been studied frequently due to their cultural and economic importance, relative sensitivity to high temperatures, and narrow thermal tolerance (Quinn, Wilhere and Krueger 2020). Amphibians also have narrow thermal tolerances, and they are particularly sensitive to changes in microclimate conditions (Bury 2008).

Hydrologic

- Streams, lakes, and ponds may have complex and extensive connections to other surface waters and groundwater resources in a watershed.
    - Hydrologic forces move material downstream.
- Fish and wildlife are adapted to, and in some instances reliant upon, the natural variability in seasonal and flood flows within a system.
- Riparian vegetation reduces the quantity of surface water runoff through rainwater capture and evapotranspiration (Wynn and Mostaghimi 2006).
- Floodplains, wetlands, and sinuous stream channels attenuate flood flows, which protects downstream areas from flooding.

Physical Habitat Characteristics

- Riparian microclimate affects many ecological processes and functions, including plant growth, decomposition, nutrient cycling, succession, productivity, migration and dispersal of flying insects, soil microbe activity, and fish and amphibian habitat (Brosofske, et al. 1997).
- Large woody debris (LWD) plays a significant role in the geomorphic formation of stream channels and in the creation of diverse channel habitat morphologies (Quinn, Wilhere and Krueger 2020).
- Streams migrate naturally which often results in complex natural geomorphology, floodplains, and heterogeneous ecosystems.
    - Bank stability is influenced by factors such as bank material, hydraulic forces, and vegetation (Ott 200).
- Beaver dams incorporate both small and large wood, and serve to slow water, retain sediment, and create pools and off-channel ponds used by rearing coho salmon and cutthroat trout (Pollock, et al. 2004, Naiman, Johnston and Kelley 1988).

2.3.1.1 Urbanization Impacts

Urbanization affects natural surface waters and riparian areas (and associated fish and wildlife) in significant and numerous ways. This section outlines the mechanisms by which urbanization impacts the key functions and processes previously described.

Changing Landcover and Impervious Surfaces

- Removal of riparian vegetation impacts water quality by increasing stream temperatures (Beschta et al. 1987; Murray et al. 2000, Moore et al. 2005, Gomi et al. 2006).
- Widespread removal of forested areas in a watershed is likely to create unstable channels (Booth, Hartley and Jackson 2002). Increased erosion and bank instability coupled with a reduction of forest cover simplify stream morphology, leading to incised, wider, and straighter stream channels (Konrad, Booth and Burges 2005).
- Impervious surfaces impact hydrologic functions.
    - Impervious surface is positively correlated with high flow volumes, daily streamflow variability and negatively correlated with groundwater recharge rates and summer low flow volumes (Burges, Wigmosta and Meena 1998, Cuo, et al. 2009, Jones 2000, Konrad and Booth 2005).
    - Flows become more synchronized and become more variable and volatile (Sheldon, et al. 2005).
    - Less dynamic stream morphology is linked to accelerated water transport and reduced temporary instream flood storage capacity (Kaufmann and Faustini 2012).
    - Hydrological functions are also altered through soil compaction, draining, and ditching across a landscape (Moore and Wondzell 2005, Booth, Hartley and Jackson 2002).

Habitat Removal, Degradation, and Fragmentation

- Habitat loss, degradation, and fragmentation have profound impacts on wildlife and their ecosystems (Gaston 2010, Wiegand, Revilla and Moloney 2005, Young, et al. 2016).

    - Habitat loss and fragmentation reduce biodiversity (MacArthur and Wilson 1967).
- Anthropogenic inputs and disturbance from high-intensity land uses (e.g., noise, light, physical intrusions by people and pets, pollution, garbage, etc.) degrade retained habitats in urban settings.
- Fragmentation from roads, fences, buildings, and various land uses restrict interpatch movements and migrations in urban landscapes (Wiegand, Revilla and Moloney 2005).
- Urban areas tend to contribute a disproportionate amount of sediment and contaminants to receiving waters (Soranno, et al. 1996). Heavy metals, bacterial pathogens, as well as PCBs, hydrocarbons, and endocrine-disrupting chemicals are aquatic contaminants that are commonly associated with urban and agricultural land uses.
    - Some contaminants have significant effects on aquatic organisms. For example, coho salmon pre-spawn mortality is caused by a breakdown product of tire wear, 6PPD-quinone (Tian, et al. 2020). Coho pre-spawn mortality is also positively correlated with the relative proportion of roads, impervious surfaces, and commercial land cover within a basin (Fiest, et al. 2011).
    - Fine sediment adversely affects stream habitat (Jensen, et al. 2009, Galbraith, et al. 2006, Knutson, et al. 2004). .
- Cumulative impacts of direct and indirect habitat alterations, including hydrologic changes, compromised water quality, and habitat fragmentation tend to reduce the habitat functions and values of wetlands and riparian areas (Azous and Horner 1997, Sheldon, et al. 2005).

2.3.1.2 Comparison to 2016 BAS Review Findings

The 2016 BAS Review (Appendix A) concluded that the previous understanding of functions and values of instream habitat and the surrounding riparian area remained generally relevant. Noted, key BAS updates included the following:

- Untreated stormwater poses a significant impact on these habitats.
- Stormwater treatment is effective and important.
- Non-fish bearing streams are important to downstream habitat, flow, and water quality conditions.
- Culverts that pass all flows and woody debris are important for maintaining habitat functions in urban settings.

2.3.2 Species and Habitats of Conservation Concern

The 2016 BAS Review (Appendix A) states:

> *The 2009 Urban Wildlife Study [The Watershed Company 2009] described the significant issues and features associated with wildlife in an urban setting. The precepts discussed in that document hold true today with only minor nuanced updates in the body of scientific literature related to the role of*

habitat gaps and disturbance (e.g., Ficetola et al. 2009, Tremblay and St. Clair 2009) and corridors (Gilbert-Norton et al. 2010) in urban wildlife habitat.

BAS continues to stress the importance of wildlife habitat corridors and connections in supporting diverse urban wildlife (Ecology 2022, WDFW 2015).

2.4 Protective Measures

2.4.1 FWHCA Identification and Classification

Numerous online resources are available that can be used to aid in determining likely presence or absence of the various types of FWHCAs. Several important online mapping tools are listed below; however, this list is not exhaustive. Not all FWHCAs are mapped, and anything identified online should be verified in the field by a qualified biologist.

- National Oceanic and Atmospheric Administration Fisheries Maps
- U.S. Fish and Wildlife Service (USFWS) Information for Planning and Consultation online tool
- WDFW Priority Habitats and Species Database (PHS on the Web)
- Washington State Department of Natural Resources (DNR) Natural Heritage Program Data Explorer

2.4.1.1 Waters of the State

Waters of the state include lakes, rivers, ponds, streams, inland waters, underground waters, salt waters, wetlands[3] and all other surface waters and watercourses (RWC 90.48.020, WAC 173-201A-020). The ordinary high water mark (OHWM) is typically used to determine the edge of surface waters for jurisdictional purposes. However, for tidal waters, the Corps uses the high tide line to determine jurisdiction, while Ecology uses the OHWM if present or the line of mean higher high tide if the OHWM cannot be found. The definition of OHWM is slightly different between the Corps and Ecology, but the meaning is essentially the same. The OHWM should be determined in the field by a qualified biologist using one of the following manuals:

- *National Ordinary High Water Mark Field Delineation Manual for Rivers and Streams* (David, et al. 2025)
- *Determining the Ordinary High Water Mark for Shoreline Management Act Compliance in Washington State* (Anderson, et al. 2016)

DNR classifies streams and other water bodies using a the "water typing system" based on various characteristics, fish use, and functions of a natural water feature (WAC 222-16-030), summarized in Table 1. Characteristics common to water typing systems are flow volume, fish use and accessibility, seasonality, and presence of salmonids. The 2016 BAS Review (Appendix A) recommended use of this

---

[3] Wetlands, while considered a type of water of the state, are typically regulated in a separate section of a local jurisdiction's critical areas regulations.

water typing system, consistent with the statewide water typing approach. However, the latest riparian management zone guidance from WDFW does not use the water typing system, but instead treats all streams equally and differentiates protection based on soil type and associated dominant tree species (Rentz, et al. 2020). This new riparian management zone guidance is discussed further in Section 2.4.2.2.

Table 3. Water type classifications using DNR's water typing system.

Type	Description
Type S= Shoreline	Streams and waterbodies that are designated "shorelines of the state" as defined in chapter 90.58.030 RCW.
Type F= Fish	Streams and waterbodies that are known to be used by fish, or meet the physical criteria to be potentially used by fish. Fish streams may or may not have flowing water all year; they may be perennial or seasonal.
Type Np= Non-Fish	Streams that have flow year round and may have spatially intermittent dry reaches downstream of perennial flow. Type Np streams do not meet the physical criteria of a Type F stream. This also includes streams that have been proven not to contain fish using methods described in Forest Practices Board Manual Section 13.
Type Ns= Non-Fish Seasonal	Streams that do not have surface flow during at least some portion of the year, and do not meet the physical criteria of a Type F stream.

2.4.2 Management Resources and Standards

2.4.2.1 Fixed-width Buffers based on Water Typing

As described in Bellevue's prior BAS paper on streams, most local jurisdictions in Washington State have managed stream and riparian habitats using fixed- or standard-width stream buffers, historically (City of Bellevue 2003a). Typically, buffer widths have been determined based upon stream type characteristics and site-specific factors using this approach. This protection mechanism arose in the forestry industry after stream habitats were impacted during the industrial forestry expansion in the mid-20th century (Richarson, Naiman and Bisson 2012). The benefit of the set-width prescriptive buffer is that it is relatively simple to establish, implement, and administer. If fixed-width buffers are implemented, buffers should be sufficiently wide to ensure that riparian buffers are effective under a range of variable conditions. The latest BAS and state guidance recommends a conceptual shift from the fixed-width buffer approach regarding the way that streams and riparian areas are protected, as described in the next section.

2.4.2.2 Riparian Management Zones

In 2020, WDFW developed BAS guidance for the protection of riparian areas (Rentz, et al. 2020, Quinn, Wilhere and Krueger 2020). The guidance emphasizes a shift in terminology and framework from the concept of "stream buffers" to "riparian management zones" (RMZs). A RMZ is defined as "…a scientifically based description of the area adjacent to rivers and streams that has the potential to provide full function based on the SPTH [site potential tree height] conceptual framework." Further, a RMZ is recommended to be regulated as a fish and wildlife habitat conservation area itself to protect its fundamental value, rather than as a buffer for rivers and streams (Rentz, et al. 2020).

WDFW's current recommendations for establishing RMZ widths are based primarily on a site potential tree height (SPTH) framework. The SPTH is defined as "…the average maximum height of the tallest dominant 4 trees (200 years or more) for a given site class." To apply their methodology, WDFW has developed a web-based mapping tool for use in determining SPTH based on the 200-year site index. Modeled SPTHs range from 75-231 feet (Rentz, et al. 2020).

WDFW recommends using the SPTH value as the basis for the RMZ width, measured from the edge of the channel migration zone or OHWM where a channel migration zone is not present. Exceptions may occur where the SPTH is less than 100 feet, in which case the agency recommends assigning an RMZ width of 100 feet at a minimum to provide adequate biofiltration and infiltration of runoff for water quality protection from most pollutants, but also in consideration of other habitat-related factors including shade and wood recruitment. A 100-foot-wide buffer is estimated to achieve 95 percent pollution removal and approximately 85 percent surface nitrogen (Rentz, et al. 2020). RMZ buffer recommendations presume the area is densely vegetated with native plants.

Acknowledging that establishing functional RMZs using the recommended methods may not be practical in many developed areas, WDFW recommends effective watershed management, preservation, and protection, resulting in nearly full restoration of riparian ecosystem habitat functions as is feasible within existing constraints. Other WDFW management recommendations for urban riparian ecosystems include delineating stream ordinary high water marks and associated riparian management zones, document current conditions and target degraded riparian areas for restoration, maintain or improve functions through regulations and voluntary measures, prioritize opportunities to maintain and restore in-stream and riparian connectivity, manage stormwater following latest Ecology manual, and require stormwater retrofit for redevelopment projects (Rentz et al. 2020).

2.4.2.3 Other Management Strategies

Many of the scientific studies that examine the functions and values associated with riparian areas have been conducted in forested environments. However, there are fundamental differences between forested, agricultural, and urban areas, including land use and hydrology. Riparian studies often do not account for the contribution of engineering and public works projects, such as surface water detention facilities, that can supplement natural riparian function in urban settings. However, WDFW notes that riparian ecosystem principles apply equally to urban settings. WDFW concludes it is critical to maintain connectivity for fish passage and terrestrial habitat corridors, manage stormwater, protect high functioning areas, and prioritize restoration in urban riparian ecosystems (Rentz et al. 2020). BAS-based literature points to a range of recommended management measures and buffer considerations to help

[4] Dominant trees are those which extend above the normal level of the forest canopy.

maintain habitat functions for fish and wildlife. Effective methods to reduce impacts from urbanization and manage associated runoff can include the following:

- Limiting or consolidating development densities and impervious surface coverage;
- Limiting vegetation clearing and retaining forest cover;
- Concentrating impact activities, particularly roads and pollutant sources, away from watercourses;
- Limiting the total area of roads and requiring joint use of new access roads;
- Protecting vegetation and limiting development on or near hydrologic source areas;
- Maintaining densely vegetated riparian buffers with native trees, shrubs, and groundcover species;
- Low impact development (LID);
- Municipal stormwater treatment;
- Public education.

. To achieve improved water quality in the City's streams, lakes, and ponds, riparian buffer areas should be utilized effectively to provide both biofiltration of stormwater runoff and protection from adjacent land uses. Both goals can be achieved by providing dense, well-rooted vegetated buffer areas.

Biofiltration swales, created wetlands, and infiltration opportunities for specific stormwater runoff discharges can be utilized to intercept runoff before it reaches stream channels. Stormwater runoff that is conveyed through stream buffers in pipes or ditch-like channels and discharged directly to stream channels "short circuits" or bypasses buffer areas. To maintain buffer functions, including water quality treatment via biofiltration, discharges should be dispersed in outer buffer areas. In areas where stormwater flows untreated through riparian buffer areas, the buffer is underutilized and is prevented from providing the intended or potential biofiltration function.

2.4.2.4 Endangered, Threatened, or Sensitive Species; Species of Local Importance; and their Habitats

Effective BAS-based strategies can be applied to protect all state and federally listed endangered or threatened species and WDFW-identified Priority Species and Habitats (PHS). WDFW, USFWS, and NMFS provide information on species-specific management recommendations that can be used to guide management at the City level or site level. There is widely available information for high profile species, though many regulated species are poorly researched and lack specific management recommendations from state agencies. Where species- or habitat-specific management recommendations are available from WDFW guidance documents, those should be followed or adapted to local regulations. General recommendations for management strategies to protect terrestrial habitat are listed below.

General Terrestrial Habitat Management Recommendations

- Existing high-quality habitats should be retained because habitat loss is one of the most important factors influencing biodiversity and loss of species (Beninde, Veith and Hochkirch 2015).
- Generally, plan development to minimize fragmentation of native habitat, particularly large, intact habitat areas. Where large forest stands exist, manage for forest-interior species and avoid fragmentation (Donnelly and Marzluff 2004, Diffendorfer, Gaines and Holt 1995, Mason, et al. 2007, Pardini, et al. 2005, WDFW 2009).
- Protect priority habitats that have a primary association with an ESA-list species or species of local importance by continuing to regulate for adherence to WDFW management recommendations and other applicable regulatory requirements.
- Control invasive species where needed on a site- and species-specific basis. Address invasive species specifically in areas where environmental conditions tend to promote infestation, including created edges, roadways, and riparian zones where they are contiguous with developed areas that may act as a seed source (Olden et al. 2004, Pimentel et al. 2005, McKinney 2002 and others).
- Maintain or provide habitat connectivity with vegetated corridors between habitat patches (Gillies and Clair 2008, Gilbert-Norton et al. 2010 and others).
- Protect, maintain, and promote habitat features such as snags and downed wood (Blewett and Marzluff 2005).
- Manage for increase native vegetative cover in landscaping and discourage lawns (Nelson and Nelson 2001).
- Plan habitat areas away from roads (Fahrig et al. 1995, Lehtinen et al. 1999).
- Promote buffers of adequate width to support wildlife guilds in adjacent habitat (Ficetola et al. 2008, Semlitsch and Bodie 2003, Crawford and Semlitsch 2007).
- Identify existing habitat patches and corridors and maintain connectivity with vegetated corridors to limit fragmentation and edge habitat (Gillies and Clair 2008, Gilbert-Norton et al. 2010). Preserve habitat patches of at least moderate size 35 ha (86 ac) within developed areas (Kissling and Garton 2008).
- Promote restoration of FWHCAs, buffers, and other management zones through critical area regulations and public outreach. Encourage stewardship on a parcel by parcel and county-wide scale.

2.5 Climate Change Impacts and Mitigation

Climate change is predicted to result in significant and irreversible impacts to fish and wildlife, and their habitats. Global climate change is anticipated to result in habitat loss and modification through temperature changes, sea level rise, ocean acidification, extreme weather events, changes in precipitation, biological invasions, food web disruptions, and disease (Lyons et al. 2022; (Nagelkerken, et al. 2023). The range of effects on fish and wildlife depend on species specific interactions and may include range shifts, phenological shifts, changes to morphology and behavior, biodiversity loss, and extinction (Sattar, et al. 2021). The cumulative impact of these factors on wildlife is anticipated to result in loss of biodiversity and increases to extinction rates (Sattar, et al. 2021).

Changes in temperatures and seasonal precipitation patterns are projected to place additional stressors on FWHCAs. Some loss of riparian vegetation is anticipated due to the stresses of climate change, primarily warmer and drier summers. A reduction in riparian vegetation potentially triggers a cascading effect. A decrease in riparian vegetation would decrease shading, increase stream temperature, decrease detrital inputs, reduce available habitat structure, and reduce stream bank stability. Changes in seasonal hydrologic cycles may increase frequency and magnitude of flashy runoff events, mobilize greater volumes of sediments and pollutants into streams, and reduce groundwater recharge that supports base stream flows in summer. Instream habitats are particularly negatively impacted by excess sediment discharge and deposition.

Hot dry summers are projected to reduce stream flow volumes and increase instream temperatures. This stressor is compounded by extreme precipitation events, flooding and erosion. All these stressors reduce instream habitat quality and stress salmonid populations, including Chinook salmon, the preferred food source for Orca whales. Global warming poses a threat to freshwater fish habitat (Crozier, Zabel and Hamlet 2008).

2.5.1 Strategies to Manage Climate Change Impacts on FWHCAs

The following actions or policies have been developed for other local jurisdictions in coordination with the University of Washington Climate Impacts Group, and are potential strategies that Bellevue could use to reduce negative climate change impacts on FWHCAs (The Watershed Company 2022).

- Promote retention of trees and forests and maintain tree replacement and reforestation requirements.
- Encourage and incentivize enhancement and restoration of native forest patches throughout the City, particularly where connectivity to one or more FWHCAs is identified. Both voluntary and required restoration planting should be paired with monitoring and maintenance that allows for dry season irrigation and adaptive management.
- Consider assisted migration for seed selection of native plants from locations that are better adapted to future climate conditions.
- Manage stormwater infrastructure to avoid and minimize discharges of increased and/or untreated runoff to streams and thereby offset the anticipated increase in intensive rainfall events. Promote the use of LIDs as a tool to effectively manage stormwater for minimal downstream impacts.
- Update and maintain regulations for habitats and species of local importance. This may include adding mapping resources to help identify the locations of potential habitats and species requiring protection and management.
- Prioritize protection of streams and riparian corridors to reduce the stresses of climate change on native fish species and anadromous fish, such as chinook salmon.
- Identify and protect cold water refugia in waterbodies.

- Conduct vulnerability assessments and climate action plans.

3. WETLANDS

3.1 Definitions

Washington State defines wetlands in WAC 365-190-030(24) as follows:

> *'Wetland' or 'wetlands' means areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands do not include those artificial wetlands intentionally created from nonwetland sites, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. However, wetlands may include those artificial wetlands intentionally created from nonwetland areas to mitigate conversion of wetlands, if permitted by the county or city.*

The Bellevue definition of a wetland closely mirrors the Washington State definition (LUC 20.25H.095):

> *Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands do not include those artificial wetlands intentionally created from nonwetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from nonwetland areas to mitigate the conversion of wetlands.*

3.2 Wetlands in Bellevue

Wetlands are relatively common throughout the Puget Lowlands and can be found throughout Bellevue (Figure 2). Wetlands most commonly occur and are typically concentrated in topographic and hydrologic low points such as valleys, depressions, the base of slopes, and along the margin of lakes and ponds. Some prominent Bellevue wetlands include those through the Mercer Slough, along the lakeshore of Meydenbauer Bay, near Kelsey and Richards Creeks, and those between Phantom Lake and Larsen Lake.

The *Bellevue Critical Areas Update: Wetland Inventory* study found that the largest number and most diverse wetlands were located in the Kelsey Creek/Mercer Slough basin, followed by the Coal Creek and Lewis basins (City of Bellevue 2003f).

3.3 Functions and Values

Wetlands are highly productive ecosystems that provide functions through physical, chemical and biological processes. The literature has previously established that wetlands provide numerous ecological functions with associated cultural and social values and economic benefits. Wetland functions vary for a given wetland based on multiple factors, including wetland landform or hydrogeomorphic class, landscape setting, vegetation structure, hydroperiods, and presence or absence of priority habitats and species.

The *Bellevue Critical Areas Update: Wetland Inventory* study discusses specific wetland functions in Bellevue by basin (City of Bellevue 2003f). Wetland functions are also summarized in the *2005 BAS Review* (Herrera 2005a). The primary ecological functions of wetlands in Washington can be grouped into the following categories (Hruby and Yahnke 2023):

- Improving water quality
    - Intercepting and detaining surface water runoff
    - Filtering sediment and pollutants
    - Uptake of nutrients including phosphorous and nitrogen
- Maintaining the water regime in a watershed (*i.e.*, hydrologic functions)
    - Desynchronizing surface water flows and reducing flooding
    - Recharging groundwater/aquifers
    - Maintaining base stream flows in the dry season
- Providing wildlife habitat
    - Seasonal/permanent inundation or saturation
    - Varying complexity of vegetative structure and diversity
    - Nesting and foraging habitat and migration corridors
    - Microclimate, refuge from heat

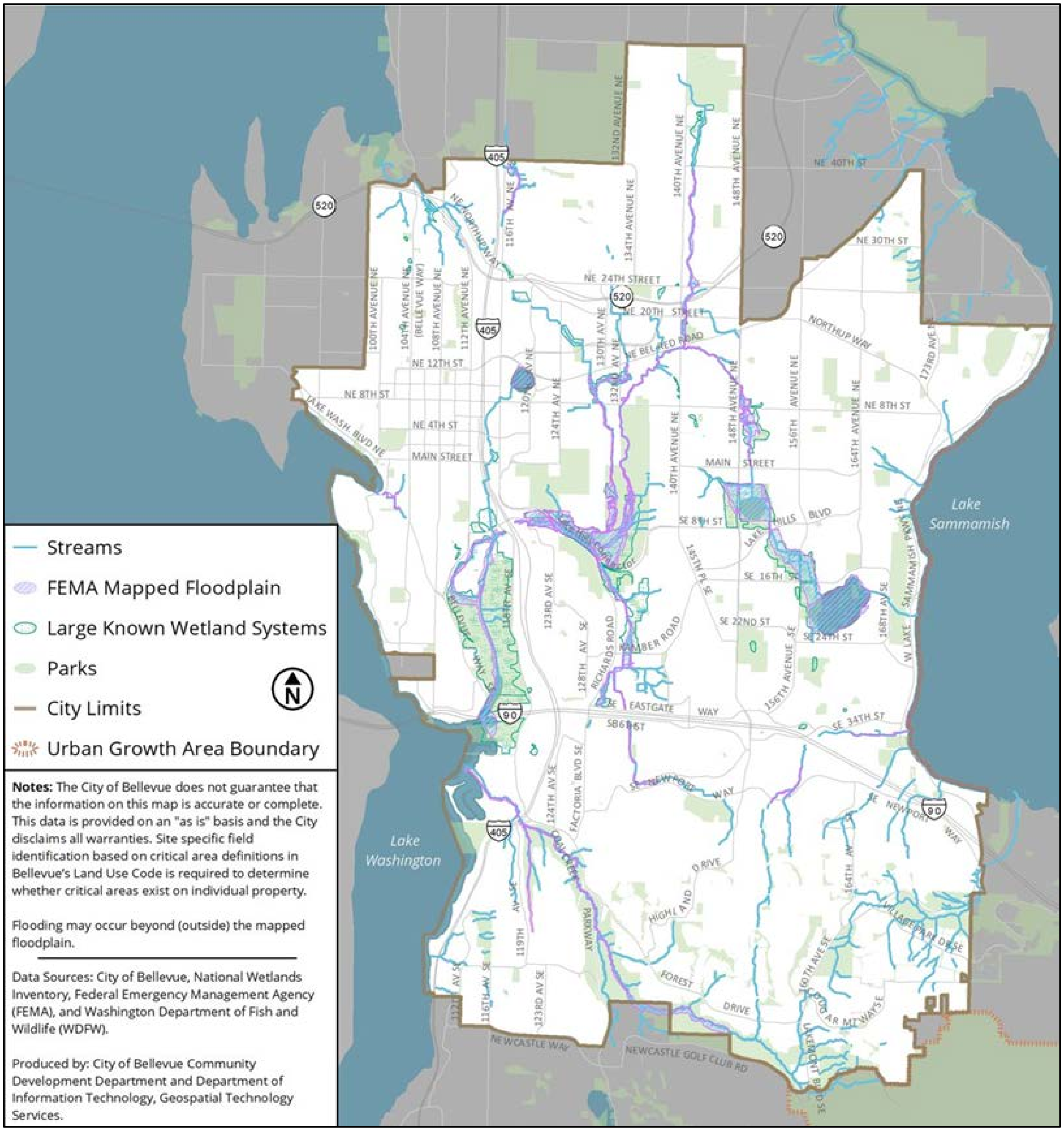

Figure 3. Map depicting locations of FEMA mapped floodplains and large known wetland systems in the City of Bellevue, from the Climate and Environment chapter of the City of Bellevue Comprehensive Plan 2044.

3.4 Protective Measures

3.4.1 Wetland Identification and Classification

County- and national-scale online resources such as the King County iMap and the National Wetland Inventory provide modeled estimates of wetland locations. While these online databases are useful planning tools, site-level planning and development require individual studies by a qualified professional. Wetlands are much more abundant than shown in inventory databases and may change over time.

The nationwide standard for wetland delineations is the U.S. Army Corps of Engineers (Corps) *Wetlands Delineation Manual* (Environmental Laboratory 1987). In Bellevue, the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region Version 2.0* (U.S. Army Corps of Engineers 2010) also applies.

The Washington State Department of Ecology (Ecology) has developed a state-wide wetland rating system that has been periodically updated using the BAS—one version for eastern Washington and one version for western Washington. The *Washington State Wetland Rating System for Western Washington* (Hruby and Yahnke 2023) applies in Bellevue and is the regional standard. This current rating system version is very similar to the prior 2014 publication, referenced in the 2016 BAS Review. Changes were focused on clarifications, formatting improvements, updated website links, and annotations. Revisions are not considered significant, which is why it is labeled as version 2.0 of the 2014 update.

Ecology's rating system is a rapid assessment tool that evaluates wetland functions in the categories of water quality, hydrology, and habitat, among a framework of three dimensions including site potential, landscape potential, and societal value (Hruby and Yahnke 2023). Using this system, wetlands are classified into one of four categories. This wetland classification system was designed to help agencies make decisions about protecting and managing wetlands. The rating system is also used to establish appropriate buffer distances from wetland categories based on the preservation of functions and values.

3.4.2 Management Resources and Standards

3.4.2.1 Wetland Buffers

Wetland buffers are the primary mechanism for protecting wetlands in Washington. Buffers provide similar ecological functions as wetlands, primarily related to water quality improvement and wildlife habitat functions (Sheldon, et al. 2005). Buffers are effective in reducing impacts from adjacent land uses on wetlands, although effectiveness can vary based on a buffer's physical characteristics of buffers (e.g., slope, soils, vegetation, and width) (Sheldon, et al. 2005) (Hruby 2013).

The following summary of key conclusions from the *Update on Wetland Buffers: The State of the Science* report (Hruby 2013) in the 2016 BAS Review (Appendix A) remains accurate:

- *Wetland buffer effectiveness at protecting water quality varies in conjunction with several factors, including width, vegetation type, geochemical and physical soil properties, source and concentration of pollutants, and path of surface water through the buffer.*
- *Wider buffers are generally higher functioning than narrower buffers.*
- *Depending on site-specific environmental factors, different buffer widths may be needed to achieve the same level of protection.*
- *To protect wetland-dependent wildlife, a broader landscape-based approach that considers habitat corridors and connections is necessary.*
- *Many animals, particularly native amphibians, require undisturbed upland habitats for their survival (Hruby 2013).*

Ecology's *Wetland Guidance for CAO Updates* (2022) is a useful tool for local jurisdictions updating the CAOs and addresses a variety of topics typically covered under local wetland regulations. In this guidance document, Ecology recommends three wetland buffer approach options that local jurisdictions can consider when updating their CAOs. The buffer options presented are based on a moderate-risk approach to protecting wetland functions (Ecology 2022). The three buffer options, summarized below, assume that wetland buffer is well vegetated with native species.

- **Option 1**. Buffer width is based on wetland category and habitat score, if minimization measures are applied, and a habitat corridor is provided. If a habitat corridor is not provided or minimization measures are not implemented, then buffer width requirements increase. Modified buffers should be not less than 75 percent of the otherwise required buffer. Option 1 provides the most flexibility.
- **Option 2**. Buffer width is based on wetland category and modified by the intensity of the impacts from proposed land use. Option 2 decreases regulatory flexibility and eliminates buffer averaging and reduction provisions through the application of corridors and minimization measures.
- **Option 3**. Buffer width is based on wetland category only. Option 3 is the least flexible and simplest to administer.

Ecology's guidance also provides recommendations for when functionally disconnected buffers may be appropriate to exclude from regulated buffer area (Ecology 2022).

3.4.2.2 Wetland Mitigation

<u>Mitigation Sequencing</u>

Mitigation sequencing is the structured process of avoiding, minimizing, and mitigating all impacts to a particular resource. Bellevue has incorporated mitigation sequencing into existing critical areas regulations in LUC 20.25H.215. This is consistent with federal directives to achieve no net loss of wetland functions and values. Mitigation sequencing is also required by the 2008 Wetlands

Compensatory Mitigation Rule issued by the U.S. Environmental Protection Agency (2008) and WAC 197.11.768. Per current Ecology guidance for CAO updates, mitigation sequencing must be applied in the following order (Ecology 2022):

Avoiding the impact altogether by not taking a certain action or parts of an action;

Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts;

Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;

Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action;

Compensating for the impact by replacing, enhancing, or providing substitute resources or environments; and/or

Monitoring the impact and taking appropriate corrective measures.

Compensatory Mitigation

Compensatory mitigation may be achieved through a programmatic approach or an approved permittee-responsible mitigation (PRM) plan. Programmatic approaches utilize third-party sponsors to obtain mitigation credits, such as a mitigation bank or in-lieu fee (ILF) program. PRM is an applicant-managed mitigation project. PRM is typically developed and implemented concurrently with wetland impacts, but it may be done in advance. Mitigation banks are state-certified to ensure ecological function replacement is achieved. ILF programs collect fees and apply the funds to restoration projects within the service area. The Corps and Ecology review and approve ILF programs. Whereas, PRM applicants must complete installation, site maintenance, monitoring, and adaptive management as needed to achieve approved mitigation plan goals and performance standards (Ecology, the Corps, and EPA 2021).

Ecology's recommendations for mitigation ratios for projects in Western Washington depend on the wetland category and type of mitigation action (Granger, et al. 2005). Mitigation ratios for direct wetland impacts are increased to account for temporal losses (Ecology 2022). Current mitigation ratio recommended by Ecology are provided in Appendix B of this report. When applying advanced mitigation, the Ecology-recommended ratios account for the wetland category and proposed mitigation actions (Ecology, the Corps, and EPA 2021).

To address ecological priorities in Washington State's watersheds, Ecology has developed additional guidance and tools for applicants, including details on using a watershed approach for mitigation site selection and the credit-debit method (Hruby 2012, Hruby, Harper and Stanley 2009). The credit-debit method is a system to calculate mitigation credits needed for a given project. The credit calculations can be used to determine compensation when utilizing in-situ mitigation, a mitigation bank, or an in-lieu fee program. Depending on specific site conditions, this may result in less or more mitigation than would be required under a set traditional mitigation ratio guidance (Hruby 2012).

Compensatory wetland mitigation methods in order of preference are (Ecology, the Corps, and EPA 2021):

1) Restoration: Re-establishment,
2) Restoration: Rehabilitation-hydrologic processes restored,
3) Creation (establishment),
4) Preservation, and
5) Enhancement

Preservation and enhancement-only mitigation are least preferred since they result in a net loss of wetland area. Ecology prefers to see preservation or enhancement in combination with a no net loss mitigation method, such as wetland creation (Ecology, the Corps, and EPA 2021).

Ecology recommends applying at least a one-to-one ratio to buffer impacts (Ecology, the Corps, and EPA 2021). A ratio greater than 1:1 may be required to replace all lost critical area functions. Ecology also recommends evaluating indirect wetland impacts to determine appropriate compensatory mitigation (Ecology, the Corps, and EPA 2021).

Monitoring

Evaluations of wetland mitigation outcomes found that most wetland mitigation does not fully replace impacted functions and falls short of the goal of no net loss (Ecology 2008, Ecology, the Corps, and EPA 2021). The goal of no net loss of wetland function cannot be achieved through mitigation alone but may be met through several factors, including adequate monitoring and maintenance and appropriate performance standards. Compensatory mitigation sites typically require performance standard monitoring for a 3- to 10-year period, to ensure that implemented sites provide the functions which were planned. There are few studies of long-term compliance with performance standards, and one assessment found a reduction in site compliance 8 to 20 years following installation (Van de Bosch and Matthews 2017). The National Research Council identifies the following factors that reduce the risk of mitigation failure: performing detailed functional assessment, including high success standards, providing detailed mitigation plans, requiring larger bonds with up-to-date market values, requiring high replacement ratios, and greater expertise (2001).

3.5 Climate Change Impacts and Mitigation

Climate change is predicted to significantly impact wetland ecosystems by altering hydrology, reducing biodiversity, disrupting carbon storage, modifying floral and faunal community composition, and increasing rates of disease (Aukema, Pricope, et al. 2017, Burkett and Kusler 2000). Anticipated hydrologic changes that impact wetlands include sea level rise and associated shifts in salinity (Burkett and Kusler 2000), increased ponding during wet seasons, and decreased water levels during dry seasons (Halabisky 2017, Mauger, Casola, et al. 2015). Changes to wetland hydrology could result in loss of wetland area and shifts in plant communities. Changes to seasonal wetland hydrologic cycles can reduce the ability of wetland soil bacteria and plants to retain, process, and sequester pollutants (EPA 2015). Although wetlands are dynamic by nature, their ability to adapt to change is limited. Wetlands that are most vulnerable or likely to experience the greatest changes from the effects of global warming are those in coastal areas and those where surface water and stormwater are main sources of hydrology.

Wetlands provide functions that assist in the mediation of climate change impacts. Wetlands are important carbon sinks (Ecology 2022). Wetlands help offset climate change through carbon storage by limiting the decomposition of organic carbon and sequestering greenhouse gas emissions (Gallagher, Zhang and Chuan 2022). Wetlands and wetland buffers, like riparian corridors, support a shaded and cool microclimate that provides refuge for wildlife from higher temperatures as well as wildlife corridors at a local or landscape scale (ASWM 2015). Wetlands attenuate flood waters, which are anticipated to increase in frequency and intensity with climate change.

While climate change is predicted to impact wetland systems, wetlands will also play a role in mitigating the extent and anticipated effects of climate change. The potential outcome of climate change impacts on wetlands is two-pronged: loss of wetland area may result in release of stored carbon; and loss of wetland area or impacts to wetland conditions may reduce or impair the functions that wetlands can provide. These “positive feedback” mechanisms can incrementally intensify climate change by releasing stored carbon into the atmosphere and magnify its adverse impacts on communities by reducing wetland areas and impairing their functions. Consequently, the value of wetland functions can be perceived as very high when considered in the context of climate change.

3.5.1 Strategies to Manage Climate Change Impacts on Wetlands

Current wetland protection standards (Ecology 2022) utilize a moderate-risk approach to wetland protection, meaning there is a moderate risk that wetland functions would be impacted when these standards (primarily buffers) are applied. The BAS review indicates that wetlands are highly valuable for anadromous fish and climate resilience, and vulnerable to climate change. The additional strategies listed below may be considered by the City for managing their wetland resources:

- Consider creating and maintaining a database of wetlands located in the city.
- Identify wetlands they may be at risk from the effects of climate change (e.g., where surface water is a primary source of hydrology).
- Incorporate climate resiliency into mitigation sequencing.
    - Consider loss of wetland functions in the landscape within the context of climate change during mitigation sequencing.
    - Plan for climate change impacts when developing mitigation/restoration plans. For example, consider a broader range of hydrologic conditions and avoid/limit use of plant species predicted to be vulnerable to climate change stresses and pests.
    - Consider assisted migration for seed selection of native plants from locations that are better adapted to future climate conditions.

- Require applicants to document compliance with all applicable local, state, and federal permit requirements.

4. GEOLOGICALLY HAZARDOUS AREAS

The purpose of regulating activities in geologically hazardous areas is to protect the public from potential risks. Geologic events may occur in hazardous areas that can result in property damage, injury, and the loss of life. The type of land use and development in these areas influences the level of risk and may, in some cases, increase the potential for a hazardous event. There is public interest in regulating these areas because a geologic event occurring on one property can impact large surrounding areas. It is important to identify where such hazard areas are located to ensure that activities and development in those areas are managed for safety and stability.

4.1 Definitions

Geologically hazardous areas are defined by Washington State as "areas that because of their susceptibility to erosion, sliding, earthquake, or other geological events, are not suited to the siting of commercial, residential, or industrial development consistent with public health or safety concerns" (WAC 365-190-030). The four main types of geologically hazardous areas are erosion hazard areas, landslide hazard areas, seismic hazard areas, and areas subject to other geologic events such as coal mine hazards and volcanic hazards (RCW 36.70A.030; WAC 365-190-120).

Bellevue does not define their comparable "geologic hazard areas" term in the LUC, but landslide hazards, steep slopes, coal mine hazards, and seismic hazards are defined and described in the following sections (LUC 20.25H.120.A).

Bellevue does not currently recognize volcanic hazard zones in the city. The 2005 BAS review (Herrera 2005a) identified ash fall as the only potential hazard from the active volcanoes in the region. Herrera recommended the following:

> *Consider performing a risk-benefit analysis to evaluate the need to protect critical facilities from the impacts of an ash-fall event. The analysis should consider ways to mitigate potential economic impacts to Bellevue caused by the disruption of regional commerce, emergency response facilities, and public utilities.*

4.1.1 Erosion Hazard Areas

Erosion hazard areas are defined by WAC 365-190-120 as:

> *Erosion hazard areas include areas likely to become unstable, such as bluffs, steep slopes, and areas with unconsolidated soils. Erosion hazard areas may also include coastal erosion areas: This information can be found in the Washington state coastal atlas available from the department of*

ecology. Counties and cities may consult with the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) for data to help identify erosion hazard areas.

Bellevue does not specifically regulate erosion hazard in the CAO; however, the Code does regulate steep slopes, a type of erosion hazard area, together with landslide hazard areas, which are also frequently susceptible to erosion. Steep slopes are defined as "*slopes of 40 percent or more that have a rise of at least 10 feet and exceed 1,000 square feet in area*" (LUC 20.25H.120). Landslide hazard areas are discussed in the following section.

4.1.2 Landslide Hazard Areas

Landslide areas are defined by WAC 365-190-120 as:

Landslide hazard areas include areas subject to landslides based on a combination of geologic, topographic, and hydrologic factors. They include any areas susceptible to landslide because of any combination of bedrock, soil, slope (gradient), slope aspect, structure, hydrology, or other factors, and include, at a minimum, the following:

- *(a) Areas of historic failures, such as:*
  - *(i). Those areas delineated by the United States Department of Agriculture Natural Resources Conservation Service as having a significant limitation for building site development;*
  - *(ii). Those coastal areas mapped as class u (unstable), uos (unstable old slides), and urs (unstable recent slides) in the department of ecology Washington coastal atlas; or*
  - *(iii). Areas designated as quaternary slumps, earthflows, mudflows, lahars, or landslides on maps published by the United States Geological Survey (USGS) or Washington Department of Natural Resources (DNR).*
- *(b) Areas with all three of the following characteristics:*
  - *(i). Slopes steeper than 15 percent;*
  - *(ii). Hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock; and*
  - *(iii). Springs or groundwater seepage.*
- *(c) Areas that have shown movement during the holocene epoch (from 10,000 years ago to the present) or which are underlain or covered by mass wastage debris of this epoch;*
- *(d) Slopes that are parallel or subparallel to planes of weakness (such as bedding planes, joint systems, and fault planes) in subsurface materials;*
- *(e) Slopes having gradients steeper than 80 percent subject to rockfall during seismic shaking;*
- *(f) Areas potentially unstable as a result of rapid stream incision, stream bank erosion, and undercutting by wave action, including stream channel migration zones;*
- *(g) Areas that show evidence of, or are at risk from snow avalanches;*
- *(h) Areas located in a canyon or on an active alluvial fan, presently or potentially subject to inundation by debris flows or catastrophic flooding; and*

(i). *Any area with a slope of 40 percent or steeper and with a vertical relief of 10 or more feet except areas composed of bedrock. A slope is delineated by establishing its toe and top and measured by averaging the inclination over at least 10 feet of vertical relief.*

Landslide areas are defined by Bellevue as (LUC 20.25H.120):

Landslide Hazards. Areas of slopes of 15 percent or more with more than 10 feet of rise, which also display any of the following characteristics:

a. *Areas of historic failures, including those areas designated as quaternary slumps, earthflows, mudflows, or landslides.*
b. *Areas that have shown movement during the Holocene Epoch (past 13,500 years) or that are underlain by landslide deposits.*
c. *Slopes that are parallel or subparallel to planes of weakness in subsurface materials.*
d. *Slopes exhibiting geomorphological features indicative of past failures, such as hummocky ground and back-rotated benches on slopes.*
e. *Areas with seeps indicating a shallow ground water table on or adjacent to the slope face.*
f. *Areas of potential instability because of rapid stream incision, stream bank erosion, and undercutting by wave action.*

4.1.3 Seismic Hazard Areas

Seismic hazard areas are defined by WAC 365-190-120 as:

Seismic hazard areas must include areas subject to severe risk of damage as a result of earthquake induced ground shaking, slope failure, settlement or subsidence, soil liquefaction, surface faulting, or tsunamis. Settlement and soil liquefaction conditions occur in areas underlain by cohesionless soils of low density, typically in association with a shallow groundwater table. One indicator of potential for future earthquake damage is a record of earthquake damage in the past. Ground shaking is the primary cause of earthquake damage in Washington, and ground settlement may occur with shaking. The strength of ground shaking is primarily affected by:

(a) *The magnitude of an earthquake;*
(b) *The distance from the source of an earthquake;*
(c) *The type or thickness of geologic materials at the surface; and*
(d) *The type of subsurface geologic structure.*

Seismic hazard areas are defined by Bellevue as "*areas of known faults or Holocene displacement, based on the most up-to-date information, or areas mapped areas of 'moderate to high' or 'high' hazard liquefaction susceptibility by the Washington Department of Natural Resources Liquefaction Susceptibility Map of King County, Washington, 2004, as amended*" (LUC 20.25H.120).

4.1.4 Coal Mine Hazard Areas

Mine hazard areas are defined by WAC 365-190-120 as:

> *Mine hazard areas are those areas underlain by, adjacent to, or affected by mine workings such as adits, gangways, tunnels, drifts, or air shafts. Factors which should be considered include: Proximity to development, depth from ground surface to the mine working, and geologic material.*

Bellevue regulates coal mine hazards which are defined as "*areas designated on the Coal Mine Area Maps or in the City's coal mine area regulations, LUC 20.25H.130, as potentially affected by abandoned coal mines; provided, that compliance with the coal mine area regulations shall constitute compliance with the requirements of this chapter in regard to coal mines.*"

4.1.5 Other Geologic Hazards

WAC 365-190-120(8) defines other types of geologic hazard areas to include volcanic and mine hazard areas. While mine hazards are regulated by the City of Bellevue Code, as defined in the previous section, volcanic hazards are not. The WAC defines volcanic hazard areas as "*areas subject to pyroclastic flows, lava flows, debris avalanche, or inundation by debris flows, lahars, mudflows, or related flooding resulting from volcanic activity*." Volcanic hazards such as pyroclastic flows and lava flows are typically associated with areas in close proximity to an active volcano. More far-reaching volcanic hazards are those associated with lahars, which are volcanic mudflows. In a lahar, the snow on a mountain rapidly melts and mixes with pyroclastic material, rocky debris, and water. This results in a slurry that flows into the valleys surrounding the volcano. For Mount Rainier, lahars from previous eruptions have flowed as far north as Kent in the Green River Valley. There is no data that would indicate that the active volcanos in Washington pose a threat to the City of Bellevue from the volcanic hazards defined in the WAC. Ash from an eruption is also a hazard; however, it is not included as part of the WAC definition of geologic hazards.

4.2 Hazard Characterization and Presence in Bellevue

Geologically hazardous areas are present throughout Bellevue, as depicted in Figure 3, below. The existing conditions described in the 2003 critical areas inventory (City of Bellevue 2003d) remains applicable.

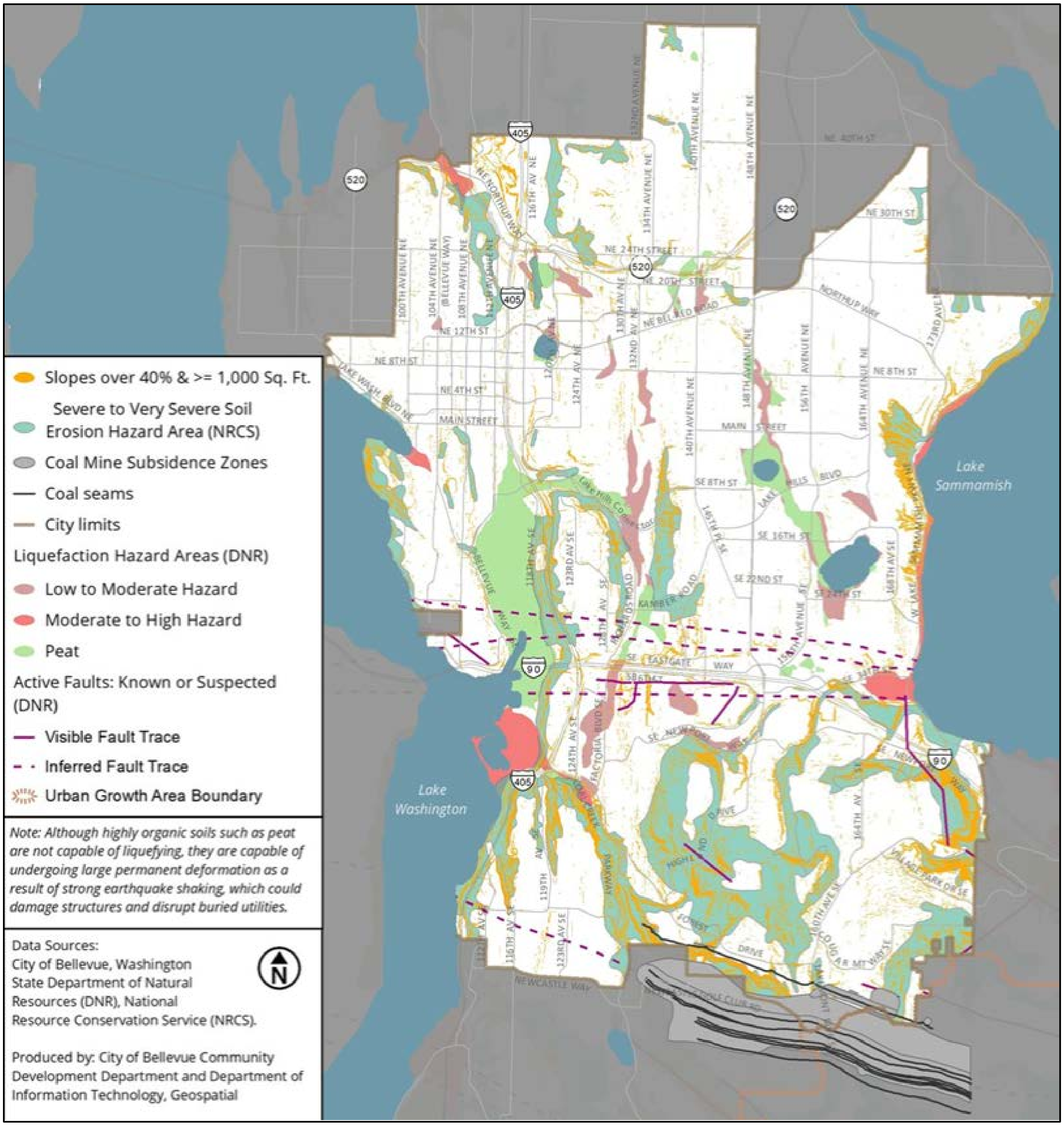

Figure 4. **Map depicting geologically hazardous areas in the City of Bellevue, from the Climate and Environment chapter of the City of Bellevue Comprehensive Plan 2044.**

4.2.1 Erosion Hazard Areas

Erosion hazard areas present risks to infrastructure, the environment, and public safety. For example, erosion may undermine the foundation of buildings or other structures, and increase the risk of landslides which threaten property and human life. There is also a direct link between erosion and impacts to other aquatic critical areas including streams, ponds, and wetlands (Dubois et al. 2018).

The stability of erosion hazard areas is influenced by the vegetation composition, structure, cover and slope of the ground. Vegetation reduces erosion through rainwater interception and by anchoring soils within root networks (Booth et al. 2002; Naiman and Decamps 1997). In cleared areas that are on slopes, rainfall tends to concentrate in small channels, and sediment can be mobilized as the water gains depth, volume, and increased flow. Small channels or rills can eventually develop into gullies in these types of exposed soils.

Erosion and landslides are natural processes that contribute sediment, rocks, and large woody debris to streams and other waterbodies. The introduction of periodic pulses or chronic turbidity and suspended solids associated with erosion has been demonstrated to harm certain types of aquatic life, particularly salmonids (Bash, Berman and Bolton 2001). This can occur from activities such as clearing vegetation, site work that exposes soils during periods of wet weather, and the creation of new impervious surfaces, which can introduce sediments and pollutants to natural waterways (Booth 1991).

A reduction in stormwater infiltration due to the creation of impervious surfaces generates more rapid runoff from land into streams and rivers. This results in an increase in peak flow volume, which in turn produces higher energy and increases the potential for streambank erosion (Booth 1990, Booth 1991, Nelson and Booth 2002).

When development encroaches on geologically hazardous areas, it also increases the probability that protective measures to prevent geologic movement, such as armoring or retaining walls, will be needed to protect property. This impacts the ecosystem by interrupting natural geologic processes. Further, when structures are placed in areas susceptible to erosion, or land use actions cause formerly stable areas to begin eroding, the risk of erosion increases for surrounding land uses as well.

4.2.2 Landslide Hazard Areas

Landslides are difficult to predict because sediment composition, topography, previous development, and hydrology all influence risk of failure. Steeper slopes are more prone to failure due to increased gravitational stresses (Shipman 2004). Certain land use modifications and development activities have the potential to increase the likelihood of landslides, such as vegetation removal, cutting into the toe of a slope, adding fill at the top of a slope, presence of pipelines that break or leak, or creation of new impervious surfaces that concentrate stormwater flow at the top of a slope. In his study in the City of Seattle, Tubbs (1974) reported that much as 80 percent of the slope failures were influenced in some way by human activity. This would indicate that steep slope areas or areas prone to landslides would not necessarily be more stable once they have been altered by human activity. However, there is precedent for permitting alterations on man-made slopes that meet certain requirements, as provided in the City of Seattle Environmentally Critical Areas Exemptions (2022). The exemption guidance allows for alternations on steep slopes that were legally created by grading and were not steep slopes prior to that legal grading, or where the steep slope is less than 20 feet in height and is located at least 30 feet from other steep slope areas (City of Seattle, 2022).

Methods for limiting the effects of human activity include limiting clearing or reestablishing plants near steep slopes or other landslide prone areas. In addition to anchoring sediments, the process of evapotranspiration by plants transforms groundwater into atmospheric vapor and intercepts rainwater (Schmidt et al. 2001; Watson and Burnett 1995). The anchoring and hydrologic functions of vegetation lower the risk of slope failure and shallow-rapid landslides (Schmidt, et al., 2001).

Alluvial fans are triangle shaped deposits of sediment which occur when mountainous areas approach topographically flatter areas. They are included in the concept of landslide hazard areas although they also share characteristics of flood hazard areas due the associated risks including debris flows, flash floods, mudflows, and outburst floods. These types of flows are extremely dangerous even at small levels because of the destructive nature of swiftly moving large debris and floodwaters. The risk of flash floods and debris flows increases following wildfires due to changing hydrologic characteristics in landscapes with bare soils and lacking vegetation (WALERT, 2023).

4.2.3 Seismic Hazard Areas

The Puget Sound area is known to be seismically active, as evidenced by recent significant seismic events including the 1949 Olympia (magnitude 7.2), the 1965 Seattle (magnitude 6.5), and the 2001 Nisqually (magnitude 6.8) Earthquakes. The seismic hazard in the area comes from three main sources: (1) Cascade Subduction Zone (interplate), (2) Benioff Zone (intraslab), and (3) shallow crustal earthquakes.

Cascade Subduction Zone earthquakes occur locally when the interface bond between the North American Tectonic Plate and the subducting Juan de Fuca Plate ruptures. In contrast to similar geologic regimes having subducting plates, such as Alaska or Chile, no earthquakes have been recorded in the Pacific Northwest from thrust fault deformation between plates. However, seismologists believe that the Cascade Subduction Zone has created great interplate earthquakes (Magnitude > 8) in the past, and is likely to produce earthquakes with magnitudes up to 9. Significant ground accelerations would occur at the site in the event of a large subduction zone earthquake; however, the long distance to the rupture area would reduce the intensity of shaking. Notwithstanding, the duration of the shaking could last several minutes.

Benioff Zone or intraslab events occur due to tensional rupture within the subducting Juan de Fuca Plate at depths of approximately 28 to 38 miles. This is the source of the largest historical local earthquakes - 1949 Olympia, 1965 Seattle, and 2001 Nisqually. This source has the potential for events with magnitudes of approximately 7.5.

The City of Bellevue is also affected by surficial faults including the Seattle Fault Zone, with the northern fault trace crossing from east to west through the southern portion of the City. Recent research indicates that this fault zone is capable of producing events with magnitudes of 6.5 to 7.5, which could cause severe damage in the Bellevue area.

Geologic hazards associated with the large earthquakes predicted for the site include seismic induced settlement, slope instability, inundation from seiches, and surface rupture. Seismic induced settlement can occur as loose, unsaturated, granular soils consolidate to become denser as a result of ground shaking. Loose, saturated soils can also experience settlement; however, in this case, the soil temporarily loses its strength in a phenomenon known as soil liquefaction. Liquefaction can also result in slope instability following an earthquake. Slope instability due to liquefaction can occur as either lateral spreading, which typically consists of a block of non-liquefied soil displacing laterally on top of a layer of liquefied soil, or flow sliding, in which the slope soils experience a chaotic flow that can displace tens of feet laterally. Both lateral spreading and flow sliding can cause significant damage to structures and other improvements and these effects must be accounted for in design.

Ground rupture occurs when the movement along a fault extends to the ground surface. This can occur as lateral displacement, that would occur on a strike-slip fault, or as vertical displacement in which one side of the fault moves up or down relative to the other side. There are mapped faults within the City of Bellevue and the possibility of ground rupture at a site should be assessed.

Lastly, there is potential for sites near Lake Washington and Lake Sammamish to experience inundation from tidal waves that form due to seismic shaking. The tidal waves that form within an enclosed, or partially enclosed body of water are called seiches. One way for a seiche to form is when the resonate frequency of a body of water matches that of the incoming seismic waves. This resonate frequency creates a standing wave that inundates the adjacent shoreline. For bodies of water such as Lake Washington and Lake Sammamish, the seismic waves would need to have a low frequency which is typically associated with earthquakes with epicenters farther away. Earthquakes that could likely result in development of a seiche would be subduction zone events. Seiches could also form if the Seattle Fault were to experience surficial fault rupture within the lake. A tidal wave would then form and impact the surrounding areas. Estimates indicate that seiches of the order of 10 feet could occur from seismic events.

The following was summarized in the 2016 BAS Review (Appendix A) and remains relevant:

> *A high resolution seismic reflection survey was completed in 2008 by Liberty and Pratt (2008) in portions of the Seattle Fault zone. Areas covered included Bellevue, Sammamish, Newcastle, and Fall City, Washington. The Seattle fault zone is a broad (5-7 km wide) east-west striking zone of faulting and deformed shallow strata. The faulting has been interpreted as reverse-slip displacement with the south-side having moved up relative to the north side of the fault zone. Geologic models have generally postulated a south-dipping reverse fault with multiple strands and back-thrusts in the hanging wall (Pratt et al., 1997; ten Brink et al, 2002 and Fisher et al. 2006). This leading edge has been termed a "deformation front" by Liberty and Pratt (2008), mainly in the form of a monoclinal fold, termed the Seattle monocline by Johnson et al (1999). The general stratigraphy consists of Quaternary age sediments overlying more reflective northward dipping Tertiary age bedrock. In addition, the Vasa Park segment of the Seattle Fault Zone has been trenched by Sherrod (2002) and has shown direct evidence of thrusting of older strata over younger strata. The younger strata being a paleosoil dated at 11,500 +/- 40 radiocarbon years B.P. (before present).*

Liberty and Pratt's interpretation places the leading edge of the Seattle Fault zone about 3 km further north than previously indicated in the prior geologically hazards areas inventory (City of Bellevue

2003d). Recommendations from the 2005 and 2016 BAS reviews (The Watershed Company 2016, Herrera 2005a) include the development of a database of geotechnical reports for properties around the Seattle fault zone.

In addition to intense ground shaking caused be faults, as described above, seismic event could also produce secondary hazards, such as landslides, liquefaction, and a seiche of Lake Washington and Lake Sammamish, which would further threaten the lives, property, and critical infrastructure of the community.

4.2.4 Coal Mine Hazard Areas

Active and closed mines pose potential hazards because they can lead to increased risks of erosion, mass wasting, and landslides near surface mines, and subsidence over collapsed tunnels and shafts in subsurface mines. Since the potential risks of subsurface mines are not obvious, evaluation and disclosure to landowners are essential to protecting infrastructure and public safety. Bellevue hosts a map of coal zones on the open data portal. The only mines designated on this inventory are abandoned mines in the Coal Creek basin.

4.3 Protective Measures

4.3.1 Identification and Classification

The Washington Geologic Information Portal[5] is a useful resource for identifying and designating geologically hazardous areas (Commerce 2023), as are previous city-specific studies like the 2004 inventory (City of Bellevue 2003d).

4.3.2 Management Resources and Standards

The primary goal of protection measures for geologic hazards is to protect people and property. Risk management occurs at the stage of planning and development. Risks can be minimized by limiting the occupancy and development in geologically hazard areas. This risk of development in geologic hazard areas is evaluated with classification systems to inform site development restrictions and requirements. One method to manage risk is the protection of buffers around geologic hazard areas to restrict development in hazard areas. For development in erosion hazard or landslide hazard area, design and construction standards are necessary to prevent the development from reducing slope stability and ensuring that development is resilient to potential hazards. Any such development in the hazard area or its buffer should be evaluated on a site-specific basis by a licensed geotechnical engineer or engineering geologist to properly assess potential for geologic hazard effects on a particular site (Rupke, Huisman and Kruse 2007). Methods used in site studies should adhere to best professional standards and include subsurface exploration and testing of soils at an appropriate frequency across the site as necessary.

[5] https://geologyportal.dnr.wa.gov/

Although the general protective approach is to avoid disturbing geologic hazard areas, WAC 365-190-080(4) states "some geological hazards can be mitigated by engineering, design, or modified construction or mining practices so that risks to health and safety are acceptable".

Additional protection strategies were identified by the SR-530 Landslide Commission following the Oso landslide that occurred in March 2014. Recommendations from the commission include integrating and funding Washington's emergency management system, supporting a statewide landslide hazard and risk mapping program, establishing a geologic hazards resilience institute, conducting landslide investigations, and advancing public awareness of geologic hazards (The SR 530 Landslide Commission 2014). To improve landslide hazard and risk mapping, collaboration among agencies and landowners is recommended along with risk prioritization, utilization of lidar mapping and GIS database tools.

Per the SR-530 Landslide Commission's 2014 findings, updates to critical area regulations are recommended to better identify and regulate land uses in geologic hazard areas. As noted in the 2016 BAS Review, "the SR530 Landslide Commission Final report (2014) recommends identifying 'critical area buffer widths based on site specific geotechnical studies' as an 'innovative development regulation,' that counties and cities should adopt (The SR 530 Landslide Commission 2014).

Seismic hazards can be managed by applying earthquake-resistant building standards to at-risk areas. The Washington State Building Code (WAC 51-50) offers guidance from the 2021 International Building Code and the 2021 International Existing Building Code with amendments specific to the State, including several directly related to seismic standards.

4.4 Climate Change Impacts and Mitigation

Geologically hazardous areas, particularly erosion hazard areas, and landslide hazard areas, are influenced by climate change. Climate change models project warmer, drier summers, and increased precipitation in other seasons while maintaining roughly the same amount of annual precipitation (Dalton, Mote and Snover 2013). Extreme precipitation events modeled by the UW Climate Impacts Group are expected to increase in intensity and frequency (Mauger et al. 2021). Increased magnitude and frequency of rain events can lead to over-saturated soils and contribute to slope instability in hazard areas. Consequentially, geologic hazard risks are anticipated to increase because rainfall intensity and duration are known indicators of landslide events (Chleborad 2006; WDNR 2020). Additionally, the severity and frequency of wildfire is expected to increase, heightening susceptibility to erosion and landslide hazards (Mauger, Casola, et al. 2015).

Changing climate is also anticipated to affect vegetation community composition and native plant mortality due to shifts in plant hardiness zones and species ranges (Lenoir and Svenning 2014). Existing species assemblages, canopy types, and root systems may be disrupted and displaced by invasive species. Although plant provenance is not the only indicator of a plants capability to stabilize slopes, opportunistic invasive plants often have shallow root systems and short lifespans that are less effective at anchoring soils than native counterparts. Himalayan blackberry, for example, is a wide spread invasive plant likely to displace lost plants and has shallow root system and can cause soil erosion by preventing the establishment of native counterparts (Gaire, et al. 2015). High levels of plant diversity also generally improve soil stability by combining multiple forms of root architecture (Ghestem, et al. 2014).

4.4.1 Strategies to Manage Climate Change Impacts on Geologically Hazardous Areas

- Encourage or require climate-informed design for development and infrastructure in or near geologic hazard areas (WDNR 2020).
- Require appropriate surface and ground water management practices for development near erosion hazard areas.
- Encourage utilization of soft shore protection strategies when supported by a site-specific assessment (not appropriate in all cases).
- Identify and prioritize geologic hazards within the City, then update mapping as needed using current practices such as LiDAR and GIS database tools.
- Keep in communication with the governor's office to ensure the City of Bellevue is included in statewide collaborative efforts to manage geologic hazard areas.
- Manage vegetation for climate resilience and slope stability.

5. FREQUENTLY FLOODED AREAS

5.1 Definitions

Frequently flooded areas (FFAs) are floodplains and flood prone areas that pose a risk to public safety. FFAs also serve important habitat functions for fish and wildlife. FFAs are defined in WAC 365-190-030(8) as follows:

> *"Frequently flooded areas" are lands in the flood plain subject to at least a one percent or greater chance of flooding in any given year, or within areas subject to flooding due to high groundwater. These areas include, but are not limited to, streams, rivers, lakes, coastal areas, wetlands, and areas where high groundwater forms ponds on the ground surface.*

Bellevue defines "area of special flood hazard" as "the land in the floodplain within the City subject to a one percent or greater chance of flooding in any given year. It is shown on the Flood Insurance Rate Map (FIRM) as Zone A, AO, AH, A1-30, AE, A99, or AR (V, VO, V1-30, VE). 'Special flood hazard area' is synonymous in meaning with the phrase 'area of special flood hazard'" (LUC 20.25H.177). FFAs in Bellevue include the following (LUC 20.25H.175):

1. *Land Subject to One-Hundred-Year Flood. The land in the floodplain subject to the flood having a one percent chance or greater of being equaled or exceeded in any given year as determined by customary methods of statistical analysis defined in the City of Bellevue Storm and Surface Water Engineering Standards, now or as hereafter amended. Also referred to as the 100-year flood.*

2. *Areas Identified on the Flood Insurance Rate Map(s). Those areas identified by the Federal Insurance Administrator in a scientific and engineering report entitled "The Flood Insurance Study (FIS) for King County, Washington, and Incorporated Areas," dated August 19, 2020, with an accompanying Flood Insurance Rate Map(s) (FIRM(s)), dated August 19, 2020, and any revisions thereto. The FIS and accompanying FIRM(s) are hereby adopted by reference, declared part of this Part 20.25H LUC, and are available for public review at the City of Bellevue. The best available information for flood hazard area identification as outlined in subsection A.6 of this section shall be the basis for regulation until a new FIRM is issued that incorporates data utilized under subsection A.6 of this section.*
3. *Additional Areas. Other areas designated by the Director pursuant to this section shall be considered frequently flooded areas.*
4. *Designation of Areas of Special Flood Hazard. Flood Insurance Rate Maps are to be used as a guide for the City of Bellevue, project applicants, and/or property owners to identify areas of special flood hazard. Flood Insurance Rate Maps may be continuously updated as areas are reexamined or new areas are identified. Newer and more restrictive information for flood hazard area identification shall be the basis for regulation.*
5. *Use of Additional Information. The Director may use additional flood information that is more restrictive or detailed than that provided in the Flood Insurance Study to designate frequently flooded areas, including data on channel migration, historical data, high water marks, photographs of past flooding, location of restrictive floodways, maps showing future build-out conditions, maps that show stream habitat areas, or similar information.*
6. *Flood Elevation Data. When base flood elevation data is not available (A and V zones), the Director shall obtain, review, and reasonably utilize any base flood elevation and floodway data available from a federal, state, or other source, in order to administer provisions for the frequently flooded areas. In areas of special flood hazard where the BFE has increased due to remapping efforts, the new BFE will establish the regulatory limit.*

5.2 Floodplains in Bellevue

Floodplains are designated in 13 of the 25 Bellevue-defined drainage basins including Mercer Slough, Kelsey Creek, Richards Creek, Sunset Creek, Coal Creek, Vasa Creek, Phantom Creek (and Lake), Valley Creek, Meydenbauer Creek, Yarrow Creek, Lake Bellevue, Larsen Lake, and Lake Sammamish. These are depicted in Figure 2.

5.3 Functions and Values

Floods are events that can result in the destruction of property and loss of life but are also part of a natural ecological process that sustains river systems. Floods typically occur following large storm events but may also result from a release of impounded water, such as from a dam or levee failure, or beaver activity. FFAs are dynamic and ecologically productive environments that provide habitat for fish and wildlife and are an important component of watershed processes including:

- Flood water storage and conveyance,
- Nutrient and sediment deposition, and
- Mobilization of large woody debris.

Floodplains have been directly impacted by agriculture, residential development, and urbanization for centuries because the geographic locations tend to be well-suited for development during periods between floods. Floodplains have also been indirectly impacted by similar watershed-scale land use changes. Increased impervious surfaces and deforestation increase flooding magnitude and frequency (Booth, Hartley and Jackson 2002). Increased flooding magnitude and frequency create greater risk for people and infrastructure within a floodplain.

Historically, approaches to mitigate floodplain risks have worsened downstream flood impacts and impacted fish and wildlife habitat (e.g., channel straightening and armoring, construction of dikes and levees, and floodplain fill). In landscape-level assessments, patterns of urban development, particularly impervious surface area and distribution, have been demonstrated to influence watershed functions (Alberti, et al. 2006). Among these are stream channel downcutting, a process associated with watersheds that have frequent and short duration high peak flows, that further disconnects floodplains, increases in-stream erosion, and deposits sediment in downstream environments leading to blocked culverts (Booth 1990). Stream incision also affects surface and ground water interactions and may result in lower water table levels (Petralia 2022).

Extreme floods have both positive and negative effects on stream health. Negative impacts include physical trauma and stress to aquatic organisms, displacement or stranding, erosion and sedimentation, loss of vegetation, pollution, disruptions to food webs and spawning, and disrupted migration. As a result, extreme floods have been documented to reduce fish densities (Milner, et al. 2013). However, some studies show that fish assemblages are resilient to the effects of floods at a basin scale and recover quickly (George, et al. 2015). Potential positive effects include the creation of new habitats and nutrient redistribution (Peters, et al. 2015).

Flooding can result in significant economic costs from damaged homes and infrastructure, business disruption, and loss of life. The human and societal costs of flooding have increased over time as the population and amount of infrastructure in floodplains has increased and from climate change.

5.4 Protective Measures

5.4.1 Identification and Classification

The Federal Emergency Management Agency (FEMA) maintains and updates flood maps, called Flood Insurance Rate Maps (FIRM). FEMA flood maps include any place considered to have a high risk of flooding, which is a one percent chance of flooding each year, or higher. FEMA maps are based on past flood events and do not include sea level rise or other climate impacts (Commerce 2023).

5.4.2 Management Resources and Standards

The National Flood Insurance Program (NFIP), administered by FEMA, publishes basic building standards that can be implemented to protect both floodplain ecological functions and buildings, infrastructure, and people from flood risk. These standards are generally the minimum required, and local jurisdictions may choose to implement higher standards to further reduce risk (Commerce 2023).

Bellevue updated their floodplain regulations in 2020 based on FEMA and Ecology guidance.

5.5 Climate Change Impacts and Mitigation

Climate change in the Pacific Northwest is anticipated to increase flood risks because of the increased precipitation paired with the increased frequency and intensity of extreme weather events (Ecology 2024). Climate change models predict that the frequency of atmospheric rivers, which contribute to severe deluges in rainwater and other extreme weather events, will become more frequent and severe (Mauger and Kennard 2017, Salathe, et al. 2014). Increased floodwater elevation and expansion of floods to new areas threaten property and public safety. Stream channel migration can also drastically alter flood risks and migration dynamics are expected to shift as a result of climate change (Mauger and Kennard 2017).

5.5.1 Strategies to Manage Climate Change Impacts on FFAs

Commerce's *Critical Areas Handbook* (2023) presents the following as an optional strategy to help local governments plan for flood risk, beyond the minimum standards:

> *Ecology's RiskMAP ("risk mapping assessment and planning") program provides additional maps that can help local governments plan for flood risk in their communities. It integrates several regulatory and nonregulatory products for hazard mitigation planning, including FEMA's National Flood Hazard Layer, 1000-year floodplain maps, depth grids (expected depth of flooding from a 100-year event), earthquake layers, landslide inventories, and building footprints for residential and critical facilities buildings. It also includes project data for RiskMAP assessment projects in certain counties. Maps of the 1000-year floodplain are included; floods of this magnitude are becoming more common with climate change and wildfires, and more communities are starting to plan for 500-year and 1000-year floods (instead of just 100-year floods). Communities may also see areas with urban flooding due to inadequate storm drainage, or issues with groundwater flooding or high sediment loads in certain streams causing them to meander into new areas. One of the most popular non regulatory products developed through RiskMAP is a map of the base flood elevation plus one, two and three feet. Base flood elevation is how high FEMA statistically predicts the water to rise in a 100-year flood event. This helps local communities understand the inundation in low lying areas. The map also shows information about buildings from local assessor's offices, like occupancy, use, value, and materials. It has a GIS model that was developed by FEMA to estimate damage to structures from a 100-year flood or an earthquake.*

Other strategies include:

- Encourage and incentivize floodplain restoration actions to restore floodplain connectivity to streams and wetlands and protect or restore riparian corridors to maintain microclimate.
- Utilize the FEMA Climate Resiliency approach to support flood hazard management planning and follow grant funding opportunities.

6. CRITICAL AQUIFER RECHARGE AREAS

6.1 Definitions

Critical aquifer recharge areas (CARAs) are defined in WAC 365-190-030 as follows:

> *Critical aquifer recharge areas are areas with a critical recharging effect on aquifers used for potable water, including areas where an aquifer that is a source of drinking water is vulnerable to contamination that would affect the potability of the water, or is susceptible to reduced recharge.*

Bellevue has not previously designated CARAs in their CAO. According to the 2016 BAS Review (Appendix A):

> *…given the limited number of wells in the City, the availability of public water supply to those areas that currently use wells, and state Safe Water Drinking Act requirements for wellhead protection, the City did not address critical aquifer recharge areas in its critical areas code.*

Additional information on drinking water resources in Bellevue is provided in the following sections. Designation of CARAs in Bellevue's CAO is warranted now based on the latest information.

6.2 CARAs in Bellevue

Most of Bellevue's drinking water is provided by the Cascade Water Alliance via Seattle Public Utilities (SPU), from the Cedar River and the south fork of the Tolt River (City of Bellevue 2016). However, some active groundwater wells provide drinking water to a small portion of Bellevue's residents. There are no sole source aquifers mapped in Bellevue (EPA n.d.).

6.2.1 Wellhead Protection Areas (WHPAs)

As documented in the 2005 and 2016 BAS reviews (Herrera 2005a, The Watershed Company 2016), a limited number of groundwater wells are present in the City. In 2005, the BAS review documented three Group A and 11 Group B water systems in Bellevue. In 2016, the BAS review noted the addition of one Group A well serving 40 connections associated with an area that had been annexed since the 2005 BAS Review. Source susceptibility in the vicinity of the annexed well was (and continues to be) rated as moderate according to Washington State Department of Health's (DOH's) database (Source

FACET

Water Assessment Program [SWAP] Mapping tool). No additional areas have been annexed since the 2016 BAS Review (Appendix A).

Figure 4 provides a current snapshot of the Wellhead Protection Areas (WHPAs) in Bellevue using DOH's SWAP Mapping tool.

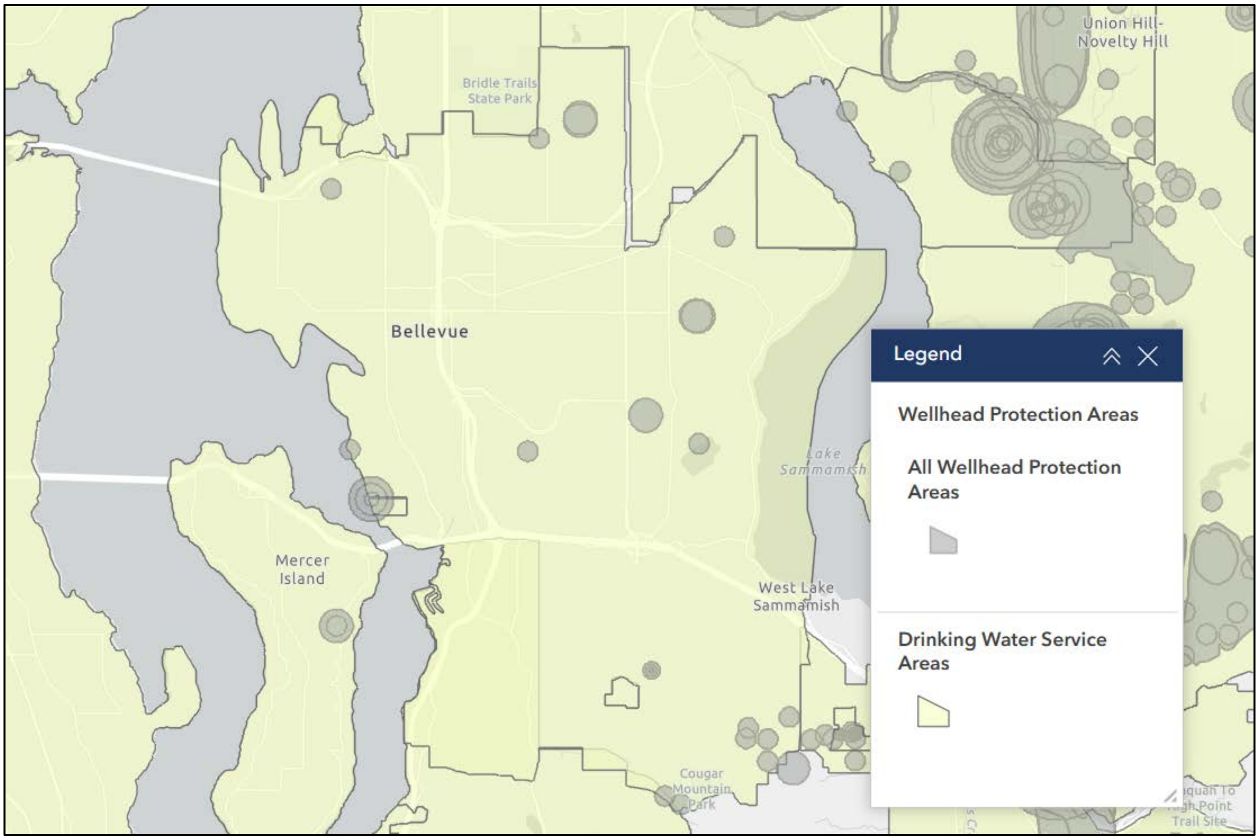

Figure 5. Map of WHPAs mapped in Bellevue using the SWAP Mapping tool.

6.3 Functions and Values

CARAs provide communities with safe drinking water. CARA functions also have potential to influence other critical areas through groundwater, including fish-bearing streams. General CARA functions and values are summarized in the following documents:

- *2005 BAS Review* (Herrera 2005a)
- *Critical Areas Handbook* (Commerce 2023)
- *Critical Aquifer Recharge Areas Guidance* (Ecology 2021)

6.3.1 WHPAs and Emergency Planning

Bellevue has developed an *Emergency Water Supply Master Plan* (2023) (Master Plan) in response to a 2018 SPU seismic study which identified significant water service supply risks that could be anticipated with a major disaster or earthquake. Existing wells in the City are identified for potential expansion or emergency use in the Master Plan. Furthermore, that Master Plan identifies several emergency water supply policies including "restrict land use and establish critical areas near wells to preserve water quality."

6.4 WHPA Protective Measures

6.4.1 Identification and Classification

DOH maintains a database of WHPAs, including locations and key attributes, that is publicly available online through the SWAP Mapping tool.

In Washington, drinking water systems are classified as follows (DOH 2017, Asinas, Raymond and Mehta 2022):

- Private Wells: Individual wells that usually serve a single residence.
- Group A Systems: Serve 15 or more connections, and 25 or more people.
- Group B Systems: Serve fewer than 15 connections, and fewer than 25 people.

WHPAs typically have four or five zones: the sanitary control area, three zones based on different water time-of-travel rates, and a buffer zone if necessary.

6.4.2 Management Resources and Standards

The *Washington State Wellhead Protection Program Guidance Document* (DOH 2017) is a useful resource for WHPA management. On the topic of addressing WHPAs as critical area, the guidance document notes the benefit of protecting noncontiguous buffer zones through CARA designations, which provide protection for the quality and quantity of public water supplies. The guidance document recommends considering number of system connections, system ownership (public or private), and contamination susceptibility when considering which WHPAs to designate as CARAs.

6.5 Climate Change Impacts and Mitigation

Climate change impacts to drinking water systems are projected based on increased drought, increased wildfires, and increased flooding (Asinas, Raymond and Mehta 2022):

- Groundwater resources may be at risk from prolonged, multi-year droughts, although the likelihood of multi-year droughts in the Pacific Northwest is unclear. More research is needed to understand past and future changes in groundwater within the context of climate change (Ecology 2024). Droughts may put pressure on groundwater supplies potentially causing aquifer depletion (Asinas, Raymond and Mehta 2022).

- Demand for aquifers during hotter summers may increase to compensate for changes in precipitation patterns and temperatures.

- Wildfires will introduce more particulates and contaminants into the environment, which settle on surface water and infiltrate into groundwater (Burton, et al. 2016, Mansilha, et al. 2020).

- Heavy rainfall and flooding can introduce surface contaminants into groundwater resources (Asinas, Raymond and Mehta 2022).

6.5.1 . Strategies to Manage Climate Change Impacts on CARAs

The following are general BAS-supported strategies to minimize climate change impacts on CARAs that may be applicable for WHPA management in Bellevue:

- Ecology recommends understanding water resources, tracking water levels and recharge sources, and focusing on water conservation as a strategy to plan for climate change impacts (Ecology 2021).
- Manage stormwater to maintain groundwater recharge in CARAs. Utilize a 20-year planning horizon to manage supply and demand given climate trends and projections (Asinas, Raymond and Mehta 2022).
- Design stormwater systems to better mimic natural systems and mitigate some of the functions lost elsewhere in the landscape due to changes in surface and groundwater inputs. For example, the use of roadside bioswales may be expanded. Stormwater treatment capacity may be increased as needed to protect water quality and manage water quantity.
- Planning and implementing flood mitigation strategies can reduce the likelihood of contaminated runoff events.
- Preserve open space and concentrate urban development away from CARAs.
- Maintain updated CARA maps and classifications.
- Continue to modify public outreach efforts to educate residents about best practices in CARAs and promote water conservation and water use efficiency programs.
- Promote and incentivize low-impact development, specifically infiltration of clean runoff to support aquifer recharge.
- .

7. REFERENCES

Alberti, M., D. Booth, K. Hill, B. Coburn, B., C. Avolio, S. Coe, and D. Spirandelli. 2006. The impact of urban patterns on aquatic ecosystems: An empirical analysis in Puget lowland sub-basins. Landscape and Urban Planning 80: 345-361.

Anderson, P. S., S. Meyer, P. Olson, and E. Stockdale. 2016. Determining the Ordinary High Water Mark for Shoreline Management Act Compliance in Washington State. Publication #16-06-029, Washington State Department of Ecology, Shorelands and Environmental Assistance Program, Olympia.

Asinas, E., C. Raymond, and A. Mehta. 2022. "Integrating Climate Resilience Into Washington State Water System Planning." A report prepared by the Unversity of Washington Climate Impacts Group. Seattle, WA. doi:10.6069/PSoE-M345.

ASWM. 2015. Wetlands and Climate Change: Considerations for Wetland Program Managers. Association of State Wetland Managers.

Aukema, J. E., N. G. Pricope, G. J. Husak, and D. Lopez-Carr. 2017. "Biodiversity Areas under Threat: Overlap of Climate Change and Population Pressures of the World's Biodiversity Priorities." (PLoS ONE) 12 (1). doi:10.1371/journal.pone0170615.

Azous, A. L., and R. R. Horner. 1997. Wetlands and Urbanization: Implications for the Future. Final Report of the Puget Sound Wetlands and Stormwater Management Research Program.

Bash, J., C. Berman, and S. Bolton. 2001. "Effects of Turbidity and Suspended Solids on Salmonids." Prepared for Washington State Transportation Commission, Washington State Transportation Center, University of Washington, Seattle.

Beninde, J., M. Veith, and A. Hochkirch. 2015. "Biodiversity in cities needs space: a meta-anlysis of factors determining intra-urban biodiversity variation." Ecology Letters 18: 581-592. doi:10.111/ele.12427.

Blewett, C. M., and J. M. Marzluff. 2005. "Effects of urban sprawl on snags and the abundance and productivity of cavity-nesting birds." The Condor (The Cooper Ornithological Society) 107: 678-693.

Booth, D. B. 1990. *Stream-channel incision following drainage-basin urbanization*. Journal of the American Water Resources Association, 26(3): 407-417. https://doi.org/10.1111/j.1752-1688.1990.tb01380.x

Booth, D. B. 1991. "Urbanization and the Natural Drainage System--Impacts, Solutions, and Prognoses." The Northwest Environmental Journal (University of Washington, Seattle.) 7(1): 93-118.

Booth, D. B., D. Hartley, and R. Jackson. 2002. "Forest cover, impervious-surface area, and the mitigation of stormwater impacts." Journal of the American Water Resources Association 38 (3): 835-845.

Brosofske, K. D., J. Chen, R. J. Naiman, and J. F. Franklin. 1997. "Harvesting effects on microclimatic gradients from small streams to uplands in western Washington." Ecological Applications 7 (4): 1188-120.

Burges, S. J., M. S. Wigmosta, and J. M. Meena. 1998. "Hydrological Effects of Land-use Change in a Zero-order Catchment." Journal of Hydrologic Engineering 86-97. doi:10.1061/(ASCE)1084-0699(1998)3:2(86).

Burkett, V., and J. Kusler. 2000. "Climate Change: Potential impacts and interations in wetlands of the United States." Journal of the American Water Resources Association 36 (2): 313-320. doi:10.1111/j.1752-1688.2000.tb04270.x.

Burton, C. A., T. M. Hoefen, G. S. Plumlee, K. L. Baumberger, A. R. Backlin, E. Gallegos, and R. M. Fisher. 2016. "Trace Elements in Stormflow, Ash, and Burned Soil following the 2009 Station Fire in Southern California." PLoS ONE 11 (5). doi:10.1371/journal.pone.0153372.

Bury, R. B. 2008. "Low thermal tolerances of stream amphibians in the Pacific Northwest: Implications for riparian and forest management." Applied Herpetology 5: 63-74.

Castelle, A.J., M. Conolly, M. Emers, E.D. Metz, S. Meyer, and M. Witter. 1992a. Wetland buffers: Use and effectiveness. Publ. 92-10. Adolfson Assoc., for Shorelands and Coastal Zone Management Program, Olympia, WA: Washington Department of Ecology (WDOE).

Chardonnet, P. H., B. Des Clers, J. R. Fisher, R. Gerhold, F. Jori, and F. Lamarque. 2002. "The value of wildlife." Revue Scientifique et Technique 21 (1): 15-51. doi:10.20506/rst.21.1.1323.

City of Bellevue. 2003a. "Bellevue Critical Areas Upate Best Available Science Paper: Streams."

City of Bellevue. 2003b. "Bellevue Critical Areas Update Best Available Science Paper: Wetlands."

City of Bellevue. 2003c. "Bellevue Critical Areas Update Best Available Science Paper: Wildlife."

City of Bellevue. 2003d. "Bellevue Critical Areas Update Geologically Hazardous Areas Inventory."

City of Bellevue. 2003e. "Bellevue Critical Areas Update Stream Inventory."

City of Bellevue. 2003f. "Bellevue Critical Areas Update Wetland Inventory."

City of Bellevue. 2023. "Emergency Water Supply Master Plan."

City of Bellevue. 2016. "Water System Plan."

Commerce. 2023. Critical Areas Handbook: A Handbook for Reviewing Critical Areas Regulations. Washington State Department of Commerce, Growth Management Services.

Crawford, J. A and R. D. Semlitsch. 2007. “Estimation of core terrestrial habitat for stream-breeding salamanders and delineation of riparian buffers for protection of biodiversity.” *Conservation Biology* 21(1): 152-158.

Crozier, L., R. W. Zabel, and A. F. Hamlet. 2008. "Predicting differential effects of climate change at the population level with life-cycle models of spring Chinook salmon." Global Change Biology 14 (2): 236-249. doi:10.1111/j.1365-2486.2007.01497.x.

Cuo, L., D. P. Lattenmaier, M. Alberti, and J. E. Richey. 2009. "Effects of a century of land cover and climate change on the hydrology of the Puget Sound basin." Hydrological Processes 23 (6): 907-933. doi:10.1002/hyp.7228.

Dalton, M. M., P. W. Mote, and A. K. Snover. 2013. Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities. Washington, DC: Island Press.

David, G. C., K. M. Fritz, T. Nadeau, B. J. Topping, A. O. Allen, P. H. Trier, S. L. Kickefski, L. A. James, E. Wohl, and D. Hamill. 2025. National Ordinary High Water Mark Field Determination Manual for Rivers and Streams (Final Version). U.S. Army Corps of Engineers, Wetlands Regulatory Assistance Program, ERDC/CRREL TR-25-1.

Desbonnet, A., P. Pogue, V. Lee, and N. Wolff. 1994. Vegetated buffers in the coastal zone - A summary review and bibliography: Coastal resources center technical report No. 2064. Narragansett, RI: University of Rhode Island Graduate School of Oceanography.

Diffendorfer, J. E., M. S. Gaines, and R. D. Holt. 1995. "Habitat fragmentation and movement corridors of three small mammals (Sigmodo, Microtus, and Peromyscus)." Ecology (Ecological Society of America) 76 (3): 827-839.

DOH. 2017. Washington State Wellhead Protection Program Guidance Document. 331-018, Washington State Department of Health, Environmental Public Health Office of Drinking Water.

Donnelly, R., and J. M. Marzluff. 2004. "Importance of Reserve Size and Landscape Context to Urban Bird Conservation." Conservation Biology 18 (3): 733-745.

Ecology. 2021. Critical Aquifer Recharge Areas Guidance. Publication #05-10-028, Washington State Department of Ecology, Water Quality Program.

Ecology. 2008. Making Mitigation Work: The Report of the Mitigation that Works Forum. Publication #08-06-018, Washington State Department of Ecology.

Ecology. 2024. Washington State Climate Resilience Strategy. Publication #24-01-006, Olympia, WA: Washington State Department of Ecology.

Ecology. 2022. Wetland Guidance for Critical Areas Ordinance (CAO) Updates, Western and Eastern Washington. Publication #22-06-014, Washington State Department of Ecology, Shorelands and Environmental Assistance Program.

Ecology, the Corps, and EPA. 2021. Wetland Mitigation in Washington State - Part 1: Agency Policies and Guidance (Version 2). Ecology Publication #21-06-003, Washington State Department of Ecology.

Environmental Laboratory. 1987. Corps of Engineers Wetlands Delineation Manual. Technical Report Y-87-1, U.S. Army Engineer Waterways Experiment Station.

EPA. 2015. Connectivity of Streams and Wetlands to Downstream Waters: A Review and Synthesis of the Scientific Evidence (Final Report). EPA/600/R-14/475F, Washington, DC: U.S. Environmental Protection Agency.

EPA. n.d. Sole Source Aquifers. Accessed April 2025. https://epa.maps.arcgis.com/apps/webappviewer/index.html?id=9ebb047ba3ec41ada1877155fe31356b.

Fahrig, L., J. Pedlar, S. Hope, P. Taylor, and J. Wagner. 1995. *Effects of road traffic on amphibian density.* Biol. Conservation 73: 177-182.

Ficotela, G. F., E. Padoa-Schioppa, and F. De Barnardi. 2008. "Influence of Landscape Elements in Riparian Buffers on the Conservation of Semiaquatic Amphibians." Conservation Biology 23(1):114-123. doi:10.1111/j.1523-1739.2008.01081.x.

Fiest, B. E., E. R. Buhle, P. Arnold, J. W. Davis, and N. L. Scholz. 2011. "Landscape Ecotoxicology of Coho Salmon Spawner Mortality in Urban Streams." PLoS ONE 6 (8): e23424.

Gaire, R., C. Astley, M. K. Upadhyaya, D. R. Clements, and M. Bargen. 2015. "The Biology of Canadian Weeds. 154. Himalayan Blackberry." Canadian Journal of Plant Science 95 (3): 557-570.

Galbraith, R. V., E. A. MacIsaac, J. S. Macdonald, and A. P. Farrell. 2006. "The effect of suspended sediment on fertilization success in sockeye (Oncorhynchus nerka) and coho (Oncorhynchus kisutch) salmon." Can. J. Fish. Aquat. Sci. 2487-2494. doi:10.1139/F06-133.

Gallagher, J. B., K. Zhang, and C. H. Chuan. 2022. "A Re-evaluation of Wetland Carbon Sink Mitigation Concepts and Measurements: A Diagenetic Solution." Wetlands 42 (23). doi:10.1007/s13157-022-01539-5.

Gaston, Kevin J. 2010. Urban Ecology. Cambridge University Press. doi:10.1017/CBO9780511778483.

George, S. D., B. P. Baldigo, A. J. Smith, and G. R. Robinson. 2015. "Effects of extreme floods on trout populations and fish communities in a Catskill Mountain River." Freshwater Biology 60(12): 2511-2522.

Ghestem, M., K. Cao, W. Ma, N. Rowe, R. Leclerc, and C. Gadenne. 2014. "A Framework for Identifying Plant Species to be used as 'Ecological Engineers' for fixing Soil on Unstable Slopes." PLoS ONE 9(8): e95876. doi:10.1371/journal.pone.0095876.

Gilbert-Norton, R. Wilson, J. R. Stevens, and K. H. Beard. 2010. *Meta-Analytic Review of Corridor Effectiveness*. Conservation Biology 24(3): 660–668. https://doi.org/10.1111/j.1523-1739.2010.01450.x

Gillies, C. S. and C. C St. Clair. 2008. *Riparian corridors enhance movement of a forest specialist in a fragmented tropical forest.*

Granger, Teri, Tom Hruby, Andy McMillan, Douglas Peters, Jane Rubey, Dyanne Sheldon, Stephen Stanley, and Erik Stockdale. 2005. Wetlands in Washington State, Volume 2: Guidance for

Protecting and Managing Wetlands. Publication #05-06-008, Washington State Department of Ecology, Olympia.

Halabisky, M. 2017. "Reconstructing the past and modeling the future of wetland dynamics under climate change." A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, School of Environmental and Forest Services, University of Washington.

Heller, Christa. 2023. Bellevue Salmon Spawner Surveys (1999-2022). City of Bellevue Utilities Engineering Division, Water Resources Planning.

Herrera. 2006. "Addendum to City of Bellevue Critical Areas Update: Risk Analysis of Council-Modified Alternative for Improving Critical Areas Protection."

Herrera. 2005a. "City of Bellevue's Critical Areas Update: 2005 Best Available Science (BAS) Review."

Herrera. 2005b. "City of Bellevue's Critical Areas Update: Risk Analysis of No Action, Regulatory, City Programs, and Best Available Science Alternatives for Improving Critical Areas Protection."

Hruby, T. 2012. Calculating credit and debits for compensatory mitigation in wetlands of Western Washington, Final report. Publication #10-06-011, Washington State Department of Ecology.

Hruby, T. 2013. Update on Wetland Buffers: The State of the Science. Publication #13-06-11, Washington State Department of Ecology.

Hruby, T., and A. Yahnke. 2023. Washington State Wetland Rating System for Western Washington 2014 Update Version 2.0. Publication #23-06-009, Shorelands and Environmental Assistance Program.

Hruby, Thomas, Kim Harper, and Stephen Stanley. 2009. Selecting Wetland Mitigation Sites Using a Watershed Approach. Publication #9-06-032, Washington State Department of Ecology.

Jensen, D. W., E. A. Steel, A. H. Fullerton, and G. R. Pess. 2009. "Impact of Fine Sediment on Egg-to-fry Survival of Pacific Salmon: A Meta-analysis of Published Studies." Reviews in Fisheries Science 17 (3): 348-359. doi:10.1080/10641260902716954.

Johnson, D. H., and T. A. O'Neil. 2001. Wildlife-Habitat Relationships in Oregon and Washington. Corvallis, OR: Oregon State University Press.

Jones, J. A. 2000. "Hydrologic process and peak discharge response to forest removal, regrowth, and roads in 10 small experimental basins, western Cascades, Oregon." Water Resources Research 36 (9): 2621-2642.

Kaufmann, P. R., and J. M. Faustini. 2012. "Simple measures of channel habitat complexity predict transient hydraulic storage in streams." Hydrobiologia 685: 69-95. doi:10.1007/s10750-011-0841-y.

Kissling, M. L. and E. O. Garton. 2008. Forested buffer strips and breeding bird communities in Southeast Alaska. Journal of Wildlife Management 72(3): 674-681.

Knutson, M. G., W. B. Richardson, D. M. Reineke, B. R. Gray, J. R. Parmelee, and S. E. Weick. 2004. "Agricultural Ponds Support Amphibian Populations." Ecological Applications 14 (3): 669-684. doi:10.1891/02-5305.

Konrad, C. P., D. B. Booth, and S. J. Burges. 2005. "Effects of urban development in the Puget Lowland, Washington, on interannual streamflow patterns: Consequences for channel form and streambed disturbance." Water Resources Research 41. doi:10.1029/2005WR004097.

Konrad, C., and D. B. Booth. 2005. "Hydroloic Changes in Urban Streams and Their Ecological Significance." American Fisheries Society Symposium (American Fisheries Society) 47: 157-177.

Lehtinen, R. M., S. M. Galatowitsch, and J. R. Tester. 1999. Consequences and habitat loss and fragmentation for wetlands amphibian assemblages. Wetlands 19:1-12.

Lenoir, J., and J. -C. Svenning. 2014. "Climate-related range shifts--a global multidimensional synthesis and new research directions." Ecography 37. doi:10.1111/ecog.00967.

MacArthur, R. H., and E. O. Wilson. 1967. The Theory of Island Biogeography. Princeton University Press.

Mansilha, C., A. Melo, Z. Martins, I. M. P. L. V. O. Ferreira, A. M. Pereira, and J. E. Marques. 2020. "Wildfire Effects on Groundwater Quality from Springs Connected to Small Public Supply Systems in a Peri-Urban Forest Area (Braga, NW Portugal)." Water 12 (4): 16. doi:10.3390/w12041146.

Mason, J., C. Moorman, G. Hess, and K. Sinclair. 2007. "Designing suburban greenways to provide habitat for forest-breeding birds." Landscape and Urban Planning 80 (1-2): 153-164. doi:10.1016/j.landurbplan.2006.07.002.

Mauger, G. S., and H. M. Kennard. 2017. Integrating Climate Resilience in Flood Risk Management: A Work Plan for the Washington Silver Jackets. Report prepared for FEMA. Climate Impacts Group, University of Washington, Seattle. doi:10.7915/CIGMP4WZ.

Mauger, G. S., and J. S. Won. 2019. Expanding the ensemble of precipitation projections for King County. Report prepared for the King County Department of Natural Resources. Climate Impacts Group, Univeristy of Washington, Seattle.

Mauger, G. S., J. H. Casola, H. A. Morgan, R. L. Strauch, B. Jones, B. Curry, T. M. Busch Isaksen, L. Whitely Binder, M. B. Krosby, and A. K. Snover. 2015. State of Knowledge: Climate Change in Puget Sound. Report prepared for the Puget Sound Partnership and the National Oceanic and Atmospheric Administration. Climate Impacts Group, University of Washington, Seattle. doi:10.7915/CIG93777D.

Mauger, G. S., J. S. Won, K. Hegewisch, C. Lynch, R. Lorente Plazas, and P. Salathé Jr. 2018. New Projections of Changing Heavy Precipitation in King County. Report prepared for the King County Department of Natural Resources. Climate Impacts Group, University of Washington, Seattle.

McKinney, M. L. 2002. “Urbanization, biodiversity, and conservation: the impacts of urbanization on native species are poorly studied, but educating a highly urbanized human population about these impacts can greatly improve species conservation in all ecosystems.” Bioscience 52(10): 883-890.

Milner, A. M., A. L. Robertson, M. J. McDermott, M. J. Klaar, and L. E. Brown. 2013. “Major flood disturbance alters river ecosystem evolution.” Nature Climate Change 3(2): 137-141.

Moore, R. D., and S. M. Wondzell. 2005. "Physical Hydrology and the Effects of Forest Harvesting in the Pacific Northwest: A Review." Journal of the American Water Resources Association (JAWRA) (American Water Resources Association) 41 (4): 763-784.

Nagelkerken, I., B. J. M. Allan, D. J. Booth, J. M. Donelson, and T. Ravasi. 2023. "The effects of climate change on the ecology of fishes." PLOS Climate 2 (8): e0000258. doi:10.1371/journal.pclm.0000258.

Naiman, Robert J., Carol A. Johnston, and James C. Kelley. 1988. "Alteration of North Amercian Streams by Beaver." BioScience 38 (11): 753-762. doi:10.2307/1310784.

National Research Council. 2001. Compensating for Wetland Losses Under the Clean Water Act. Washington, DC: The National Academies Press. doi:10.17226/10134.

Nelson, G.S. and S.M. Nelson. 2001. Bird and butterfly communities associated with two types of urban riparian areas. Urban Ecosyst. 5:95-108.

Olden, J. D., N. L. Poff, M. R. Douglas, M. E. Douglas, and K. D. Fausch. 2004. Ecological and evolutionary consequences of biotic homogenization. Trends in ecology & evolution 19(1): 18-24.

Ott, Robert A. 200. Factors affecting stream bank and river bank stability, with an emphasis on vegetation influences. Region III Forest Resources & Practices Riparian Management Annotated Bibliography.

Pardini, R., S. M. de Souza, R. Braga-Neto, and J. P. Metzger. 2005. "The role of forest structure, fragment size and corridors in maintaining small mammal abundance and diversity in an Atlantic forest landscape." Biological Conservation 124: 253-266. doi:10.1016/j.biocon.2005.01.033.

Peters, D. L., D. Caissie, W. A. Monk, S. B. Rood, and A. St-Hilaire. 2015. “An ecological perspective on floods in Canada.” Canadian Water Resources Journal / Revue Canadienne Des Ressources Hydriques 41(1–2): 288–306. https://doi.org/10.1080/07011784.2015.1070694

Petralia, J. 2022. The Effects of Channel Incision and Land Use on Surface-Water/Groundwater Interactions in the Teanaway River Basin, Washington, USA. https://digitalcommons.cwu.edu/etd/1780.

Pimentel, D., R. Zuniga, and D. Morrison. 2005. “Update on the environmental and economic costs associated with alien-invasive species in the United States.” Ecological economics 52(3), 273-288.

PlanIT Geo, Inc. 2023. "An Assessment of Urban Tree Canopy in Bellevue, WA."

Pollock, M. M., G. R. Pess, T. J. Beechie, and D. R. Montgomery. 2004. "The Importance of Beaver Ponds to Coho Salmon Production in the Stillaguamish River Basin, Washington, USA." North American Journal of Fisheries Management (American Fisheries Society) 24: 749-760.

Quinn, T., G. F. Wilhere, and K. L. Krueger. 2020. Riparian Ecosystems, Volume 1: Science Synthesis and Management Implications. Habitat Program, Washington Department of Fish and Wildlife, Olympia.

Raymond, C., H. Morgan, D. Peterson, and J. Halofsky. 2022. A Climate Resilience Guide for Small Forest Landowners in Western Washington. A Collaboration of the University of Washington Climate Impacts Group, the U.S. Forest Service, and the Northwest Climate Hub. doi:10.6069/FT3K-EC80.

Rentz, T., A. Windrope, K. Folkerts, and J. Azerrad. 2020. Riparian Ecosystems, Volume 2: Management Recommendations. Habitat Program. Washington State Department of Fish and Wildlife, Olympia.

Richarson, J. S., R. J. Naiman, and P. A. Bisson. 2012. "How did fixed-width buffers become standard practice for protecting freshwaters and their riparian areas from forest harvest practices?" Freshwater Science (The Society for Freshwater Science) 31 (1): 232-238. doi:10.1899/11-031.1.

Roop, H. A., A. K. Morgan, A. K. Snover, and M. Krosby. 2020. "Shifting Snowlines and Shorelines: The Intergovernmental Panel on Climate Change's Special Report on the Ocean and Cryophere and Implications for Washington State." Briefing paper prepared by the Climate Impacts Group, University of Washington, Seattle. doi:10.6069/KTVN-WY66.

Rupke, Huisman, and Kruse. 2007. "Stability of Man-made Slopes." Engineering Geology 91 (1): 16-24.

Salathe, E. P., A. F. Hamlet, C. F. Mass, S. Lee, M. Stumbaugh, and R. Steed. 2014. "Estimates of Twenty-First-Century Flood Risk in the Pacific Northwest Based on Regional Climate Model Simulations." Journal of Hydrometeorology (American Meteorological Society) 15: 1881-1899. doi:10.1175/JHM-D-13-0137.1.

Sattar, Q., M. E. Maqbool, R. Ehsan, and S. Akhtar. 2021. "Review on climate change and its effect on wildlife and ecosystem." Open Journal of Environmental Biology 6 (1): 008-014. doi:10.17352/ojeb.000021.

Semlitsch, R. D. and J. R. Bodie. 2003. "Biological criteria for buffer zones around wetlands and riparian habitats for amphibians and reptiles." Conservation biology 17(5): 1219-1228.

Sheldon, D., T. Hruby, P. Johnson, K. Harper, A. McMillan, T. Granger, S. Stanley, and E. Stockdale. 2005. Wetlands in Washington State, Volume 1: A Synthesis of the Science. Publication #05-06-006, Washington State Department of Ecology.

Shirk, A., H. Morgan, M. Krosby, C. Raymond, G. S. Mauger, and L. Helbrecht. 2021. Preparing Washington Department of Fish and Wildlife for a changing climate: assessing risks and opportunities for action. A collaboration of the Washington Department of Fish and Wildlife and University of Washington Climate Impacts Group.

Snover, A. K., C. L. Raymond, H. A. Roop, and H. Morgan. 2019. "No Time to Waste. The Intergovernmental Panel on Climate Change's Special Report on Glocal Warming of 1.5°C and Implications for Washington State." Briefing paper prepared by the Climate Impacts Group, University of Washington, Seattle. Updated 02/2019.

Snover, A. K., L. Whitely Binder, J. Lopez, E. Willmott, J. Kay, D. Howell, and J. Simmonds. 2007. Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments. In association and published by ICLEI - Local Governments for Sustainability, Oakland, CA.

Soranno, P. A., S. L. Hubler, S. R. Carpenter, and R. C. Lathrop. 1996. "Phosphorus loads to surface waters: A simple model to account for spatial pattern of land use." Ecological Applications (Ecological Society of America) 6 (3): 865-878.

The SR 530 Landslide Commission. 2014. "The SR-530 Landslide Commission Final Report."

The Watershed Company. 2016. "City of Bellevue Critical Areas Regulations Technical Report-Part 1: Update to Best Available Science and Existing Conditions."

Tian, Z., H. Zhao, K. T. Peter, M. Gonzalez, J. Wetzel, C. Wu, X. Hu, et al. 2020. "A ubiquitous tire rubber-derived chemical induces acute mortality in coho salmon." Science 1-10. doi:10.1126/science.abd6951.

Tubbs, Donald W. 1974. Landslides in Seattle. Department of Natural Resources, Division of Geology and Earth Resources, Information Circular No. 52.

U.S. Army Corps of Engineers. 2010. Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region (Version 2.0). ERDC/EL TR-10-3, Wetlands Regulatory Assistance Program.

Van de Bosch, K., and J. W. Matthews. 2017. "An Assessment of Long-term Compliance with Performance Standards in Compensatory Mitigation Wetlands." Environmental Management 59: 546-556. doi:10.1007/s00267-016-0804-1.

Voisin, N., D. Rose, D. Broman, N. Sun, and I. Kraucunas. 2023. Exploring Multiscale and Earth System and Human-Earth System Dynamics in the Puget Sound Region. Scoping Study Report, PNNL-33801, Pacific Northwest National Laboratory.

WDFW. 2009. Landscape Planning for Washington's Wildlife: Managing for Biodiversity in Developing Areas. Washington Department of Fish and Wildlife, Olympia, WA.

WDFW. 2015. Washington's State Wildlife Action Plan. Washington Department of Fish and Wildlife, Olympia, WA.

Wiegand, T., E. Revilla, and K. A. Moloney. 2005. "Effects of Habitat Loss and Fragmentation on Population Dynamics." Conservation Biology 19 (1): 108-121. doi:10.1111/j.1523-1739.2005.00208.x.

Wong, S.L., and R.H. McCuen. 1982. Design of vegetative buffer strips for runoff and sediment control. Annapolis, MD: Maryland Department of Natural Resources, Coastal Resources Division, Tidewater Administration.

Young, H. S., D. J. McCauley, M. Galetti, and R. Dirzo. 2016. "Patterns, Causes, and Consequences of Anthropocene Defaunation." Annual Review of Ecology, Evolution, and Systematics 47: 333-358. doi:10.1146/annurev-ecosys-112414-054142.

APPENDIX A. 2016 BAS Review

City of Bellevue Critical Areas Regulations Technical Report

Prepared for:

Development Services Department
450 110th Ave. NE
P.O. Box 90012
Bellevue, WA 98009

Prepared by:

The Watershed Company

750 Sixth Street South
Kirkland . WA 98033
p 425.822.5242
f 425.827.8136
watershedco.com

Golder Associates

18300 NE Union Hill Road
Suite 200
Redmond, Washington, 98052

August 2016

The Watershed Company Reference Number: 160349

EXECUTIVE SUMMARY

To comply with Growth Management Act (GMA) mandates, the City of Bellevue is currently in the process of updating its Critical Areas Ordinance. The City last comprehensively updated its critical areas regulations in 2006. To support the City's GMA-mandated Critical Areas Ordinance update, The Watershed Company prepared a two-part technical report, Part 1 – Update to Best Available Science and Existing Conditions, and Part 2 – Gap Analysis. These documents 1) identify relevant science related to management of critical areas since the previous critical areas update, as well as significant changes to existing conditions; and 2) recommend updates to the City's critical area provisions that comply with State guidance and best available science (BAS).

Part 1 – Update to Best Available Science and Existing Conditions

This document provides an update to the body of scientific literature and agency guidance since previous BAS documents were prepared in 2003 (Critical Areas Inventories), 2005 (City of Bellevue's Critical Areas Update- 2005 Best Available Science Review), and 2009 (Bellevue Urban Wildlife Habitat Literature Review). Similarly, updates to existing conditions since the completion of the previous BAS and existing conditions review are addressed where relevant. This updated review of science is intended to build on the existing body of literature, and unless otherwise specified, it does not supersede the previous findings. Findings for streams, wetlands, terrestrial wildlife habitat, frequently flooded areas, and geologic hazard areas are briefly summarized below. The BAS review does not address critical aquifer recharge areas, which are not regulated under the current City of Bellevue code. The Critical Aquifer Recharge Areas Guidance Document was published by the Washington Department of Ecology in January 2005, and it has not been updated since that time.

- Streams and Riparian: Recent BAS generally supports the previous understanding of functions and values of instream habitat and the surrounding riparian area. Key updates to the BAS recognize the significant impacts of untreated stormwater and the effectiveness of stormwater treatment, as well as the importance of non-fish bearing streams to downstream habitat, flow, and water quality conditions. Additionally, new science identifies the significance of culverts that pass all flows and woody debris for maintaining habitat functions in urban settings.

- Wetlands: Primary BAS-based updates to wetland protections include wetland identification and classification based on functions, as well as approaches to calculating and implementing wetland mitigation.

- Terrestrial Habitat and Corridors: The BAS presented in 2009 related to urban wildlife in the City of Bellevue remains pertinent. This section identifies several changes to the designation of species at the state and federal level, and it briefly summarizes state and federal management recommendations (where they exist) for species of local importance.

- Frequently Flooded Areas (FFAs): Frequently flooded areas (FFA) are managed to reduce potential risks to public safety. FFAs can also provide valuable instream habitat benefits, such as low-velocity instream habitat during high-flow events. To comply with the conditions of the 2008 FEMA Biological Opinion and incorporate BAS on FFA functions, floodplain habitat assessments are required in addition to standard flood safety measures for projects within floodplains.

- Geological Hazard Areas: This section addresses recent updates in the understanding of seismic hazard areas and the extent and potential threat associated with toe runout below landslide hazard areas. The significance of the issue of toe runout distances became clear following the Oso landslide in 2014.

Part 2 – Gap Analysis reviews the existing critical areas regulations and identifies areas of the code that should be updated to be consistent with science-based recommendations. Recommendations in the gap analysis are based on a review of the GMA requirements, the BAS review (Part 1), and current critical area regulations (Bellevue Land Use Code (LUC) Part 20.25H). Critical area regulations will need to align with BAS practices, and any deviations from BAS recommendations must be documented and justified. In general, recommendations based on BAS-based guidance from the Department of Ecology are fairly prescriptive, whereas recommendations from primary BAS literature allow for more flexibility in interpretation of policy implications and application to revising City code. Recommendations for the City of Bellevue's critical areas code update are summarized in brief below.

- Designation of Critical Areas and Dimensional Standards: Discrepancies are noted between the language used in the recently adopted Comprehensive Plan and the description of critical areas in Part 20.25H. We recommend clarifying the designation of critical areas to ensure consistency with the Comprehensive Plan and state law.

- Streams: In order to maximize consistency with state practices, we propose considerations related to the Permanent and Interim Water Typing System and the location from which to measure stream buffers. Based on the science identifying the significance of stormwater treatment, the City should require that stormwater treatment and low impact development measures are implemented.

- Wetlands: Wetland delineation criteria need to be based on the federal manual and regional supplement to align with Washington Administrative Code (WAC) 173-22-035. Wetland classifications should be based on the current 2014 Wetland Rating System for Western Washington (Ecology publication #14-06-029). The City should consider how and when to allow use of the credit/debit tool, mitigation banking, and in-lieu fee programs.

- Geologic Hazard Areas: Based on the updated understanding of toe-runout distance risks following the Oso landslide, the city should revise the toe-of-slope setback to account for site-specific conditions in landslide hazard areas. The City should also designate areas of high seismic hazard as critical areas.

- Habitat Associated with Species of Local Importance: State and federal listing of sensitive, threatened, and endangered terrestrial species have changed since the last critical areas update. The City should consider adopting the State's priority species list as species of local importance to ensure that suite of species protected by City regulations are consistent with the most up-to-date conditions and scientific understanding.

- Frequently Flooded Areas: A 2008 Biological Opinion required cities enrolled in the National Flood Insurance Program to ensure regulatory standards that protect the habitat value of floodplains for threatened salmonids and southern resident killer whales. The City should update its code standards for frequently flooded areas to describe when a floodplain habitat assessment is required and the necessary components of such an assessment.

CITY OF BELLEVUE CRITICAL AREAS REGULATIONS TECHNICAL REPORT-PART 1

Update to Best Available Science and Existing Conditions

Prepared for:

Development Services Department
450 110th Ave. NE
P.O. Box 90012
Bellevue, WA 98009

Prepared by:

THE WATERSHED COMPANY

750 Sixth Street South
Kirkland . WA 98033
p 425.822.5242
f 425.827.8136
watershedco.com

Golder Associates

18300 NE Union Hill Road
Suite 200
Redmond, Washington, 98052

August 2016

The Watershed Company Reference Number: 160349

TABLE OF CONTENTS

List of Figures

List of Tables

1 Introduction

With passage of the Growth Management Act (GMA), local jurisdictions throughout Washington State (State), including the City of Bellevue (City), were required to develop policies and regulations to designate and protect critical areas. Critical areas, as defined by the GMA (Revised Code of Washington [RCW 36.70A.030(5)), include wetlands, areas with a critical recharging effect on aquifers used for potable water, fish and wildlife habitat conservation areas, frequently flooded areas, and geologically hazardous areas. The GMA directs jurisdictions to periodically conduct a thorough review and update their Comprehensive Plan and regulations (RCW 36.70A.130). When updating critical areas policies and regulations, jurisdictions must include the best available science (BAS). Any deviations from science-based recommendations should be identified, assessed and explained (Washington Administrative Code [WAC] 365-195-915). In addition, jurisdictions are to give special consideration to conservation or protection measures necessary to preserve or enhance anadromous fisheries.

The City of Bellevue last comprehensively updated its critical areas regulations in 2006. This report provides an overview of the science relevant to the functions and values of wetlands, streams, wildlife habitat, and geologic hazards completed since the last comprehensive review. In addition to the summary of BAS-based recommendations, new information on the location, extent, and general conditions of existing critical areas in the City of Bellevue was investigated, and is reported, where available. Information presented in the *City of Bellevue- 2005 BAS Review* and 2003 critical areas inventory reports continues to provide the scientific basis and environmental setting upon which conservation measures are generally based. Rather than reiterate that scientific basis here, this report relies on the understanding conveyed in the earlier reports and highlights additional scientific research and findings, as well as new agency guidance since 2005.

This report is the first of a two-part technical report. Part 2-Gap Analysis reviews the existing critical areas regulations and identifies areas of the code that should be updated to be consistent with science-based recommendations.

2 Streams and Riparian Areas

2.1 Updates to Best Available Science for Protection of Functions and Values

The recent scientific literature supports and builds on the *City of Bellevue- 2005 BAS Review* document. As noted above, the following discussion is not intended to supersede the previous BAS reports, but rather to identify additional information that builds on the existing understanding. This new information may provide a more nuanced understanding of specific functions and values of streams and riparian areas.

2.1.1 Urbanization and Streams

The *City of Bellevue- 2005 BAS Review* summarized the role of natural disturbances in maintaining stream functions and a diversity of habitats. It also noted that disturbances associated with human activities tend to reduce habitat diversity. In recent years, the interactions between urbanization and hydrology have been further investigated. Urban land cover is correlated with increased high flows, increased variability in daily streamflow, reduced groundwater recharge, and reduced summer low flow conditions (Konrad and Booth 2005, Cuo et al. 2009). Changes in hydrology related to development are generally associated with soil compaction, draining, and ditching across the landscape, increased impervious surface cover, and decreased forest cover (Moore and Wondzell 2005).

In addition to effects on hydrology, significant, new research has helped clarify the ecological effects of stormwater and wastewater discharges. Heavy metals, bacterial pathogens, as well as PCBs, hydrocarbons and endocrine-disrupting chemicals are aquatic contaminants that are commonly associated with urban land uses. Although all metals can be toxic at high concentrations, cadmium, mercury, copper, zinc, and lead are particularly toxic even at low concentrations. Chronic and acute exposure to heavy metals have been found to impair, injure, and kill to aquatic plants, invertebrates, fish, and particularly salmonids (Dethier 2006, Hecht et al. 2007, McIntyre et al. 2008, Baldwin et al. 2011, McIntyre et al. 2012). In general, heavy metals and hydrocarbons are found in road runoff, and these contaminants can reach the City's streams directly through existing stormwater systems. Stormwater systems that circumvent buffers limit the opportunity to filter runoff through adjoining soils and vegetation. Accordingly, stream buffers are typically underutilized for treatment of hydrocarbons and other pollutants found in typical stormwater runoff.

Recent research in the Puget Sound region has identified mature coho salmon that return to creeks and die prior to spawning, a condition called pre-spawn mortality (Feist et al. 2011, Sholz et al. 2011, Spromberg et al. 2015). The condition is linked to urbanized watersheds and is positively correlated with the relative proportion of roads, impervious surfaces, and commercial land cover within a basin (Feist et al. 2011). Pre-spawn mortality was first documented in Bellevue streams in 2000 (City of Bellevue 2016). Between 2000 and 2014, rates of pre-spawn mortality in Kelsey Creek ranged from zero to 100 percent (City of Bellevue 2016). An experimental release of adult coho salmon into Kelsey and Coal Creeks indicated that spawning success was markedly lower in Kelsey Creek (0-0.3% success) compared to Coal Creek (22-41% success) (City of Bellevue 2016).

Recent evidence indicates that some component of untreated road runoff causes pre-spawn mortality, as well as other lethal and sub-lethal effects to juvenile salmonids (McIntyre 2015, Spromberg 2015). Based on a model of the effects of pre-spawn mortality on coho salmon populations, depending on future rates of urbanization, localized extinction of coho salmon populations could occur within a matter of years to decades (Spromberg and Scholz 2011). Recent studies have found that biofiltration of urban stormwater prevents sub-lethal and lethal effects of urban stormwater in juvenile salmon and prevents pre-spawn mortality in coho salmon (McIntyre et al. 2015, Spromberg et al. 2015). These findings point to the critical function of effective riparian buffers, and where that is not possible, the use of green stormwater infrastructure to filter urban runoff.

In summary, urbanization and urban infrastructure can significantly affect stream habitat, water quality, and aquatic life. Low impact development measures that limit impervious surfaces and encourage infiltration of precipitation can effectively help to counteract these impacts. The City of Bellevue is taking several steps to encourage low impact development and retrofits that improve stormwater runoff. These measures include the development of the Natural Drainage Practices Maintenance Guidelines (2009), the Storm and Surface Water System Plan (City of Bellevue 2016) and the Low Impact Development Principles Project, and revision of the Phase II National Pollutant Discharge Elimination System (NPDES) permit (due in December 2016) to require use of low impact development where feasible.

2.1.2 River Continuum

The *City of Bellevue- 2005 BAS Review* presented the River Continuum concept, which describes various functions and characteristics of rivers, ranging from headwater streams to large rivers. Since the *City of Bellevue- 2005 BAS Review*, several studies have further investigated the River Continuum concept and the significance of non-fish bearing streams and hydrologic source areas, where runoff converges and groundwater rises to form surface water drainageways.

Riparian areas associated with headwater streams produce significant quantities of invertebrates (Wipfli 2005, Wipfli et al. 2007) that are transported downstream to fish-bearing waters. In many cases, small, intermittently flowing channels are productive rearing areas for juvenile salmonids (e.g., Wigington et al. 2006, Colvin et al. 2009).

Hydrologic changes from development are expected to be most significant in small- to intermediate-sized streams with naturally low seasonal and storm flow variability (Konrad and Booth 2005). Qiu et al. (2009) and Tomer et al. (2009) modeled the effects of protecting these hydrologic source areas related to water quality. Because increased surface water flows are responsible for the increased transport of pollutants, they found that buffers were most effective in maintaining water quality conditions in watersheds where these hydrologic source areas were protected in riparian buffers.

Longitudinal continuity of buffers along streams is also an important factor determining the effectiveness of buffers at improving channel conditions. Riparian continuity is correlated with abundance and diversity of sensitive invertebrates (Wooster and DeBano 2006) and metrics of physical stream conditions (McBride and Booth 2005). A watershed-scale study in Southwest Washington found that stream conditions were best maintained with continuous buffers, compared to patch buffers or no buffers (Bisson et al. 2013).

2.1.3 Sediment

As described in the *City of Bellevue- 2005 BAS Review*, fine sediment adversely affects stream habitat by filling pools, embedding gravels, reducing gravel permeability and increasing turbidity. Upland clearing and grading can result in long-term increases in fine sediment inputs to streams (Gomi et al. 2005). Numerous studies have investigated the effectiveness of varying widths of buffers at filtering sediment, typically finding high sediment filtration rates in relatively narrow buffer areas (reviewed in Yuan et al. 2009).

It is significant to note, however, that many of these studies occur in laboratory or field plot experiments, which tend to have much shorter field lengths (hillslope length contributing to drainage) than would be encountered in real-world scenarios (*i.e.*, ~5:1 ratio of field length to riparian width for a field plot compared to 70:1 ratio in NRCS guidelines). Since water velocities tend to increase with field length, field plot experiments may suggest better filtration than would be encountered under real-world conditions. Additionally, field-scale experiments generally do not account for flow convergence, which reduces sediment retention (Helmers et al. 2005) or for stormwater components that bypass filter strips through ditches, stormwater infrastructure, and roads (Verstraeten et al. 2006). Therefore, the effectiveness of filter strips at filtering sediment under real-world conditions and at the catchment scale is likely to be lower than what is reported in field plot experiments.

In addition to width, the slope, vegetation density, and sediment composition of a riparian area have significant bearing on sediment filtration potential. A recent model of sediment retention in riparian zones found that a grass riparian zone as small as 4 m (13 ft) could trap up to 100% of sediment under specific conditions (2% hillslope over fine sandy loam soil), whereas a 30 m (98 ft) grass riparian zone would retain less than 30% of sediment over silty clay loam soil on a 10% hillslope (Dosskey et al. 2008, Figure 2.1). This study exemplifies the effects that soil type and hillslope have on sediment retention.

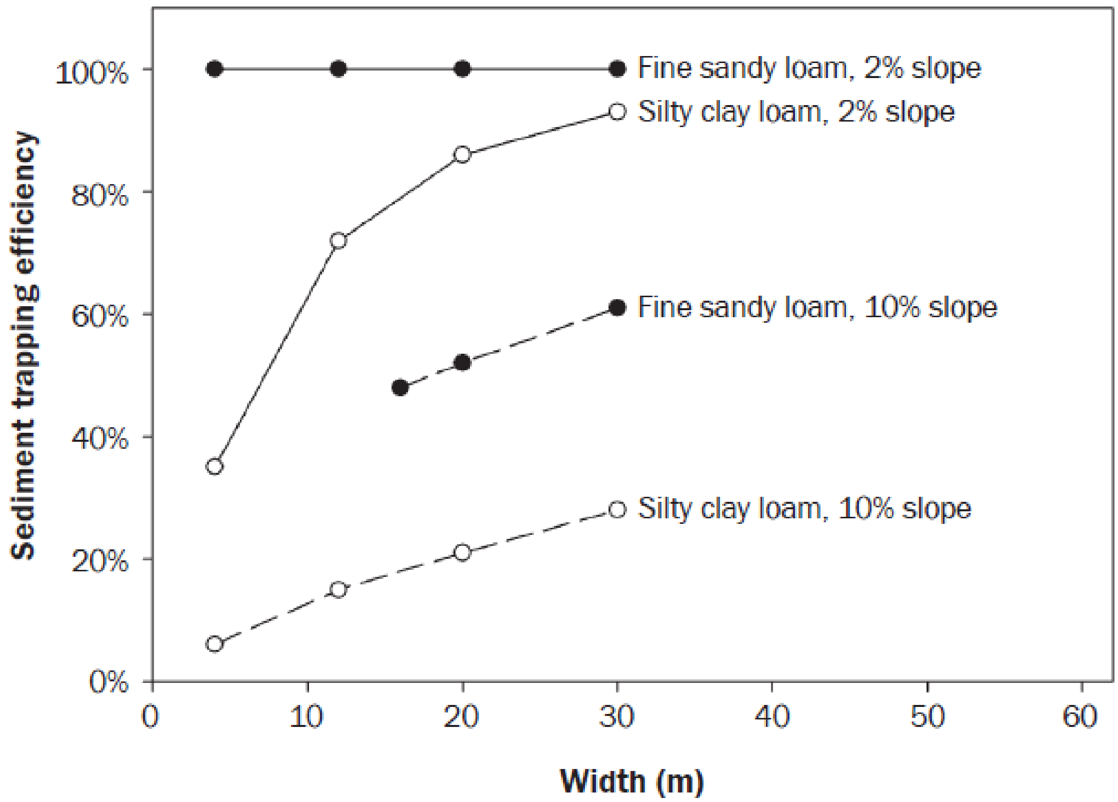

Figure 2.1. Sediment trapping efficiency related to soil type, slope, and buffer width. (Figure from Dosskey et al. 2008).

Vegetative composition within the buffer also affects sediment retention. Vegetation tends to become more effective at sediment and nutrient filtration several years after establishment (Dosskey et al. 2007). Dosskey et al. (2007) did not find a significant difference between the filtration effectiveness of established grass and forested buffers. However, a meta-analysis of 81 buffer studies indicated that all-grass and all-forest buffers tend to more effectively filter sediment compared to buffers with a mix of grass and forested vegetation (Zhang et al. 2010). Additionally, whereas thin-stemmed grasses may become overwhelmed by overland flow, dense, rigid-stemmed vegetation provides improved sediment filtration that is expected to continue to function better over successive storm events (Yuan et al. 2009).

2.1.4 Nutrients

As described in the *City of Bellevue- 2005 BAS Review*, in excess concentrations, nitrogen and phosphorus can lead to poor water quality conditions, including reduced dissolved oxygen rates, increased pH, and eutrophication (Mayer et al. 2005, Mayer et al. 2007)). Excessive amounts of nitrogen and phosphorus speed up eutrophication and algal blooms in receiving waters, which can deplete the dissolved oxygen in the water and result in poor water quality and fish kills (Mayer et al. 2005, Dethier 2006, Heisler et al. 2008). Riparian zones can reduce nitrogen pollution through nutrient uptake, assimilation by vegetation, and through denitrification (Sobota et al. 2012).

The rate of nitrogen removal from runoff varies considerably depending on local conditions, including soil composition, surface versus subsurface flow, riparian zone width, riparian composition, and climate factors (Mayer et al. 2005, Bernal et al. 2007, Mayer et al. 2007). Nutrient assimilation is also dependent on the location of vegetation relative to the nitrogen source, the flowpath of surface runoff, and position in the landscape (Baker et al. 2006).

A meta-analysis of studies of nutrient removal in riparian buffers ranging from 1-200 m (3-656 ft) concluded that buffers wider than 50 m (164 ft) remove nitrogen more effectively than buffers less than 25 m (82 ft) wide; however, within the categories of 0-25 m (0-82 ft), 25-50 m (82-164 ft), and >50 m (164 ft), factors other than buffer width determine nitrogen removal effectiveness (Mayer et al. 2007). Riparian zones less than 15 m (49 ft) actually contributed to nitrogen loading in some cases (Mayer et al. 2007). Another meta-analysis of nutrient removal studied buffers up to 22 m (72 ft) wide, and found that these buffers effectively removed 92 and 89.5 percent of nitrogen and phosphorus, respectively (Zhang et al. 2010).

Mayer et al. (2005, 2007) found that riparian zones ranging from 1-200 m (3-656 ft) generally removed 89% of *subsurface* nitrates regardless of riparian zone width. On the other hand, nitrate retention from *surface* runoff was related to riparian zone width, where 50%, 75%, and 90% surface nitrate retention was achieved at widths of 27 m (88 ft), 81 m (266 ft), and 131 m (430 ft) respectively (Mayer et al. 2007). This suggests that surface water infiltration in the riparian zone should be a priority to promote effective nutrient filtration.

The composition of the riparian zone also affects the efficiency of nutrient removal. Reviews of buffer effectiveness have found that forested riparian zones remove nitrogen and phosphorus more efficiently than grass/forested riparian zones (Zhang et al. 2010). And Mayer et al. (2007) found that herbaceous buffers had the lowest effectiveness compared to forested wetland, forested, and forested/herbaceous buffers. Other studies have found conflicting results, indicating that grass buffers remove nitrogen and phosphorus as well or better than forested buffers (reviewed in Polykov 2005). These findings indicate that the nitrogen removal efficiency of buffers can vary depending on the size and species composition of the buffer.

Removal of phosphorus by riparian buffers is dependent on the form of phosphorus entering the buffer. Whereas phosphorus that is adsorbed by soil particles is effectively removed through sediment retention within a buffer, the retention of soluble phosphorus relies on infiltration and uptake by plants (Polyakov et al. 2005). One long-term study found that phosphorus uptake was directly proportional to the plant biomass production and root area over the four-year study period (Kelly et al. 2007). If a riparian buffer becomes saturated with phosphorus, its capacity for soluble phosphorus removal will be more limited (Polyakov et al. 2005). Another long-term study found that following a 15-year establishment period, a 40-meter (131 ft) wide, three-zoned buffer reduced particulate phosphorus by 22 percent, but dissolved phosphorus exiting the buffer was 26 percent higher than the water entering the buffer, so the buffer resulted in no net effect on phosphorus (Newbold et al. 2010).

In summary, most riparian zones reduce subsurface nutrient loading, but extensive distances are needed to reduce nutrients in surface runoff. Filtration capacity decreases with increasing loads (Mayer et al. 2005), so best management practices across the landscape that reduce nutrient loading will improve riparian function.

2.1.5 Large Woody Debris

The science discussed in the *City of Bellevue- 2005 BAS Review* related to large woody debris is still relevant today. Roni et al. (2014) summarized the scientific understanding of the effectiveness of placed wood. A 2007 report presented information on the large wood loading densities in unmanaged streams in Washington State (Fox and Bolton 2007). The study found that the bankfull width of a stream was the most predictive indicator of wood volume and the overall density of wood. The authors recommended that streams in a degraded state (e.g., below the median) should be managed to meet or exceed the wood loading densities of the 75th percentile of unmanaged streams of a similar bankfull width and geographic position.

A 2012 study by Lassettre and Kondolf identified issues with retaining large wood in urban streams. They found that large wood is often removed from urban streams to address flooding and road maintenance issues. As culverts are replaced, resizing them to allow passage of flood flows and woody debris, consistent with the Washington Department of Fish and Wildlife's 2013 Water Crossing Design Guidelines, should help to allow more large woody debris to be retained in urban stream systems.

2.1.6 Temperature

Building on the science discussed in the *City of Bellevue- 2005 BAS Review*, several studies have documented significant increases in maximum stream temperatures associated with the removal of riparian vegetation (e.g., Moore et al. 2005, Gomi et al. 2006, Pollock et al. 2009).

Two studies in the Pacific Northwest considering the effects of partial forest retention on microclimate found that retention of 15 percent of a forest basal area was not sufficient to maintain microclimate conditions (Heithecker and Halperin 2006, Aubry et al. 2009); however, 40 percent basal area retention resulted in cooler mean air temperatures than clearcut conditions and light conditions similar to an undisturbed forest (Heithecker and Halperin 2006). This indicates that moderate forest cover is necessary to maintain forest microclimate conditions.

2.1.7 Invertebrates

The *City of Bellevue- 2005 BAS Review* noted that aquatic invertebrates are sensitive to water quality, flows, and habitat structure, and they are often considered as indicators of stream habitat conditions (Utz et al. 2009). Hydrologic changes associated with basin and subbasin development have been correlated to degraded indices of invertebrate community integrity (DeGasperi et al. 2009). DeGasperi et al. (2009) proposed that the frequency and range of flood pulses may best explain the correlation between the hydrologic effects of urbanization and the observed degradation of invertebrate communities. Utz et al. (2009) reported that sensitive aquatic invertebrates were not present when impervious cover was in the range of 3 to 23 percent, and the sensitivity of invertebrates to impervious surface cover varied with hydrogeomorphic factors.

Although urbanization at a sub-basin scale is correlated with a reduction in sensitive invertebrate species, those urbanized sub-basins with intact riparian buffers along the longitudinal stream gradient maintain a higher proportion of sensitive species compared to those without vegetated riparian corridors (Walsh et al. 2007, Shandas and Alberti 2009).

2.1.8 Stream Typing

The *City of Bellevue- 2005 BAS Review* referenced the permanent statewide water typing system (WAC 222-16-030), which remains the recommended statewide water typing approach. The *City of Bellevue- 2005 BAS Review* described all non-fish-bearing waters as "Type N." Today, however, the permanent water typing system differentiates between perennial (Type Np) and seasonal (Type Ns) non-fish-bearing streams. The permanent water typing system was intended to be used where stream type mapping is available. DNR water typing has been mapped for most streams in Bellevue (https://fortress.wa.gov/dnr/protectiongis/fpamt/default.aspx); however, some streams are mapped as "unknown" and other streams may not be mapped at all.

In addition to the WAC definition under the permanent statewide water typing system, the state has also established interim statewide water typing system (WAC 222-16-031) intended to apply before water type mapping is complete. The interim stream typing criteria provide additional physical criteria that help to establish whether a stream is likely to be fish-bearing or perennial.

2.1.9 Summary of the Implications of the BAS Update to the Management of Streams

The range of buffer widths for stream protection presented in the *City of Bellevue- 2005 BAS Review* remain valid based on the current review of literature. The updated literature review suggests additional emphasis on the following management considerations:

- Low impact development, with an emphasis on infiltration can help reduce, and in some cases eliminate, significant adverse effects of urban land uses on flows, habitat, water quality, and aquatic life.
- Protection of hydrologic source areas, including intermittent and non-fish bearing streams, as well as headwater wetlands, is particularly significant for protecting downstream habitat and water quality functions.
- Buffer effectiveness varies depending on site-specific conditions, including slope, sediment, and site topography.
- The most effective buffers are densely vegetated to promote infiltration, nutrient uptake, resist erosion.
- Infrastructure improvements that replace culverts with those that meet current Washington Department of Fish and Wildlife (WDFW) guidelines are expected to

improve instream habitat by allowing more large woody debris to remain in urban streams.

2.2 Updates to Existing Conditions

The Final Storm and Surface Water System Plan (SSWSP)(City of Bellevue 2016, including appendices) provides an extensive and up-to-date description of existing conditions relating to both water quality and habitat in the City's streams. That document should be referenced for a summary of existing conditions relative to surface waters in the City of Bellevue. Highlights from that document are summarized below.

2.2.1 Basin conditions

The SSWSP reports that as of 2008, 46 percent of the total area in Bellevue was impervious and that in 2007, 36 percent of the total area of the City was tree canopy. Tree canopy cover in the city decreased 20 percent between 1986 and 2006. American Forests recommends a city-wide goal of 40 percent tree canopy in urban areas to maintain environmental benefits (2008). Basins that currently meet the American Forests recommendation of 40 percent tree canopy include Beaux Arts, Coal Creek, Goff Creek, Lewis Creek, Mercer Slough, North Sammamish, Phantom Creek, South Sammamish, Vasa Creek, and Yarrow (City of Bellevue 2016).

In general, tree canopy is higher and impervious area lower adjacent to streams than in the overall drainage basin. This difference is likely associated with critical area requirements for buffers along streams.

2.2.2 Water quality and Flow

Nine stream segments, two Lake Washington sampling sites, and two Lake Sammamish sampling sites are listed as impaired per the Ecology's 2012 water quality assessment. Streams were rated as impaired due to high fecal coliform bacteria counts, high water temperatures, and/or low dissolved oxygen.

In addition to chemical parameters, a rating system known as the Benthic Index of Biotic Integrity (B-IBI) can be used to assess long-term stream conditions. In Bellevue, 36 sites were sampled for B-IBI ratings between 1998 and 2014. The most recent B-IBI scores show 46 percent of all Bellevue sites ranked as poor and 25 percent ranked as very poor (City of Bellevue). These ratings are similar to other urban sites sampled in the Puget Sound lowlands.

The intensity and frequency of peak flows in Kelsey Creek have increased as Bellevue has become more urbanized (City of Bellevue 2016).

3 WETLANDS

3.1 Updates to Best Available Science for Protection of Functions & Values

3.1.1 Identification and Classification

Per WAC 173-22-035, wetland delineations shall be conducted in accordance with the federal wetland delineation manual and applicable regional supplements. The U.S. Army Corps of Engineers (Corps) Wetland Delineation Manual (Corps 1987) and the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region Version 2.0* (Regional Supplement) (Corps May 2010) should be the applied methodology.

The Washington Department of Ecology (Ecology) Washington State Wetland Rating System is the most commonly used and regionally accepted wetland classification system. This rating system was last updated in June 2014 (Hruby 2014; Ecology Publication No. 14-06-019). It is a four-tier wetland rating system, which grades wetlands on a points-based system in terms of functions and values. Ecology specifically developed this tool to allow for relatively rapid wetland assessment while still providing some scientific rigor (Hruby 2004). This rating system incorporates other classification elements, such as Cowardin (Cowardin et al. 1979), hydrogeomorphic) classifications (Brinson 1993), and special characteristics such as bogs and mature forests. As described in the Ecology Rating System guidance: “This rating system was designed to differentiate between wetlands based on their sensitivity to disturbance, their significance, their rarity, our ability to replace them, and the functions they provide” (Hruby 2004, Hruby 2014). The rationale for each wetland category under the Ecology Rating System is described below.

- Category I: These are the most unique or rare high-functioning wetland types that are highly sensitive to disturbance and/or relatively undisturbed wetlands with functions that are impossible to replace in a human lifetime.
- Category II: These wetlands are high functioning and difficult, though not impossible, to replace, and provide a high level of some functions.
- Category III: These wetlands provide a moderate level of functions and can often be adequately replaced with a well-planned mitigation project. They have generally been disturbed in some way and are characterized by landscape fragmentation and less diversity.
- Category IV: These wetlands are low functioning and can be replaced or improved. They are characterized by a high level of disturbance and are often dominated by invasive weedy plants.

Wetland categorization provides an important tool for managing impacts. “The intent of the rating categories is to provide a basis for developing standards for protecting and managing the wetlands. Some decisions that can be made based on the rating include the width of buffers needed to protect the wetland from adjacent development and permitted uses in, and around, the wetland" (Hruby 2014).

3.1.2 Wetland Buffers

The synthesis of science review for buffers was re-evaluated by Ecology in 2013 (Hruby 2013). Most of the conclusions from the 2005 literature review are still valid (Sheldon et al. 2005; Hruby 2013). The primary conclusions of the 2013 review are as follows.

- Wetland buffer effectiveness at protecting water quality varies in conjunction with several factors, including width, vegetation type, geochemical and physical soil properties, source and concentration of pollutants, and path of surface water through the buffer.
- Wider buffers are generally higher functioning than narrower buffers.
- Depending on site-specific environmental factors, different buffer widths may be needed to achieve the same level of protection.
- To protect wetland-dependent wildlife, a broader landscape-based approach that considers habitat corridors and connections is necessary.
- Many animals, particularly native amphibians, require undisturbed upland habitats for their survival (Hruby 2013).

As noted above, the Wetland Rating System was developed to categorize wetlands in accordance with the level of sensitivity and significance, and the categories may be used as a tool to assign appropriate buffer widths. For example, it is appropriate to provide the greatest buffer protection for the highest functioning wetlands that are most difficult to replace. In addition, because habitat protection requires the large buffers to protect the most vulnerable and sensitive species, those wetlands with higher habitat scores warrant wider buffers. On the other hand, lower functioning wetlands with low habitat scores typically primarily support water quality functions, and buffers at the smaller end of the range would tend to provide adequate protection for those functions. Buffers at the smaller end of the scale may be appropriate for small, structurally simple wetlands, with fragmented landscape connections resulting from adjacent development in the city.

Based on the above type of rationale, Ecology developed recommended buffer width management strategies in Appendix 8-C of Wetlands in Washington State, Volume 2 – Protecting and Managing Wetlands (Granger et al. 2005). Hruby's 2013 literature review of wetland buffer science did not prompt any new buffer width recommendations, although Ecology has updated its buffer width recommendations to correspond with the current outputs of the Wetland Rating System for Western Washington (Hruby 2014).

3.1.3 Mitigation Sequencing

To bolster protection of our national wetland resources, no net loss policy was adopted in 1988 and has been upheld through the present administration. The no net loss policy requires a balance between wetland loss due to development and wetland mitigation to prevent further loss of the country's total wetland acreage. In 2008, the U.S. Environmental Protection Agency (EPA) issued the Wetlands Compensatory Mitigation Rule. This rule emphasizes BAS to promote innovation and focus on results.

Wetland mitigation is typically achieved through a series of steps known as mitigation sequencing, a sequence of steps taken "to reduce the severity of an action or situation" (Ecology et al. 2006). Ecology recommends that the CAO contain clear language regarding mitigation sequencing. The mitigation sequence according to the implementing rules of the State Environmental Policy Act (SEPA) (Chapter 197-11-768 WAC) follows:

(1) Avoiding the impact altogether by not taking a certain action or parts of an action;

(2) Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts;

(3) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;

(4) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action;

(5) Compensating for the impact by replacing, enhancing, or providing substitute resources or environments; and/or

(6) Monitoring the impact and taking appropriate corrective measures.

3.1.4 Compensatory Mitigation

Per Ecology, compensatory mitigation should replace lost or impacted wetland and buffer functions, unless out-of-kind mitigation can meet formally identified goals for the watershed. Ecology recommends prioritizing mitigation actions, location(s), and timing. Following mitigation sequencing, after demonstrating that a proposed wetland impact is unavoidable and has been minimized to the extent practical, compensatory mitigation is required by local, state and federal agencies. In general order of preference the agencies recommend wetland compensation in the form of: 1) re-establishment or rehabilitation, 2) creation (establishment), 3) enhancement, and 4) preservation (WDOE et al. 2006).

Wetland re-establishment or rehabilitation occurs when a historic or degraded wetland is returned to a naturally higher functioning system through the alteration of physical or biologic site characteristics. Re-establishment is typically achieved by restoring wetland hydrology; this may include removing fill or plugging ditches. Re-establishment achieves a net gain of wetland acres. Rehabilitation is achieved by repairing or restoring historic functions in a degraded wetland. Restoring a floodplain connection to an existing wetland by breaching a dike is an example of rehabilitation. Rehabilitation does not result in new wetland area.

Wetland creation is the development of a wetland at a site where a wetland did not naturally exist. Proximity to a reliable water source and landscape position are key design requirements for successful wetland creation (WDOE et al. 2006).

Both wetland enhancement and preservation result in a net loss of wetland acreage. Wetland enhancement typically increases structural diversity within a wetland, thus improving functions, or quality. Preservation of high functioning wetland systems in danger of decline may also be proposed as mitigation. While enhancement and preservation do not increase wetland acreage, these actions may result in long-term functional gains (WDOE et al. 2006).

3.1.4.1 Mitigation Ratios

Mitigation ratios are intended to replace lost functions and values stemming from a proposed land use while also accounting for temporal losses. Mitigation ratios recommended by Ecology in 2005 for wetland impacts can be found in Table 3-2 below. As noted above, the Corps and Ecology have a mandate to maintain "no net loss" of wetlands. Wetland creation and restoration are preferable to enhancement alone because wetland enhancement does not replace wetland area, and therefore, enhancement alone would result in a loss of wetland area. Ecology guidance does allow for enhancement as sole compensation for wetland impacts at quadruple the standard ratio (Granger et al. 2005). The higher ratios for enhancement-only are intended to encourage actions that maintain existing wetland acreage and to ensure sufficient area of enhancement to retain wetland functions and values when a net loss of wetland acreage results.

Table 3-2. Ecology Recommended Mitigation Ratios (Granger et al. 2005)*

Category and Type of Wetland Impacts	Creation	Re-establishment-Rehabilitation Only	Creation and Rehabilitation	Creation and Enhancement	Enhancement Only
Category IV	1.5:1	3:1	1:1 C and 1:1 RH	1:1 C and 2:1 E	6:1
Category III	2:1	4:1	1:1 C and 2:1 RH	1:1 C and 4:1 E	8:1
Category II	3:1	6:1	1:1 C and 4:1 RH	1:1 C and 8:1 E	12:1
Category I: Forested	6:1	12:1	1:1 C and 10:1 RH	1:1 C and 20:1 E	24:1
Category I: Bog	Not possible	6:1 RH of a bog	Not possible	Not possible	Case-by-case
Category I: based on total functions	4:1	8:1	1:1 C and 6:1 RH	1:1 C and 12:1 E	16:1 E

*This document, Appendix 8-C of *Wetlands in Washington State, Volume 2 – Protecting and Managing Wetlands* (Granger et al. 2005).
Legend: C = Creation, RH = Rehabilitation, E = Enhancement

3.1.4.2 Credit-Debit Method

To give regulators and applicants a functions-based alternative to set mitigation ratios, the Washington State Department of Ecology recently developed a tool called the credit-debit method. This method, like the Ecology wetland rating form, is a peer reviewed rapid assessment tool. The credit-debit approach may be used to calculate functional gain of the proposed mitigation and functional loss due to proposed wetland impacts. This generates acre-points that can be compared in a balance sheet. Depending on specific site conditions, this may result in less or more mitigation than would be required under a set the standard mitigation ratio guidance (Hruby 2011). Both the ratios from Table 3-2 and the Credit-Debit Method are scientifically defensible methods to calculate required compensatory mitigation.

At present, the credit-debit method is used primarily for calculating credits for mitigation banks and in-lieu fee programs, such as the King County Mitigation Reserves Program. Other local jurisdictions still use mitigation ratios, as described above, yet many also allow the use of the credit-debit method to enable use of mitigation banks and in lieu fee programs. Because it is still early in the application of the credit-debit method, it is difficult to directly compare the outcomes of the credit-debit approach to use of mitigation ratios. Because it is a site-specific tool, it is expected that the credit-debit approach may result in higher or lower mitigation requirements relative to mitigation ratios depending on specific site conditions.

3.1.4.3 Mitigation Location

The Agencies (Ecology, Corps, and the U.S. Environmental Protection Agency Region 10) recommend selecting mitigation sites based on proximity to the impact and potential ability to replace impacted functions. In order of preference, a mitigation site should be:

> "in the immediate drainage basin as the impact, then the next higher level basin, then the other sub-basins in the watershed with similar geology, and finally, the river basin" (WDOE et al. 2006).

In the past decade, national and state policies have shifted toward using a broader scale approach for mitigation site selection. A recent forum convened by Ecology and composed of regulators, businesses, and environmental/land use professionals recommend that local jurisdictions "establish an ecosystem- or watershed-based approach to mitigation" (WDOE 2008). The ecosystem and watershed-based approach to mitigation looks beyond the property where the impact is proposed to evaluate if off-site compensatory mitigation within the local watershed is a viable option and would have greater benefit to ecosystem functions in the long-term. This is becoming more relevant as land use intensity increases and on-site mitigation has the potential to be more isolated on a landscape-scale, thus reducing some functional potential. Due to the limited success of on-site mitigation, particularly in highly developed areas, a broader watershed scale approach is increasingly desirable and is viewed by the regulatory agencies as more sustainable (WDOE 2008). To guide practical applications of BAS-based compensatory mitigation, the Agencies issued an Ecology publication, *Selecting Wetland Mitigation Sites Using a Watershed Approach* (Hruby et al. 2009). As noted by Azous and Horner 2001 (in Hruby et al. 2009), recreating or maintaining wetland functions in a highly developed landscape may not be sustainable. To account for this, the watershed approach may require a combination of on- and off-site mitigation to achieve functional gains equivalent to the proposed losses (WDOE et al. 2006).

Watershed-based planning is a way for local jurisdictions to manage ecologic resources sustainably. Ecology recently developed a Puget Sound Watershed Characterization project.

This project provides a landscape-scale perspective to help planners manage their wetland and wildlife resources in a targeted and effective manner. It is a coarse-scale tool that uses GIS-based water flow, water quality, and habitat assessments to compare areas within a watershed for restoration and protection value (WDOE 2010).

3.1.4.4 Mitigation Timing

Mitigation actions may occur concurrent with the impact or before project impacts. The mitigation ratios provided by Ecology (Table 3-2) assume concurrent mitigation actions. The amount of mitigation required may be reduced for an advanced mitigation project that reduces the temporal loss of functions. In other words, compensatory mitigation that is completed at the time of impact will take several years to reach full functions; however, when mitigation is completed in advance of the impact, the mitigation area will be more mature and higher functioning at the time the impact occurs. Because the lag period between impact and mitigation is reduced or eliminated with advance mitigation, mitigation ratios may be reduced.

3.1.4.5 Compensatory Mitigation Alternatives

Compensatory mitigation can occur through permittee-responsible mitigation (on-site or off-site), mitigation banks, or in-lieu fee programs. In recent years, with permittee-responsible mitigation as the typical approach, several studies have concluded that despite regulatory mechanisms to ensure "no net loss" of wetlands, substantial loss has occurred, both in terms of wetland area and wetland functions (Matthews and Endress 2008). Losses through compensatory mitigation have been attributed to poor restoration success and a lag time between impacts and mitigation (Bendor 2009).

The increased establishment and use of wetland mitigation banking and in-lieu fee programs has been proposed as a solution to the issues that affect on-site mitigation because 1) regulators can devote more time to monitoring and ensuring the success of mitigation banks, 2) mitigation bank sites are generally situated in an ecologically significant area, and 3) mitigation banks tend to aggregate projects into larger wetlands that may provide more functions than small, isolated wetlands (Bendor and Brozovic 2007, Keddy et al. 2009). The Agencies have stated that, "Mitigation banks provide an opportunity to compensate for impacts at a regional scale and provide larger, better-connected blocks of habitat in advance of impacts" (WDOE et al. 2006). Mitigation banks are also advantageous because mitigation credits generally become available in stages as the wetland permit conditions are met and restoration is successful. This helps minimize the lag time that can create a temporal loss in wetland function (Bendor 2009). Based on this and similar rationale, in 2008, EPA and the U.S. Army Corps of Engineers jointly promulgated regulations revising and clarifying requirements regarding compensatory mitigation, and establishing the following hierarchal preference for implementation of compensatory mitigation:

1. Mitigation banks
2. In-lieu fee programs
3. Permittee-responsible mitigation under a watershed approach

4 Permittee-responsible mitigation through on-site and in-kind mitigation
5 Permittee-responsible mitigation through off-site or out-of-kind mitigation

Despite the theoretical merits of wetland banking, studies of wetland banking success have been largely equivocal in terms of its documented merits (Mack and Micacchion 2006, Reiss et al. 2009). Currently in King County, the Springbrook Creek Mitigation Bank is approved, but its service area does not extend into Bellevue, meaning that impacts in the city cannot be mitigated at the Springbrook Creek Mitigation Bank. Ecology and the Corps are reviewing the Keller Farm Mitigation Bank in Redmond, the service area of which would be expected to include the City of Bellevue. Approved mitigation banks go through a rigorous state certification process. The certification process includes financial assurance requirements. Oversight from Ecology, the Corps, and other relevant agencies and a phased release of bond funds as mitigation bank performance standards are achieved help support mitigation success.

Another mitigation option is an in-lieu fee program. In-lieu fee programs are similar to mitigation banks, except that projects are implemented after credits are purchased, rather than before. In-lieu fee programs are operated by public agencies. The King County Mitigation Reserves Program (MRP) is an in-lieu fee program that was certified under 2008 federal rules. The program is designed to satisfy mitigation obligations for a wide variety of permit types and may be applied to City permits if the city code allows it. The City of Bellevue is within the MRP service area. If allowed by local code, applicants within King County can use the MRP to buy credits for off-site mitigation. By purchasing credits, the applicant satisfies compensatory mitigation requirements and has no further involvement in the mitigation implementation. The MRP pools funds from the sale of credits in a given service area to develop mitigation sites from a predefined roster. The MRP plans, implements, monitors and maintains projects at chosen sites. At multiple points in the process, an Interagency Review Team will review and approve project proposals.

From an economic perspective, it may be more cost effective for small projects to pay a third party for mitigation credits through a mitigation bank or in-lieu fee program than to proceed with the design, permitting, and implementation of a small mitigation project (Bendor and Brozovic 2007). However, where in-lieu fee programs and mitigation banks include the cost of land acquisition, such as the MRP, credits tend to cost significantly more than on-site mitigation. Additionally, large projects may be able to plan, permit, and implement a large mitigation project for less than the cost of mitigation bank credits.

The City may wish to develop a policy prioritizing use of on-site versus off-site mitigation. The following considerations should factor into such a policy. From a landscape perspective, mitigation banking and in-lieu fee programs have a tendency to drive wetland mitigation from urban to rural areas (Bendor and Brozovic 2007). This migration may be driven by the lower cost of land in rural areas compared to urban areas or the availability of large areas of land for wetland restoration in rural areas (Bendor and Brozovic 2007; Robertson and Hayden 2008). A shift from small, urban wetlands to larger, rural wetlands may allow for a net increase in functions; however, small urban wetlands provide significant water quality functions and may be particularly important for controlling flooding in highly urbanized environments (Boyer and Polasky 2004), such as in the City of Bellevue. Urban wetlands may also provide recreational and educational opportunities and aesthetic values (Ehrenfeld 2000). Finally, developing urban wetlands may entail high "opportunity costs," meaning that once lost they will be difficult to replace because of the high price of land in urban areas (Boyer and Polasky 2004). These factors should be considered when developing policies related to the use of mitigation banking and in-lieu fee programs in the City of Bellevue.

3.1.5 Assuring Mitigation Success

The Agencies recommend requiring financial assurances to ensure the success of a mitigation project. "Financial assurances may take the form of performance bonds or letters of credit. Applicants should check with their local planning department to determine if the local government will require performance bonds or other forms of financial assurances. A bond should estimate all costs associated with the entire compensatory mitigation project, including site preparation, plant materials, construction materials, installation oversight, maintenance, monitoring and reporting, and contingency actions expected through the end of the required monitoring period" (WDOE et al. 2006).

Compensatory mitigation projects should be protected in perpetuity. Legal mechanisms, such as deed restrictions and conservation easements, are typically used to achieve this (WDOE et al. 2006).

Additionally, physical site protection may be needed to keep people, pets, and equipment out of mitigation sites. Split-rail fencing and/or critical area signs indicating that the area should not be disturbed are typically required for site protection (WDOE et al. 2006).

3.2 Updates to Existing Conditions

Aerial photos, LiDAR, and GIS data are commonly used for broad-scale analysis of wetland resources. The USFWS's National Wetland Inventory uses aerial imagery to map likely wetland areas (Figure 3.1).

In 2011, the Washington State Department of Ecology released the Puget Sound Watershed Characterization tool, which utilizes GIS data to perform various basin-scale analyses (Stanley et al. 2011). The Puget Sound Watershed Characterization provides interactive mapping that identifies priority areas on a landscape basis for the protection and restoration of functions related to water flow and water quality (available at https://fortress.wa.gov/ecy/coastalatlas/wc/landingpage.html). These maps can help inform the significance of wetland functions at various locations along the landscape. Figure 3.2 below shows a snapshot of the City of Bellevue indicating the relative density of wetlands and undeveloped floodplains (Wilhere et al. 2013).

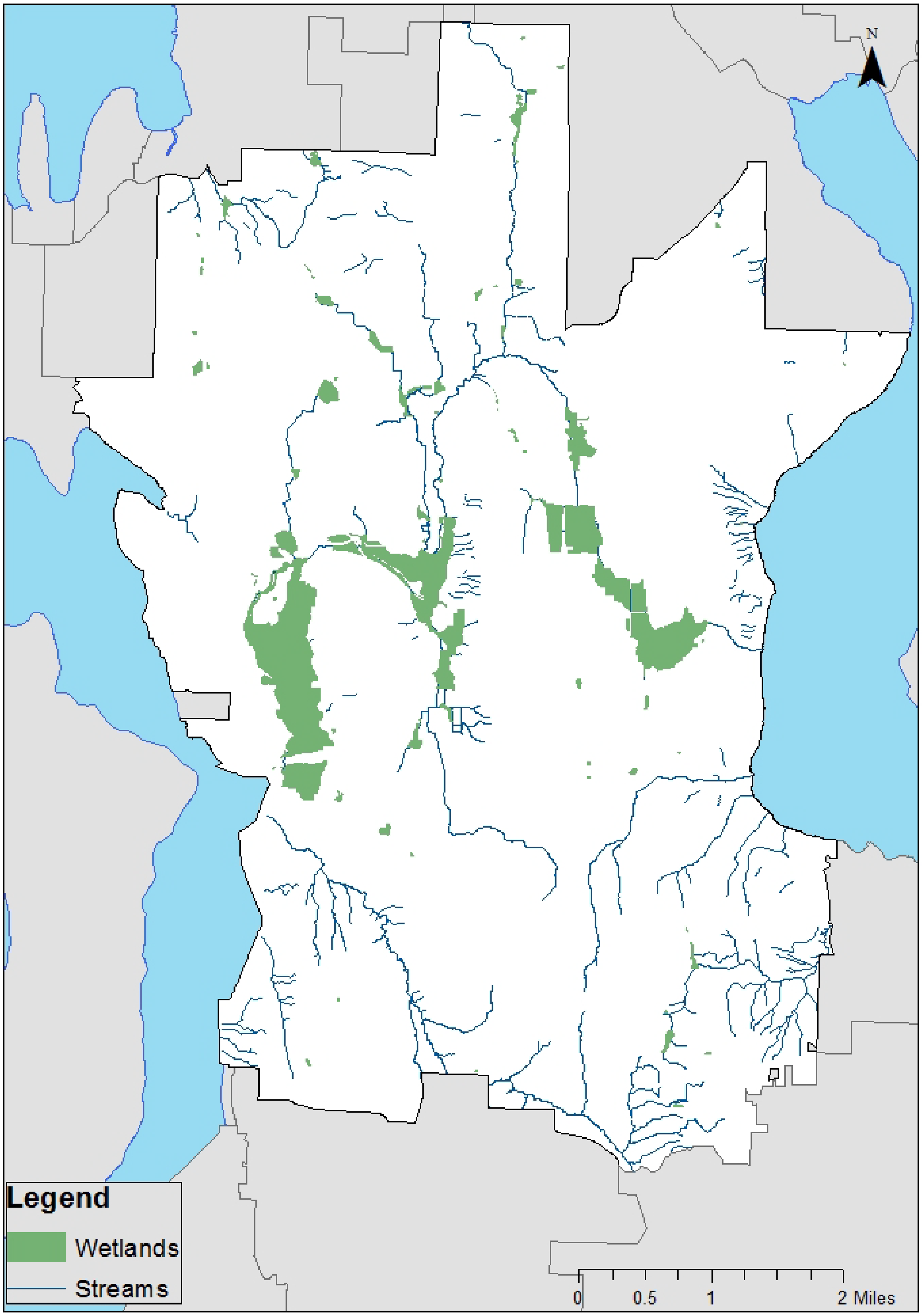

Figure 3.1. Map of wetlands in the City of Bellevue (data from USFWS and City of Bellevue)

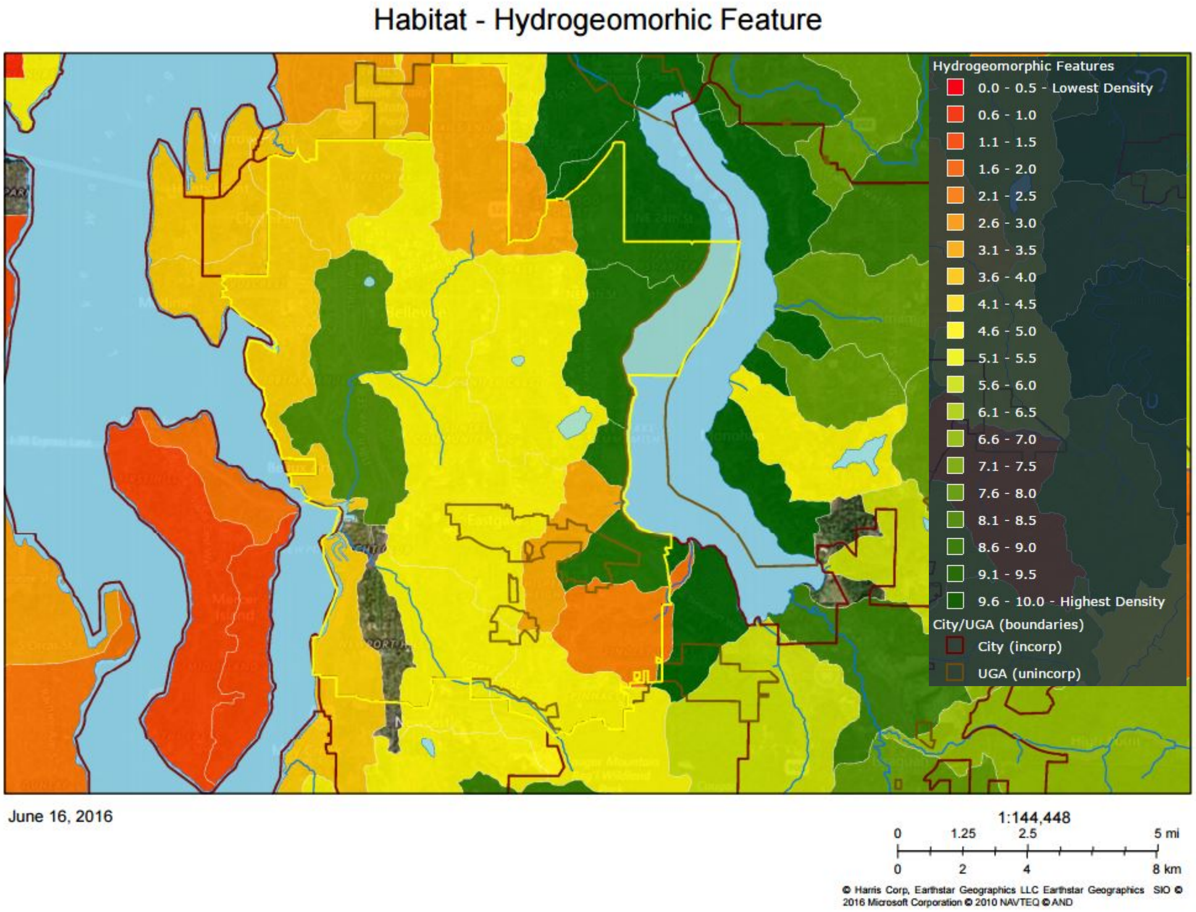

Figure 3.2. Relative density of hydrogeomorphic features, wetlands and undeveloped floodplains, within the city of Bellevue using the Puget Sound Watershed Characterization Tool.

4 TERRESTRIAL HABITAT AND CORRIDORS

4.1 Updates to Best Available Science for Protection of Functions and Values

The *City of Bellevue- 2005 BAS Review* gave a general overview of terrestrial habitat functions and values. The City supplemented the *City of Bellevue- 2005 BAS Review* with a *Bellevue Urban Wildlife Habitat Literature Review* (2009 Urban Wildlife Study) (The Watershed Company 2009). The following analysis builds on these two documents and identifies changes in the science, regulatory listings, or management recommendations since they were written.

4.1.1 Urban Wildlife Habitat

The 2009 Urban Wildlife Study described the significant issues and features associated with wildlife in an urban setting. The precepts discussed in that document hold true today with only minor nuanced updates in the body of scientific literature related to the role of habitat gaps and disturbance (e.g., Ficetola et al. 2009, Tremblay and St. Clair 2009) and corridors (Gilbert-Norton et al. 2010) in urban wildlife habitat.

4.1.2 Endangered, Threatened, or Sensitive Species, Species of Local Importance

The City of Bellevue Code specifies 23 Species of Local Importance (LUC 20.25H.150). These species encompass all state and federally listed sensitive, threatened, and endangered species, as well as priority species likely to occur within the city, and some species that do not have any state or federal status (Table 4.1). Changes in the state and federal designations of species designated since 2005 are noted in Table 4.1.

State and federal species-specific management recommendations for designated terrestrial species of local importance are summarized below. WDFW species-specific recommendations are often referenced in local jurisdictions' critical areas regulations.

Table 4-1 Species of Local Importance per LUC 20.25H.150

Species	State Listing	Federal Listing	Change to listed status since 2005?	State or Federal Management Recommendations?
Bald eagle *Haliaeetus leucocephalus*	Sensitive	Species of Concern	Yes- no longer state or federally threatened (state- 2008) (federal-2007) Proposed to be removed from State sensitive list (July 2016)	Yes (USFWS)
Peregrine falcon *Falco peregrinus*	Sensitive	Species of Concern	Proposed to be removed from State sensitive list (July 2016)	Yes
Common loon *Gavia immer*	Sensitive			Yes
Pileated woodpecker *Dryocopus pileatus*	Candidate			Yes
Vaux's swift *Chaetura vauxi*	Candidate			Yes
Merlin *Falco columbarius*			Yes- No longer State Candidate	No
Purple martin *Progne subis*	Candidate			Yes
Western grebe *Aechmophorus occidentalis*	Candidate			No
Great blue heron *Ardea herodias*	Priority Species			Yes

Species	State Listing	Federal Listing	Change to listed status since 2005?	State or Federal Management Recommendations?
Osprey *Pandion haliaetus*			No- no longer State priority species (1999)	No
Green heron *Butorides striatus*				No
Red-tailed hawk *Buteo jamaicensis*				No
Western big-eared bat *Plecotus townsendii*	Candidate	Species of Concern		Yes
Keen's myotis *Myotis keenii*	Priority Species			Yes
Long-legged myotis *Myotis volans*	Priority Species			Yes
Long-eared myotis *Myotis evotis*	Priority Species			Yes
Oregon spotted frog *Rana pretiosa*	Endangered	Threatened	Yes- federally threatened (2013)	Yes
Western toad *Bufo boreas*	Candidate		Yes- no longer federal Species of concern	No
Western pond turtle *Clemmys marmorata*	Endangered	Species of Concern		Yes
Chinook salmon *Oncorhynchus tshawytscha*	Candidate	Threatened		see Stream section
Bull trout *Salvelinus confluentus*	Candidate	Threatened		see Stream section
Coho salmon *Oncorhynchus kisutch*		Species of Concern		see Stream section
River lamprey *Lampetra ayresi*	Candidate	Species of Concern		see Stream section

The meaning of state and federal statuses are described as follows:

- Federal Endangered: a species in danger of extinction throughout all or a significant portion of its range
- Federal Threatened: a species likely to become endangered in the foreseeable future throughout all or a significant portion of its range
- Federal Species of Concern: informal term, not defined in the federal Endangered Species Act, which commonly refers to species that are declining or appear to be in need of conservation
- State Endangered: wildlife species native to the state of Washington that is seriously threatened with extinction throughout all or a significant portion of its range within the state
- State Threatened: wildlife species native to the state of Washington that is likely to become an endangered species within the foreseeable future throughout a significant

portion of its range within the state without cooperative management or removal of threats

- State Sensitive: wildlife species native to the state of Washington that is vulnerable or declining and is likely to become endangered or threatened in a significant portion of their range within the state without cooperative management or removal of threats
- State Candidate: fish and wildlife species that the Department will review for possible listing as State Endangered, Threatened, or Sensitive
- State Priority Species: species that require protective measures for their survival due to their population status, sensitivity to habitat alteration, and/or recreational, commercial, or tribal importance. Priority species include State Endangered, Threatened, Sensitive, and Candidate species; animal aggregations (e.g., heron colonies, bat colonies) considered vulnerable; and species of recreational, commercial, or tribal importance that are vulnerable.
- State Monitor Species are those that require management, survey, or data emphasis for one or more of the following reasons:
  - They were classified as endangered, threatened, or sensitive within the previous five years.
  - They require habitat that is of limited availability during some portion of their life cycle.
  - They are indicators of environmental quality.
  - There are unresolved taxonomic questions that may affect their candidacy for listing as endangered, threatened, or sensitive species.

4.1.3 State and Federal Species-specific Management Recommendations

Where State or federal management recommendations for species of local importance area available, they are described below. For those species for which specific state or federal management recommendations do not exist, available management recommendations are also summarized.

These were summarized for nine species in the 2003 *Bellevue Critical Areas Update Best Available Science Paper: Wildlife* (City of Bellevue 2003). Currently applicable state and federal management recommendations are described below.

4.1.3.1 Bald Eagle

WDFW previously required bald eagle management plans for development within the vicinity of a bald eagle nest. Since the state changed the bald eagle status from threatened to sensitive in 2007, it no longer asserts regulatory authority over bald eagle management, nor does it provide current management recommendations. The USFWS provides management recommendations under the regulatory purview of the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. These recommendations focus on establishing management areas associated with different habitat features (e.g., nesting, roosting, perching), as summarized in the national bald eagle guidelines (USFWS 2007). Nesting recommendations are relevant to the City of Bellevue.

4.1.3.2 Peregrine Falcon

WDFW maps two known occurrences of peregrine falcon in Bellevue, one near the Interstate 90 bridge over Lake Washington and another in downtown Bellevue. WDFW recommends protection of Peregrine falcons through year-round and season buffering, wetland protection, pesticide restrictions, powerline avoidance, retaining trees and snags, maintaining nest sites and winter feeding habitats. Year-round a protective buffer width of 1,310 feet is recommended around any nest site. During nesting season the buffer width increases to 2,620 feet for forest practices and 1,640 feet for aircraft approaches. Nesting season is March 1 – June 30 (Hays and Milner 1999).

4.1.3.3 Common Loon

Loons are not known to breed in or near the City, but they may over-winter in the area (Lewis et al. 1999). Loons are sensitive to mercury levels; activities that may elevate mercury levels should be avoided (Lewis et al. 1999). Other recommendations relate to breeding habitat, which is not known to occur in Bellevue.

4.1.3.4 Pileated Woodpecker

WDFW management recommendations to protect pileated woodpecker habitat include, maintaining large stands of dead and decaying trees used for nesting, and retaining stumps and large woody debris used for foraging (Lewis and Azerrad 2003). Coniferous forest stands about 60 year old or older should be retained at >70% canopy cover and have at least 2 snags/10 acres that are 30-inches in diameter. Seven snags per acre, at least 90-feet tall with diameters of 61-122-inches are recommended for nesting and roosting habitat (Lewis and Azerrad 2003). These recommendations apply in areas with intact forested areas.

4.1.3.5 Vaux's Swift

Vaux's swifts are summer residents throughout wooded areas of Washington (Lewis et al. 2002). WDFW recommends protecting existing forest stands, particularly old growth, retaining large hollow snags and future snag trees, and retaining large defective or rotting trees (Lewis et al. 2002). Chimneys occupied by nesting or roosting Vaux's swifts should not be disturbed between May and September. Pesticide use in or near nests and roosts should be avoided; appropriate buffer widths for pesticide applications range from 100 feet to 1,640 feet (Lewis et al. 2002).

4.1.3.6 Merlin

Merlins were placed on the Washington candidate list in 1997 due to apparent rarity and a concern about the effects of timber harvest practices. However, they were removed from the list in 2010. Although merlins are rare and localized breeders, they are not particularly sensitive to human activities and there does not seem to be any immediate or widespread threat to their populations (WDFW 2012).

4.1.3.7 Purple Martin

To protect purple martin, WDFW recommends retaining any pilings or snags with purple martin nests, retain snags in or near water, and create snags at forest openings and edges (Hays and Milner 2003). Pileated woodpeckers and northern flickers create cavities that can be used by purple martins, so habitats should be managed to support these mutually beneficial birds (Hays and Milner 2003). Pesticide use in purple martin habitat should be avoided or highly restricted (Hays and Milner 2003).

4.1.3.8 Western Greebe

Western greebes breed in inland lakes of Eastern Washington in the summer, and migrate west to the Puget Sound region and the Pacific Coast in winter (WDFW 2012). Threats to over-wintering western grebe are thought to be diminishing forage fish prey populations and oil spills. Other factors that may threaten over-wintering western greebes include fishing bycatch and derelict fishing gear (WDFW 2012). Specific management recommendations that would apply to the City of Bellevue are not indicated.

4.1.3.9 Great Blue Heron

One great blue heron rookery is mapped by WDFW in the City of Bellevue along Kelsey Creek. WDFW recommends protection mechanisms for Heron Management Areas, which consist of the nesting colony, year-round and seasonal buffers, foraging habitat, and congregation areas where they exist (Azerrad 2012). Specifically, clearing vegetation, grading, and construction should never occur in the core zone (breeding area and year-round management zone), and other potential disturbances, including recreation and vegetation management, should be minimized or restricted to the period outside of the breeding season. Foraging habitat should be protected with riparian buffers, and activities such as vegetation removal, logging, perch tree disturbance, wetland filling, and construction should be minimized. Heron colonies closer to human activity may tolerate more disturbance than colonies in more undisturbed areas; therefore, appropriate buffers may be smaller in more developed areas. Year-round and seasonal management recommendations are provided in Table 4-2.

Table 4-2. Great blue heron recommended management zones from Azerrad 2012

Adjacent land use	Distance from Nesting Colony	Management Practice
Undeveloped (0-2% developed area)	300 m (984 feet)	Avoid clearing vegetation, grading, and construction year-round
Suburban/rural (3-49% developed area)	200 m (656 feet)	
Urban (>50% developed area)	60 m (196 feet)	
All Uses	200 m (656 feet)	Avoid loud noises February-September
	400 m (1320 feet)	Avoid extreme loud noises February-September

4.1.3.10 Osprey, Green Heron, and Red-Tailed Hawk

No specific WDFW management recommendations are available for the osprey, green heron, or red-tailed hawk. As noted in Table 4-1, WDFW removed osprey from the priority species list in 1999. Red-tailed hawks and green herons are also not included in the priority species list. Red-tailed hawks are the most common and widespread hawk in North America. Populations of both osprey and red-tailed hawks numbers are increasing in Washington State (BirdWeb, electronic reference). Population trends for green heron are not documented in Washington. Protection of small wetlands is especially important for green heron (BirdWeb, electronic reference).

4.1.3.11 Western big-eared bat

WDFW recommends maintaining and repairing old buildings and mines used by bat colonies for roosting. Sites that support nursery and hibernation roosts are not suitable for recreational use. Bat access to contaminated water should be restricted and pesticide use should be avoided or highly restricted. Retention of forest patches and snags and riparian/aquatic systems used for foraging and roosting are important for conservation of the species (Woodruff et al. 2005, Hayes and Wiles 2013).

4.1.3.12 Myotis Bats- Keen's Myotis, Long-legged myotis, and Long-eared myotis

Keen's myotis, long-legged myotis, and long-eared myotis are primarily associated with forested areas (Hayes and Wiles 2013). Keen's myotis have not been documented to occur in King County (WDFW 2012). Maintenance a high density of snags, both away from and in proximity to aquatic areas, provides significant habitat for these species (Hayes and Wiles 2013). Buffers around snag areas should be considered where bat colonies are present (Hayes and Wiles 2013).

4.1.3.13 Oregon Spotted Frog

The Oregon spotted frog was federally listed as threatened in 2013 (Federal Register August 29, 2013). In Washington, Oregon spotted frogs are known to occur only within six subbasins/ watersheds: the Sumas River; Black Slough in the lower South Fork Nooksack River; the Samish River; Black River (a tributary to the Chehalis River); Outlet Creek (a tributary to the Middle Klickitat River); and Trout Lake Creek (a tributary of the White Salmon River) (Federal Register, May 11, 2016). Based on the Oregon Spotted Frog Screening Model (Germaine and Costentino 2004), wetlands in the City of Bellevue are unlikely to meet all the criteria necessary to support the presence of Oregon spotted frogs. Specifically, wetlands in Bellevue are unlikely to meet the criterion that less than 9.8% of the area within a mile of the wetland's perimeter is developed. Critical habitat has recently been designated for the Oregon spotted frog (Federal Register, May 11, 2016), but does not include any portion of the Cedar/Sammamish watershed.

4.1.3.14 Western Toad

No specific WDFW management recommendations are available for the western toad.
The western toad is widely distributed in the western United States and Canada (Stebbins 1954, 1985 as cited in Davis 2002). Declining populations have been documented in areas across the

range, even in relatively pristine environments (Davis 2002). Local population trends are not known.

4.1.3.15 Western Pond Turtle

WDFW recommends managing any watercourse within 0.5 mile of a site known to contain western pond turtles. A protective 1,300-1,600 foot buffer is recommended around all water bodies inhabited by western pond turtles. Emergent logs or stumps should be retained; the turtles utilize them for basking. Logs should be provided if such habitat is lacking. Wetland alterations should be avoided. Sunny embankments and open sites should be protected from vehicles and other trampling uses; these areas are used for nesting. Native fish and amphibian populations should be retained; new species should not be introduced. Additionally, pesticide use should be avoided. Logging should be restricted with 1,300 feet of waters inhabited by these turtles (McAllister 1999).

4.2 Updates to Existing Conditions

The Storm and Surface Water System Plan (2016, including appendices) provides an extensive and up-to-date description of existing conditions relating to both riparian corridors and forest cover within the city. That document should be referenced for a summary of existing conditions relative to terrestrial habitat and corridors within the City of Bellevue.

Figure 4.1 below, shows terrestrial open space blocks in the City of Bellevue and ranks them based on ecological integrity. Ecological integrity is defined as the ability to support and sustain a biologic community typical of natural habitat in this region (Parrish et al. 2003 in Wilhere et al. 2013). The ecologic or landscape integrity of open space blocks is a function of size, shape, proximity to other open space blocks and land use patterns (Wilhere et al. 2013). As is typical of urban environments, the ecological integrity of open space block in the City of Bellevue is relatively low. As described in the 2003 Bellevue Critical Areas Update Best Available Science Paper: Wildlife (City of Bellevue), riparian areas and forested steep slopes comprise the majority of Bellevue’s remaining habitat corridors and linkages.

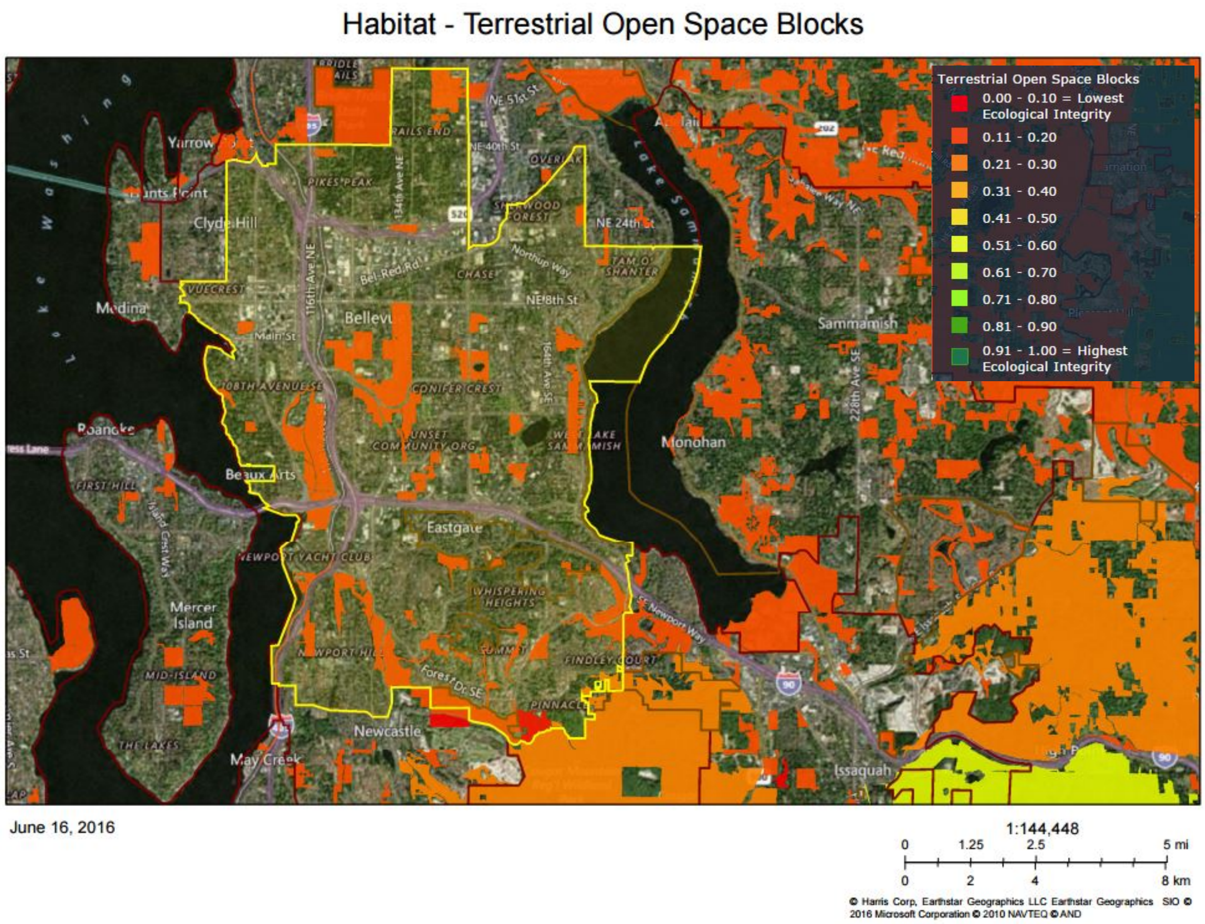

Figure 4.1. Terrestrial Open Space Blocks in City of Bellevue.

5 FREQUENTLY FLOODED AREAS

5.1 Update to Best Available Science for Protection of Functions and Values

Frequently flooded areas (FFA) are regulated to manage potential risks to public safety. Such areas also provide valuable instream habitat benefits, such as low velocity habitat during flood events.

A 2008 National Marine Fisheries Service (NMFS) biological opinion related to the implementation of the Federal Emergency Management Agency's (FEMA) National Flood Insurance Program (NFIP) in the Puget Sound Region summarizes the importance of floodplain functions for threatened salmonids and endangered southern resident killer whales (NMFS 2008). As a result of this biological opinion, cities and counties in the Puget Sound region are required to either amend regulations to protect floodplain functions or require habitat assessments for development in the floodway or floodplain. Through either approach, the city must ensure that development within the Special Flood Hazard Area (100-year floodplain) and riparian buffer zone, which extends 250 feet from the ordinary high water mark where a flood feature is present, does not adversely affect water quality, water quantity, flood volumes, flood velocities, spawning substrate, or floodplain refugia for listed salmonids. The biological opinion also applies to mapped floodways and channel migration zones.

Standards that continue to protect human life from flood hazards and provisions that ensure compliance with the 2008 NFIP biological opinion will help ensure that floodplain ecological functions are maintained.

5.2 Updates to Existing Conditions

FEMA completed a Flood Insurance Study (FIS) for King County in 2010, which was supplemented in 2013. The preliminary Digital Flood Insurance Rate Maps (DFIRM) resulting from the FIS update are listed as “on hold,” and are not yet in effect. A comparison of the existing Flood Insurance Rate Map (Q3) and the preliminary DFIRM indicates that few areas have changed with the updated floodplain study information (Figure 5.1).

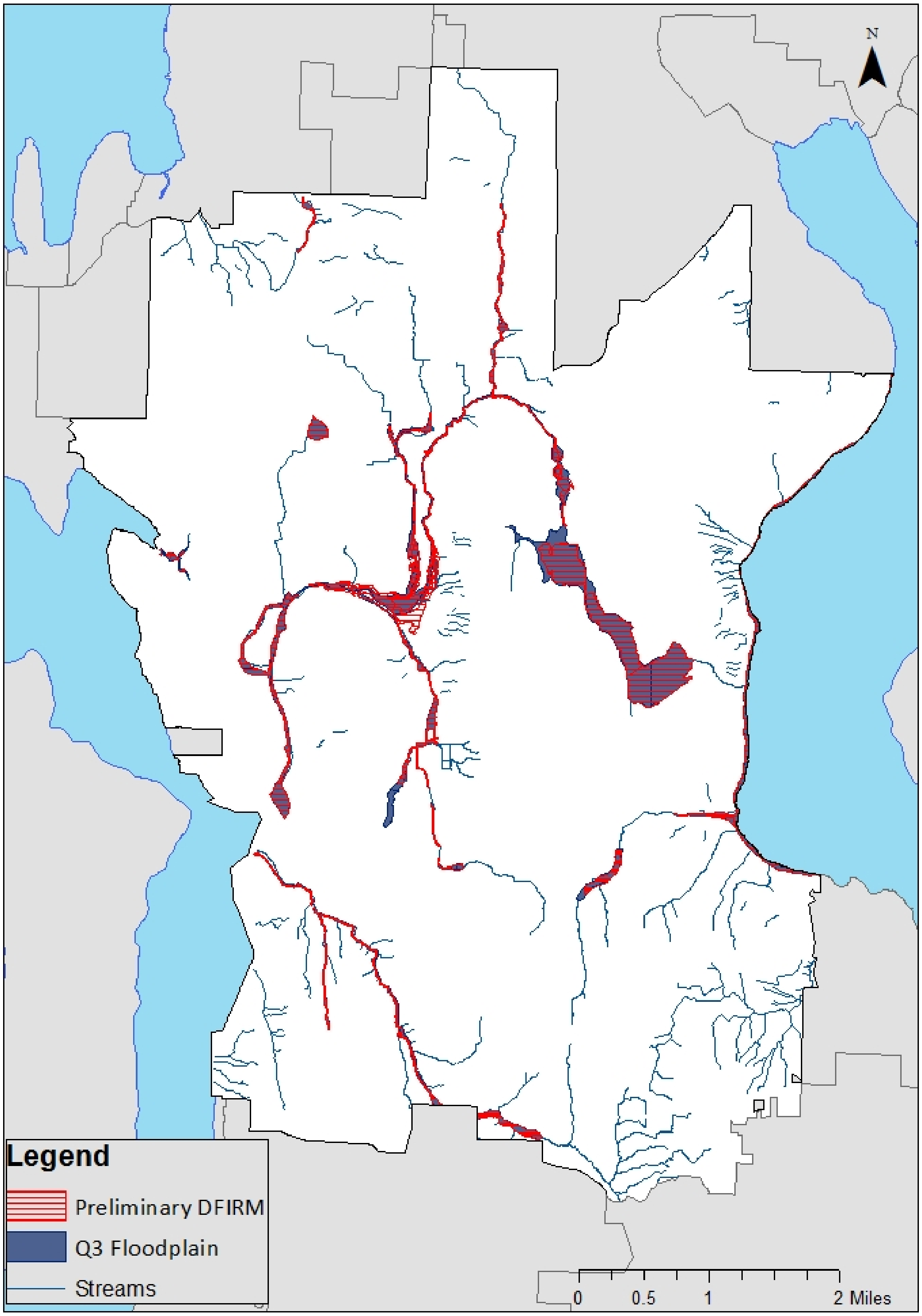

Figure 5.1 Map showing currently effective (Q3) and preliminary (DFIRM) floodplain mapping.

6 Geologic Hazard Areas

6.1 Updates to Best Available Science for Protection of Functions and Values

Geologically Hazardous Areas are generally regulated in order to identify areas where naturally occurring geologic processes may pose a threat or hazard to the health and safety of citizens if development activity is inappropriately sited in areas of significant hazard. The 2003 *Bellevue Critical Areas Update Geologically Hazardous Areas Inventory* (City of Bellevue) identified five types of potential geologic hazard areas. These areas include:

- Steep slopes/landslide hazard areas: includes areas potentially susceptible to landslide based on a combination of topographic, geologic, and hydrologic factors.
- Erosion Hazard areas: includes at least those areas identified by the Natural Resources Conservation Service (NRCS) as having a "severe" rill and inter-rill erosion hazard.
- Seismic hazard areas: includes areas subject to severe risk of damage as a result of earthquake induced ground shaking, slope failure, settlement, soil liquefaction, or surface faulting. In addition, the City of Bellevue identified seiche hazard areas along the City's shorelines adjacent to Lake Washington and Lake Sammamish.
- Coal mine hazard areas
- Liquefaction hazard areas

In addition to those areas listed above, the *City of Bellevue- 2005 BAS Review* also addressed potential local effects of volcanic hazards.

All of these potential geologic hazards have the potential to adversely affect the City of Bellevue's community function and impair the value of human life and property.

The delineation and review of existing geologic hazard areas are generally consistent with current science. However a few areas could use updating based on more current information since the last Best Available Science (BAS) Review in 2005.

Seismic Hazard Areas

A high resolution seismic reflection survey was completed in 2008 by Liberty and Pratt (2008) in portions of the Seattle Fault zone. Areas covered included Bellevue, Sammamish, Newcastle, and Fall City, Washington. The Seattle fault zone is a broad (5-7 km wide) east-west striking zone of faulting and deformed shallow strata. The faulting has been interpreted as reverse-slip displacement with the south-side having moved up relative to the north side of the fault zone. Geologic models have generally postulated a south-dipping reverse fault with multiple strands and back-thrusts in the hanging wall (Pratt et al., 1997; ten Brink et al, 2002 and Fisher et al. 2006). This leading edge has been termed a "deformation front" by Liberty and Pratt (2008), mainly in the form of a monoclinal fold, termed the Seattle monocline by Johnson et al (1999). The general stratigraphy consists of Quaternary age sediments overlying more reflective northward dipping Tertiary age bedrock. In addition, the Vasa Park segment of the Seattle Fault Zone has been trenched by Sherrod (2002) and has shown direct evidence of thrusting of older strata over younger strata. The younger strata being a paleosoil dated at 11,500 +/- 40 radiocarbon years B.P. (before present).

Based on the results of the seismic reflection survey, Liberty and Pratt interpret the leading edge of the Seattle Fault zone approximately 3 km farther north than the northern edge of the Seattle Fault Zone as shown on Figure G-2, Geologic Hazards map in the 2003 Bellevue Critical Areas Update Geologically Hazardous Areas Inventory.

The potential for mitigation of surface fault rupture hazards will depend on the accuracy by which fault traces can be delineated as well as the recurrence intervals for which earthquakes capable of producing surface rupture occur. This can be difficult because of the glacially modified and urbanized landscape has obscured or removed most surface evidence. As more information is gained on the limits of the Seattle fault zone and the potential for surface fault rupture, consideration should be given by the City of Bellevue to encourage studies to better delineate limits of the Seattle fault zone as well as the recurrence intervals of earthquake events. As was mentioned in the 2005 BAS Review, the City can assist such efforts by compiling a database of geotechnical reports for properties located within and around the Seattle fault zone.

The City might consider requiring disclosure statements from property owners as part of property transactions if known documented evidence of surface faulting or deformation exists on a particular parcel.

The Geologic Hazards map shown on Figure G-2 of the 2003 Bellevue Critical Areas Update Geologically Hazardous Areas Inventory does not include the Mercer Slough area as a Liquefaction Hazard area. The Mercer Slough area is a wetland area and presents a liquefaction hazard. The King County Flood Control District Map 11-5 for Liquefaction Susceptibility, dated May 2010, shows a moderate to high level of liquefaction for the Mercer Slough area. The Liquefaction Susceptibility Map of the Greater Eastside Area, King County, Washington (Palmer et al., 2002) shows the Mercer Slough area as underlain by peat deposits. Peat by itself is not susceptible to liquefaction but may experience settlement resulting from earthquake shaking. Peat is commonly interstratified with sand strata and lenses that are liquefiable.

Landslide Hazard Areas

Debris flow run out distances have come to the forefront since the March 2014 Oso landslide. Landslide and steep slope regulations commonly focus on setback distances from the crest of slopes, with minimal attention given to the setback distance from the toe of slopes. Of concern are setback recommendations from the toes of slopes where incised drainages in the slope may be the source of shallow debris flows and associated run out distance from mouth of the ravine. Site specific evaluations should be required by a qualified geologist to determine the potential for debris flow/slide occurrence. The SR530 Landslide Commission Final report (2014) recommends identifying "critical area buffer widths based on site specific geotechnical studies" as an "innovative development regulation," that counties and cities should adopt (SR 530 Landslide Commission).

6.2 Updates to Existing Conditions

Given the geologic timescale, existing conditions as described in the 2003 Bellevue Critical Areas Update Geologically Hazardous Areas Inventory are considered current.

7 Critical Aquifer Recharge Areas

Drinking water in the City of Bellevue is supplied through the Cascade Water Alliance. Critical Aquifer Recharge Areas (CARAs) are not addressed in this report. Best available science and recommendations for these types of critical areas were included in the *City of Bellevue- 2005 BAS Review*. However, given the limited number of wells in the City, the availability of public water supply to those areas that currently use wells, and state Safe Water Drinking Act requirements for wellhead protection, the City did not address critical aquifer recharge areas in its critical areas code. The Critical Aquifer Recharge Areas Guidance Document was published by the Washington Department of Ecology in January 2005, and it has not been updated since that time.

Since the 2005 BAS Review, the City has updated its Water System Plan. The City's 2016 Water System Plan identifies four emergency water supply wells maintained by the City, as well as several more that are held in reserve for emergency use. The City intends to eventually use these groundwater wells, which the City acquired through incorporation of water districts into the City's water service area, for emergency-only water production. The wells currently do not provide potable water. The Washington State Department of Health has not yet required a Wellhead Protection Plan because of the limited approved use of the wells. A Wellhead Protection Plan will be required before expanded use of the wells.

Since the 2006 critical areas update, the City annexed the Hilltop neighborhood, which includes an additional Class A well serving 40 connections (Department of Health Electronic Reference). Aquifer susceptibility in the vicinity of the well is rated as moderate (Department of Health Electronic Reference). Hilltop was annexed from unincorporated King County, and under the King County Code, the Hilltop area was not designated as a CARA.

8 Shorelines

The City is in the process of updating its Shoreline Management Act. Under the proposed update, shorelines themselves are not regulated as critical areas, and critical areas within shoreline jurisdiction would be regulated under LUC Part 20.25H. The review of best available science addressed throughout this document is also applicable to shoreline critical areas.

9 References

9.1 General

City of Bellevue. 2003. Bellevue Critical Areas Update- Geologically Hazardous Areas Inventory.

Herrera Environmental Consultants, Inc. 2005. City of Bellevue's Critical Areas Update 2005 Best Available Science (BAS) Review.

The Watershed Company. 2009. Bellevue Urban Wildlife Habitat Literature Review.

9.2 Streams and Riparian Areas

American Forests. 2008. Urban Ecosystem Analysis: City of Bellevue Washington. American Forests, Washington, D.C. www.americanforests.org.

Aubry K., C. Halpern, and C. Peterson. 2009. Variable-retention harvests in the Pacific Northwest: a review of short-term findings from the DEMO study. Forest Ecology Management 258(4):398-408.

Baker M.E., D.E. Weller, and T.E. Jordan. 2006. Improved methods for quantifying potential nutrient interception by riparian buffers. Landscape Ecology 21(8):1327-45.

Baldwin, D.H., Tatara, C.P., and Scholz, N.L. 2011. Copper-induced olfactory toxicity in salmon and steelhead: extrapolation across species and rearing environments. Aquatic Toxicology, 101:295-297.

Bernal, S., F. Sabater, A. Butturini, E. Nin, and S. Sabater. 2007. Factors limiting denitrification in a Mediterranean riparian forest. Soil Biology & Biochemistry 39 (10): 2685-2688.

Bisson, P. A., S.M. Claeson, S.M. Wondzell, A.D. Foster, and A. Steel. 2013. Evaluating Headwater Stream Buffers: Lessons Learned from Watershed- scale Experiments in Southwest Washington. Pgs. 165-184 In: Anderson, P. D. and Ronnenberg, K. L. (eds.). Density Management in the 21st Century: West Side Story. General Technical Report, PNW-GTR-880. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

City of Bellevue. 2009. Natural Drainage Practices Maintenance Guidelines.

City of Bellevue. 2016. Storm and Surface Water System Plan.

Colvin, R., G.R. Giannico, J. Li, K.L. Boyer, and W.J. Gerth. 2009. Fish use of intermittent watercourses draining agricultural lands in the upper Willamette River Valley, Oregon. Transactions of the American Fisheries Society. 138: 1303-1313.

Cuo, L., D.P. Lettenmaier, M. Alberti, and J.E. Richey. 2009. Effects of a century of land cover and climate change on the hydrology of the Puget Sound basin. Hydrologic Processes 23(6):907-33.

Davis, T.M. 2002. Research Priorities for the Management of the Western toad, *Bufo boreas*, in British Columbia. B.C. Ministry of Water, Land and Air Protection, Biodiversity Branch, Victoria, BC. Wildlife Working Report No. WR-106.

DeGasperi C., H. Berge, K. Whiting, J. Burkey, J. Cassin, R. Fuerstenberg. 2009. Linking hydrologic alteration to biological impairment in urbanizing streams of the Puget lowland, Washington, USA. Journal of the American Water Resources Association 45(2):512-33.

Dosskey, M.G., K.D. Hoagland, and J.R. Brandle. 2007. Change in filter strip performance over ten years. Journal of Soil and Water Conservation 62(1):21-32.

Dosskey, M. G., M. J. Helmers, and D. E. Eisenhauer. 2008. A design aid for determining width of filter strips. Journal of Soil and Water Conservation 63(4):232-241.

Feist, B. E., E.R. Buhle, P. Arnold, J.W. Davis and N.L. Scholz. 2011. Landscape Ecotoxicology of Coho Salmon Spawner Mortality in Urban Streams. PLoS ONE 6(8):e23424. doi:10.1371/journal.pone.0023424.

Fox, M. and S. Bolton. 2007. A regional and geomorphic reference for quantities and volumes of instream wood in unmanaged forested basins of Washington State. North American Journal of Fisheries Management 27(1):342-359.

Gomi, T., D. Moore, and M. Hassan. 2005. Suspended sediment dynamics in small forest streams of the Pacific Northwest. Journal of the American Water Resource Association 41(4):877-98.

Gomi, T., R. D. Moore, and A.S. Dhakal. 2006. Headwater Stream Temperature Response to Clear-cut Harvesting with Different Riparian Treatments, Coastal British Columbia, Canada. Water Resources Research. Vol. 42, W08437, doi:10.1029/2005WR004162.

Hecht, S.A., D.H. Baldwin, C.A. Mebane, T. Hawkes, S.J. Gross, and N.L. Scholz. 2007. An overview of sensory effects on juvenile salmonids exposed to dissolved copper: applying a benchmark concentration approach to evaluate sublethal neurobehavioral toxicity. NOAA Technical Memorandum NMFS-NWFSC-83.

Helmers, M.J., D.E. Eisenhauer, M.G. Dosskey, T.G. Franti, J.M. Brothers, and M.C. McCullough. 2005. Flow pathways and sediment trapping in a field-scale vegetative filter. Transactions of the ASAE 48:955-968.

Heisler, J., M. Glibertb, J.M. Burkholder, D.M. Anderson, W. Cochlane, W.C. Dennison, Q. Dortch, C.J. Gobler, C.A. Heil, E. Humphries, A. Lewitus, R. Magnien, H.G. Marshall, K. Sellner, D.A. Stockwell, D.K. Stoecker, M. Suddleson. 2008. Eutrophication and harmful algal blooms: A scientific consensus. Harmful Algae 8 (3-13)

Heithecker, T. and C. Halpern. 2006. Variation in microclimate associated with dispersed-retention harvests in coniferous forests of western Washington. Forest Ecology and Management 226(1-3): 60-71.

Heithecker, T. and C. Halpern. 2007. Edge-related gradients in microclimate in forest aggregates following structural retention harvests in western Washington. Forest Ecology Management 248(3):163-73.

Jensen, D.W., E.A. Steel, A.H. Fullerton, G.R. Pess. 2009. Impact of Fine Sediment on Egg-To-Fry Survival of Pacific Salmon: A Meta-Analysis of Published Studies. Reviews in Fisheries Science.

Kelly J.M., J.L. Kovar, R. Sokolowsky, T.B. Moorman. 2007. Phosphorus uptake during four years by different vegetative cover types in a riparian buffer. Nutrient Cycling in Agroecosystems 78(3):239-51.

Konrad, C.P., and D.B. Booth. 2005. Hydrologic changes in urban streams and their ecological significance. In L. R. Brown, R. H. Gray, R. M. Hughes, and M. R. Meador (editors). Effects of urbanization on stream ecosystems. Symposium 47. American Fisheries Society, Bethesda, Maryland.

Lassettre, N.S. and G.M. Kondolf. 2012. Large woody debris in urban stream channels: redefining the problem. River Research and Applications 28: 1477-1487.

Mayer, P.M., S.K. Reynolds, J. Marshall, D. McCutchen, and T.J. Canfield. 2007. Meta- Analysis of Nitrogen Removal in Riparian Buffers. Journal of Environmental Quality. 36: 1172-1180.

Mayer, P.M., S.K. Reynolds, D. McCutchen, and T.J. Canfield. 2005. Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness: A Review of Current Science and Regulations. EPA/600/R-05/118. Cincinnati, Ohio, U.S. Environmental Protection Agency.

McBride, M. and D.B. Booth. 2005. Urban impacts on physical stream condition: Effects of spatial scale, connectivity, and longitudinal trends. Journal of the American Water Resources Association 41:565-580.

McIntyre, J. K., D. H. Baldwin, J. P. Meador, and N. L. Scholz. 2008. Chemosensory deprivation in juvenile coho salmon exposed to dissolved copper under varying water chemistry conditions. Environmental Science & Technology 42:1352-1358.

McIntyre, J. K., D.H. Baldwin, D. Beauchamp, and N.L. Scholz. 2012. Low-level copper exposures increase visibility and vulnerability of juvenile coho salmon to cutthroat trout predators. Ecological applications : a publication of the Ecological Society of America, 22(5):1460–71.

McIntyre, J.K., Davis, J.W., Hinman, C., Macneale, K.H., Anulacion, B.F., Scholz, N.L. & Stark, J.D. 2015. Soil bioretention protects juvenile salmon and their prey from the toxic impacts of urban stormwater runoff. Chemosphere, 132: 213–219.

Moore, R.D. and S.M. Wondzell. 2005. Physical hydrology and the effects of forest harvesting in the Pacific Northwest: a review. Journal of the American Water Resources Association 41:763-784.

Moore, R.D., D.L. Spittlehouse, and A. Story. 2005. Riparian microclimate and stream temperature response to forest harvesting: a review. Journal of the American Water Resources Association 41:813-834.

Newbold, J. D., S. Herbert, B.W. Sweeney, P. Kiry, and S.J. Alberts. 2010. Water Quality Functions of a 15-Year-Old Riparian Forest Buffer System. JAWRA Journal of the American Water Resources Association, 46: 299–310.

Pollock, M.M., T.J. Beechie, M. Liermann, and R.E. Bigley. 2009. Stream temperature relationships to forest harvest in western Washington. Journal of the American Water Resources Association 45(1):141–156.

Polyakov, V. A. Fares, and M.H. Ryder. 2005. Precision Riparian Buffers for the Control of Nonpoint Source Pollutant Loading into Surface Water: A Review. Environmental Review. 13: 129-144. Published on the NRC Research Press Web site at http://er.nrc.ca/ on 16 August 2005.

Qiu, Z. 2009. Assessing Critical Source Areas in Watersheds for Conservation Buffer Planning and Riparian Restoration. Environmental Management: 44:968-980.

Roni, P., T. Beechie, G. Pess, and K. Hanson. 2014. Wood placement in river restoration: fact, fiction, and future direction. Canadian Journal of Fisheries and Aquatic Sciences 72(3):1731-1748.

Scholz, N. L., M. S. Myers, S. G. McCarthy, J. S. Labenia, J. K. McIntyre, G. M. Ylitalo, L. D. Rhodes, C. A. Laetz, C. M. Stehr, B. L. French, B. McMillan, D. Wilson, L. Reed, K. D. Lynch, S. Damm, J. W. Davis, and T. K. Collier. 2011. Recurrent die-offs of adult coho salmon returning to spawn in Puget Sound lowland urban streams. PloS one 6(12):e28013.

Shandas, V. and M. Alberti. 2009. Exploring the role of vegetation fragmentation on aquatic conditions: Linking upland with riparian areas in Puget Sound lowland streams. Landscape Urban Planning 90(1-2):66-75.

Sobota, D. J., S.L., Johnson, S.V. Gregory, and L.R. Ashkenas. 2012. A Stable Isotope Tracer Study of the Influences of Adjacent Land Use and Riparian Condition on Fates of Nitrate in Streams. Ecosystems 15:1-17

Spromberg, J.A. and N.L. Scholz. 2011. Estimating the Future Decline of Wild Coho Salmon Populations Resulting from Early Spawner Die-Offs in Urbanizing Watersheds of the Pacific Northwest, USA. Integrated Environmental Assessment and Management. Vol 7. No 4: 648-656.

Spromberg, J.A., Baldwin, D.H., Damm, S.E., McIntyre, J.K., Huff, M., Sloan, C.,Anulacion, B,Davis, J.W., and Scholz, N.L. 2015. Coho salmon spawner mortality in western US urban watersheds: bioinfiltration prevents lethal storm water impacts. Journal of Applied Ecology 53: 398-407.

Tomer, M., M. Dosskey, M. Burkart, D. James, M. Helmers, and D. Eisenhauer. 2009. Methods to Prioritize Placement of Riparian Buffers for Improved Water Quality. Agroforestry Systems 75:17-25.

Utz, R., R.H. Hilderbrand, and D.M. Boward. 2009. Identifying regional differences in threshold responses of aquatic invertebrates to land cover gradients. Ecological Indicators 9:556–567.

Verstraeten, G, J. Poesen, K. Gillijns, G. Govers. 2006. The use of riparian vegetated filter strips to reduce river sediment loads: an overestimated control measure? Hydrologic Processes 20(20):4259-67.

Walsh CJ, K. A. Waller, J. Gehling and R. MacNally. 2007. Riverine invertebrate assemblages are degraded more by catchment urbanization than by riparian deforestation. Freshwater Biology 52: 574–587.

Wigington, Jr., P.J., J.L. Ebersole, M.E. Colvin, et al. 2006. Coho salmon dependence on intermittent streams. Frontiers in Ecology and the Environment 10:513–18.

Wipfli M.S., J.S. Richardson, and R.J. Naiman. 2007. Ecological linkages between headwaters and downstream ecosystems: Transport of organic matter, invertebrates, and wood down headwater channels. Journal of the American Water Resources Association 43(1):72-85.

Wipfli, M. S. 2005. Trophic linkages between headwater forests and downstream fish habitats: implications for forest and fish management. Landscape and Urban Planning 72:205-213.

Zhang, X., X. Liu, M. Zhang, and R.A. Dahlgren. 2010. A review of vegetated buffers and an meta-analysis of their mitigation efficacy in reducing nonpoint source pollution. Journal of Environmental Quality 39:76-84.

9.3 Wetlands

Bendor, T. and Brozovic, N. 2007. Determinants of spatial and temporal patterns in compensatory wetland mitigation. Environmental Management 40(3), pp. 349-364.

Bendor, T. 2009. A dynamic analysis of the wetland mitigation process and its effects on no net loss policy. Landscape and Urban Planning 89(1), pp. 17-27.

Boyer, T. and Polasky, S. 2004. Valuing urban wetlands: a review of non-market valuation studies. Wetland 24(4), pp. 744-755.

Brinson, M. M. 1993. A hydrogeomorphic classification for wetlands. Technical Report WRP-DE-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. NTIS No. AD A270 053.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish and Wildlife Service. Publ. #FWS/OBS-79/31. 131 p.

Ehrenfeld, J.G. 2000. Evaluating wetlands within an urban context. Ecological Engineering 15(3), pp. 253-265.

Granger, T., Hruby, T., McMillan, A., Peters, D., Rubey J., Sheldon, D., Stanley, S., Stockdale, E. 2005. Wetlands in Washington State, Volume 2 – Guidance for Protecting and Managing Wetlands. Washington State Department of Ecology Publication No. 05-06-008.

Hruby, T. 2004, Rev. 2006 (Updated Oct. 2008). Washington State Wetland Rating System for Western Washington. Washington State Department of Ecology Publication No. 04-06-025. Olympia, Washington.

Hruby, T., K Harper, S. Stanley. 2009. Selecting Wetland Mitigation Sites Using a Watershed Approach. Washington State Department of Ecology Publication No. 09-06-032. Olympia, WA.

Hruby, T. 2011. Calculating Credit and Debits for Compensatory Mitigation in Wetlands of Western Washington. Operational Draft. Washington State Department of Ecology Publication No. 10-06-011. Olympia, WA.

Hruby, T. 2013. Update on Wetland Buffers: The State of the Science, Final Report. 2013. Ecology Publication No. 13-06-11. Washington State Department of Ecology. Olympia, WA.

Hruby, T. 2014. Washington State Wetland Rating System for Western Washington: 2014 Update. Department of Ecology Publication # 14-06-019. SEA Program, Olympia, Washington.

Keddy, P.A., Fraser, L.H., Solomeshch, A.I., Junk, W.J., Campbell, D.R., Arroyo, M.T., Alho, C.J. 2009. Wet and wonderful: the world's largest wetlands are conservation priorities. BioScience 59(1), pp. 39-51.

Mack, J.J. and Micacchion, M. 2006. An ecological assessment of Ohio mitigation banks: vegetation, amphibians, hydrology, and soils. Environmental Protection Agency, Division of Surface Water, Wetland Ecology Group, Columbus, Ohio. Ohio EPA Technical Report WET/2006-1.

Matthews, J.W. and Endress, A.G. 2008. Performance Criteria, Compliance Success, and Vegetation Development in Compensatory Mitigation Wetlands. Environmental Management 41(1), pp. 130-141.

Reiss, K.C., Hernandez, E., Brown, M.T. 2009 Evaluation of permit success in wetland mitigation banking: a Florida case study. Wetlands 29(3), pp. 907-918.

Sheldon, D., T. Hruby, P. Johnson, K. Harper, A. McMillan, T. Granger, S. Stanley, and E. Stockdale. 2005. Wetlands in Washington State, Vol. 1: A Synthesis of the Science. Washington State Department of Ecology Publication #05-06-006. Olympia, Washington.

Spieles, D.J. 2005. Vegetation development in created, restored, and enhanced mitigation wetland banks of the United States. Wetlands 25(1), pp. 51-63.

U.S. Army Corps of Engineers. 2010. Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region (Version 2.0). Environmental Laboratory ERDC/EL TR-08-13, Wetlands Regulatory Assistance Program, U.S. Army Corps of Engineers Engineer Research and Development Center, Vicksburg, Mississippi.

U.S. Army Corps of Engineers. 1987. Corps of Engineers Wetlands Delineation Manual. Technical Report Y-87-1, Wetlands Research Program, U.S. Army Corps of Engineers Engineer Research and Development Center, Vicksburg, Mississippi.

WAC (Washington Administrative Code). November 2013. Washington State Legislature. Viewed online: http://apps.leg.wa.gov/WAC/default.aspx

WDOE (Washington State Department of Ecology), U.S. Army Corps of Engineers Seattle District, and Environmental Protection Agency Region 10. 2006a. Wetland Mitigation in Washington State Part 1 – Agency Policies and Guidance. Ecology Publication No. 06-06-011a.

WDOE (Washington State Department of Ecology), U.S. Army Corps of Engineers Seattle District, and Environmental Protection Agency Region 10. 2006b. Wetland Mitigation in Washington State Part 2 – Developing Mitigation Plans. Ecology Publication No. 06-06-011b.

WDOE (Washington State Department of Ecology). 2008. Making Mitigation Work. The Report of the Mitigation that Works Forum. Ecology Publication No. 08-06-018.

WDOE (Washington State Department of Ecology). 2010. Puget Sound Watershed Characterization: Introduction to the Water Flow Assessment for Puget Sound, A Guide for Local Planners. Ecology Publication No. 10-06-014.

9.4 Terrestrial Habitat and Conditions

Adams, A.L., Recio, M.R., Robertson, Dickinson, B.C., K.M.J., and Van Heezik, Y. 2014. Understanding home range behavior and resource selection of invasive common brushtail possums (*Trichosurus vulpecula*) in urban environments. Biological invasions 16(9), pp. 1791-1804.

Azerrad, J.M. 2012. Management Recommendations for Washington's Priority Habitats and Species: Great Blue Heron (Ardea herodias). 3-1 to 3-18 in E. Larsen, J. M. Azerrad, N. Nordstrom, editors. Management Recommendations for Washington's Priority Species, Volume IV: Birds. Washington Department of Fish and Wildlife, Olympia, Washington, USA.

BirdWeb. Electronic Reference. Available at: http://www.birdweb.org/birdweb/ [Accessed June 27, 2016]

City of Bellevue. 2003. Bellevue Critical Areas Update Best Available Science Paper: Wildlife.

Federal Register. 11 May 2016, final rule designation of critical habitat for the Oregon Spotted Frog.

Federal Register. Volume 79, No. 169, 29 August 2014, Threatened Status for Oregon Spotted Frog - final rule

Ficetola, G.F., Padoa-Schioppa, E., De Bernardi, F. 2009. Influence of landscape elements in riparian buffer on the conservation of semiaquatic amphibians. Conservation Biology 23(1), pp. 114-123.

Germaine, S. and B. Costentino. 2004. Screening Model for Determining Likelihood of Site Occupancy by Oregon Spotted Frogs (*Rana pretiosa*) in Washington State.

Gilbert-Norton, L, R Wilson, JR Stevens, and KH Beard. 2010. A meta-analytic view of corridor effectiveness. Conserv. Biol. 24:660-668.

Hayes, G. and G. Wiles. 2013. State of Washington Bat Conservation Plan.

Hays, D. and R. Milner. 1999. Peregrine Falcon. In Larsen, E. J. Azzerrad, and N. Nordstrom Eds. Management Recommendations for Washington's Priority Species- Volume IV: Birds.

Hays, D. and R. Milner. 2003. Purple Martin. In Larsen, E. J. Azzerrad, and N. Nordstrom Eds. Management Recommendations for Washington's Priority Species- Volume IV: Birds.

Lewis, J. and J. Azerrad. 2003. Pileated Woodpecker. In Larsen, E. J. Azzerrad, and N. Nordstrom Eds. Management Recommendations for Washington's Priority Species- Volume IV: Birds.

Lewis, J, R. Milner, and M. Whalen. 1999. Common Loon. In Larsen, E. J. Azzerrad, and N. Nordstrom Eds. Management Recommendations for Washington's Priority Species- Volume IV: Birds.

Lewis, J., M. Whalen, and R. Milner. 2003. Vaux's Swift. In Larsen, E. J. Azzerrad, and N. Nordstrom Eds. Management Recommendations for Washington's Priority Species-Volume IV: Birds.

McAllister, Kelly R., Scott A. Richardson, and Derek W. Stinson. 1999. *Washington State recovery plan for the western pond turtle*. Olympia, WA: Washington Department of Fish and Wildlife.

McKinney, M.L. 2008. Effects of urbanization of species richness: a review of plants and animals. Urban ecosystems 11(2), pp. 161-176.

McKinney, A.M. and Goodell, K. 2010. Shading by invasive shrub species reduces seed production and pollinator services in a native herb. Biol. Invasions 12, pp. 2751-2763.

Stanley, S., S. Grigsby, D. Booth, D. Hartley, R. Horner, T. Hruby, J. Thomas, P. Bissonnette, J. Lee, R. Fuerstenberg, P. Olson, and G. Wilhere. 2011. Puget Sound Characterization, Volume 1: The Water Resources Assessments. Ecology Publication #11-06-016. Washington Department of Ecology, Olympia, Washington.

Tremblay, MA and CC St Clair. 2009. Factors affecting the permeability of transportation and riparian corridors to the movements of songbirds in an urban landscape. Journal of Applied Ecology 46:1314-1322.

USFWS (United States Fish and Wildlife Service). 2007. National bald Eagle Management Guidelines. 23 pgs.

Washington Department of Fish and Wildlife. 2012. Threatened and Endangered Wildlife State of Washington Annual Report.

Wilhere, G.F., T. Quinn, D. Gombert, J. Jacobson, and A. Weiss. 2013. A Coarse-scale Assessment of the Relative Value of Small Drainage Areas and Marine Shorelines for the Conservation of Fish and Wildlife Habitats in Puget Sound Basin. Washington Department Fish and Wildlife, Habitat Program, Olympia, Washington.

Woodruff, K., and H. Ferguson. 2005. "Townsend's Big-Eared Bat." Management Recommendations for Washington's Priority Species.

9.5 Frequently Flooded Areas

Federal Emergency Management Agency (FEMA). 1996. Q3 Flood Map King County, Washington.

Federal Emergency Management Agency (FEMA). 2010. Flood Insurance Study King County, Washington and Incorporated Areas.

Federal Emergency Management Agency (FEMA). 2013. Flood Insurance Study King County, Washington and Incorporated Areas- Revised.

National Marine Fisheries Service (NMFS). 2008. Endangered Species Act- Section 7 Consultation Final Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation- Implementation of the National Flood Insurance Program in the State of Washington- Phase 1 Document Puget Sound Region.

9.6 Geologic Hazard Areas

Fisher, M.A., Hyndman, R.D., Johnson, S.Y., Brocher, T.M., Crosson, R.S., Wells, R. E., Calvert, A. J., and tenBrink, U.S. 2006. Crustal structure and earthquake hazards of the subduction zone in southwestern British Columbia and western Washington. In Earthquake Hazards of the Pacific Northwest Coastal and Marine regions, R. Kayen (editor), U.S. Geological Survey Professional Paper 1661-C, 28 pp.

Johnson S .Y., Dadisman, S.V., Childs, J.R., Stanley, W.D. 1999. Active tectonics of the Seattle fault and central Puget Lowland: implications for earthquake hazards, Geological Society of America Bulletin111, 1042-1053

Liberty, Lee M. and Pratt, Thomas L. 2008. Structure of the Eastern Seattle Fault Zone, Washington State: New Insights from Seismic Reflection Data; Bulletin of the Seismological Society of America; vol. 98, no. 4, pp 1681-1695.

Pratt, T.L., Johnson, S.Y., Potter, C.J., and Stephenson, W, J. 1997. Seismic reflection images beneath Puget Sound, western Washington State: the Puget Lowland thrust sheet hypothesis, Journal of Geophysical Research 102(27) 469-27,490.

Palmer, Stephen P., Evans, Brian D., and Schasse, Henry W. 2002. Liquefaction Susceptibility of the Greater Eastside Area, King County, Washington; Washington Division of Geology and Earth Resources Geologic Map GM-48.

Sherrod, B. L. 2002. Late Quaternary Surface Rupture along the Seattle fault zone near Bellevue, Washington; (Abstract S21C-12) Eos transactions AGU 83, no.47 (Fall Meet Suppl.) S21C-12.

SR530 Landslide Commission. December 15, 2014. Final Report. Available at: http://www.governor.wa.gov/sites/default/files/documents/SR530LC_Final_Report.pdf [Accessed July 1, 2016]

ten Brink, U.S., Molzer, P.C., Fisher, M.A., Blakely, R.J., Bucknam, R.C., Parsons, T., Crosson, R.S., Creager, K.C. 2002. Subsurface geometry and evolution of the SFZ and the Seattle basin, Washington, Bulletin of the Seismological Society of America 92, 1737-1753.

9.7 Critical Aquifer Recharge Areas

City of Bellevue. 2016. Water System Plan Vol. 1 and 2.

Washington Department of Health. Electronic Reference. Available at: http://www.doh.wa.gov/CommunityandEnvironment/DrinkingWater/SourceWater/SourceWaterProtection#how [Accessed July 1, 2016]

10 Acronyms and Abbreviations

BAS.................Best Available Science
CAO ....Critical Areas Ordinance
CARA.............Critical Aquifer Recharge Area
City ....City of Bellevue
Corps .............U.S. Army Corps of Engineers
Ecology ....Washington State Department of Ecology
EPA ................U.S. Environmental Protection Agency
FEMA.............Federal Emergency Management Agency
FFA.................Frequently Flooded Areas
FWHCA ....Fish and Wildlife Habitat Conservation Areas
GMA...............Growth Management Act
LUC ....Bellevue Land Use Code
NFIP ....National Flood Insurance Program
PHS.................Priority Habitats and Species
SEPA ....State Environmental Policy Act
State................Washington State
SSWSP............Storm and Surface Water System Plan
WAC...............Washington Administrative Code
WDFW ....Washington Department of Fish and Wildlife