Technical Report

Best Available Science Research
Vancouver Critical Areas Ordinance Update

Submitted to

City of Vancouver
Vancouver, Washington

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Submitted by

WSP USA
210 East 13th Street, Suite 300
Vancouver, Washington 89660-3231

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TECHNICAL REPORT

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Washougal Critical Areas Ordinance Update

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LIST OF ACRONYMS AND ABBREVIATIONS

ASCE	American Society of Civil Engineers
ASFPM	Association of State Floodplain Managers, Inc.
BAS	best available science
BMP	best management practice
CAO	critical areas ordinance
CARA	critical aquifer recharge area
City	City of Vancouver
CMZ	channel migration zone
CRS	community rating system
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
FIRM	flood insurance rate map
GMA	Growth Management Act
I-5/I-205	Interstate 5/Interstate 205
I-Codes	International Codes (2018, 2015, 2012, and 2009)
LIDAR	light detection and ranging
LWD	large woody debris
NAI	No Adverse Impact
NEHRP	National Earthquake Hazard Reduction Program
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
PHS	priority habitats and species
PRM	permittee-responsible mitigation
RCW	Revised Code of Washington
RMZ	riparian management zone
SEPA	State Environmental Policy Act
SFHA	special flood hazard area
SMA	Shoreline Management Act
$SPTH_{200}$	200-year site potential tree height
SR 14/SR 500	State Route 14/State Route 500
UGA	urban growth area
USACE	U.S. Army Corps of Engineers
USDA-NRCS	U.S. Department of Agriculture Natural Resources Conservation Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VMC	Vancouver Municipal Code
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WSDOT	Washington State Department of Transportation

1.0 INTRODUCTION

As a fully planning county, Clark County and all municipalities within it, including the City of Vancouver (City), are required to periodically update their critical areas ordinance (CAO) on the schedule set out in the Growth Management Act (GMA) (see Revised Code of Washington [RCW] Sections 36.70A.130 and 36.70A.172). The CAO update needs to comply with the GMA, State Environmental Policy Act (SEPA), and must also meet requirements of the Shoreline Management Act (SMA) for regulation of critical areas within shorelines. The Washington Administrative Code (WAC) provides additional requirements for designation of critical areas in WAC 365-190. The deadline for the update of the CAO, other regulations as necessary, and the Comprehensive Plan of the City of Vancouver is June 30, 2025.

Critical areas in Vancouver are currently protected by the City's CAO (Vancouver Municipal Code [VMC] 20.740), first adopted in 2005, as required by RCW 36.70A.172. The protection of these critical areas is important to preserve the ecological functions and values of the City's natural environment and for the protection of public health, safety, and welfare of Vancouver's residents. Critical areas include habitats of local importance, fish and wildlife habitat conservation areas, frequently flooded areas, geologically hazardous areas, wetlands, and critical aquifer recharge areas (CARAs). CARAs are regulated under VMC 14.26, "Water Resources Protection," separately from the City's other critical areas provisions contained in VMC 20.740.

The CAO was most recently updated in 2020, specifically an amendment to Frequently Flooded Areas. Evolving best available science (BAS) for critical areas means the City's CAO may not reflect the latest science or guidance from the State of Washington. BAS is defined in WAC 365-195 (see further discussion below under Section 3.0 of this report). As an example, the City's CAO needs to be updated to meet the most recent riparian management guidance from the Washington Department of Fish and Wildlife (WDFW) – *Riparian Ecosystems, Volume 1: Science Synthesis and Management Implications (Quinn et al. 2020) and Riparian Ecosystems, Volume 2: Management Recommendations (Rentz et al. 2020)*. City staff have also mentioned that they would prefer that the CARA regulations in VMC 14.26 be integrated with the other critical areas regulations in VMC 20.740.

This report consists of a background of the City's existing critical areas landscape, review of BAS and critical area resource documents, and guidance that provide BAS-based approaches to protecting the functions and values of critical areas. The BAS review includes peer-reviewed literature, gray literature, expert opinion and the anecdotal experience of professionals that is relevant to the City, documents prepared for other jurisdictions, guidance prepared by state and federal agencies, and research from across the country regarding the effectiveness of existing standards and the state of the science. This document presents the findings of the review and Appendix B lists the literature, data, and reports used to review the state of BAS for each regulated critical area.

2.0 VANCOUVER'S CRITICAL AREAS LANDSCAPE

The geography of Vancouver's critical areas is discussed in this section. As a supplement to this section, see the critical areas maps contained in Appendix A. Together, the description and maps provide the general distribution of Vancouver's critical areas. Also discussed below are how critical areas are designated areas as per the City's CAO and any differences in designation compared with WAC 365-190.

2.1 HABITATS OF LOCAL IMPORTANCE

Habitats of Local Importance (VMC 20.740.100) are critical areas for fish and wildlife habitat that are not designated as priority habitats and species by the State, but are designated as locally significant by the City. These are determined by a need for protection due to existing high diversity of fish or wildlife species, declining populations, habitat scarcity, areas sensitive to disturbance from human activity or development, or other unique local habitat functions. Designated areas also need to be sufficient in size to support the species or habitat functions and this designation will not compromise the ability of the City to achieve Comprehensive Plan goals. A habitat of local importance must also have a proposed management strategy that describes how the functions of the habitat will be protected after designation. Vancouver has not designated any habitats of local importance and they are, therefore, not discussed further in this report.

2.2 WETLANDS

Wetlands are areas that support vegetation adapted to life in saturated soil conditions under normal circumstances (VMC 20.740.140). Wetlands must be designated in accordance with the definition in RCW 36.70A.030 and in accordance with the federal wetland delineation manual and regional supplements (WAC 173-22-035). Wetlands include swamps, marshes, bogs, and similar areas, but do not include artificial wetlands intentionally created (e.g., irrigation and drainage ditches, canals, and detention facilities). Counties and cities must adopt a rating system for wetlands. The rating system most frequently used (also used by Vancouver) is the joint rating system developed by the Washington State Department of Ecology (Ecology) and the U.S. Army Corps of Engineers (USACE).

Areas in the City that have prevalent wetland areas are along the banks of the Columbia River, Vancouver Lake, Burnt Bridge Creek, Fisher Creek, and Love Creek; areas between Vancouver Lake and the Columbia River; Curtin Springs Wildlife Habitat; Vancouver Lake Park; Centerpointe Park; areas west of Northeast Padden Parkway and Northeast Andresen Road; areas in the Port of Vancouver; and other mapped areas as shown in Appendix A.

2.3 CRITICAL AQUIFER RECHARGE AREAS

CARAs are areas where rainfall and surface water can infiltrate into the subsurface and recharge aquifers used for potable water. CARAs are regulated under VMC 14.26, which was recently updated in City Ordinance M-4372 codified in August 2022. The purpose of this code is to protect the City's water resources by reducing risks of groundwater contamination by establishing development regulations and minimum standards (VMC 14.26). Aquifer areas must be classified according to the vulnerability of an aquifer, which is determined by the combined effect of hydrogeological susceptibility to contamination and the potential contaminant releases that may impact the aquifers (WAC 365-190-100). The entire area within the City's jurisdictional boundaries is designated as CARA under VMC 14.26.115.B. The City further identifies Special Protection Areas within the citywide CARA that are those areas within 1,900 feet of any municipal water supply well.

2.4 GEOLOGICALLY HAZARDOUS AREAS

Landslide, seismic, and erosion hazard areas are geologically hazardous areas (VMC 20.740.130). Coal mine and volcanic hazards also qualify as geologically hazardous areas (WAC 365-190-120), but these do not occur in Vancouver.

Landslides: Landslide areas are generally characterized by the following identifying potential factors per the City's CAO: slopes greater than 25 percent on a property and adjacent areas within 100 feet and areas of historic or active landslides. WAC 365-190-120 defines landslide areas as areas delineated by the U.S. Department of Agricultural Natural Resources Conservation Service (USDA-NRCS) as having significant limitations for building development; coastal areas mapped as Classes u (unstable), uos (unstable old slides), and urs (unstable recent slides) in Ecology's Coast Atlas; or areas designated as quaternary slumps, earthflows, mudflows, lahars, or landslides on maps published by the U.S. Geological Survey (USGS) or Washington State Department of Natural Resources (DNR). Also, it includes areas with slopes steeper than 15 percent; hillsides intersecting geological contacts with a permeable sediment overlaying an impermeable sediment or bedrock; and springs or groundwater seepage. WAC goes further in defining landslides as areas that have shown movement during the Holocene epoch or which are underlain or covered by mass wastage debris from this epoch; slopes parallel or subparallel to planes of weakness in subsurface materials; slopes having gradients steeper than 80 percent subject to rockfall during seismic shaking; areas potentially unstable as a result of rapid stream incision, erosion, and undercutting by wave action, including stream channel migration zones; areas that show evidence or are at risk from snow avalanches; areas located in a canyon or on an active alluvial fan subject to inundation by catastrophic flooding; and any area with a slope of 40 percent or steeper with a vertical relief of 10 or more feet and not composed of bedrock.

Areas of the City that are identified as areas of potential instability landslide areas by information provided by Clark County Maps Online are slopes south of and above Burnt Bridge Creek in central Vancouver and bordering Burnt Bridge Creek on both sides from Falk Road to NW Fruit Valley Road; slopes above the Columbia River paralleling State Route 14 (SR 14) and Evergreen Boulevard; parallel to Fruit Valley Road; and areas along Southeast Evergreen Highway east of Interstate 205 (I-205) between SR 14 and the Columbia River and west of Southeast 192nd Avenue. The only areas mapped as areas of historic or active landslides are along Burnt Bridge Creek immediately east of Vancouver Lake and along Evergreen Highway east of I-205. Mapped landslide areas of high confidence by the USGS Landslide Inventory are located around Burnt Bridge Creek Park; along the eastern side Northwest Fruit Valley Road and north of West 39th Street; areas north of SR 500 at Arnold Park and

Bosco Farm Neighborhood Park; areas south of SR 500 along Burnt Bridge Creek and Burnt Bridge Creek Park; an area in Dubois Park; and area just west of Dubois Park and between East Mill Plain Boulevard and East Evergreen Boulevard (see Appendix A).

Seismic Hazard Areas: The City designates seismic hazard areas as those with low to moderate, moderate, moderate to high, or high liquefaction susceptibility, or Peat Deposits; areas of fill; National Earthquake Hazard Reduction Program (NEHRP) ground shaking amplification soils C to D, D, D to E, and E; and fault rupture hazard areas. WAC 365-190-120 defines seismic hazard areas as those subject to a severe risk of damage as a result of ground shaking induced by an earthquake, slope failure, settlement or subsidence, surface faulting, or tsunamis. It also includes areas with a historical record of earthquake damage.

Areas mapped with liquefaction susceptibility risk are typically found in Vancouver along the Columbia River generally west of Southeast Ellsworth Road; areas between the Columbia River and Vancouver Lake; areas along Burnt Bridge Creek; Spring Branch Creek; and areas north and south of SR -500 and Northeast 95th Street. Areas of the City with NEHRP ground shaking amplifications of C to D or higher are generally located west of I-5 near Vancouver Lake. The area north of SR 500 and between I-5 and I-205 are generally Class D; south of SR 500 and east of I-205 are generally Site Class C; faults associated with the Quaternary Lacamas fault zone are present on the eastern side of Vancouver, that generally trends southeast starting at Northeast 28th Street and Northeast 38th Avenue to the Columbia River and ending east of Government Island. Related faults also traverse the very northeast corner of the city, generally around Northeast Fourth Plain Boulevard and Northeast 162nd Avenue.

Erosion Hazard Areas: Erosion hazard areas under Vancouver's CAO are areas identified as having a severe erosion hazard by the 1972 USDA Soil Conservation Service Soil Survey of Clark County Washington. These include erosion hazard areas along banks, streams, and rivers due to flow patterns creating regression or retreat of these banks. Erosion hazard areas are defined by WAC 365-190-120 as areas that are likely to become unstable, such as bluffs, steep slopes, and areas with unconsolidated soils. In the City, erosion hazard areas are found generally along Burnt Bridge Creek adjacent and west of I-5, east of Northwest Fruit Valley Road between West 39th Street and Burnt Bridge Creek, along the Portland Vancouver Junction Rail line between I-5 and Northeast Saint James Road, an area bounded to the west and east by Fort Vancouver Way and Northeast 87th Avenue and to the north and south by East 18th Street and SR 14, and other mapped areas as shown in Appendix A.

2.5 FREQUENTLY FLOODED AREAS

Frequently Flooded Areas are areas of special flood hazards (VMC 20.740.120) determined by the Federal Emergency Management Agency (FEMA) and scientific and engineering reports entitled Flood Insurance Study effective September 5, 2012 and any subsequent revisions. Areas designated as frequently flooded areas as defined by WAC 365-190-110 are those that affect human health and safety and to public facilities and services. Jurisdictions may optionally designate and consider the future flow flood plain; the potential effects of a tsunami; high tides with strong winds; sea level rise and extreme weather events, including those resulting from global climate change; and greater surface runoff caused by increased impervious surfaces.

Frequently flooded areas in the City are found along the Columbia River, Burnt Bridge Creek, and Vancouver Lake and areas between Vancouver Lake and the Columbia River.

2.6 FISH AND WILDLIFE HABITAT CONSERVATION AREAS

Areas that are determined as fish and wildlife habitat conservation areas (VMC 20.740.110) are based on site conditions and varying available data. These areas include habitat used for any life stage of an endangered, threatened, or sensitive fish or wildlife species; priority habitats and areas associated with priority species as determined by the Washington Department of Fish and Wildlife (WDFW); rivers, lakes, streams and naturally occurring ponds; locally significant habitat areas or habitats of local importance; and riparian management areas are riparian buffers. WAC 395-190-130 defines fish and wildlife habitat conservation areas as those that are commercial and recreational shellfish areas; kelp and eelgrass beds; herring, smelt, and other forage fish spawning areas; naturally occurring ponds under 20 acres and their submerged aquatic beds; waters of the state; and state natural area preserves, natural resource conservation areas, and state wildlife areas.

Primary fish and wildlife habitat conservation areas in the city, including riparian and non-riparian habitat areas, and species areas that can be found along the Columbia River, Burnt Bridge Creek, Fisher Creek, Love Creek, Vancouver Lake and areas between the lake and the Columbia River, South Vancouver Lake Lowlands, Burnt Bridge Creek Greenway, parks along the banks of the Columbia River, Biddlewood Natural Area, Henry J. Biddle Natural Area, Mimsi Marsh, Ellsworth Springs East, David Douglas Park, Blandford Canyon West, Meadowbrook Marsh, along the Portland Vancouver Junction Rail between I-5 and Northeast Saint James Road, and other areas as mapped in Appendix A.

3.0 WHAT IS BEST AVAILABLE SCIENCE?

A foundational element of all CAO updates is documenting the BAS that supports the new and/or revised regulations. As regulated by RCW 36.70A.172, BAS must be used in developing policies and development regulations in order to protect functions and values of critical areas. BAS is utilizing the best, most current information available from a valid scientific process or sources that have been adopted by the scientific community. According to WAC 365-195-905, counties and cities may use a list of identified resources from local, state, or federal natural resources that have met the criteria of BAS. The responsibility of including BAS in development and implementation of critical areas policies or regulations rests on each jurisdiction. However, counties and cities should consult with a qualified scientific expert or team to identify scientific information, determine BAS, and assess applicability to critical areas. The scientific expert or experts may use professional judgment regarding critical areas but shall use criteria set out in WACs 365-195-900 through 365-195-925 and any other technical guidance provided by the department. Characteristics of BAS include:

- **WAC 365-195-900** – Jurisdictions must identify and include BAS in accordance with WAC for updates and adoption of policies and regulations, including for periodic review and evaluation to determine a jurisdiction is meeting statutory obligations.
- **WAC 365-190-905** – Assessment criteria are provided for jurisdictions to determine whether information gathered for development of critical areas policies and regulations is adequate for BAS. It also provides guidance on the types of information that can be used, determining qualified professionals, setting responsibilities of jurisdictions, and validating scientific information.
- **WAC 365-190-910** – Obtaining BAS is regulated by this statute and includes consulting with state and federal natural resource agencies and tribes for efficient development of scientific information and recommendations. Counties or cities may also have their own scientific data that is or can be eligible for BAS.
- **WAC 365-190-915** – Criteria are listed for using BAS in the development of policies and development regulation and shall protect the functions and values of the critical areas. BAS shall be included in the decision-making process. Jurisdictions shall use BAS with variances and exemptions determinations regarding generally applicable critical areas policies and development regulations. Nonscientific information (legal, social, cultural, economic, and political) used for critical area policies and regulations departing from BAS shall:
  - Identify information on record that supports its decision in departing science-based recommendations;
  - Explain rationale for its departure from science-based recommendations; and
  - Identify potential risks to a critical area or areas function and values, and any reducing risks with additional measures.
- **WAC 365-190-920** – Inadequate scientific information relating to a jurisdiction's critical areas shall utilize a "precautionary or a no risk approach" or use a formal adaptive management program that relies on scientific methods.
- **WAC 365-190-925** – Jurisdictions must give "special consideration" for necessary conservation or protection measures to preserve or enhance anadromous fisheries. Record evidence shall be provided with protected habitat that includes all life stages of anadromous fish.

Scientific information can be produced only through a valid scientific process as listed above and BAS must be used in developing policies and development regulations in order to protect functions and values of critical areas (RCW 36.70A.172). The BAS research presented below meets State requirements and includes scientific information that is readily available, is of high quality, and/or has been independently peer-reviewed.

4.0 WETLANDS

Wetlands are highly productive and valuable ecosystems that provide high-quality habitat to various terrestrial and aquatic flora and fauna, protect water quality by filtering contaminants and promoting infiltration, provide aquifer recharge, and slow the velocity of and retain flood waters protecting downstream communities from the impacts of flooding. Current BAS for wetlands includes guidance for the identification, classification, and categorization of wetlands, information regarding useful and effective protective buffers, and guidance for mitigating impacts to wetlands, including mitigation sequencing and compensatory mitigation, all of these are factors in protecting and maintaining wetland functions and values. This section of the report discusses the functions and values provided by wetlands and information regarding their identification, classification/characterization, and protection and management.

4.1 FUNCTIONS AND VALUES

4.1.1 Functions in General

Wetland functions are the interactions between the structural components of the wetland, and the physical, chemical, and biological processes within the wetland and surrounding landscape (Sheldon et al. 2005). Because wetlands provide functions at many scales, from the microscopic to watershed level, functions are generally grouped into one of three categories: biochemical, hydrologic, and habitat functions. Not all wetlands provide the same level of functions, and most functions are dependent on a number of factors that include the presence and kind of vegetation, soil type, water regime and residence time of water, and position within the landscape. Additionally, the value of an individual wetland may differ from another because of external factors, such as the presence of nearby contaminant sources (e.g., agricultural practices), runoff from adjacent impervious surfaces, proximity to resident and anadromous fish-bearing streams, precipitation patterns, likelihood of flooding, and/or changes in regional climate conditions. The following sections provide a broad overview of the functions provided by wetlands, and examples of the value of these functions to society. The discussion is not exhaustive but is meant to show representative examples of the findings of existing science regarding the functions provided by wetlands (Sheldon et al. 2005).

4.1.2 Biochemical Functions

Biochemical functions include nutrient cycling, removal and retention of metal and toxic organic compounds, and sediment stabilization, among others. Water quality can be impaired by the presence of contaminants, including sediments, phosphorous, metals and organic compounds, and/or pathogens. As discussed in Ecology's *Wetlands in Washington State Volume 1 – A Synthesis of the Science* (Sheldon et al. 2005), wetlands improve water quality by promoting sedimentation, absorbing and precipitating contaminants, biodegrading contaminants by supporting microbes that break them down, removing nitrogen through nitrification and denitrification processes, and helping retain and remove pathogens by detaining water and aiding microorganisms that feed on bacteria. These natural processes provide water quality protection that reduces society's dependency on water quality treatment facilities, protect local resources such as fish stocks that may be impaired by contaminated water, and help promote the health and safety of communities by limiting the presence of pathogens, metals, and toxic organic compounds in the drinking water that is provided by groundwater and surface water resources (Sheldon et al. 2005).

4.1.3 Hydrologic Functions

The hydrologic functions provided by wetlands include flood attenuation, groundwater recharge, decreased downstream erosion, and reduction in peak flows, among others. The hydrologic functions of wetlands are related to their ability to retain more surface water than terrestrial habitats; the many wetlands across a watershed retain and gradually release runoff and surface water that would otherwise flow directly into surface waters (Adamus et al. 1991, *in* Sheldon et al. 2005). While these functions are associated with water storage, an individual wetland's ability to store surface or subsurface water is additionally influenced by a number of factors, including the wetland's location within the landscape, soils and vegetation, and the type or class of the wetland (Sheldon et al. 2005). These functions can contribute to the long-term health, safety and financial benefits to downstream communities; for example, wetlands in floodplains dissipate the erosive forces of flood waters, and can store large volumes of surface water; these functions act to protect downstream communities from flooding events, and channel migration, and minimize damage to structures and other assets such as cropland.

4.1.4 Habitat Functions

Wetlands provide habitats for various species, including species that are dependent on wetland habitat for their entire life cycle, species that rely on wetlands for a single life stage, and species that use wetlands on occasion, such as for drinking water, or as a stopover point during migration (Johnson and O'Neil 2001). Wetlands support anadromous and resident fish, reptiles and amphibians, waterfowl and migratory birds, and terrestrial species, as well as a variety of aquatic invertebrates and microorganisms. The use of a wetland by any specific animal or group of animals depends on factors that include hydrologic regime, structure and complexity of vegetation, proximity to other habitat, climate/seasonality, and topography, among others (Adamus et al. 1991, Mitsch and Gosselink 2000). Many of the species that rely on wetlands for all or part of their life cycle have unique societal and cultural values. For example, wetlands provide juvenile rearing habitat for salmon, and they provide habitat for waterfowl that are valued for recreation (e.g., birding and hunting). Wetlands supply habitat for protected species, such as migratory birds, WDFW priority species, and state and federally listed threatened and endangered species.

4.1.5 Carbon Sequestration Functions

According to RCW 70A.45.010, carbon sequestration is defined as the process of capturing and storing atmospheric carbon dioxide through biologic, chemical, geologic, or physical processes. Wetlands are known to be some of the largest stores of carbon on the planet (USGCRP 2018). Wetland soils are anoxic (oxygen-poor), and therefore slow decomposition and lead to the accumulation of organic matter (Nahlik and Fennessy 2016). The amount of carbon storage depends upon wetland type and size, vegetation, the depth of wetland soils, groundwater and nutrient levels, pH, and other factors. Wetland soils also store carbon that flows in from upland areas, through soil erosion or movement of vegetative debris (Kusler and Christie 2011). Climate modeling has shown a potential favorable ratio of greenhouse gas production to sequestration in future climate change scenarios, meaning wetlands could become an even greater carbon sink than during current conditions. Global warming may affect the period of time it takes a wetland to become a net sink, but may also increases the amount of sequestered carbon significantly depending on local climate conditions (Mitsch et al. 2013). However, disturbed or warmed wetlands typically release greenhouse gases that contribute the most to global warming (i.e., carbon dioxide, methane, and nitrous oxide) (Mitsch et al. 2013).

4.1.6 Impacts

Disturbances to wetlands and the functions they provide can occur at several geographic scales, and can be created by and depend on a variety of land uses, the land use intensity/severity, and the scale at which the disturbance occurs (Sheldon et al. 2005). Disturbances include vegetation removal and increased impervious surfaces, agricultural practices, logging and development, and other activities that alter natural drainage patterns, fill wetlands, and increase inputs of pollutants. Each of these disturbances may affect the functions and values of wetlands by increasing water volume and flow rates after storm events; increasing sediment and other pollutants in runoff; contributing to habitat fragmentation; increasing erosion, and/or reducing biodiversity (Sheldon et al. 2005).

Protecting wetland resources entails the regulation of direct and indirect impacts to wetlands and should be guided by BAS. Direct wetland impacts are activities that include filling, draining, or adversely impacting the vegetation within a wetland. Indirect impacts result from changes to the surrounding landscape that negatively influence the physical, chemical, or biological characteristics of a wetland, such as its hydroperiod, microclimate or habitat connectivity, for example (McMillan 2000).

4.2 IDENTIFICATION AND CLASSIFICATION

Section 365-190-090 of the WAC and RCW 36.70A.030 define wetlands as,

> *… 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 non-wetland 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 1 July 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 non-wetland areas to mitigate the conversion of wetlands.*

To address regional wetland characteristics and improve the accuracy of wetland delineations, the USACE issued regional supplements to its wetland delineation manual (1987) on which the state manual is based. Therefore, current wetland methodology is based on the USACE manual and the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast* Region (Version 2.0) (regional supplement) (USACE 2010). The USACE manual provides the methodology for identifying jurisdictional wetlands based on an examination of vegetation, soils, and hydrology. Vancouver's CAO references the "approved federal wetland delineation manual and applicable regional supplements but does not specifically reference the manual and supplement by name (see VMC 20.740.120).

WAC 365-190-090 also indicates that when designating wetlands, counties and cities should use a rating system that evaluates the existing wetland functions and values to determine what functions must be protected, and, when developing wetland rating systems, jurisdictions should consider using the wetland rating system developed jointly by Ecology and the USACE. Ecology's *Wetland Rating System for Western Washington* (Hruby 2014) is the most commonly used and regionally accepted wetland classification system, and categorizes wetlands based on their specific attributes, including rarity, sensitivity, and the functions they provide. To identify and classify wetlands, the system incorporates other classification systems, including the hydrogeomorphic classification and classification of plant communities (Cowardin et al. 1979), as well as classification based on special characteristics. As described in the Ecology guidance, the 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 2014). The intent of the system is to provide a basis for developing standards to protect and manage wetlands. Vancouver's CAO uses the *Wetland Rating System for Western Washington* (Hruby 2014) in compliance with WAC 365-190-090.

4.3 BEST AVAILABLE SCIENCE FOR WETLAND PROTECTION

The protection of the functions and values provided by wetlands is generally recognized as achievable (in part) by using protective wetland buffers. Buffers are vegetated areas adjacent to an aquatic resource (a wetland for purposes of this discussion) that can, through various processes, reduce the impacts of adjacent land uses (Sheldon et al. 2005). Functions provided by buffers include removing sediments, excess nutrients, and toxics; influencing the microclimate; maintaining habitat connectivity; and minimizing adjacent disturbances. The effectiveness of buffers to protect wetland functions and values is generally related to the type of wetland function to be protected, the activities that are being buffered, and the characteristics of both the wetland and its associated buffer. For example, differing widths for effective buffers for water quality protection, and habitat for a specific species have been documented. Additionally, different buffer widths to protect a similar function may be necessary depending on the stressors associated with the different wetlands that provide the function. Generally, the characteristics that most influence buffer functions include vegetation, slope of the buffer, the soils, and the width of the buffer; of these, just vegetation and buffer width can be manipulated or controlled easily (Sheldon et al. 2005).

It is generally accepted that the width of a buffer should be related to the wetland functions that need protecting, the intensity of the adjacent land use, and the condition of the adjacent buffer. While the BAS states unanimously that buffers are effective in protecting wetlands functions and values, there is significant debate about how much buffer is necessary to protect particular functions. In order to protect the ecological functions and values of wetlands, it is necessary for regulators to consider a number of ecological principles, and their implications for development and the use of natural resources. These principals include factors such as temporal and spatial functions of ecological processes and implications of development, direct and cumulative impacts, and the type, intensity, and duration of impacts to natural resources.

As stated in Ecology's *Wetlands in Washington State Volume 2 – Protecting and Managing Wetlands* (Granger et al. 2005),

> *[a]uthors who synthesized the literature on the effectiveness of buffer widths suggest buffers between 25 and 75 feet for wetlands with minimal wildlife habitat functions and adjacent low-intensity land uses; 50 to 150 feet for wetlands with moderate habitat functions or adjacent high-intensity land uses; and 150 to 300 feet for wetlands with high habitat functions. Effective buffer widths for protecting water quality ranged from 25 to 50 feet for 60 percent removal of pollutants, to 150 to 200 feet for 80 percent removal of pollutants.*

Ecology suggests assessing the potential risk to wetlands as a result of development and the amount of risk that is acceptable; this risk assessment can offer a local jurisdiction insight on appropriate protective measures for implementation (Granger et al. 2005). This means that regulations implementing larger, rather than smaller, buffers around all wetlands would be characterized as lower risk for preserving functions and values, whereas a jurisdiction that implements narrower buffers would have a higher risk of impacting functions and values, and the narrower buffers would be unlikely to provide all of the functions necessary to protect wetlands.

In October 2022, Ecology released new guidance offering three different approaches to establishing protective buffers. Buffer Option 1 offers the most flexibility in buffer widths based on the wetland category, level of impacts from adjacent land uses, and the functions of the wetland (i.e., habitat, special characteristics, etc.), and offers opportunities for buffer reductions (Ecology 2022b). Buffer Option 2 established buffer widths based on wetland category and the existing or proposed adjacent land use, with no options for buffer averaging or reductions. Buffer Option 3 includes fixed buffer widths based solely on the wetland category with no opportunity for buffer reductions or averaging. These three options offer local jurisdictions different approaches with different risk tolerances to choose from when developing or updating their critical areas ordinances.

4.4 SCIENCE OF IMPACTS AND MITIGATION

When a change in land use has the potential to adversely affect a wetland, regulatory agencies require the applicant to conduct wetland mitigation, as part of a national "no net loss" policy toward protecting wetlands. "No net loss of wetland functions and values" is a federal and state policy goal that emerged in 1989 and has been a mainstay of land use regulations since then (National Research Council [NRC] 2001). To date, the no net loss policy has been interpreted to mean that wetlands should be conserved wherever possible, and that wetlands converted to other uses must be offset through compensatory mitigation to provide the same functions and values that have been lost (NRC 2001). As described in the 1990 Memorandum of Agreement between the U.S. Environmental Protection Agency (EPA) and the USACE (EPA and USACE 1990), the mitigation sequence is a three-step sequence that helps guide decisions and to determine the type and level of mitigation required under Clean Water Act Section 404/401 Regulations. The Washington SEPA (Chapter 43-21C RCW), administered by Ecology, also requires that a sequence of actions be taken for proposals that will impact wetlands (mitigation sequence). The following are the steps in the mitigation sequence according to the implementing rules of SEPA (Chapter 197-11-768 WAC):

- 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 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.

If, through mitigation sequencing, it is determined that compensatory mitigation is necessary, an applicant has several alternatives for how to approach compensation. The alternatives, reviewed and described by Ecology et al. (2021), are prioritized as follows:

- Mitigation bank credits: Allows applicants to compensate for wetland loss by purchasing credits from a bank that is commissioned to restore, create, enhance, or preserve wetland areas in providing compensatory mitigation for authorized impacts to wetlands.
- In-lieu fee program credits: Allows applicants to compensate for wetland losses by paying a fee to a third party, such as a government agency or conservation organization, where the fee is used to ensure wetland protection, creation, and enhancement of wetlands.
- Permittee-responsible mitigation (PRM) under a watershed approach.

- PRM that is on site and in-kind.
- PRM that is off site and/or out-of-kind.

PRM includes the following approaches:

- Restoration: Re-establishment of wetland conditions where they formerly, but no longer, exist.
- Creation: Establishment of wetland conditions in a location where wetland conditions previously did not exist or that has not been a wetland within the last 100 to 200 years.
- Enhancement/Exchange: Modifying a specific structural feature of an existing degraded wetland to improve one or more functions based on management objectives.
- Preservation: Protection of an existing and well-functioning wetland from perspective future development threats.
- Mixed Compensatory Mitigation: Involves more than one of the listed types of compensatory mitigation.

Additionally, Ecology adopted an approach for estimating the functions lost when a wetland is altered, and to estimate the gain in functions that may result from restoration, creation, enhancement, and/or preservation (Hruby 2011). This methodology estimates the type and area of compensation to be provided based on functions of the wetland being altered (i.e., debits) and the amount the proposed compensatory mitigation will create (i.e., credits). The guidance establishes that the proposed compensatory mitigation is acceptable when the "credit" score for the mitigation project is higher than the "debit" score for the impacted wetland (Hruby 2011)

As a result of failure of many previous mitigation projects, USACE, Ecology, and some Washington jurisdictions are encouraging the use of mitigation banks and in-lieu fee programs because these can offer greater assurance for mitigation success to both the applicant and the jurisdiction (USACE and EPA 2008; Ecology 2009).

4.5 SUMMARY EVALUATION OF EXISTING ORDINANCE AND RECOMMENDATIONS

To maintain consistency with state and federal wetland delineation methods, the City should adopt the latest federal wetland delineation manual and its supplements for use in delineating wetlands. This is not expected to change the outcome of wetland delineation efforts within the City, as state and federal regulators already require this methodology to determine wetland boundaries.

Additionally, to be consistent with state and federal guidance on the use of mitigation banks and in-lieu fee programs for compensatory mitigation, the City should update the mitigation code section (VMC 20.740.140[C][2]) to reflect this preference. This is not expected to change the options available to applicants but to clarify the preference for banks and in-lieu fee programs over permittee-responsible options that have not shown a high likelihood of success.

Finally, to be consistent with state wetland protection guidance, the City should update the code to reflect recent guidance published by Ecology in October 2022. . The recent guidance includes the following additional recommendations that should be included in the updated code:

- Reformatted buffer tables, including the incorporation of previous adjustments to the range of habitat scores based on review of the referenced wetland data used to calibrate the Washington wetland rating system
- Updated and expanded minimization measures table for use with the buffer tables
- Functionally disconnected buffers
- Clarified corridor requirements and expanded applicability
- Clarified geographic scope of exemption guidance for small wetlands
- Recommendations from the 2021 interagency wetland mitigation guidance document
- Updated definitions
- New language addressing the role of wetland functions in mitigating climate change (e.g., carbon sequestration)

These updates may have some changes on how wetlands are protected with buffers and the ability to reduce buffers based on the new guidance.

5.0 CRITICAL AQUIFER RECHARGE AREAS

The GMA requires the protection of public groundwater drinking supplies. The supply of public drinking water depends on the availability of groundwater, and without replenishment, the amount of water in aquifers can be diminished or even depleted (Ecology 2021a). CARAs are "areas with a critical recharging effect on aquifers used for potable water where an aquifer that is a source of drinking water is vulnerable to contamination that would affect the potability of the water" (WAC Chapter 365-190). By protecting CARAs, a community can focus its efforts and resources on protecting the most critical groundwater drinking supplies.

CARAs are regulated by Section 14.26 of the VMC.

5.1 FUNCTIONS AND VALUES

Regulating CARAs protects public drinking water from contamination by hazardous materials and waterborne pathogens, helps ensure the future availability of groundwater, and is less expensive than post-contamination cleanup or treatment of groundwater. Studies have shown that funding initiatives to protect groundwater is more cost-effective than cleaning up groundwater after contamination occurs (Ecology 2021a). Contaminated public drinking water can cause illness, bring about the ingestion of chemicals or other harmful substances, and incur costs as new wells must be developed or contaminated soils and/or groundwater must be remediated (Ecology 2021a).

5.2 IDENTIFICATION AND CLASSIFICATION

The Washington State Department of Health (DOH) regulates and maps drinking water wells. CARAs recommended for protection by WAC 365-190-100 include:

- Wellhead Protection Areas: These areas are defined as "the boundaries of the 10-year time of groundwater travel". Clark County Maps Online maps wellhead locations based on information from DOH and the 1-, 5-, and 10-year time of travel zones around these wellheads. Time-of-travel zone information comes from DOH's Source Water Assessment Program mapping tool.
- Sole Source Aquifers: These areas are designated by the EPA pursuant to the Federal Safe Drinking Water Act. Nearly all of Clark County and the city of Vancouver are located within the Troutdale Sole Source Aquifer (EPA 2006).
- Susceptible Groundwater Management Areas: These areas are designated as moderately or highly vulnerable or susceptible in an adopted groundwater management program developed pursuant to WAC Chapter 173-100. There is no adopted groundwater management program for Vancouver or mapped groundwater management areas in the city.
- Special Protection Areas: These areas are defined by WAC 173-200-090 and designated by Ecology. There are special protection areas currently mapped for Vancouver.
- Moderately or Highly Vulnerable Recharge Areas: These areas are moderately or highly vulnerable to degradation or depletion because of hydrogeologic characteristics as delineated in a hydrogeologic study. These areas are not mapped.

CARAs are identified by their vulnerability. Vulnerability is the combination of hydrogeological susceptibility (the high potential for surface recharge and infiltration in CARAs due to the permeability of the soil around them) and the potential of contamination sources based on an analysis of existing land uses. Clark County designates Municipal Wellhead Protection Areas shown on Clark County MapsOnline that indicate different zones that estimate the time it would take for a pollutant release to reach the wellhead area. Vancouver's CAO designates Special Protection Areas within CARAs as those within 1,900 feet of any municipal wellheads These areas are mapped by Clark County MapsOnline.

5.3 BEST AVAILABLE SCIENCE FOR CARAS

BAS for protecting CARAs recommends addressing both recharge and discharge areas. Aquifer recharge occurs where stormwater, irrigation water, and other water infiltrates into the ground. Using resources and land in various ways can impact aquifer recharge areas; some examples of risks include the contamination of CARAs by hazardous materials or reducing recharging effects by increasing impervious surfaces. Discharge areas are locations where groundwater flows from the surface such as a spring, wetland, or well. Discharge areas are typically protected by other critical areas regulations such as wetland and riparian area requirements.

BAS recommends protecting public groundwater by limiting potential contamination risks within CARAs and promoting land use and development standards that maintain groundwater quality, withdrawals and recharge. In order to support the adequate recharge of its aquifers, a municipality can limit impervious surfaces, encourage low impact development, and use other stormwater best management practices (BMPs) such as raingardens. A commonly used resource for identifying BMPs that will protect groundwater recharge and water quality is the *Stormwater Management Manual for Western Washington* (Ecology 2019).

Some land use activities have been identified as high risk for groundwater contamination, and jurisdictions should consider prohibiting these uses within priority CARAs or requiring strict pollution prevention requirements to further mitigate potential risks. BAS also recommends the identification and monitoring of existing high-risk uses within CARAs. Examples of high-risk uses in CARAs include landfills, wood treatment facilities, chrome platers, tank farms, and facilities that treat, store, or dispose of hazardous waste (Ecology 2021a).

Other uses may present a moderate or low risk of contamination within a CARA, and can be permitted as conditional uses, provided that they meet BMPs and other requirements to ensure protection of the CARA.

Groundwater wells and construction of groundwater wells are potential conduits that could connect the aquifer with potential overlying contaminants. Well construction standards in WAC 246-290 and 246-291 are intended to help reduce the risk of contamination. However, many wells were installed prior to adoption of well construction standards. Jurisdictions often distinguish between Group A and Group B wells as defined by the Washington Department of Health. Group A wells are "water systems providing service to 15 or more service connections used by year-round residents for 180 or more days within a calendar year regardless of the number of people, or regularly serving at least 25 year-round residents for more than 180 days per year." Group B water systems serve less than 15 service connections and less than 25 people per day or 25 or more people per day during fewer than 180 days per calendar year. (WAC 246-290-020). Both types of wells have the potential to act as conduits and, therefore, the City of Vancouver should consider regulating, not only Group A wells, but also Group B wells.

5.3.1 Science of Impacts and Mitigation

Protection of water supply well heads in a sole-source aquifer is of primary importance to the City of Vancouver. Designation of CARAs is intended to protect the water supply by adopting and enforcing regulations that are supported by science-based mitigation measures. Potential releases of pollutants can infiltrate into the ground and ultimately to groundwater where they can then travel with the groundwater. Where contaminated groundwater is withdrawn from supply wells, these wells may require treatment to remove pollutants or reduce them to non-hazardous levels. The science behind wellhead protection areas considers the path from surface release to wellhead and aims to identify specific sensitive areas that can be protected with appropriate land-use controls to minimize potential future contamination and costs related to treatment.

The groundwater management areas and program requirements cited in WAC 173-100 should be considered in Vancouver's municipal code revisions. The WAC includes additional detailed elements that provide a more comprehensive technical characterization of groundwater resources and how they are managed. As an example, elements pertaining to groundwater quality, wellhead protection areas, and groundwater quantity evaluations within a coordinated program would likely add value to the City's water resources protection and management.

5.4 SUMMARY EVALUATION OF EXISTING ORDINANCE AND RECOMMENDATIONS

The current Special Wellhead Protection Areas designated by the City (VMC 14.26.115[B][2]). are solely based on the 1,900-foot radius around a production well. While groundwater flow in the immediate vicinity of the well may be primarily circular, and thus support a radius-based zone, the science suggests that larger areas upgradient of a wellhead will be more capable of bringing contaminated groundwater to a well than an equal distance downgradient of the wellhead. This is shown by the Clark County maps that represent different "residence" time zones for groundwater travel to a wellhead. These expanded wellhead protection zones should be based on state of the practice groundwater flow modelling to establish the radius of wellhead "capture zones" that should provide better, more science-based protection zones than a standard 1,900-foot radius. It is recommended that Special Protection area boundaries be modified to reflect physical processes that are involved with groundwater infiltration and potential contamination, similar to what has been done for Clark County.

Designations of CARAs should be reconciled with those listed in WAC 365-190-100.

The City should consider regulating Group B wells in addition to Group A wells. Once draft regulations are developed, the City should look use test case reviews to determine that regulations are effective and tailored to meet the City's objectives and BAS standards.

6.0 GEOLOGICALLY HAZARDOUS AREAS

6.1 FUNCTIONS AND VALUES

The GMA recognizes four main types of geologic hazards: landslide hazard areas, erosion hazard areas, seismic hazard areas, and areas subject to other geologic events such as coal mine hazards and volcanic hazards. All of these geologic events are risks to human health and safety and can damage property. Managing geologically hazardous areas is necessary to ensure the safety and wellbeing of city residents, and to prevent avoidable damage and/or loss of public and private property. In addition, according to the Washington Department of Commerce, "geologically hazardous areas also have an important function in maintaining habitat integrity." Geologic processes, including mass wasting events, such as landslides and debris flows, contribute needed sediment and wood for building complex instream habitats, estuarine marshes, and beaches important for fisheries, wildlife, and recreation." (Commerce 2021) The section below addresses the BAS for designating and mapping geologically hazardous critical areas in the interests of human health, structural safety, and the contributions of these areas to the natural environment.

6.2 IDENTIFICATION AND CLASSIFICATION

The DNR website "Geologic Hazards and the Environment" provides information and maps of seismic hazards, landslides, and erosion hazards and is an important BAS mapping source. DNR's Geologic Information Portal is a BAS information source for mapping landslide, seismic, and erosion hazards. Erosion hazards are also mapped by corresponding soil type through the USDA-NRCS online web soil survey of Clark County. Geologic hazards are also commonly identified through site-specific geologic or geotechnical engineering studies where agency-produced hazard mapping is insufficient.

The city landscape has various environments susceptible to geologic hazards as noted in Section 2.0 of this report; many of these areas are also subject to erosion hazards (see the Geologically Hazardous critical areas map in Appendix A). Seismic hazard areas are also discussed below, and coal mine and volcanic hazards do not exist within Vancouver.

6.3 BEST AVAILABLE SCIENCE FOR LANDSLIDE HAZARDS

According to DNR, "Washington is one of the most landslide-prone states in the country, with hundreds to thousands of events each year" (DNR 2021a). Landslides are mass wasting events with soil and rock moving downslope and are more frequent after precipitation events when ground becomes saturated and soil loses its strength. Gravity, water, and friction all play a role in landslides. There are many different types of landslides, but slides generally fall into two categories: shallow and deep-seated (DNR 2021a). Literature tends to focus on how to categorize and map these hazards. DNR's Division of Geology and Earth Resources recently completed landslide hazard mapping in the Columbia River Gorge and this data is available on DNR's Geologic Information Portal website and is considered BAS for designation of landslides in the city in the absence of site-specific studies. These mapped features are located east of Vancouver.

Site-specific geotechnical studies with a delineation of landslide hazards and recommended mitigation measures for building in and/or near these areas are considered BAS based on the criteria in WAC 365-195-905. The literature contains mitigation measures and best practices for site development near landslide hazards. According to the USGS, "the simplest means of dealing with landslide hazards is to avoid construction on steep slopes and existing landslides; however, this is not always practical" (Highland and Brobrowsky 2008). The USGS recommends other mitigation, including slope stabilization, by channeling drainage away from the landslide, draining groundwater away from the landslide, minimizing surface irrigation, using retaining walls, retaining/planting vegetation, and seeking professional advice (Highland and Brobrowsky 2008). Burns and Mickelson (2012) recommends a buffer from the top of shallow landslide-prone slopes equal to twice the vertical height of the slope for high or moderate susceptibility landslide areas or an average of 30 feet.

6.3.1 Science of Impacts and Mitigation

Slope instability is attributable to natural and man-made causes. While large geologically controlled landslides are found further up the Columbia River valley, these types of large landslides are not typically found within the Vancouver city limits. They types of landslides that may occur in the city are smaller slope failures associated with over-steepened slopes along rivers, streams or bluff edges. While these areas of instability may not be extensive, local mitigation activities can be implemented to minimize the potential damages associated with them, similar to erosion hazards.

6.4 SUMMARY EVALUATION OF EXISTING ORDINANCE AND RECOMMENDATIONS

The City should update the landslide hazard areas section of their development code based on the current WAC definitions. VMC 20.740.130(A)(1) currently lists indicators for potential landslide hazard areas in the City and are not entirely inclusive or current with the State-defined indicators. This section of the VMC should be revised to directly define and reference the definition of landslide hazard areas pursuant WAC 365-190-120(6).

Potentially unstable slopes will typically coincide with areas of soil erosion hazards within the city of Vancouver. Grading, construction, or slope erosion mitigation activities in these areas should include consultation of a licensed engineering geologist to help ensure that the potential for instability has been appropriately evaluated and mitigation measures appropriately designed and established. The City should consider including BMPs in its code for landslide hazard areas. If applicants implement these BMPs, then they could avoid filing a critical areas report.

6.5 BEST AVAILABLE SCIENCE FOR EROSION HAZARDS

Erosion is “the wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep” (Washington State Department of Transportation [WSDOT] 2021). The 1972 USDA-NRCS soil survey of Clark County classifies the erosion potential of soil types as slight, moderate, severe, and very severe. According to “Understanding Soil Risks and Hazards, Using Soil to Survey to Identify Areas with Risks and Hazards to Human Life and Property,”

…construction activities can have serious detrimental effects on the soil on construction sites. Topsoil removal, grading, and filling drastically reduce soil quality on these sites, resulting in long-term adverse impacts on plant growth and runoff. Removal of topsoil inhibits biological activity and reduces the supply of organic matter and plant nutrients ... Erosion from construction sites has offsite environmental and economic impacts. (USDA-NRCS 2004). Further, the VMC Chapter 14.24 meets BAS regarding avoidance and mitigation of erosion activities.

The 1972 soil survey is considered BAS for erosion hazards generally in the city and the county. The geography of erosion hazard areas in Vancouver is noted in Section 2.0 of this report. Soils rated by USDA-NRCS as “severe” or “very severe” are those with an erodibility index of 0.75 or greater and, in most jurisdictions across the state, are classified as regulated critical areas. In addition to the 1972 soil survey, Clark County MapsOnline also includes a Severe Erosion Hazards Area map that should also be considered BAS. BMPs for development or alteration in erosion hazard areas tend to focus not on prohibiting development, but on requiring erosion controls during construction, eliminating clearing activities during the wet season, and directing the drainage around these areas so as not to exacerbate pre-existing erosion potential. Ecology’s *Stormwater Management Manual for Western Washington* (Ecology 2019) is considered a BAS document for erosion control methods. In “Understanding Soil Risks and Hazards,” which is considered to be BAS, USDA-NRCS recommends the following erosion control techniques during construction:

- Divide the project into smaller phases, clearing smaller areas of vegetation.
- Schedule excavation during low-rainfall periods when possible.
- Fit development to the terrain.
- Excavate immediately before construction instead of exposing the soil for months or years.
- Cover disturbed soils with vegetation or mulch as soon as possible and thus reduce hazard of erosion.
- Divert water from disturbed areas.
- Control concentrated flow and runoff, thus reducing the volume and velocity of water from work sites and preventing the formation of rills and gullies.
- Minimize the length and gradient of slopes (e.g., use bench terraces).
- Prevent the movement of sediment to off-site areas.
- Inspect and maintain all structural control measures.
- Install windbreaks to control wind erosion.
- Avoid soil compaction by restricting the use of trucks and heavy equipment to limited areas.
- Break up or till compacted soils prior to vegetating or placing sod.
- Avoid dumping excess concrete or washing trucks on site.
- Revegetate exposed surfaces to provide immediate permanent or intermittent cover.

6.5.1 Science of Impacts and Mitigation

Erosion hazard impacts include unstable slopes that may threaten structures, as well as potentially excessive sediment contributions to surface waters of the City.

Mitigation of these impacts can be addressed with BMPs outlined above, as well as preventing activities that over-steepen slopes that can contribute to slope instability and threaten infrastructure installations.

6.6 SUMMARY EVALUATION OF EXISTING ORDINANCE AND RECOMMENDATIONS

For construction or development work that is performed in erosion hazard areas, it is recommended that erosion mitigation work to be performed by a certified erosion and sediment control lead in accordance with Ecology requirements.

Additional structure for the regulations could be added to link to WAC 220-660-120 and 220-660-130 to expand BAS for erosion protection.

The City should consider including BMPs in its code for erosion hazard areas. If applicants implement these BMPs, then they could avoid filing a critical areas report.

6.7 BEST AVAILABLE SCIENCE FOR SEISMIC HAZARDS

Earthquakes can be incredibly expensive and destructive natural hazard events that can level buildings and damage public infrastructure. According to DNR, “Washington has the second highest risk of large and damaging earthquakes in the nation as a result of its geologic setting” (DNR 2021b). WAC 365-190-120 defines seismic hazards as geologically hazardous areas and requires that jurisdictions adopt CAOs regulating development in them. This same WAC section defines seismic hazard areas as “areas subject to a severe risk of damage as a result of earthquake induced ground shaking, slope failure, settlement or subsidence, soil liquefaction, surface faulting or tsunamis.”

According to USGS, “ground shaking or ground motion is the movement of the earth’s surface due to earthquakes and is produced by seismic waves that are generated by sudden slip on a fault and travel through the earth and along its surface” (USGS 2021). Ground shaking is the most frequently observed effect of an earthquake. The degree of ground shaking will depend on the geologic conditions and soil types for a given area. The NEHRP has delineated “site classes” to characterize the degree of shaking and or amplification that can occur in response to an earthquake. Clark County MapsOnline includes a map of NEHRP site class for Vancouver that should be considered BAS for seismic design to mitigate earthquake effects. Generally the City is dominated by Site Classes C and D, with areas around drainages and Vancouver Lake including areas with more sever site classes of D and E.

The USGS defines liquefaction as “the phenomenon that occurs when loose, saturated sediments at or near the ground surface lose their strength in response to strong ground shaking from an earthquake” (USGS 2021). Clark County MapsOnline includes a map of Liquefaction Susceptibility that should be considered BAS for Vancouver. Throughout most of Vancouver, the liquefaction susceptibility is low to very low; however, a susceptibility of moderate to high has been mapped around the Vancouver Lake area, as well as low lying areas adjacent to the Columbia River.

Further some areas with higher groundwater levels associated with surface streams also indicate a liquefaction susceptibility of low to moderate.

DNR's Washington Geologic Survey and its Geologic Information Portal have online map information for active faults, seismic scenarios, and liquefaction susceptibility that is considered to be BAS for seismic hazards. Clark County MapsOnline shows faults running southeast to northwest on the east side of the city that appear to be associated with the Lacamas Fault zone aligned slightly further east through Lacamas Lake. The design level earthquake in the city is a Cascadia Subduction Zone earthquake, which would have strong shaking intensity.

The following documents represent BAS for earthquake design:

- NEHRP Recommended Seismic Provisions for New Buildings and Other Structures (FEMA 2020)
- Minimum Design Loads for Buildings and Other Structures, American Society of Civil Engineers (ASCE) 7 (2016 ASCE-7 Standard) (ASCE 2016)
- 2018 International Building Code (International Code Council 2018)

6.7.1 Science of Impacts and Mitigation

Mitigation of ground shaking due to seismic events requires recognition of the appropriate site class for a given site, as well as appropriate construction standards and seismic design considerations. Use of appropriate construction methods that consider the earthquake hazards and site response will minimize potential impacts from earthquake events.

6.8 SUMMARY EVALUATION OF EXISTING ORDINANCE AND RECOMMENDATIONS

Soft-story structures that possess little structural shear resistance on lower levels of a building are specifically recognized as susceptible to severe damage from a seismic event. Many municipalities have implemented soft-story seismic retrofit ordinances to address these risks and help mitigate earthquake-related structural damage.

Seismic shaking hazards (VMC 20.740.130[A][2][b]) for the city should be amended to add Site Class E as areas around Vancouver Lake are appropriately categorized and thus should also be amended for liquefaction areas of moderate to high and above (VMC 20.740.130[A][2][a][1]).

7.0 FREQUENTLY FLOODED AREAS

7.1 FUNCTIONS AND VALUES

Good management of frequently flooded areas can protect downstream areas and reduce the risk of flooding to public safety and property. In addition, floodplains also provide valuable instream and off-channel habitat to a variety of species and are important for water quality protection. Floodplains enhance biological productivity and help maintain biodiversity and the ecological value of ecosystems (FEMA 2007).

7.2 IDENTIFICATION AND CLASSIFICATION

Frequently flooded areas are defined as areas that will be inundated by a flood event having a 1 percent chance of being equaled or exceeded in any given year. The 1 percent annual chance flood is also referred to as the base flood or 100-year flood. In Washington, jurisdictions are required to regulate the 100-year floodplain as a critical area, at a minimum, but may also optionally regulate other areas, including channel migration zones, areas inundated by the flood of record, areas subject to groundwater flooding, or streams where the path of flood waters can be unpredictable (Ecology 2021b).

As part of its continuing effort to improve floodplain management practices, FEMA encourages communities to steer development away from the floodplains documented in flood insurance rate map (FIRM) panels. FIRM panels are official maps of communities in which FEMA has delineated special flood hazard areas (SFHAs) and the risk premium zones applicable to the community. As the impacts of climate change become more prevalent, floods are expected to become more frequent. Revised FIRMs and the Flood Insurance Study for Clark County became effective September 5, 2012 and revised maps for properties along the Washougal River, Little Washougal River, and behind the Port of Camas-Washougal's levee on the Columbia River became effective January 19, 2018 (Clark County Public Works 2021). Flood hazard areas within Vancouver include those referenced in Section 2.0 of this report.

7.3 BEST AVAILABLE SCIENCE FOR FREQUENTLY FLOODED AREAS

Development within floodplains has always been popular because humans want to live near water and use it for recreation and commercial and industrial purposes. However, development within a floodplain results in a problematic cycle, as development alters the natural flow and drainage patterns of the floodplain, and the development is in turn damaged by flooding in the altered floodplain (FEMA 2007).

Developing or updating frequently flooded areas ordinances can be an opportunity to promote flood safety and protect ecological habitat through locally appropriate standards (Ecology et al. 2021). The fundamental floodplain management program that most ordinances are built on is FEMA's National Flood Insurance Program (NFIP). FEMA manages NFIP in order to provide disaster assistance for properties subject to flood damage. The minimum requirements of the NFIP protect the health, safety, and welfare of the community by protecting buildings from the 100-year flood, which FEMA refers to as SFHAs.

FEMA encourages communities to use the FEMA elevation certificate as an official record showing that new buildings and substantial improvements in all identified SFHAs have been properly elevated. This elevation information is also needed to show compliance with the floodplain management ordinance and can be used by the property owner to obtain flood insurance.

Limiting development within floodplains reduces the need for "structural solutions," which are both expensive and disruptive to the local environment (Association of State Floodplain Managers, Inc. [ASFPM] 1993). BAS recommends limiting all development within floodplains (including grading and fill) and prohibiting new residential development. Repairs, reconstruction, or improvements to an existing structure within the floodplain may be allowed, but consideration should be given to the design and structural integrity of these improvements.

The BAS for development within floodplains is generally agreed upon as being the applicable flood resistant provisions of the 2021, 2018, 2015, 2012, and 2009 International Codes (I-Codes); the referenced standard ASCE 24, Flood Resistant Design and Construction; and NFIP requirements. FEMA has compiled the applicable I-Codes provisions into a single document, "Flood Resistant Provisions of the 2021 International Codes" (FEMA 2021). General recommendations for development within a floodplain include:

- For buildings located within more than one SFHA, the provisions associated with the most restrictive SFHA should apply.
- It should be demonstrated through hydrologic and hydraulic analyses performed by an accredited professional that the grading and/or fill will not result in any increase in flood levels.
- Grading and fill should not be approved unless fill is placed, compacted, and sloped to minimize shifting, slumping, and erosion during the rise and fall of flood water.
- Exterior walls extending below the base flood elevation should be constructed with flood-damage-resistant materials.
- The finished ground level of an under-floor space (e.g., a crawl space) should be equal to or higher than the outside finished ground level on one side or more.
- Anchoring to prevent flotation.
- Using flood-resistant construction materials and methods.
- Preventing infiltration of flood waters in utility systems.
- Elevating residential and nonresidential construction above the base flood elevation.

7.3.1 Science of Impacts and Mitigation

The most common types of direct human disturbance to floodplains are filling and clearing—often associated with residential development, agriculture, forest practices, or infrastructure improvements—and channelization. The combination of these activities often results in a disconnection of the channel from its floodplains. Floodplains can also be affected indirectly, through alterations of flow regime resulting from flow regulation (e.g., dams and reservoirs) and water withdrawals (e.g., irrigation). Climate change will also affect the flow regime, potentially exacerbating other types of human disturbance within floodplains (ESA 2014).

The BAS for development within floodplains encourages addressing floodplain development to promote flood safety and ecological habitat protection by developing standards beyond the minimum NFIP requirements. The NFIP encourages such activities through the community rating system (CRS), which provides reduced flood insurance premiums in participating communities (FEMA 2010b, ASFPM 2016).

ASFPM's No Adverse Impact (NAI) floodplain management describes how a community's mitigation program can be augmented and improved (ASFPM 2016). It also identifies how communities can receive CRS credits for implementing NAI tools, which include:

- Flood Acquisition and Relocation Mitigation Projects
- Waterway Restoration through Dam Removal
- Nonstructural Erosion Control and Shoreline Stabilization
- Sustainable Stormwater Management, and
- Mitigating Critical Facilities
- Similarly, Ecology's enhanced flood safety steps include: Habitat protection and endangered species protection.
- Higher regulatory standards beyond the FEMA minimums: For example, some jurisdictions use the "flood of record" elevations to regulate the minimum elevation of structures, where the record flood is higher than the 100-year flood elevation used by FEMA.
- Climate change and unique circumstances: A jurisdiction may have unique risks due to the potential for tsunamis, high tides with strong winds, sea level rise or extreme weather events that it may want to address.

Washington State law (RCW 86.16) contains some additional requirements that are more restrictive than the NFIP, and FEMA requires that communities meet state standards as well. WAC 173-158 outlines administrative rules for implementing RCW 86.16. In addition to adopting the NFIP standards in 44 Code of Federal Regulations parts 59 and 60, WAC 173-158 sets additional standards regarding construction in the floodway and avoiding negative impacts on wetlands.

A Regional Guidance was prepared for communities in the Puget Sound Basin to assist them in meeting the ESA requirements as clarified in the Biological Opinion issued by National Marine Fisheries Service (FEMA 2010b). The Regional Guidance can be used as a reference by communities who wish to prepare studies considering the foreseeable future land use changes in establishing future base flood elevations.

7.3.1.1 Climate Change

WAC 365-190-110 requires classifications of frequently flooded areas to include, at a minimum, the FEMA 100-year floodplain designation. It also states that communities should consider the future flow floodplain at build out, the potential effects of climate change, and the effects of increasing impervious surfaces.

The current FEMA guidelines for assessing flood frequency are based on the assumptions that flood distribution is not significantly affected by climatic trends or longer-term cycles and that historical flood behavior is representative of future events. As such, flood studies and floodplain mapping that has been developed based on FEMA guidance may not reflect future watershed and floodplain conditions as affected by climate change (FEMA 2010b, ESA 2014).

FEMA published the impact of climate change and population growth on the NFIP through the year 2100 (FEMA 2013b). Changes to precipitation, land use and sea level rise were considered. The study shows that by the year 2100, the 100-year floodplain depth and lateral size are projected to increase, on average, by 45 percent above current levels across the nation.

In Washington, climate change is expected to exacerbate flooding due to increasing temperature, decreasing snowpack, higher intensity rain events and sea level rise. Further from the coast, flooding is more sensitive to changes in river flow than sea level rise. The highest river flows and heavy rainfall events are generally expected to increase in rain-dominant and in mixed rain and snow watersheds (Mauger and Kennard 2017).

7.3.1.2 Future Land Use

Nationally, about 70 percent of the future increases in the 100-year floodplain areas and flood depth can be attributed to climate change while the remaining 30 percent represents the influence of normal population growth (i.e., land use) (FEMA 2013b). On the contrary, future hydrologic and floodplain conditions in the Puget Sound are more influenced by changes in land cover and land use than by climate change (FEMA 2010b). As such, there is little concrete guidance for how to interpret BAS in determining and mapping future floodplain conditions locally. General agreement is that it is most important to capture future conditions for smaller streams that are in or near areas that are likely to urbanize, such as in or near a city or its urban growth area (UGA).

FEMA recommends that communities evaluate changes to the base flood from expected future watershed development based on the development patterns laid out in their local long range land use plans. At the request of a community and with the approval of FEMA, FIRMs, and Flood Insurance Study reports may include, for informational purposes, flood hazard areas based on projected- or future-conditions hydrologic and hydraulic analyses (FEMA 2019).

7.3.1.3 Channel Migration Zones (CMZ)

Channel migration is a natural geologic process, which describes how a stream or river channel moves over time. Streams and rivers may change course or migrate through a variety of factors, such as erosion and deposition of sediments, which alter their geology, geometry, and functionality. As streams and rivers change course, their potential hazards also change. While these processes normally occur over long periods of time, quick avulsions in a single storm, flooding, or human influences can rapidly affect the speed at which a channel changes course or migrates over time (Rapp and Abbe 2003).

In unconfined valleys of Western Washington, lateral channel migration is the primary physical process that creates biodiversity on floodplains. This channel migration also presents a hazard to adjacent communities and infrastructure. These costs and benefits of channel migration make it a central consideration in floodplain management and restoration. The Washington State Shoreline Master Program (SMP) Guidelines require counties to identify the general location of CMZs as part of the shoreline planning process. Managing development within the CMZ allows for the occurrence of fluvial processes, maintains channel complexity and habitat diversity, and reduces potential damage to infrastructure within hazardous areas (Ecology 2014). Ecology has developed tools to guide identification of CMZs from basic planning level assessments to detailed project level assessments (Rapp and Abbe 2003, Legg and Olson 2014, Legg et al. 2014, Olson et al. 2014, Legg and Olson 2015).

Potential CMZs have been identified and mapped throughout Clark County (Clark County 2010). Stream and river reaches are identified as having a Moderate-Low, Moderate, Moderate-High, and High potential for channel migration based on review of existing data. In some cases, field checks were performed on streams that WDFW thought had migrated. Existing relevant data used in this analysis include channel characteristics, such as confinement and gradient; geographic information system soils and geology data; aerial photographs; maps; light detection and ranging (LIDAR); and/or spatial and temporal data (Clark County 2010). Streams that have High CMZ ranking within Vancouver or its UGA are predominantly Salmon Creek and some parts of Burnt Bridge Creek.

7.4 SUMMARY EVALUATION OF EXISTING ORDINANCE AND RECOMMENDATIONS

Vancouver's frequently flooded areas ordinance (VMC 20.740.120) is generally consistent with state (RCW 86.16) and federal NFIP requirements for flood control and protection. VMC 20.740.120 identifies regulated flood hazard areas, provides procedures for development permits, review, and enforcement, and floodproofing requirements.

Vancouver could also consider the future flow floodplain at buildout, the potential effects of climate change, and the effects of increasing impervious surfaces when designating and frequently flooded areas (WAC 365-190-110).

Recommendation: Require, or at a minimum encourage, consideration of future conditions during investigation of base flood elevation. Updated standards could reference available guidance for future conditions (FEMA 2010b, FEMA 2013, FEMA 2019), Washington RiskMAP program (Ecology 2022a) or other more useful and applicable methods that may become available in the future.

Clark County's approach to classification and definition of CMZs is consistent with approaches described in literature on CMZ mapping. Map 27 in the Clark County (2010) Shoreline Inventory and Characterization Report, which shows the potential CMZs, is incorporated by reference in VMC 20.740.120 and development in the CMZ is regulated similar to a SFHA that is not the floodway. The determination of what land use is allowed within different parts of the CMZ is based upon a policy decision rather than a science-based determination, and therefore not restricted by BAS criteria. Jurisdictions, such as King County and Pierce County, regulate severe risk CMZs as floodways.

Recommendation: Consider regulating severe risk CMZs as floodways, where new development is generally not allowed.

8.0 FISH AND WILDLIFE HABITAT CONSERVATION AREAS

Fish and wildlife habitat conservation areas are the various highly productive and diverse ecosystems that provide resources and functions necessary for fish and wildlife and the surrounding human populations. These critical area functions include, but are not limited to, the protection of sensitive species, water quality, and bank stability, and the provision of corridors for movement between habitat and of habitat for foraging, nesting, overwintering, rearing, escape, and cover. These areas also benefit local communities by providing water quality improvements and protection from flooding, and financial opportunities related to recreation, tourism, and education, among others. BAS indicates that the identification and characterization of these areas, and providing protective measures such as buffers for them, is critical to maintaining the functions and values they provide. This report relies primarily on WDFW management recommendations, which are a consolidation of scientific literature and information on the importance of various habitats.

8.1 IDENTIFICATION AND CLASSIFICATION

The following fish and wildlife habitat conservation areas are applicable to the city and must be considered for classification and designation per WAC 365-190-130:

a) Areas where endangered, threatened, and sensitive species have a primary association, including federal and state species (WDFW priority habitats and species, including riparian habitat areas) and state priority habitat areas associated with state priority species.

b) Habitats and species of local importance, as determined locally; including heritage tree sites within the city.

c) Naturally occurring ponds under 20 acres and their submerged aquatic beds that provide fish or wildlife habitat.

d) Waters of the state:
   - Type S waters are all waters, within their bankfull width, as inventoried as "shorelines of the state" under RCW Chapter 90.58 and the rules promulgated pursuant to Chapter 90.58, including periodically inundated areas of their associated wetlands. Type S shorelines are regulated under the city's shoreline

master program (1974) that the City is currently updating. The Columbia River and Washougal River within the city are Type S waters.

– Type F waters are segments of natural waters that are not classified as Type S waters and have a high fish, wildlife, or human use. These are segments of natural waters and the periodically inundated areas of their associated wetlands. Gibbons Creek is an example of a Type F water within the city.
– Type Np waters are all segments of natural waters within defined channels that are perennial non-fish habitat streams. Perennial streams are waters that do not go dry at any time of a year of normal rainfall. However, for the purpose of water typing, Type Np waters include the intermittently dry portions of the perennial channel below the uppermost point of perennial flow.
– Type Ns waters are all segments of natural waters within defined channels that are not Type S, F, or Np waters. These are seasonal, non-fish habitat streams in which surface flow is not present for at least some portion of a year of normal rainfall and are not located downstream from any stream reach that is a Type Np water. Type Ns waters must be physically connected by an aboveground channel system to a Type S, F, or Np water.

e) Lakes, ponds, streams, and rivers planted with game fish by a governmental or tribal entity.

f) State natural area preserves, natural resource conservation areas, and state wildlife areas.

The fish and wildlife habitat conservation areas described above have been identified by the WAC for their intrinsic value and because they contribute to the state's biodiversity. This review addressed the BAS regarding the functions and values of these habitat conservation areas and the measures recommended to protect them. Each of the fish and wildlife habitat conservation areas noted above that are present within the city are important to various ecosystems. For example, riparian areas cover a relatively small area but they support a higher diversity and abundance of fish and wildlife than any other habitat (Rentz et al. 2020). Riparian areas also support a significant number of threatened, endangered, sensitive, and priority species, and directly influence instream habitat; therefore, protecting riparian areas is directly linked to several fish and wildlife habitat conservation areas listed above (i.e., waters of the state). Protecting riparian habitat areas meets several of the goals and policy recommendations of WAC 365-190.130 Fish and Wildlife Habitat Conservation Areas. The BAS regarding the protection of riparian habitats is discussed below.

Additionally, areas associated with federally listed threatened, endangered, sensitive, and candidate species are determined by the U.S. Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration (NOAA) Fisheries. Areas associated with state-listed threatened, endangered and sensitive species are determined by WDFW. Determinations of state and federally listed species are made (by mandate of the WAC and ESA, respectively) solely on the basis of the best scientific and commercial data available. Thus, the protection of these species, by nature of their designation, is rooted in BAS. Furthermore, both the USFWS and NOAA Fisheries have developed rigorous species assessments in order to collect data about a given species. The data includes, but is not limited to, information about the life history, biology, population structure and abundance, and threats and vulnerability to the species. In addition to aiding in the determination of species listings, the information collected in these assessments is used to support and advise on policy and management recommendations. As their designations and protection are rooted in BAS, these species are not discussed in detail in this report.

8.2 BEST AVAILABLE SCIENCE FOR FISH AND WILDLIFE HABITAT CONSERVATION AREAS

8.2.1 Riparian Areas

Riparian areas are situated adjacent to aquatic habitat and are transitional areas that contain elements of both aquatic and upland ecosystems, which mutually influence each other.

Functions provided by riparian areas include water quality, streambank stabilization, maintaining moist and mild microclimates and cool stream temperatures, nutrient cycling/inputs, and flood control. Riparian areas also offer multilayered habitat structure and complexity that provide habitat for breeding, rearing, forage, cover, escape, and migration, and habitat connectivity between aquatic and terrestrial habitats. Functioning riparian habitat is essential for a number of threatened, endangered, sensitive, and priority species, including salmon and steelhead, reptiles and amphibians, cavity nesting birds, and migratory birds, among others (Rentz et al. 2020). While protecting these areas can be controversial and restrict the development potential of private and public property, on the other hand, limiting development in riparian areas can benefit humans by protecting water quality in streams and rivers used as drinking water and can promote healthy fish populations that are a source of food for people.

WDFW's *Management Recommendations* indicates that the protection of riparian habitat may yield the greatest gains for fish and wildlife (and by extension humans) while involving the least amount of area, when compared to other habitats, because riparian habitat:

- covers a relatively small area yet supports a higher diversity and abundance of fish and wildlife than any other habitat;
- provides important fish and wildlife breeding habitat, seasonal ranges, and movement corridors;
- is highly vulnerable to alteration; and
- has important social values, including water purification, flood control, recreation, and aesthetics.

Approximately 85 percent of Washington's wildlife species have been known to use riparian habitat associated with rivers and streams (Thomas 1979). Many of these species are dependent on riparian areas for at least one stage in their life cycles, while others may use riparian areas only occasionally or to move between habitats

(O'Connell et al. 1993). Reptiles, amphibians, cavity nesting ducks and other waterfowl, beaver, otter, and great blue heron are examples of species that rely almost exclusively on riparian area habitats and their proximity to water, and mild microclimates for breeding, nesting, rearing, forage, and cover. Other species, such as migratory birds, rely on these highly productive habitats as stopover locations during seasonal migration, or as breeding and rearing habitat before or after migration, and thus may be present only during specific seasons (Andelman and Stock 1994).

Riparian areas are linked by definition to instream fish habitat and support its functions for fish. Seventy-seven species of fish inhabit freshwater in Washington for all or a portion of their lives (Wydoski and Whitney 1979), including ESA-listed salmon and various other native aquatic species. Riparian areas provide a number of physical, chemical, and biological processes for instream habitats, including maintaining appropriate water temperatures; stabilizing stream channels and banks; providing inputs of large woody debris (LWD); regulating stream velocity; storing, conserving, and purifying water; providing nutrient inputs and cycling; and providing and maintaining migratory habitat (Cummins 1974, Harmon et al. 1986, Beschta 1978, Sullivan et al. 1987, Meehan and Bjornn 1991, Swanston 1991). LWD inputs from riparian areas provide complex stream structure, including pools and riffles, and cover for hiding and escape. Side channels, backwater wetlands, and floodplains also provide invaluable rearing, hiding, cover, and escape habitat for juvenile salmon.

Riparian areas are not just valuable as fish and wildlife habitat, they provide important water quality, flood control, recreation, and aesthetics functions for people as well. Functioning riparian areas can filter 40 to 90 percent of organic debris and environmental pollutants from surface water before the pollutants enter stream channels (Lowrance et al. 1984, Rhodes et al. 1985). The natural water quality functions provided by riparian areas can reduce the contamination, and ease our reliance on water quality treatment facilities. When flood waters move through riparian areas, vegetation acts to slow stream water velocity, and the slowed flood waters deposit sediment loads, and infiltrate soils. Because functioning riparian areas retain flood waters and reduce their velocity and erosive forces, these areas protect downstream communities from flooding and stream bank erosion, and minimize flood damage to structures and other assets such as cropland (Griggs 1984, Roseboom and Russell 1985, Booth 1991). In addition to their preventive functions for people (water quality and flood prevention), riparian areas also provide financial benefits by supporting recreational opportunities for hunting and fishing (Theurer et al. 1985). Other recreational activities supported by functioning riparian habitat include hiking, bird watching, camping, and tourism (Knutson and Naef 1997).

8.2.2 Priority Habitats and Species

8.2.2.1 Biodiversity Areas and Corridors

Biodiversity areas and corridors are areas of habitat that are relatively important to various species of native fish and wildlife. WDFW's mapping tool for priority habitats and species (PHS) identifies a biodiversity area within the City associated with Burnt Bridge Creek. Biodiversity areas that have been identified as biologically diverse through a scientifically based assessment conducted over a landscape scale (e.g., ecoregion, countywide or citywide, watershed, etc.). These areas could also be within a city or a UGA and contain habitat that is valuable to fish or wildlife and is mostly comprised of native vegetation. Relative to other vegetated areas in the same city or UGA, the mapped area is vertically diverse (e.g., multiple canopy layers, snags, or downed wood), horizontally diverse (e.g., contains a mosaic of native habitats), or supports a diverse community of species as identified by a qualified professional who has a degree in biology or closely related field and professional experience related to the habitats or species occurring in the biodiversity area. These areas may have more limited wildlife functions than other priority habitat areas due to the general nature and constraints of these sites in that they are often isolated or surrounded by highly urbanized lands (WDFW 2008).

Corridors are areas of relatively undisturbed and unbroken tracts of vegetation that connect fish and wildlife habitat conservation areas, priority habitats, areas identified as biologically diverse, or valuable habitats within a city or UGA (WDFW 2008).

8.2.2.2 Oregon White Oak Woodlands

Oregon white oak (*Quercus garryana*) is Washington's only native oak. WDFW's PHS mapping tool identifies several areas of Oregon white oak in the city. Although limited and declining, oaks and their associated floras comprise distinct woodland ecosystems. The various plant communities and stand age mixtures within oak forests provide valuable habitat that contributes to wildlife diversity statewide. In conjunction with other forest types, oak woodlands provide a mix of feeding, resting, and breeding habitat for many wildlife species. More than 200 vertebrate and a profusion of invertebrate species use Washington's oak woodlands. Some species occur in especially high densities, whereas others are not typically found in Washington. Oaks provide habitat for species that are state listed as Sensitive, Threatened, Endangered, or candidates for these listings (Larsen and Morgan 1998).

"Priority Oregon white oak woodlands are stands of pure oak or oak/conifer associations where canopy coverage of the oak component of the stand is $25%; or where total canopy coverage of the stand is <25 percent, but oak accounts for at least 50 percent of the canopy coverage present. The latter is often referred to as an oak savanna. In non-urbanized areas west of the Cascades, priority oak habitat is stands 0.4 hectare (1 acre) in size. In urban or urbanizing areas, single oaks, or stands of oaks <0.4 hectare (1 acre), may also be considered priority habitat when found to be particularly valuable to fish and wildlife (i.e., they contain many cavities, have a large diameter at breast height, are used by priority species, or have a large canopy)" (Larsen and Morgan 1998).

Oregon white oak woodlands are used by an abundance of mammals, birds, reptiles, and amphibians. Many invertebrates, including various moths, butterflies, gall wasps, and spiders, are found exclusively in association with this oak species. Oak/conifer associations provide contiguous aerial pathways for animals such as the State Threatened western gray squirrel, and they provide important roosting, nesting, and feeding habitat for wild turkeys and other birds and mammals. Dead oaks and dead portions of live oaks harbor insect populations and provide nesting cavities. Acorns, oak leaves, fungi, and insects provide food. Some birds, such as the Nashville warbler, exhibit unusually high breeding densities in oak. Oaks in Washington may play a critical role in the conservation of neotropical migrant birds that migrate through, or nest in, Oregon white oak woodlands (Larsen and Morgan 1998).

The decline of Oregon white oak woodlands has been accelerated by human activities –primarily oak removal. Conifer encroachment is a significant threat to remaining oaks, particularly on the west side of the Cascades and in portions of the Columbia Gorge, and is aggravated by urban development, fire suppression, timber conversion, and cattle grazing. Grazing is a primary use of oak woodlands and reduces species richness of ground cover, increases soil moisture, compacts soils, and disturbs sod, all of which may promote conifer growth and encroachment west of the Cascades. East of the Cascades, these pressures may also affect oak woodlands. In addition, the selective harvest of east-side conifers is detrimental to those wildlife species that depend on mixed oak/conifer associations. Fire suppression has also contributed to the decline of Oregon white oak woodlands. Natural fires and those intentionally set by Native Americans historically played a paramount role in oak forest ecology, especially natural oak regeneration. Frequent low-intensity fires curbed conifer encroachment, controlled stand density, and initiated oak sprouting. Today, managed burning can help restore degraded oak habitat (Larsen and Morgan 1998).

8.3 SCIENCE OF IMPACTS AND MITIGATION

8.3.1 Riparian Ecosystems

The scientific literature supports the importance of riparian ecosystems and the importance of maintaining riparian vegetation to support stream channel stability and the longitudinal, lateral, and vertical connectivity to quality fish and wildlife habitat. Management of riparian areas should regulate all land use activities that affect riparian ecosystems to ensure that the existing functions and values are protected from development. Land use impacts include impacts from forestry, road infrastructure, agriculture, urbanization, and stream channel modification. These impacts can affect important stream and riparian ecosystem components that create diverse habitats including large wood recruitment, nutrient inputs, diverse stream channel morphology (i.e., riffles, pools, runs, etc.), stream temperature regulation, groundwater recharge, pollutant removal, filtering of sediment and nutrients, etc.

Large Wood

Impacts from land uses, including forestry, agriculture, and urbanization affecting riparian forests, remove riparian forests and can lead to a reduction in the availability of large wood to fish bearing streams. Riparian forest management is key to conservation of fish habitats in forested areas in Washington.

Stream Temperature

Studies have clearly shown that a reduction of stream shade from vegetation removal results in warmer summer stream temperatures (Sridhar et al. 2004; Allen et al. 2007).

The type and condition of riparian vegetation plays an important role in the amount of solar radiation reaching a stream's surface. Management of vegetation in riparian areas can affect stream temperatures, which impacts fish, amphibians, and invertebrate populations and survival. Fish can be sensitive to altered thermal regimes, especially salmonids, which can be sensitive to high water temperatures and have a narrow thermal tolerance (Farrell et al. 2008; Eliason et al. 2011; Ayllon et al. 2013).

Pollutant Removal

Riparian buffers help reduce the flow of pollutants to aquatic ecosystems with removal functions depending on the complex interactions between vegetation, soil, and hydrology. Because of the variability between vegetation, soil, and hydrology, as well as spatial and temporal variability, pollutant removal functions can vary greatly between and within riparian sites. This variability can make management decisions regarding riparian buffer width difficult to determine, as there has been no widely accepted recommendations on buffer width. Desired pollutant removal outcomes should be based on:

1. Factual information regarding the anticipated impacts or outcomes of policy options (i.e., science);
2. An understanding of stakeholders' priorities and preferences (i.e., values); and
3. A process for using science and values to explore tradeoffs amongst policy options (Wilhere and Quinn 2018).

Filtering of Sediment and Nutrients

Riparian areas provide filtration for sediment and crucial sources and sinks for organic matter and nutrients for streams. Riparian areas are important areas that facilitate the movements of nutrients between upland areas and streams. Impacts to riparian areas that result in a physical disconnection or degradation of the integrity of the riparian area function will negatively affect the ability of the riparian area to provide filtering or removal of sediment and nutrients.

8.3.1.1 Management Recommendations

Generally, recommendations include limiting or restricting activities that may affect riparian areas negatively; examples include tree and vegetation removal, road building, agriculture and grazing, and clearing and earth moving for development (Knutson and Naef 1997). There is limited specific information regarding the level of development or activity a riparian area can withstand, and while they provide similar functions, all riparian areas are different, and support different communities of species; therefore, WDFW recommends a conservative approach to riparian habitat protection. To protect the functions and values of riparian areas, WDFW recommends designating riparian areas that are wide enough to allow proper functioning of riparian and aquatic ecosystems, including protection of instream habitat through temperature and sediment control, preservation of fish and wildlife habitat, and connectivity between aquatic, riparian, and upland habitats. The goal of this recommendation is to protect the full range of riparian functions, not just instream habitat by buffering adjacent, more upland uses. WDFW-published literature showed that widths recommended for riparian management zones (RMZs) that protect the full range of ecological functions necessary to support fish and wildlife is estimated by one 200-year site potential tree height ($SPTH_{200}$). The RMZ in areas of the state that currently or historically supported forests (i.e., Vancouver) is defined as the distance of one SPTH, where the $SPTH_{200}$ is the average maximum height attained by dominant trees at 200 years of age, measured from the edge of the active channel or CMZ, whichever is wider. The RMZ describes the area that has the potential to provide full riparian function, regardless of its current conditions. Measuring the RMZ width at the outer edge of the CMZ ensures that when the stream migrates, it will still be adjacent to the zone of influence that can provide riparian function (Rentz et al. 2020).

The RMZ is a scientifically based description of the area adjacent to rivers and streams that has the potential to provide full functions based on the $SPTH_{200}$ conceptual framework (Rentz et al. 2020). WDFW notes that most riparian areas in forested ecoregions the $SPTH_{200}$ is 100 feet or greater, and so the RMZ is delineated using one $SPTH_{200}$. However, if the $SPTH_{200}$ is less than 100 feet, WDFW recommends that the RMZ be delineated based on the pollution removal function, which is considered a minimum of 100 feet because this distance will achieve 95 percent or more removal efficacy of phosphorous, sediment, and most pesticides (Rentz et al. 2020).

Current site conditions should always be considered when reviewing regulations, with the ultimate goal of maintaining remaining riparian functions. Additional management recommendations include improving functions through voluntary restoration, and maintaining and enhancing connectivity laterally along the stream. Areas closer to the stream provide the greatest conservation benefit and should be prioritized for preservation, replanting, or restoration. Using low impact development techniques to better manage stormwater, and adopting a stormwater design manual equivalent to Ecology's most current version of Stormwater Management Manual for Western Washington are also recommended (Rentz et al. 2020).

To aid with site-specific RMZ delineation, WDFW created an internet-based mapping tool that reports recommended widths for RMZs statewide based on $SPTH_{200}$. The tool also notes instances where a 100-foot RMZ should be applied to support the pollution removal function. Appendix 1 of the management recommendations provides guidance on how to use these interactive maps. The guidance notes that in highly altered areas where soil data are not available, it may be necessary to estimate $SPTH_{200}$ values based on nearby soils.

8.3.1.2 Mitigation

A near consensus of scientific opinion holds that the most effective and reliable means of maintaining viable self-sustaining fish, especially salmon, is to maintain/restore ecosystems to conditions that resemble or emulate their historical range of natural variability (Swanson et al. 1994; Reeves et al. 1995; Bisson et al. 2009). This opinion is based in part on the complexity of processes that affect the expression of habitats over time and space.

The following steps in the mitigation sequence according to the implementing rules of SEPA (Chapter 197-11-768 WAC) would apply to riparian areas:

- 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 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.

8.3.2 Priority Habitat and Species

WDFW's PHS list is periodically updated and includes species and habitats for which special conservation measures should be taken. The PHS list explains why each priority habitat and species is on the list, shows which counties have that species or habitat, and provides links to PHS management recommendations. Cities and counties use the PHS list when designating and protecting Fish and Wildlife Habitat Conservation Areas under the GMA and SMA.

8.3.2.1 Oregon White Oak Woodlands Management Recommendations

WDFW's *Management Recommendations* for Oregon white oak woodlands are designed to maintain and enhance the integrity of Oregon white oak woodlands, reverse the trend of oak habitat loss, and promote the protection of oak habitat that is presently in good condition. Oaks west of the Cascades and in wetter sites along the Columbia Gorge should be cut only for stand enhancement. Replacing the wholesale removal of mixed oak/conifer stands with selective cutting would reduce fragmentation and conifer encroachment, and it would benefit structural and vegetative species diversity within oak forests. Encroaching conifers within oak groves should be thinned, and conifers adjacent to these stands should be retained for wildlife. An alternative to removing trees is to leave them standing as snags (Larsen and Morgan 1998).

Specific recommendations include the following:

- Do not cut Oregon white oak woodlands except for habitat enhancement.
- Allow only early spring, low-impact cattle grazing.
- Allow low-impact recreation (hunting, fishing, hiking, and mushroom and acorn collecting).
- Selectively harvest individual oaks to improve stand age-class and structural diversity.

- Thin encroaching conifers in oak woodlands west of the Cascades and along the Columbia Gorge; do not remove conifers from mixed stands east of the Cascades.
- Retain large, dominant oaks and standing dead and dying trees.
- Create snags when thinning oaks or conifers instead of removing trees.
- Leave fallen trees, limbs, and leaf litter for foraging, nesting, and denning sites.
- Retain contiguous aerial pathways.
- Conduct prescribed burns where appropriate.

8.4 SUMMARY EVALUATION OF EXISTING ORDINANCE AND RECOMMENDATIONS

The City should update the Fish and Wildlife Conservation Areas section (VMC 20.740.110) of their development code based on the current RCWs and WACs, including (1) revising the definition of fish and wildlife habitat conservation areas to be consistent with the State's definition, (2) add language to the existing ordinance that addresses priority habitat and species and their associated management recommendations (i.e., habitat associated with listed species, oak woodlands, biodiversity areas, etc.), (3) add language to the existing ordinance that addresses changes in how riparian management areas are determined and protected, and (4) add conservation and protection measures that preserve or enhance anadromous fish and their habitat important for all life stages.

Specific recommendations by WDFW associated with riparian management areas for urban riparian ecosystems include the following (Rentz et al. 2020):

- Update riparian area widths to meet WDFW guidance.
- Delineate urban RMZs to protect what areas remain and to highlight lost or degraded areas to target for restoration.
- Quantify current conditions, with a goal of maintaining and improving functions through regulatory and voluntary means.
- Identify and prioritize restoration opportunities and projects within the RMZ
    - Protect riparian functions that remain, especially in places that are relatively high functioning; implement actions that enhance degraded functions
    - Prioritize opportunities to maintain and restore in-stream and riparian connectivity.
    - Adopt a stormwater design manual equivalent to Ecology's most current manual for western Washington
    - Manage stormwater by adopting Ecology's latest manual regarding LID for new development, redevelopment and retrofit projects.
- When replacing or removing existing infrastructure with in an RMZ:
    - Map RMZ to pinpoint the best sites to restore – consider connectivity and adjacency to other priority habitats;
    - Improve aquatic connectivity by replacing culverts and removing barriers to movement;

- Revegetate with native plants and consider improvements for wildlife by integrating structures necessary for nesting, breeding and foraging;
- As infrastructure is remodeled or replaced, incorporate additional setbacks for streams;
- Control access to RMZ to limit soil compaction; and
- Avoid operating equipment near the stream to reduce sedimentation and soil compaction; and avoiding using chemicals in the RMZ that are not approved for use there by Ecology.

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APPENDIX A

DRAFT CRITICAL AREAS MAPS

APPENDIX B

BEST AVAILABLE SCIENCE SOURCES

RESEARCH SOURCES

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