FACET Formerly DCG / Watershed

Best Available Science (BAS) Review

# Lewis County Critical Areas Ordinance Update

**MARCH 26, 2025**

*Prepared for:*

Lewis County
2025 NE Kresky Avenue
Chehalis, WA 98532

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Prepared by:

Tami Camper
Environmental Planner
B.S. in Environmental Science at Western Washington University, M.S. Biology-Botany at CalPoly Humboldt

**Sam Payne**
Ecologist
B.S. in Environmental Science at Western Washington University, P.S.M. in Fish and Wildlife Administration at Oregon State University, and P.C. Wetland Science & Management at University of Washington
SWS certified professional wetland scientist and ISA certified arborist

**Kim Frappier**
Senior Environmental Planner and Urban Forester
B.A. in English at Boston College, M.S. in Restoration Ecology and P.C. in Wetland Science & Management at the University of Washington
ISA certified arborist

**Nell Lund**
Senior Ecologist & Principal of Natural Resources
B.S. in Biology at Arizona State University, P.C. in Wetland Science & Management at the University of Washington
SWS certified professional wetland scientist

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

Kirkland Office
750 6th Street S
Kirkland, WA 98033
425.822.5242

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

*Cover Page Photo-Cathedral Falls (photo credit Exotic Hikes)*

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# 1. Introduction

## 1.1 Report Purpose

This review of the best available science (BAS) was compiled to support Lewis County's Critical Areas Ordinance (CAO) update. Various policies in Washington State and Lewis County require that projects be evaluated prior to approval. These policies include the Washington Administrative Code (WAC), Lewis County Code (LCC) and Revised Code of Washington (RCW). These codes will be referred to throughout the document by the sections that are relevant to the resource. These codes and other relevant policies are available to the public via websites listed in the bibliography of the document.

The Washington State Growth Management Act (GMA) requires that cities and counties "include the 'best available science' [BAS] when developing policies and development regulations to protect the functions and values of critical areas and must give 'special consideration' to conservation or protection measures necessary to preserve or enhance anadromous fisheries"[1] (WAC 365-195-900). Regulated critical areas include wetlands, areas of critical recharging effect on critical aquifers used for potable water, fish and wildlife habitat conservation areas, frequently flooded areas, and geologically hazardous areas, wetlands [RCW 36.70A.030 and LCC 17.38.010-1040].

BAS documents include a literature review of the applicable body of knowledge and are prepared by qualified subject matter experts in relevant fields. According to WAC 365-195-905, characteristics of a valid scientific process include peer review, standardized methods, logical conclusions and reasonable inferences, quantitative analysis, proper context, and references. Common sources of scientific information include research, monitoring, inventory, modeling, assessment, and synthesis (WAC 365-195-905). BAS literature reviews are a synthesis of the current scientific body of knowledge, and only resources that meet these requirements are included as reference materials for this BAS..

The BAS review is a resource for critical area management but is not intended to provide definitive answers for all policy and regulatory decisions. Policy and regulations should incorporate BAS but also necessitate decision-making processes outside the realm of science. This is because governance and management embody values, politics, and motivations that are not falsifiable and cannot be empirically determined. Additionally, ecological systems are highly complex, and the scientific body of knowledge is constantly evolving with the advancement of new research and technology. Despite these advancements, there are limits to the current state of science and certain topics may not be fully understood. Where there is scientific disagreement in the literature about subjects, this review presents a range of potential ideas, theories, or findings. In accordance with WAC 365-195-920, decision-makers may opt for a precautionary, or no-risk approach, when scientific information is inadequate.

As of 2024, the GMA requires CAOs to incorporate and evaluate the influences of climate change on each type of critical area. Climate change is anticipated to have profound effects on natural systems and inclusion of this topic allows for decision-makers to respond by incorporating climate resilience into policies and regulations.

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

This BAS review serves as a reference for Lewis County for planned CAO updates, a component of comprehensive updates to the unified development code. Following the establishment of this BAS review, a gap analysis will be developed to identify current shortcomings and provide recommendations on critical area regulation updates.

# 2. Critical Aquifer Recharge Areas (CARA)

## 2.1 Definition

As described in WAC 365-190-030 for critical aquifer recharge areas (CARA),

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

LCC 17.38.820 categorizes CARAs in Lewis County as follows:

(a) Category I - Category I critical aquifer recharge areas are those areas that are:

(i) Within a mapped 10-year time-of-travel area for a Group A public water system. If the 10-year time-of-travel area is not available, the location of the Category I area shall be determined based on the largest mapped time-of-travel area available.

(ii) Within a mapped one-year time-of-travel area for a Group B public water system. If the location of the time-of-travel area is not mapped, the distance shall be based on the Washington State Department of Health "assigned time-of-travel" area.

(b) Category II - Category II critical aquifer recharge areas are those areas with highly permeable soils that provide rapid recharge with limited groundwater protection. Predominant soil series and types are those listed as Category II soils in LCC 17.38.850.

(c) Category III - Category III, moderate aquifer sensitivity areas, are those locations with aquifers present, but which have a surface soil material that encourages runoff, slows water entry into the ground, or provides some filtration of water. Predominant soil series and types are those listed as Category III soils in LCC 17.38.850.

Groundwater is water that exists underground in saturated pore spaces of soil and rock. The upper surface of the saturated zone is called the water table[2]. An aquifer is a geologic formation that readily transmits groundwater to wells or springs above ground. According to WAC 173-150-030, an aquifer is defined as "*any geologic formation that will yield water to a well or other withdrawal works in sufficient quantity for beneficial use*." Aquifer recharge occurs when water infiltrates the ground and flows to an aquifer. An aquifer can be confined or unconfined. An unconfined aquifer is one with no aquitard (a geologic formation that does not readily transmit water) or aquiclude (a geologic formation that does not allow for the transmission of water) between the water and the ground surface. A confined aquifer is a deeper aquifer that is separated from the surface by an aquitard or aquiclude and is often under pressure. Groundwater recharge areas are characterized by decreasing hydraulic head with depth (the

[2] https://www.usgs.gov/faqs/what-groundwater

direction of groundwater movement is downward). Groundwater discharge areas are characterized by increasing hydraulic head with depth (the direction of groundwater movement is upward, towards the surface (Driscoll, 1986; Winter, 1998)

The Department of Ecology (Ecology) considers *aquifers used for potable water* as those with existing wells or and their protection area, a sole-source aquifer, planned to be used for potable water in the future, and aquifers otherwise identified as an important supply (ECY 2021a). Maintenance of potable water uses and potential uses of aquifers require the management of water quality and quantity, which is covered in the following section.

## 2.2 Functions and Values

The goal of establishing CARAs is to protect the functions and values of a community's drinking water by preventing pollution and maintaining supply. RCW 36.70A.172 requires counties and cities to include the best available science in developing policies and development regulations to protect the functions and values of critical areas. In addition, counties and cities are also required to give special consideration to conservation or protection measures necessary to preserve or enhance anadromous fisheries (ECY, 2021a).

Since groundwater is a vital component of stream flow, it is necessary to maintain the groundwater supply to streams where needed to protect salmon and other anadromous species. Groundwater conditions can also influence geologic hazards, including landslide hazards and erosion hazards.

### 2.2.1 Water Quality

While aquifer recharge areas serve to replenish groundwater supplies, they can also serve as a conduit for the introduction of contaminants to groundwater. Vulnerability to public water supply is primarily influenced by two main factors, the history of contamination loading and hydrogeologic susceptibility of the aquifer (WDOH 2017).

Contamination loading refers to the quantity and types of pollutants present in an area, including exposure concentration, frequency, and chemical composition. Together, susceptibility and loading potential determine the vulnerability of an aquifer. To be considered vulnerable, an aquifer would need to be both susceptible and have significant contamination loading. For example, a highly susceptible aquifer may have a low vulnerability if the land use within the area is primarily open space, since there is minimal contamination loading. Likewise, an industrial site with multiple leaking storage containers may not create significant vulnerability if it is separated from the nearest aquifer by several hundred feet of dense glacially compressed clay.

Aquifer susceptibility refers to how easily water and pollutants can move from the surface through the ground to reach the underlying aquifer. There are many factors which influence susceptibility including the following (Eberts et al. 2013; ECY 2021a):

1. Characteristics of the vadose zone including depth to watertable and travel time. Travel time is influenced by hydrogeologogical factors including material composition and preferential flow paths
2. Permeability
3. Infiltration rate

4. Chemical retardation
5. Adsorption
6. Hydraulic conductivity
7. Hydrologic and pressure gradients
8. Groundwater flow direction
9. Groundwater flow rate

Permeability of the vadose zone can be estimated from soil and geologic mapping. The Washington Department of Natural Resources (DNR) has an interactive web-based geologic map of the state which provides some insight into the permeability of the vadose zone[3]. Depth to an aquifer of a site can also be estimated by examining existing public data such as well logs in the vicinity. As mentioned above, well logs are available at the Ecology website[4]. Using nearby well data alone may be insufficient. Aquifers are managed and monitored by local water purveyors.

### 2.2.2 Water Quantity

Potable water and groundwater-dependent, landscape-scale ecological processes are both supported by groundwater quantity and can be influenced by land use and human activities. This section provides a description of hydrologic processes in aquifers related to water quantity and the effects of human activities on these resources.

The quantity of water available in an aquifer is a balance between recharge, storage, and discharge. Aquifers have discrete recharge and discharge areas. Since groundwater movement is the result of downward gravitational forces, the location of recharge areas in aquifers is typically at a higher elevation than its discharge areas. This is not universal because subsurface conditions may result in groundwater flow and hydrologic gradients do not always reflect surficial topography (Driscoll 1986). Aquifer recharge can originate from rainfall, snowmelt, lakes, rivers, streams, or wetlands. Aquifer discharge occurs when water leaves the aquifer and is discharged to surface water. These areas can include seeps, springs, wetlands, streams, lakes, estuaries, and shorelines. Extraction from wells or by other means is also considered an aquifer discharge.

Land use and development typically alter the dynamics of aquifer recharge within a basin. For example, replacing forests with buildings, roads, driveways, lawns, and even pastures typically reduces the recharge to underlying aquifers, while simultaneously increasing the peak runoff rates to streams. In rare instances, however, some land uses can increase recharge rates. For example, if homes in an area receive water from a river or lake and discharge that water into septic systems, the result can be an increase in recharge to the underlying aquifer, and one that has potential for introducing contaminants (Dunne & Leopold 1978; Winter 1998).

Agricultural, residential, commercial, and/or industrial development may result in alterations to the natural hydrologic cycle by stripping vegetative cover, removing and destroying native soil structure, modifying surface drainage patterns, and adding impervious and nearly impervious surfaces, such as roads and other compacted soils. The root zone is an important factor to consider because evaporation

[3] https://fortress.wa.gov/dnr/geology/?Site=wigm
[4] http://apps.ecy.wa.gov/welllog/mapsearch.asp

and transpiration of water by plants reduces the water available for groundwater recharge and can account for much or most of the rainfall during some months (Shao et al. 2019). Loss of water in stream channels and riparian areas due to water withdrawal and consumptive use of water from streams, rivers and aquifers further reduces groundwater recharge (ECY 2021a).

Observed groundwater declines are primarily a result of changes in groundwater recharge and well water withdrawals. The Hirst Decision (*Whatcom County vs. Hirst 2016*) is a landmark case where the Washington State Supreme Court ruled that water is not legally available if a new well would impact a protected river or stream, or an existing senior water right. In response, Ecology collaborated with local partners to develop watershed plans under the Streamflow Restoration Act (Engrossed Substitute Senate Bill 6091) in Water Resource Inventory Areas (WRIA) 7, 8, 13, 14, and 15. In general, these regulations seek to balance consumptive water rights with the maintenance of base stream flows necessary to support fish, particularly anadromous fish.

Lewis County is primarily in WRIAs 23 (Upper Chehalis) and 26 (Cowlitz), however central-northern portions of the county fall within WRIAs 11 (Nisqually) and 13 (Deschutes). The Deschutes WRIA is covered under the Streamflow Restoration Act (Figure 1).

The Watershed Planning Act (ESHB 2514) is also applicable to CARAs in Washington State. This legislation, created in 1998, encourages voluntary planning by local governments, citizens, and tribes for water supply and use, water quality, and habitat at the WRIA or multi-WRIA level. Grants are available to conduct assessments of water resources and develop goals and objectives for future water resource management.

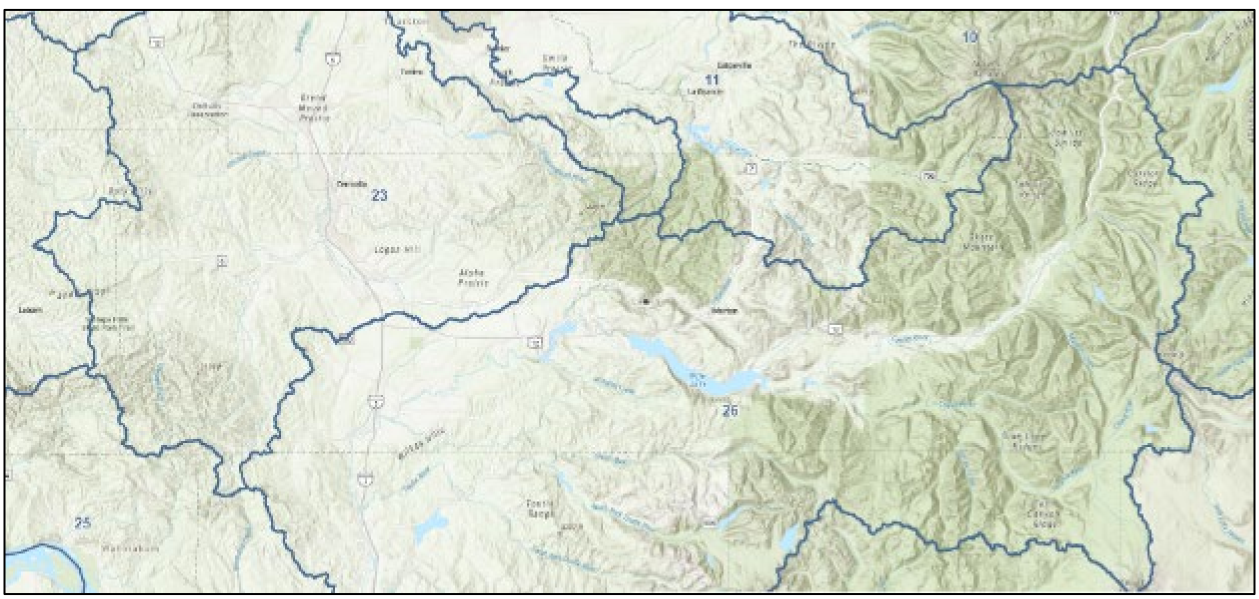


**Figure 1.** Lewis County WRIA Map[5]

[5] https://gis.ecology.wa.gov/portal/apps/webappviewer/

## 2.3 Key Protection Strategies

Key protection strategies for CARAs are based on identifying and protecting CARAs through regulations and educational community outreach. Current 2021 Ecology CARA Guidance recommends the following eight steps to characterize and protect CARAs in a local community:

1. Identify where groundwater resources are located.
2. Analyze the susceptibility of the natural setting where groundwater occurs.
3. Inventory existing potential sources of groundwater contamination.
4. Classify the relative vulnerability of groundwater to contamination events.
5. Designate areas that are most at risk to contamination events.
6. Protect by minimizing activities and conditions that pose contamination risks.
7. Ensure that contamination prevention plans and best management practices (BMPs) implemented and followed. Review BMPs for infiltration designs with water quality treatment. Stormwater control usually affects the vadose zone and seasonal water tables with low risk to deeper water supply aquifers. Some exceptions are those glacial outwash plains with extensive deposits of coarse gravels near the surface.
8. Manage groundwater withdrawals and recharge impacts to maintain availability for drinking water sources and maintain stream base flow from groundwater to support in-stream flows, especially for salmon-bearing streams.

Detailed guidance on completing the eight steps above is provided in Ecology Publication 05-10-028 (ECY, 2021a).

Lewis County regulations including classification, prohibited activities, permitted activities, conditions, sensitivity ratings for soil types, CARA report requirements, and BMPs are specified in LCC Article VI. Lewis County code (LCC 17.26.040) further specifies that project applicants should explore low-impact development (LID) techniques including rainwater harvesting, reverse slope sidewalks, vegetated roofs, bio-retention areas, and pervious pavement.

Lewis County maintains CARA mapping and GIS layers which are available to the public via the Lewis County GIS Web Map (Figure 2)[6]. GIS data is also available for download from the Lewis County GIS library.[7] Sole Source Aquifers (SSAs) are not present in Lewis County.[8]

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[6] https://gis.lewiscountywa.gov/webmap/

[7] https://maps.lewiscountywa.gov/

[8] https://epa.maps.arcgis.com/apps/webappviewer/index.html?id=9ebb047ba3ec41ada1877155fe31356b

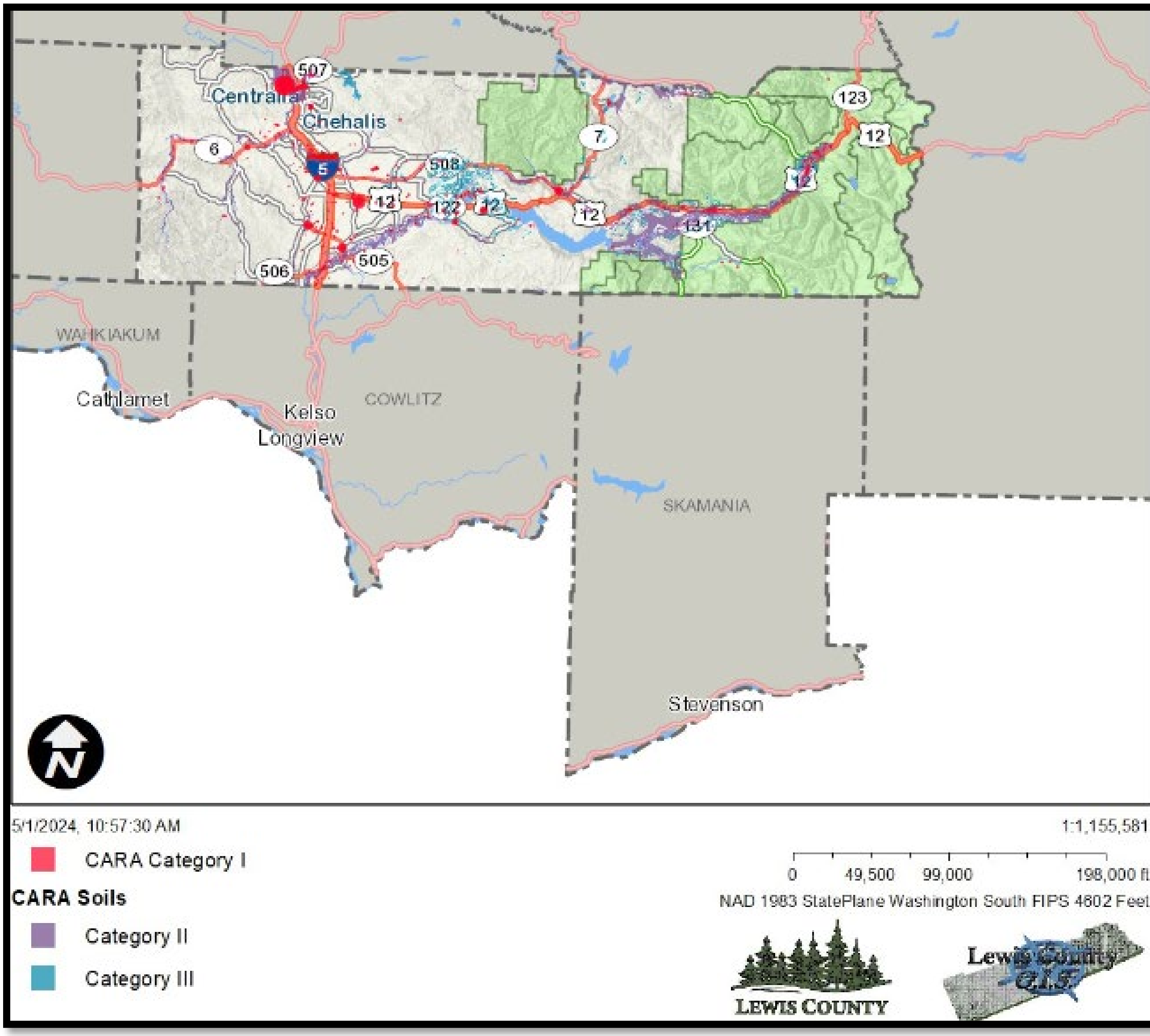


**Figure 2.** Lewis County Aquifer Recharge Areas.[9]

[9] https://arcgis.lewiscountywa.gov/arcgispublic/

## 2.4 Climate Change Impacts & Mitigation

Climate change impacts groundwater quality and quantity are influenced by regional trends as summarized below. Changes to surface water inputs can alter the timing, frequency, and duration of surface water presence and are projected to alter hydrologic patterns that can affect interactions with groundwater.

- Changes in precipitation levels in summers may reduce ground surface saturation during the growing season (Mauger et al. 2019). Higher temperatures will also increase the rate of evaporation in surface waters. This will likely reduce wetland areas and the groundwater recharge they provide during the dry season. This can influence streams, wetlands, and other surface waters impacted by groundwater in addition to anthropogenic consumption.
- Wildfires will introduce more particulates and contaminants into the environment, which settle on surface water and infiltrate into groundwater (Burton et al. 2016; Mansilha et al. 2020).
- Increased winter flooding increases the likelihood of overwhelming stormwater treatment facilities and flooding roads. Thereby transporting contaminants into surface water, including local streams and wetlands that can infiltrate and contaminate aquifers (Mauger et al 2019).
- Rising sea levels increases the potential for salt water intrusion into coastal aquifers (Mauger et al. 2015).
- Demand for aquifers may increase as crops require greater levels of groundwater consumption to compensate for changes in precipitation.

Altered patterns of precipitation resulting from climate change are projected to include earlier peak stream flows, increased frequency and extent of flooding, and reduced summer flows (Mauger, et al., 2015). Groundwater is believed to be more resilient to the effects of climate change relative to surface water resources (HDR 2019). The primary stressors to aquifers are changes in the timing and amount of groundwater recharge, and increased pressure to use groundwater as surface water conditions change. Ecology recommends focusing on water conservation as a strategy to plan for climate change impacts (ECY 2021a).

Other stressors on CARAs that may require further study include reclaimed water use and temporary construction dewatering. Ecology recommends that jurisdictions conduct a multi-year infiltration study (ECY 2021a). Population growth also presents challenges for protecting CARAs as land use intensity increases (ECY 2021a). For example, multi-year droughts can increase reliance on groundwater sources, lead to reductions in groundwater tables, aquifer depletion, and potentially result in saltwater intrusion (Asinas et al. 2022).

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### 2.4.1 Strategies to Manage Climate Change Impacts to CARAs

- Manage stormwater to maintain groundwater recharge in CARAs. Utilize a 20-year planning horizon to manage supply and demand given climate trends and projections
- Design stormwater systems to better mimic natural systems and mitigate some of the functions lost elsewhere in the landscape due to changes in surface and groundwater inputs. For example, the use of roadside bioswales may be expanded. Stormwater treatment capacity may be increased as needed to protect water quality and manage water quantity.
- Planning and implementing flood mitigation strategies can reduce the likelihood of contaminated runoff events.
- Preserve open space and concentrate urban development away from CARAs.
- If necessary, strengthen regulatory protection of CARAs. For example, the County may review the CARA mapping, determine the areas of highest risk to drinking water, and prioritize protection of those areas. The County can reduce the risk of groundwater contamination by prohibiting land uses that are high-risk within high-priority areas. Public outreach education on best management practices (BMPs) for spills and leaks can also be improved.
- Maintain updated CARA maps and classifications.
- Review regulatory requirements for reclaimed water use and temporary dewatering during construction to ensure adequate protections are in place. This may involve additional County-specific studies.
- Continue to modify public outreach efforts to educate residents about best practices in CARAs and promote water conservation and water use efficiency programs.
- Promote and incentivize low-impact development, specifically infiltration of clean runoff to support aquifer recharge.
- Balance growth and development with the preservation and restoration of open spaces and native vegetation tracts.

# 3. Frequently Flooded Areas (FFA)

## 3.1 Definition

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

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

Per LCC 17.38.910 FFAs are defined as follows:

> *frequently flooded areas within Lewis County shall be classified using the following criteria: frequently flooded areas shall be those lands, identified by the Federal Emergency Management Agency, as falling within the 100-year frequency floodplain in the Flood Insurance Study for Lewis County, Washington, Unincorporated Areas, the most current version thereof, with accompanying flood insurance rate maps and floodway maps or the best available information based on past flood records or special studies.*

Per LCC 17.10.030 "Channel migration zone" (CMZ) means:

> *the area along a river or stream within which the channel can reasonably be expected to migrate over time as a result of normally occurring processes. It encompasses that area of lateral stream channel movement that can be identified by credible scientific information that is subject to erosion, bank destabilization, rapid stream incision, and/or channel shifting, as well as adjacent areas that are susceptible to channel erosion. Linear facilities parallel to the direction of flow, including roads and railroads and flood control levees permanently maintained by a public agency, may be considered to form the boundary of a channel migration zone.*

Channel migration zones are classified and mapped in Lewis County in the following manner (Figure 3):

> *(I) Classification of Channel Migration Zones. Channel migration zones are areas within which a river channel can be expected to migrate over time due to hydrologically and geomorphologically related processes.*
>
> *(2) Mapped channel migration zones are based on:*
>
> *(a) The location of severe and moderate channel migration areas as identified with the report: Channel Migration and Avulsion Potential Analyses: Upper Nisqually River, Pierce County, Washington, produced by GeoEngineers for Pierce County Public Works and Utilities, Water Programs Division, 2007, 59 pages; or as revised.*
>
> *(b) The location of severe and moderate channel migration areas identified within the report: Geomorphic Evaluation and Channel Migration Zone Analysis Addendum: Cowlitz River, near Packwood and Randle, Lewis County, Washington, produced by GeoEngineers for the Lewis County Public Works Department, 2009, 76 pages; or as revised.*
>
> *(c) The location of historical migration zones (HMZ), avulsion hazard zones (AHZ), and erosion hazard areas (EHA) within the report Reach Analysis and Erosion Hazard Management Plan: Cispus River from River Mile 12.3 (Greenhorn Creek) to River Mile 17.6 (Cispus Road Bridge), prepared by Herrera Environmental Consultants, Inc. for the Lewis County Public Works Department, 2004, 105 pages; or as revised.*

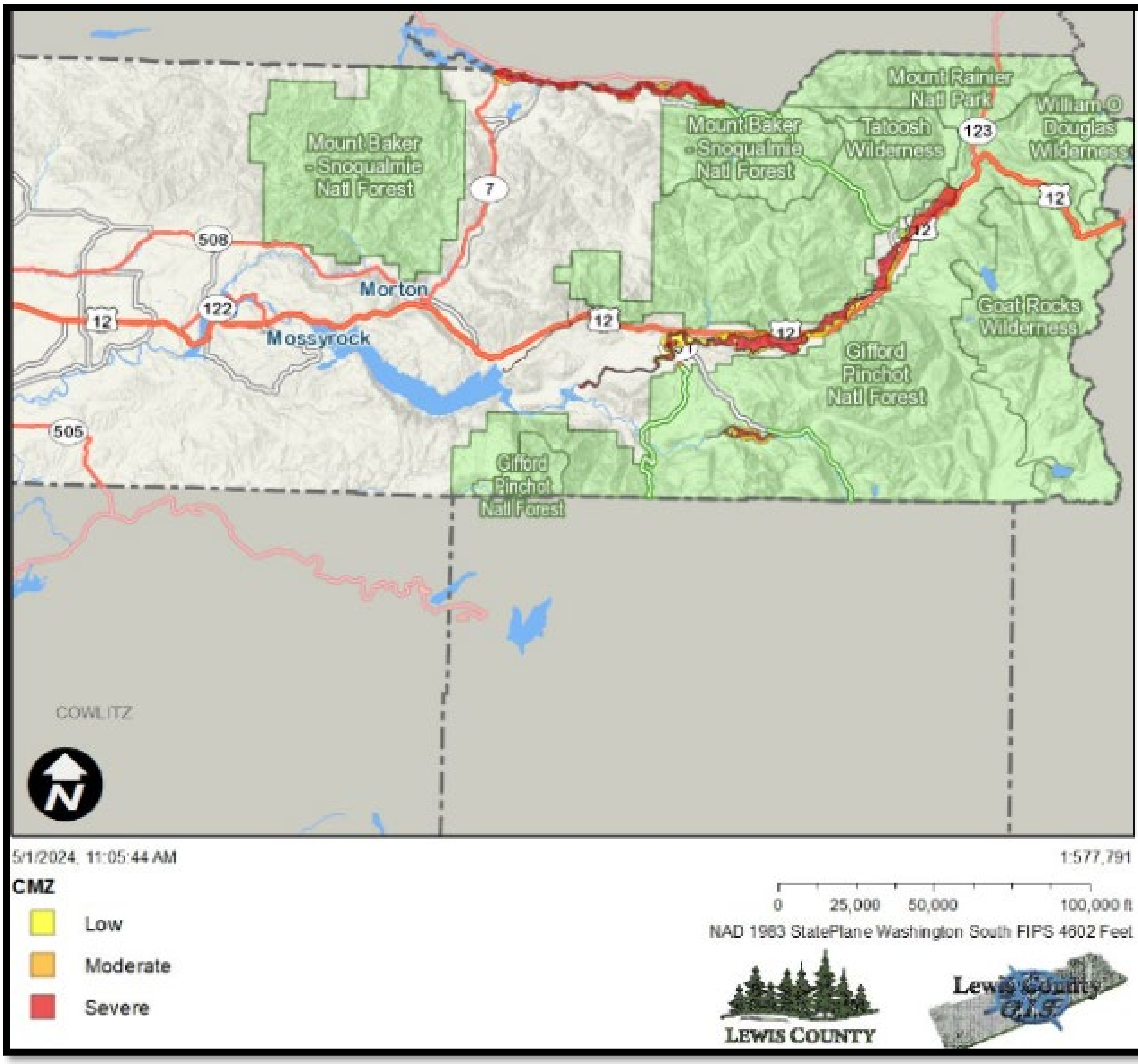


**Figure 3.** Lewis County Channel Migration Zones.[10]

[10] https://arcgis.lewiscountywa.gov/arcgispublic/

## 3.2 Functions and Values

Floods are regularly occurring weather  events that can result in destruction of property and loss of life, but are also responsible ecological processes that sustain river systems. Floods  typically occur following large storm events, but may also result from a collapse of impounded water, such as from a dam or levee failure, or beaver activity. FFAs are dynamic and ecologically productive environments that provide important habitats for fish and wildlife and floodplain storage that alleviates downstream flood zone impacts. These processes overlap with many of the functions of Fish and Wildlife Conservation Areas (FWHCAs) as discussed in Section 6.2.1, so this section briefly summarizes processes and functions as they relate to floodplain dynamics.

Dynamic hydrologic processes, including the mobilization of large woody debris and other allochthonous inputs, can be critical to the maintenance of fish and wildlife habitat (Naiman & Decamps 1997; Petts et al. 2005). High-flow channels carved into floodplains provide important habitat for a variety of fish species and create areas of refuge from the high-velocity flows. Streams overtop their banks during periods of high flow and deposit sediment load, cumulatively forming a flood plain (Dunne and Leopold 1978; Knighton 1998). Floodplains also provide storage of floodwaters that can reduce the severity of other areas in the watershed and contribute to infiltration and aquifer recharge.

Streams are often modified to protect development from destructive floods, typically in the form of channel straightening and armoring. These modifications can cause rivers to become disconnected from their natural floodplains and associated wetlands (Booth 1990). Other land use changes associated with urbanization such as impervious surfaces and deforestation also influence floodplains by increasing the magnitude and frequency of floods (Booth et al. 2002). In landscape-level assessments, patterns of urban development, particularly impervious surface area and distribution, have been demonstrated to influence watershed functions (Alberti et al. 2006). Among these are stream channel downcutting, a process associated with watersheds that have frequent and short duration high peak flows, that further disconnects floodplains, increases in-stream erosion, and deposits sediment in downstream environments leading to blocked culverts (Booth 1990).

Flooding can result in significant economic costs from damaged homes and infrastructure, business disruption, and loss of life. Floodplains have been used for agriculture, residential development, and urbanization for centuries because the geographic locations tend to be well-suited for development during periods between floods. The proximity of development to rivers and large water bodies, and advantages in travel, transport, and discharge of waste, otherwise provide ideal settlement locations. Dikes, levees, and associated floodplain fill have been a historically common approach to protecting development, which has consequentially worsened flood impacts to some downstream areas and sometimes failed to protect the areas that were intended. Altered river dynamics, including sediment and large woody debris accumulation as well as increased flows associated with upstream land use changes, has overwhelmed some aging flood control works that have not been maintained or improved. The human and societal costs of flooding have increased over time as the population and amount of infrastructure in floodplains has increased and from climate change.

## 3.3 Key Protection Strategies

Floodplain protection strategies serve the dual purpose of protecting property and infrastructure, and the ecological integrity of streams and watersheds. In 2009, Lewis County created a Comprehensive

Flood Hazard Management Plan (CFHMP) (Brown and Caldwell, 2009). A CFHMP is a planning document that presents information about existing streams, rivers, land uses, and regulations related to flood hazards; identifies goals for flood hazard reduction consistent with the needs of residents, businesses, and neighboring jurisdictions; and identifies flood hazards, evaluates alternative solutions, and recommends future projects or program modifications to address these hazards.; and lastly certification from the Emergency Management Division of the Washington State Military Department / local emergency management organization (ECY, 2021a).

Lewis County also created a brochure regarding flooding and other hazards for citizens to prepare for flooding. The document states the following regarding flooding in Lewis County:

> *"Floods are one of the most common and costly natural disasters. Since 1990, Lewis County has experienced 16 Presidentially Declared Disasters; 12 (71 %) of those were caused by flooding. Preparing now for flood situations can minimize injury to you and your family and speed the recovery process. The 2006 East Lewis County flood (record levels) caused $26.6 million in public/private damages and two deaths. The West Lewis County record flood in 2007 documented preliminary damages exceeding $166 million to over 3,000 homes and businesses. These events translate to years of financial losses to businesses, transportation systems, tax revenues and public/private property structures…*
>
> *…There are five major river systems that contribute to flooding conditions in Lewis County. The Cowlitz and Nisqually Rivers in Eastern Lewis County and the Chehalis, Newaukum and Skooku1nchuck in Western Lewis County. China Creek also has had a dramatic impact in the Centralia area. Generally, widespread flooding in Lewis County occurs when there is just too much water in too short a time for the streams and riverbanks to hold and absorb it. Man-made changes to a basin also can affect the size of floods. The magnitude of flooding depends on intensity and duration. Combinations of several factors add to that including: rainfall amount, pre-existing river, and existing soil conditions (was the ground wet or frozen before the storm) size of the area, elevations of a basin and sometimes the amount of snowpack...*
>
> *...Floods can happen at any time during the year, but Lewis County's patterns begin in late November and end about the last of March. Fall and early winter floods are produced by heavy rainfall on wet or frozen ground. Winter and early spring floods typically are caused by rainfall and a melting snowpack. As we convert more forest land to lawns, lots and impervious surfaces, more "urban" flooding (ponding in the fields and alongside roadways) is increased. Retention capacity decreases and runoff increases." (Lewis County, 2018)*

One of the primary strategies to reduce hazards associated with FFAs is to restrict development in mapped flood zones (Figures 4 and 5). Lewis County has adopted Flood Damage Prevention and other policies. Flooding strategies are also addressed in the Shoreline Master Program (SMP) published in 2021 and the 2009 CFHMP (Lewis County, 2021; Brown and Caldwell, 2009).

Floodplain management is generally based on a no-adverse-impact strategy (ASFPM, 2003). This approach requires floodplain property owners to ensure that their land use does not adversely affect flood storage or flood risk to others, including flow velocities and erosion. This is commonly achieved by requiring no net increase in flood elevations. This approach protects natural floodplain processes and encourages restoration, such as reconnecting side channels and reducing armoring.

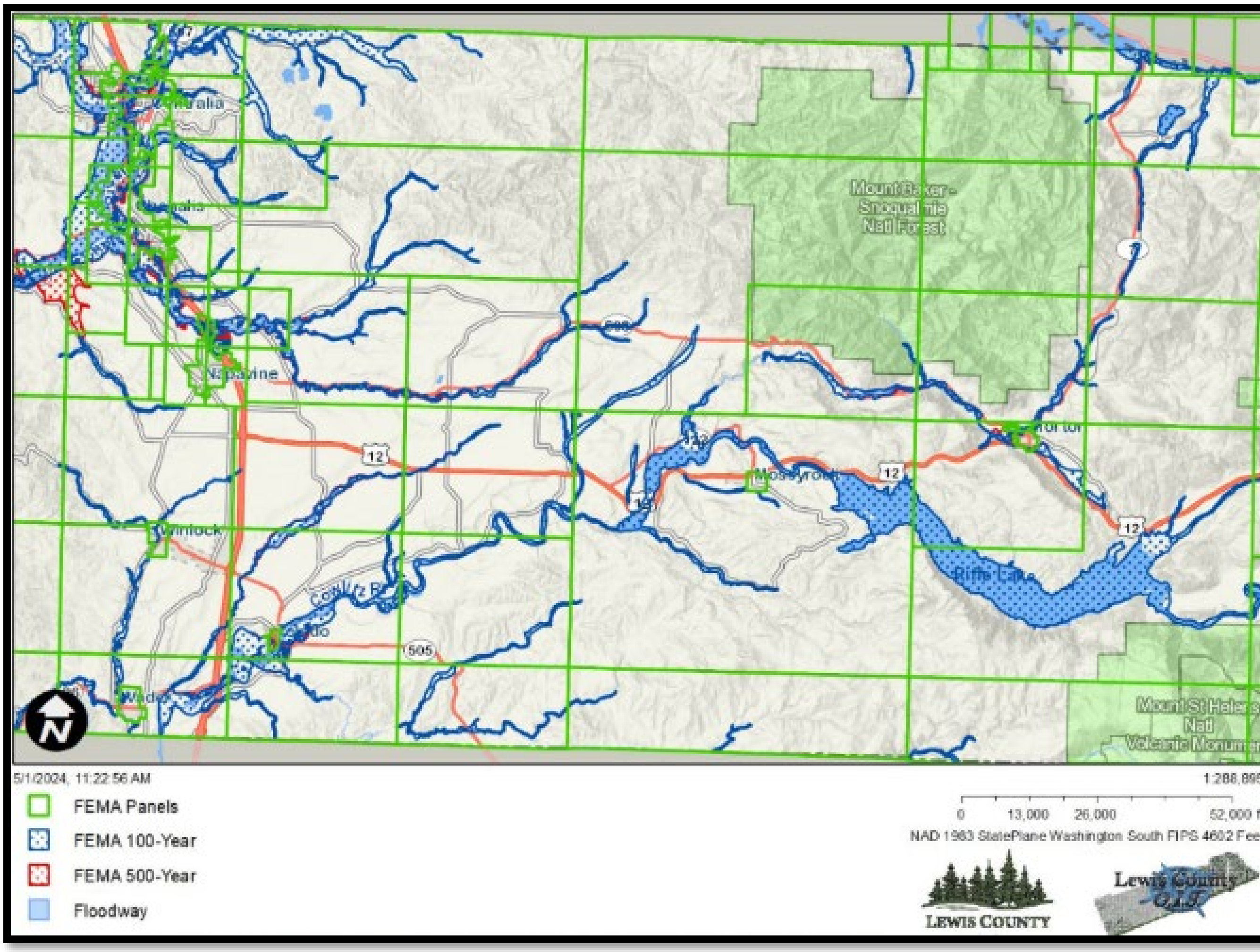


**Figure 4.** Lewis County Floodzones (Western).[11]

[11] https://arcgis.lewiscountywa.gov/arcgispublic/

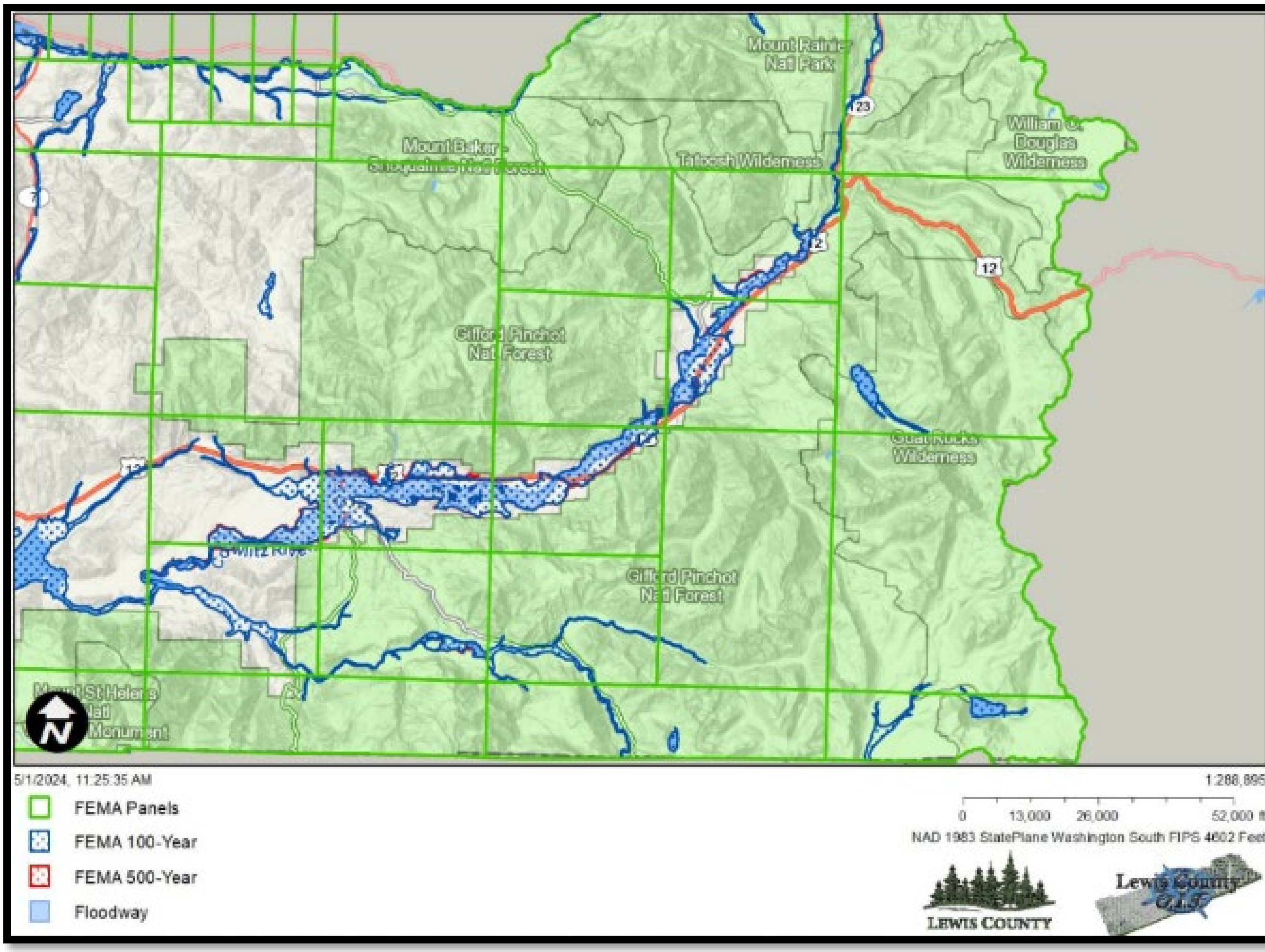


**Figure 5.** Lewis County flood zones (Eastern).[12]

[12] https://arcgis.lewiscountywa.gov/arcgispublic/



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## 3.4 Climate Change Impacts & Mitigation

Climate change in the Pacific Northwest is anticipated to result in wetter autumns and winters and drier summers (Mote and Salathe 2010). Climate change models predict that the frequency of atmospheric rivers, which contribute to severe deluges in rainwater and other extreme weather events, will become more frequent and severe (Mauger & Kennard 2017; Salathe et al. 2014). Greater flood risks are predicted as a result of the increased precipitation paired with the increased frequency and intensity of extreme weather events (ECY 2021a). The resulting increase in floodwater elevation and expansion of floods to new areas is a risk to property and public safety. Stream channel migration can also drastically alter flood risks and migration dynamics are expected to shift as a result of climate change (Mauger and Kennard 2017). Climate change can also influence flooding in coastal areas due to sea level rise, high tides, storm surges and waves (Mauger and Kennard 2017).

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

### 3.4.1 Strategies to Manage Climate Change Impacts to FFAs

The Washington Silver Jackets is an interagency group that was formed in 2010 to plan and manage flood risks. This group works to develop improved estimates of future flooding, develop resources for local planners, build capacity and coordinate on resiliency, improve public engagement, and coordinate floodplain management goals (Mauger & Kennard, 2017). The University of Washington Climate Impacts Group has collaborated with the Washington Silver Jackets to integrate climate change predictions and impacts into flood management planning efforts. This resulted in the development of the report: *Integrating Climate Resilience in Flood Risk Management: a Work Plan for the Washington Silver Jackets Team* which provides a framework for strategic management (Mauger & Kennard 2017). The work plan recommendations include:

- Develop improved estimates of future flood impacts (Mauger & Kennard 2017).
- Develop resources for local planners (Mauger & Kennard 2017).
- Build capacity and coordination on resiliant floodplain management (Mauger & Kennard 2017).
- Improve public engagement (Mauger & Kennard 2017).
- Coordinate floodplain goals and mangement (Mauger & Kennard 2017).
- Maintain and update CFHMP and SMP to support stormwater management, salmonid habitat, and streamflow planning (ECY 2021a).
- Implement and enforce Lewis County and Washington State laws and policies regarding flood prevention during permitting and development.
- Encourage and incentivize floodplain restoration actions to restore floodplain connectivity to streams and wetlands and protect or restore riparian corridors to maintain microclimate.

- Utilize the FEMA Climate Resiliency approach to support flood hazard management planning and follow grant funding opportunities.
- Refine topographic floodplain analysis to identify potential changes in floodplain extents.

# 4. Geologic Hazard Areas

WAC 365-190-030 defines geologically hazardous areas as:

> *Areas that because of their susceptibility to erosion, sliding, earthquake, or other geological events, are not suited to the siting of commercial, residential, or industrial development consistent with public health or safety concerns. (WAC 365-190-030)*

The four main types of geologically hazardous areas recognized in the GMA are erosion hazard areas; landslide hazard areas; seismic hazard areas, and areas subject to other geologic events such as coal mine hazards and volcanic hazards (RCW 36.70A.030 and WAC 365-190-120). Lewis County regulates these four categories of geologic hazard areas in LCC Chapter 17.38-Critical Areas.

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

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

## 4.1 Definitions

### 4.1.1 Erosion Hazard Area

Erosion Hazard Areas regulated by Lewis County include shoreline, riverine, and soil erosion hazard areas. Shoreline erosion hazard areas include areas landward of the ordinary high-water mark (OHWM) of a freshwater lake or pond. Riverine erosion hazard areas include the CMZ of rivers listed in CMZ section 3.1 of this document. Soil erosion hazard areas contain slopes of 20 percent or greater and are classified as having severe, or very severe erosion potential by the Soil Conservation Service, US Department of Agriculture (USDA).

Lewis County classifies erosion hazard areas as follows (LCC 17.38.640):

> *Erosion hazard areas are those areas that have severe or very severe erosion potential as detailed in the soil descriptions contained in the Web Soil Survey for Lewis County, Washington, Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Available online at:* https://websoilsurvey.sc.egov.usda.gov *Accessed December 1, 2016.*

### 4.1.2 Landslide Hazard Area

Landslide hazard areas are defined by Lewis County as "*areas susceptible to landslides because of any combination of bedrock, soil, slope (gradient), slope aspect, structure, hydrology, or other physical factors. Potential landslide hazard areas exhibit one or more of the following characteristics:*

*1. Sensitive Sloped Areas. Slopes exceeding 30 percent with a vertical relief of 10 or more feet except areas composed of competent rock and properly engineered slopes designed and approved by a geotechnical engineer licensed in the state of Washington and experienced with the site;*

*2. Areas designated by the Soil Conservation Service as having severe limitation for building site development;*

*3. Areas that have shown evidence of historic failure or instability, including but not limited to back-rotated benches on slopes; areas with structures that exhibit structural damage such as settling and racking of building foundations; and areas that have toppling, leaning, or bowed trees caused by ground surface movement;*

*4. Slopes greater than 15 percent that have a relatively permeable geologic unit overlying a relatively impermeable unit and having springs or groundwater seepage;*

*5. Areas potentially unstable as a result of rapid stream incision, stream bank erosion, and undercutting by wave action include slopes exceeding 10 feet in height adjacent to streams, and lakes with more than a 30 percent gradient;*

*6. Areas located in a canyon or active alluvial fan, presently or potentially subject to inundation by debris flows or catastrophic flooding; and*

*7. Areas that are at risk of mass wasting due to seismic forces*." (LCC 17.24.101)

Regulated landslide hazard areas are classified by the presence of any of the following indicators per LCC 17.38.650:

*(1) Classification of Steep Slope Hazard Areas. Steep slope hazard areas are areas where there is not a mapped or designated landslide hazard, but where there are steep slopes equal to or greater than a 35 percent slope with a vertical relief of 10 or more feet. Steep slopes which are less than 10 feet in vertical height and are not part of a larger steep slope system, and steep slopes created through previous legal grading activity, are not regulated steep slope hazard areas. Presence of a steep slope suggests potential slope stability problems.*

*(2) Classification of Landslide Hazard Areas. Landslide hazard areas are those areas meeting any of the following criteria:*

*(a) Areas subject to previous slope failures, including areas of unstable old or recent landslides;*

*(b) Areas with all of the following characteristics:*

*(i) A slope greater than 15 percent;*

*(ii) Hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock; and*

*(iii) Springs or ground water seepage;*

*(c) Slopes that are parallel or sub-parallel to planes of weakness (such as bedding planes, joint systems, and fault planes) in subsurface materials;*

*(d) Slopes having gradients greater than 80 percent subject to rockfall during seismic shaking;*

*(e) Areas potentially unstable as a result of rapid stream incision and streambank erosion or undercutting;*

*(f) Areas located in a canyon, on an alluvial fan, or presently or potentially subject to inundation by debris flows or catastrophic flooding.*

*(3) Mapped Landslide Hazard Areas. Landslide hazard areas include the following mapped sources:*

*(a) Areas mapped as "unstable," "landslides," and "old landslides" in the Slope Stability Study of the Centralia-Chehalis Area, Lewis County, Washington, by Allen J. Fiksdal, Department of Natural Resources, Division of Geology and Earth Resources, 1978.*

*(b) Areas included in the Landslides and Landforms maps available from the Washington Department of Natural Resources Division of Geology and Earth Resources, dated July 2016, or as amended.*

### 4.1.3 Seismic Hazard Area

Seismic hazard areas are defined by Lewis County as "areas subject to damage resulting from earthquake-induced landsliding, seismic ground shaking, dynamic settlement, fault rupture, soil liquefaction, or flooding caused by tsunamis and seiches" (LCC 14.100.020).

Seismic hazard areas are areas subject to damage resulting from earthquake-induced landslides, seismic ground shaking, dynamic settlement, fault rupture, soil liquefaction, or flooding caused by tsunamis and seiches. Seismic hazards are identified in DNR's Geologic Information Portal[13]. The DNR Geologic Information Portal contains information projecting the Cascadia, Seattle, and Tacoma Seismic Scenarios which extend throughout Lewis County.

Lewis County regulates seismic hazard areas as follows (LCC 17.38.660):

*(1) Classification of Seismic Hazard Areas. Seismic hazard areas are locations subject to severe risk of damage as a result of earthquake-induced soil liquefaction, ground shaking amplification, slope failure, settlement, or surface faulting.*

*(a) All structures that require a building permit within Lewis County are required to be consistent with the D1 seismic zone (as specified in the International Building Code).*

*(b) Active faults or trenches are considered seismic hazards.*

*(c) Areas of known faults and soil liquefaction hazards are depicted in Ground Response Geographic Information System data dated June 2010 and Seismogenic Features data dated*

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

*April 2016 and retrieved from the Washington Department of Natural Resources Division of Geology and Earth Resources. (Lewis County, 2024a)*

### 4.1.4 Volcanic Hazard Area

Lewis County defines volcanic hazard areas as "locations where the risk to life and property by a large volcanic event is high. For the purpose of these regulations, damage from lahars and near volcano hazards constitute the primary volcanic hazards. Volcanic tephra (ash), while disruptive and potentially dangerous, is not considered a volcanic hazard that is subject to these regulations. Volcanic hazard areas are shown on maps available from the United States Geological Service (USGS) Volcano Hazards Program." (LCC 17.38.670)

Volcanic hazard areas also include areas that have not been recently affected but could be affected by future such events. The classes of lahar hazards (Class I, II, and III) were classified in a 1998 USGS open-file report on Mount Rainier's volcanic hazards (Hoblitt, et al., 1998).

Lewis County prepared a multi-jurisdictional hazard mitigation plan with the cities of Centralia, Chehalis, Morton, Mossyrock, Napavine, Toledo, Vader, Winlock, and Pe Ell hazards which includes volcanic hazards. The County is located in the Mount Adams lava/lahar (volcanic mudflows) zone and within the Mount Rainier lahar, pyro flow, and blast zones[14].

### 4.1.5 Mine Hazard Area

Mine hazard areas are directly underlain by, adjacent to or abutting, or affected by old mine workings such as adits (horizontal passage), tunnels, drifts, or airshafts that have the potential for subsidence.

LCC 17.38.680 defines mine hazards areas as follows:

> *(1) Classification of Mine Hazard Areas. Mine hazard areas are those areas within 100 horizontal feet of a mine opening at the surface or which are underlain at a depth of 300 feet or less by mine workings. Known locations of historic mines are identified in the Washington State Department of Natural Resources, Division of Geology and Earth Resources, Open File Report 94-7; The Washington State Coal Mines Map Collection: A Catalog, Index, and User's Guide, by H.W. Schaase, M. Lorraine Koler, Nancy A. Eberle, and Rebecca A. Christie, 1994, 107 pages; Open File Report 84-6, Inventory of Abandoned Coal Mines in the State of Washington, by F.V. LaSalata, M.C. Meard, T.J. Walsh, and H.W. Schaase, 1985, 42 pages; and specific maps and surveys of mine workings on file with the Division of Geology and Earth Resources.*

## 4.2 Hazard Characterization

### 4.2.1 Erosion Hazard Area

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

[14] https://www.cityofcentralia.com/DocumentCenter/View/1116/Volcanic-Hazard-Mitigation-Plan-Map-PDF

Erosion and landslides are natural processes that contribute sediment, rocks, and large woody debris to streams and other waterbodies. The introduction of periodic pulses or chronic turbidity and suspended solids associated with erosion has been demonstrated to harm certain types of aquatic life, particularly salmonids (Bash et al. 2001). This can occur from activities such as clearing vegetation and the creation of new impervious surfaces, which can introduce sediments and pollutants to natural waterways (Booth 1991). Further discussion of the effects of erosion and sediment on streams is provided in Section 6.2.1.

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

### 4.2.2 Landslide Hazard Area

Landslides are difficult to predict because bluff geology, sediment composition, topography, and hydrology all influence the risk of failure. Steeper slopes are more prone to failure due to increased gravitational stresses (Shipman, 2004). Landslides are also common in interior Lewis County above rivers and streams and steep terrain. Certain land use modifications and development activities have the potential to increase the likelihood of landslides to occur, such as vegetation removal and the creation of new impervious surfaces. In addition to anchoring sediments, the process of evapotranspiration by plants transforms groundwater into atmospheric vapor and intercepts rainwater (Schmidt, et al., 2001; Watson & Burnett). The anchoring and hydrologic functions of vegetation lower the risk of slope failure and shallow-rapid landslides (Schmidt, et al., 2001). The DNR Geologic Information Portal provides mapping for known landslide areas within Lewis County (Figures 6 and 7).

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

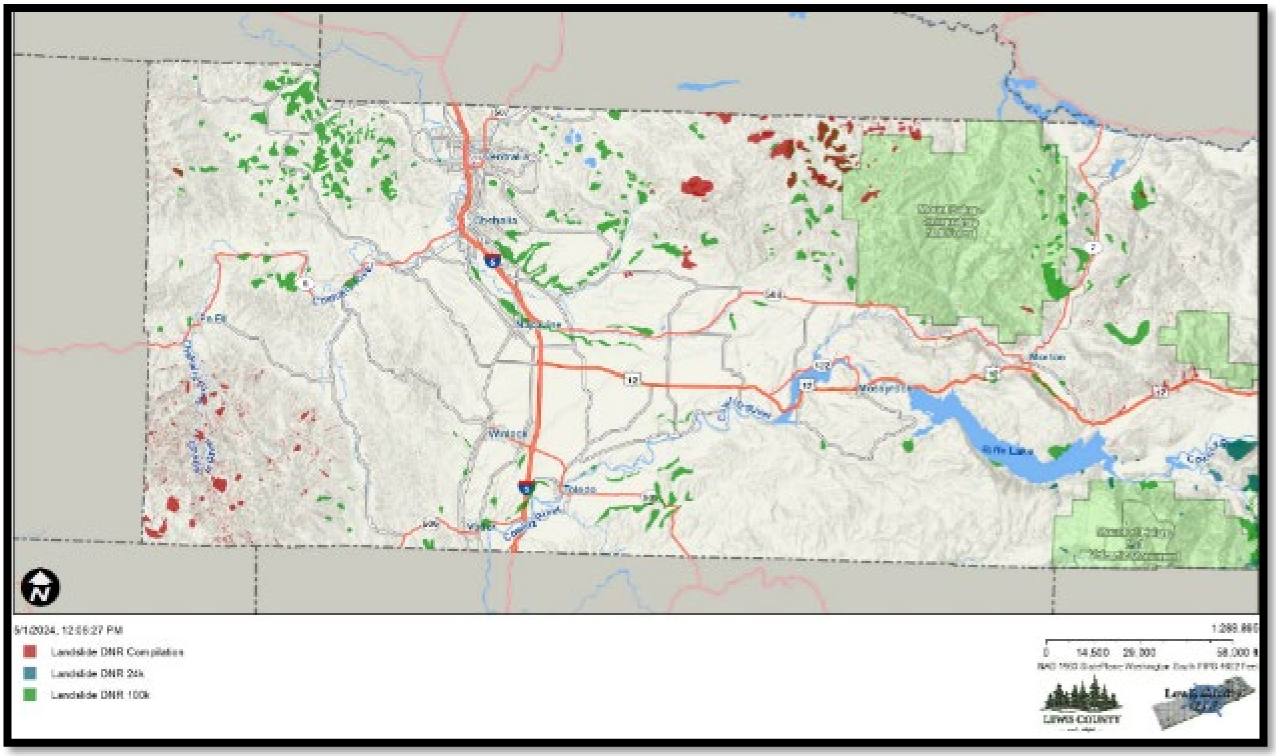


**Figure 6.** Lewis County Landslide Hazard Areas (Western).[15]

15 https://arcgis.lewiscountywa.gov/arcgispublic/

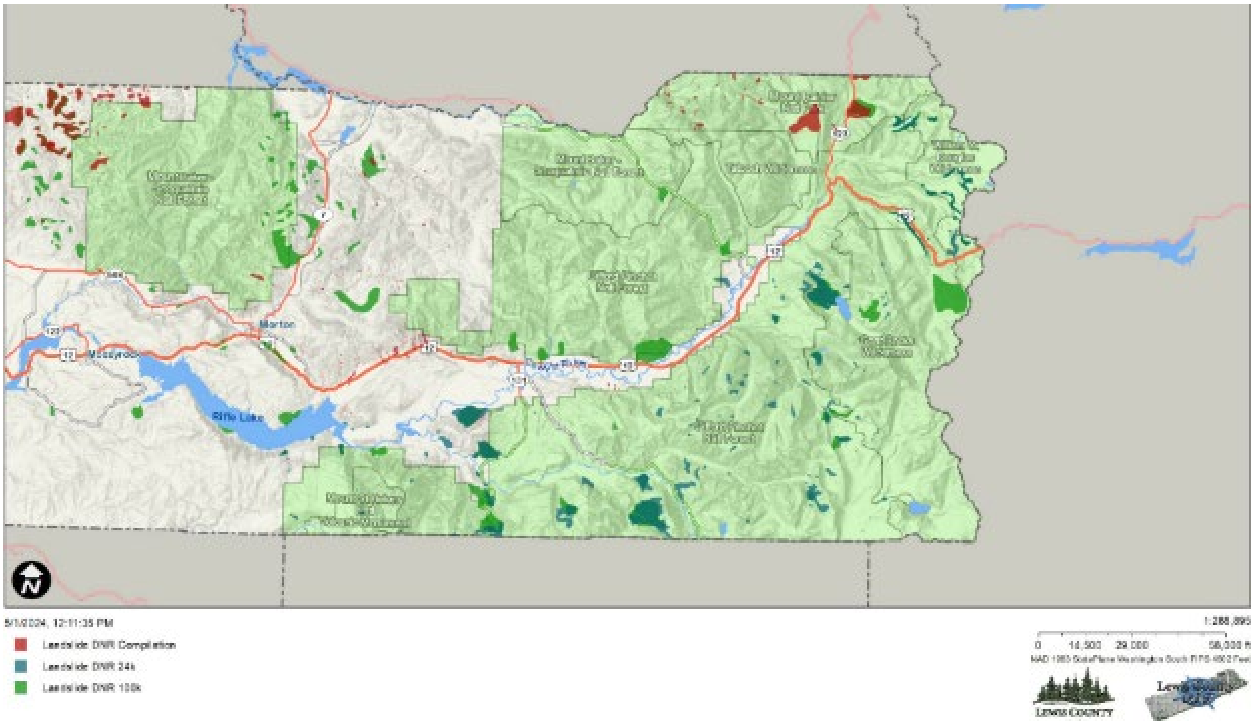

Figure 7. Lewis County Landslide Hazard Areas (Eastern).[16]

### 4.2.3 Seismic Hazard Area

Though Lewis County rates earthquake hazards as low probability, it rates vulnerability as high with a high overall risk rating. Lewis County prepared a map of earthquake isolation areas and bridge damaged based on WSDOT Bridge Damage Analysis of Theoretical Cascadia Subduction Zone (Magnitude 9.0) (Figure 8) The Lewis County All Hazards Brochure states that large magnitude earthquakes (greater than 6.0) have occurred repeatedly in the Puget Sound region. In 1909, an event estimated to be a 6.0 struck in the San Juan Islands. Other Large events followed in 1939, 1946, 1949, 1965, and 2001. Lewis County had substantial damages in all these events (Lewis County, 2018).

Secondary hazards associated with seismic events include liquefaction of the soil, rockfall, landslides, dam failure, levee failure, and tsunamis or seiches. Liquefaction hazard areas within Lewis County are mapped by the DNR. Lewis County has multiple areas with high liquefaction susceptibility (Figure 9).

[16] https://arcgis.lewiscountywa.gov/arcgispublic/



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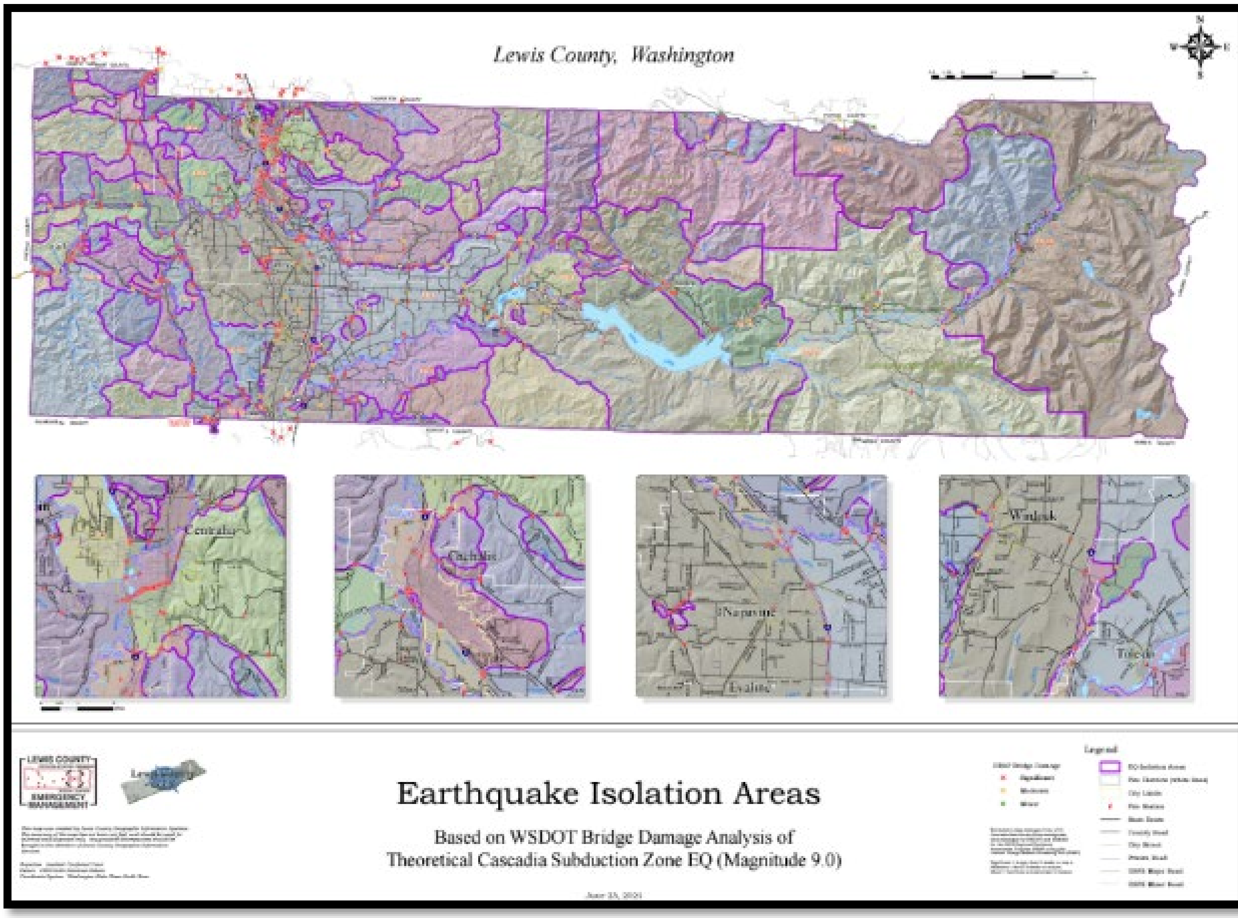


**Figure 8.** Lewis County Earthquake Isolation Areas.[17]

[17] https://lewiscountywa.gov/media/documents/EQ_Isolation2021_4ft_whiteFD.pdf

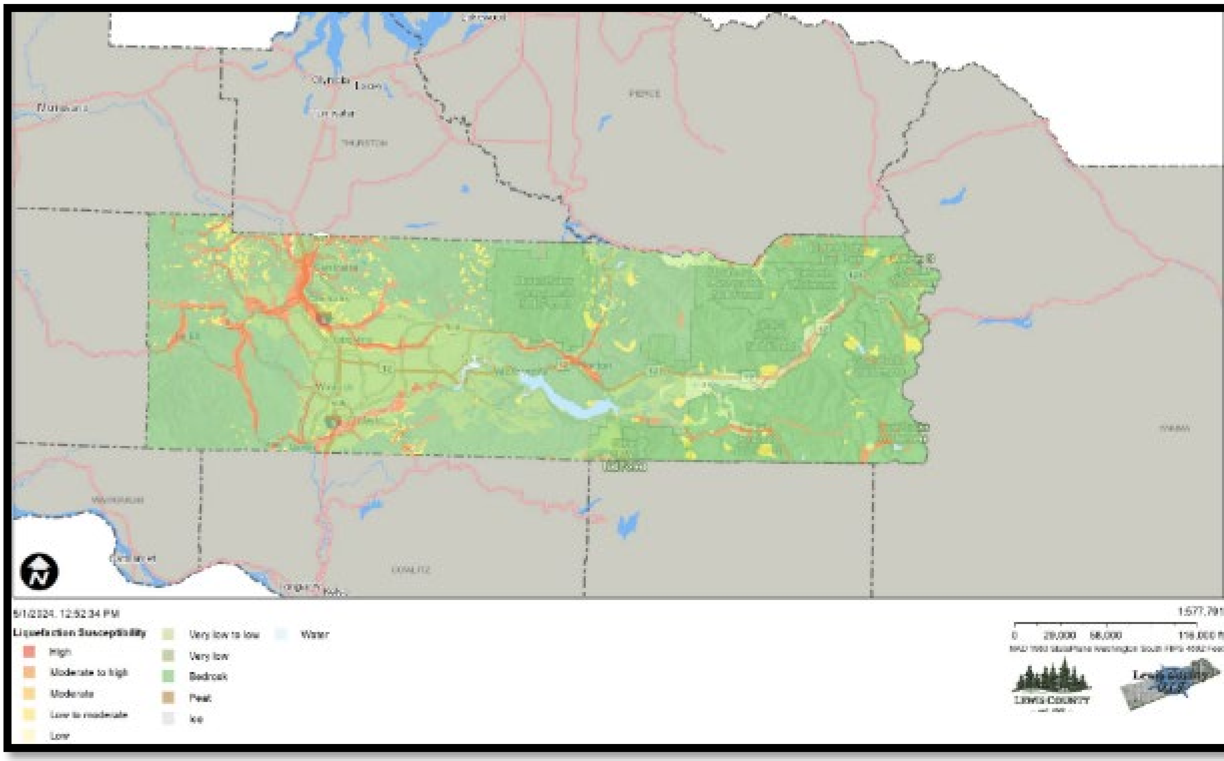


**Figure 9.** Lewis County Liquefaction Susceptibility.[18]

## 4.2.4 Volcanic Hazard Area

There are five major active volcanos in Washington which include Mount Rainier, Mount Saint Helens, Mount Adams, Mount Baker, and Glacier Peak (Figure 10). These mountains are part of a volcanic arc that extends from northern California to British Columbia (Hildreth, 2007). All of these volcanoes have erupted in the last 250 years and together have erupted over 200 times in the prior 12,000 years (Pringle, 1994).

Mount Rainier is the highest peak in the Cascade Range at 4,392 m. It is in Pierce County, Washington, and has a high threat potential. During an eruption 5,600 years ago, the once-higher edifice of Mount Rainier collapsed to form a large crater open to the northeast much like that at Mount St. Helens after the 1980 eruption. Ensuing eruptions rebuilt the summit, filling the large collapsed crater. Large lahars from eruptions and collapses of this massive, heavily glaciated andesitic volcano have reached as far as the Puget Sound lowlands. Since the last ice age, several dozen explosive eruptions spread tephra (ash, pumice) across parts of Washington. The last magmatic eruption was about 1,000 years ago. Extensive hydrothermal alteration of the upper portion of the volcano has contributed to its structural weakness promoting collapse. An active thermal system driven by magma deep under the volcano has melted out a labyrinth of steam caves beneath the summit icecap (USGS, 2024).

Mount Adams is located in the Yakima Nations Reserve in Skamania and Yakima Counties and has a high threat potential. It lies in the middle of the Mount Adams volcanic field—a 1,250 km$^2$ area

[18] https://arcgis.lewiscountywa.gov/arcgispublic/


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comprising at least 120, mostly basaltic volcanoes that form spatter and scoria cones, shield volcanoes, and lava flows. The volcanic field has been active for at least the past one million years. Mt Adams was active from about 520,000 to about 1,000 years ago and has erupted mostly andesite. Eruptions have occurred from ten vents since the last period of glaciation about 15,000 years ago. Approximately 6,000 and 300 years ago, debris avalanches from the southwest face of Mount Adams generated clay-rich lahars that swept more than 30 $km^2$ south of the volcano along the White Salmon River. The summit of Mount Adams contains a large section of unstable altered rock that can spawn future debris avalanches and lahars (USGS, 2024).

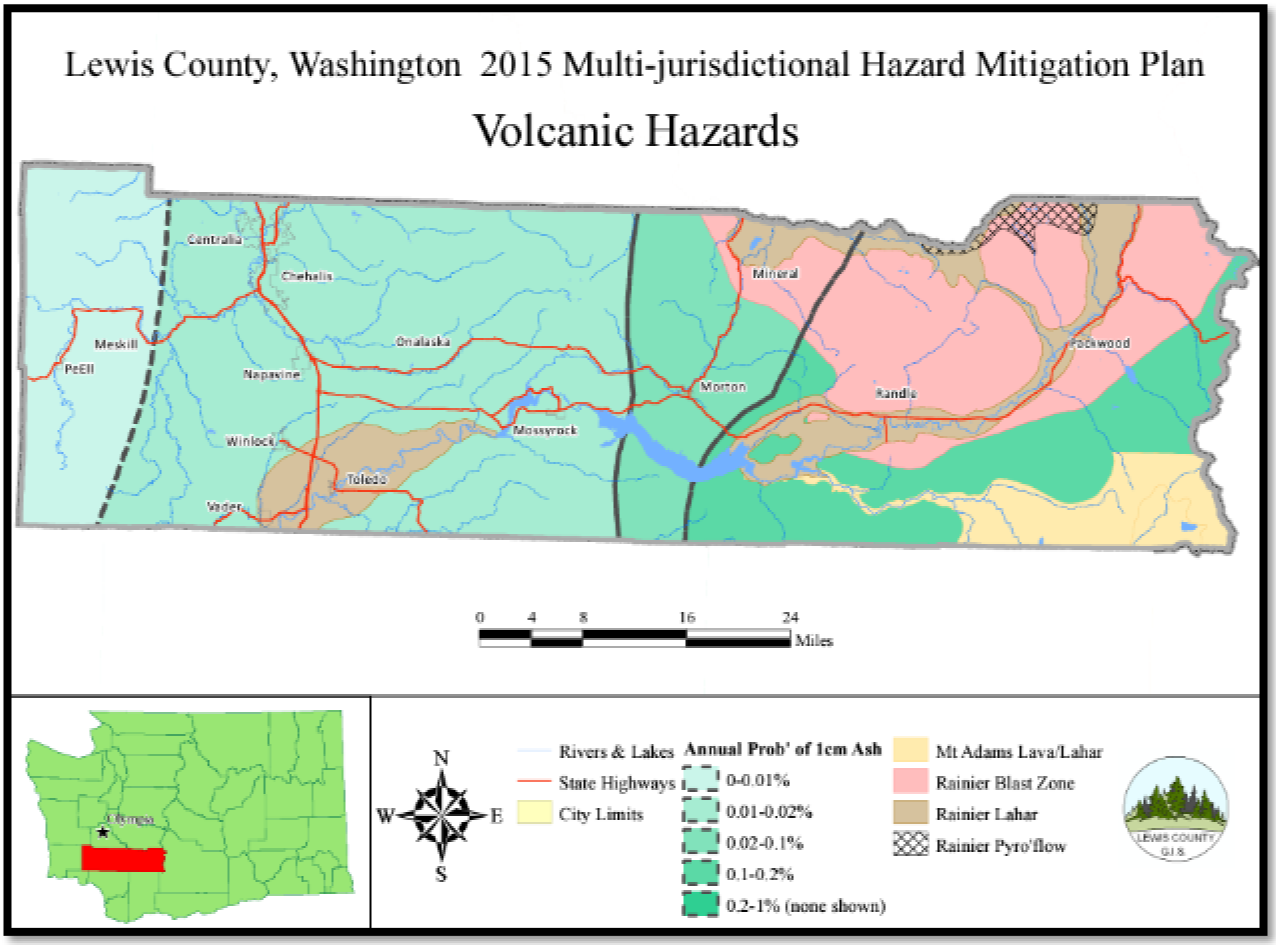


**Figure 10.** Lewis County Volcanic Hazard Mitigation Plan[19]

[19] https://www.cityofcentralia.com/DocumentCenter/View/1116/Volcanic-Hazard-Mitigation-Plan-Map-PDF

### 4.2.5 Mine Hazard Area

Active and closed mines pose potential hazards because they can lead to increased risks of erosion, mass wasting, and landslides near surface mines, and subsidence over collapsed tunnels and shafts in subsurface mines. Since the potential risks of subsurface mines are not obvious, evaluation and disclosure to landowners are essential to protecting infrastructure and public safety.

Lewis County has 246 records of mining claims on public land managed by the Bureau of Land Management (BLM) and 40 records of mining mines listed by the United States Geological Survey (USGS). Mined commodities are primarily aggregates, but also include mercury, silica, lead, silver, gemstones, zinc, arsenic, titanium, nickel, manganese, chromium, copper, and aluminum. (Diggins, 2024)

Lewis County has completed a study and mapped mines which are primarily rock aggregate mines. Aggregate from Lewis County is used for maintenance of several critical transportation routes including I-5 and State Route 12 (SR-12), in addition to building needs. Outwash deposits near Centralia can provide the county with sand and gravel resources. However, these deposits may become inaccessible because of urban encroachment. Alluvial deposits, primarily located near Toledo, are the main aggregate supply in the region. With increasing environmental regulation and fishery habitat concerns, the permitting of new mines in these deposits will be challenging (Eungard, 2015).

Alluvium has historically been the source of aggregate for the county. Sand and gravel eroded from the Cascade Range and glacial deposits are deposited along rivers and streams. While being transported along channels, the sand and gravel are locally concentrated, depending on channel morphology. Finer-grained materials such as clay and silt are deposited further downstream or outside river channels during flood events. Historic mining of alluvium occurred in every major river channel and is most evident in the Cowlitz River channel between Toledo and Vader. There are four mines active in alluvium, and 15 mines and 19 pits with historical activity (Eungard, 2015).

At the current yearly per capita usage of 13.5 tons and total permitted aggregate supply of 60.6 million tons, Lewis County has a maximum of 45 years (until 2060) of accessible aggregate. Factors that may shorten or lengthen the timeline for resource depletion include changes in population growth, market flux, other economic drivers, large infrastructure projects, and additional permitting of aggregate resources for mining (Eungard, 2015).

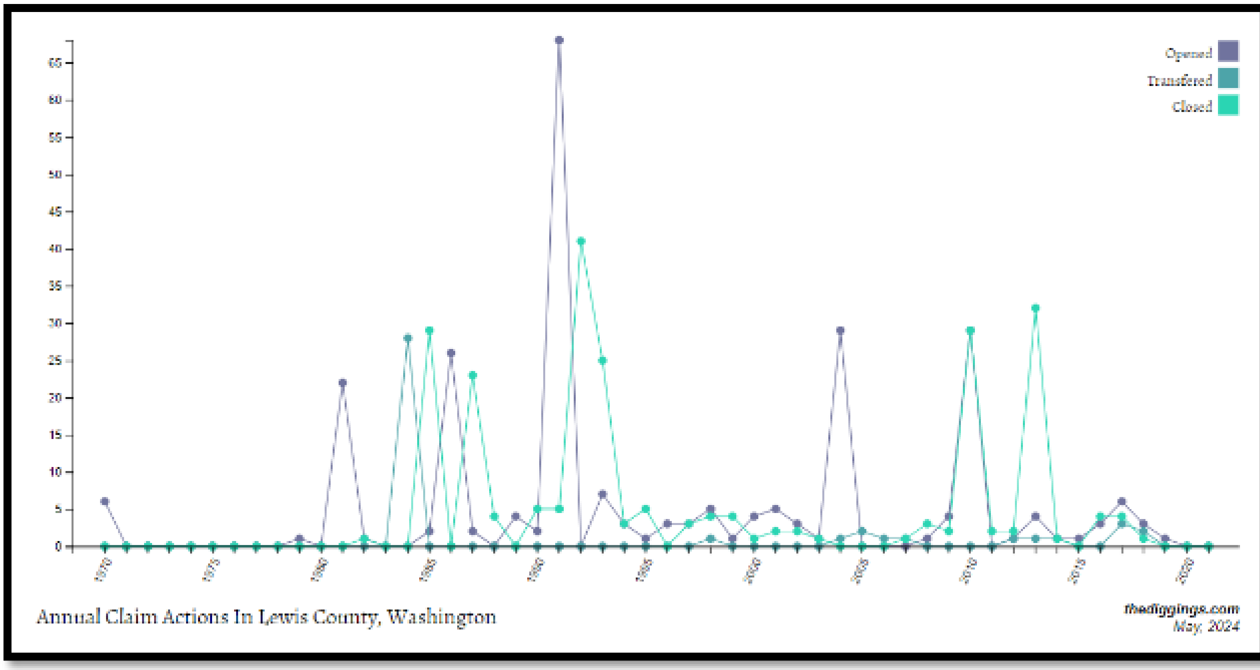


**Figure 11.** Mining claims in Lewis County.

## 4.3 Climate Change Impacts and Mitigation

Geologically hazardous areas, particularly erosion hazard areas, and landslide hazard areas, are anticipated to be influenced by climate change. Climate change models project warmer, drier summers, and increased precipitation in other seasons while maintaining roughly the same amount of annual precipitation (Dalton, Mote, & Snover, 2013). Extreme precipitation events as modeled by the University of Washington Climate Impacts Group are expected to increase in intensity and frequency (Mauger, Morgan, & Won, 2021). Consequentially, geologic hazard risks are anticipated to increase because rainfall intensity and duration are known indicators of landslide events (Chleborad, 2006; WDNR, 2020). Increased magnitude and frequency of rain events can lead to over-saturated soils and contribute to slope instability in hazard areas. Changing climate patterns are also anticipated to result in changes in vegetation community composition and native plant mortality due to shifts in plant hardiness zones and species ranges. Existing species assemblages, canopy types, and root systems may be disrupted and displaced by species that are less effective at providing soil stabilization.

### 4.3.1 Management Recommendations for Climate Change Impacts

- Encourage or require climate-informed design for development and infrastructure in or near geologic hazard areas (WDNR, 2020).
- Require appropriate surface and groundwater management practices for development near coastal bluffs.
- Encourage utilization of soft shore protection strategies.
- Identify and prioritize geologic hazards within the County, then update mapping as needed using current practices such as LiDAR and GIS database tools.

- Keep in communication with the governor's office to ensure Lewis County is included in statewide collaborative efforts to manage geologic hazard areas.
- Manage vegetation for climate resilience and slope stability.

# 5. Wetlands

## 5.1 Definition

Scientists have worked to develop a wetland definition based on scientifically defensible criteria since interest in managing and protecting wetland resources was scaled up in the 1950s. When the Clean Water Act of 1977 (CWA) was signed into law, a definition was agreed upon and applied consistently on a national scale. It is defined as follows (33 CFR § 328.3):

> *Wetlands are areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.*

Washington State also has a wetlands definition that is similar to the CWA but includes certain exceptions for artificial wetlands. It is defined in WAC 365-190-030(22) as follows:

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

The Lewis County definition of a wetland mirrors the Ecology definition, as follows (LCC 17.10.230):

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

## 5.2 Functions and Values

Wetland processes provide many functions that are recognized for their social, ecological, and economic benefits. Three functional categories, which include water quality, hydrology (water quantity), and habitat, are typically considered to be most crucial in terms of their influence on that natural and built environment and are the focus of this analysis. Wetland values refer to the resources a wetland provides that are valued by society, for their ecological, economic, recreational, or aesthetic benefits.

Wetland functions are influenced by hydrogeomorphic characteristics of a site which affect how water moves through a wetland system (Brinson 1993; Hruby 2014). For example, wetlands situated in depressions (depressional wetlands), have greater floodwater retention capacity than slope or flat wetlands. Wetland functions are also influenced by landscape scale and site scale characteristics including vegetation structure, hydroperiods, proximity to potential sources of pollution, and priority habitat corridors and connectivity. Many of the functions and services wetlands provide are valuable to society, such as water storage, flood protection, pollutant and nutrient attenuation, and habitat supporting fisheries (Hattermann et al. 2008). Since these functions are provided naturally, or through restoration projects they are often less costly than engineered solutions (Hattermann et al. 2008).

For regulatory purposes in Washington, wetland functions and values are typically categorized in a rating system. The most widely accepted rating system, the *Washington State Wetland Rating System for Western Washington: 2014 Update, version 2*, was developed by the Department of Ecology and is considered to be the regional standard by all regulating agencies (Hruby and Yahnke 2023). This rating system is a rapid assessment tool that evaluates wetland functions in the categories of water quality, hydrology, and habitat, among a framework of three dimensions of site potential, landscape potential, and societal value (Hruby and Yahnke 2023).

### 5.2.1 Water Quality Functions

Wetlands can improve water quality in waterways through several physical, chemical, and biological processes including settling, filtration, diffusion, volatilization, oxidation, precipitation, adsorption, ion exchange, UV radiation, biodegradation, evapotranspiration, and biotransformation (Sheldon, et al., 2005). Wetlands perform these functions to varying degrees depending on several factors including residence time of polluted waters, vegetation structure and density, and soil composition (Hruby & Yahnke, 2023). Wetlands uptake nutrients, particularly nitrogen and phosphorus, and mediate the effect of nutrient spikes to downstream areas (Sheldon, et al., 2005). Wetland plants and associated microorganisms can take up and remove nitrogen through the biochemical processes of nitrification and denitrification, which occur in respective aerobic and anaerobic conditions (Sheldon, et al., 2005). Low oxygen concentrations that are common to wetland environments allow them to be sinks for copper, a heavy metal (Kerr, et. al., 2009). Studies of constructed wetlands have shown wetland plants remediate pharmaceuticals and personal care products (PPCPs) to various extents (Wang, et. al., 2019; Zhang, et. al, 2014).

### 5.2.2 Hydrologic Functions

Hydrologic wetland functions include groundwater recharge, reduction in peak surface water flows, reduced stream erosion, and flood-flow desynchronization (Sheldon, et al., 2005). Flood-flow desynchronization is a landscape-scale process where peak flows of sub-basins vary temporally in a watershed and lower the magnitude of downstream flooding (Adamus, Clairain, Smith, & Young, 1991). This has a cumulative effect on the magnitude and intensity of individual peak flow events (Sheldon, et al., 2005).

Impervious surface area within a drainage basin has been demonstrated to alter wetland hydrology by increasing or decreasing flows from the surrounding landscape, affecting hydroperiods and flood severity (Sheldon, et al., 2005). These modified hydroperiod regimes are often accompanied by other impacts, such as stream channel erosion and downcutting, and sediment deposition (Sheldon, et al., 2005). Changes in wetland ponding depths, hydroperiods, or water level fluctuation dynamics can also impact wetland plant communities (Schueler, 2000).

### 5.2.3 Habitat Functions

A diverse group of fauna depends on wetlands for at least a portion of their life cycle, including wetland-associated mammals, waterfowl, fish, invertebrates, reptiles, and amphibians (Kauffman et al. 2001; Sheldon 2005). There is a diverse range of ecological variables and factors that influence habitat functions and quality, such as buffer width and condition, vegetative structure, habitat interspersion, wetland hydroperiods, and landscape setting (Hruby and Yahnke 2023). A meta-analysis of the relative effects of landscape-scale wetland area and landscape matrix quality on wetland vertebrates found that while species abundance generally increases in landscapes with more wetland areas, the abundance of some taxa such as amphibians are more sensitive to the larger landscape conditions (Quesnelle et al. 2015). Native species diversity for most taxa is also negatively correlated with the degree of urbanization, though overall species richness is often greatest in areas of intermediate disturbance (Guderyahn et al. 2016; Müller et al. 2016).

Wildlife are also sensitive to water quality impairments which affect wetlands. Additionally, habitat fragmentation tends to reduce the habitat functions and values a wetland provides (Azous and Horner 2010; Sheldon et al. 2005). Land disturbance associated with urban and rural development results in habitat loss and reduces the area of buffers between wetlands and human land use impacts.

## 5.3 Key Protection Strategies

Wetlands are protected through government regulations at the local, state, and federal levels, with each requiring impact avoidance, minimization, and mitigation. Effective wetland protection strategies include regulatory protocols to identify and classify wetlands, assign buffer widths, and require impact avoidance and compensatory mitigation for any wetland or buffer impacts. Additionally, the preservation of local and landscape-scale corridors can be protected by establishing corridor protection regulations for developments near wetlands.

### 5.3.1 Wetland Identification and Classification

To protect wetlands, a qualified professional must first identify them. The nationwide standard for wetland delineations is the 1987 Army Corps of Engineers (Corps) *Wetlands Delineation Manual* with the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region Version 2.0* (Regional Supplement). The Regional Supplement provides greater detail on determining the presence or absence of wetlands specific to the region.

The *Ecology Wetland Rating System for Western Washington* was first issued in 2004, annotated in 2006, revised in 2014, and annotated in 2023. One major change made during the 2014 update changed the points scale and provided intermediate ranking for each assessed function, scoring to a high, medium, or low. These rankings better reflect the coarseness of the tool. Additional clarifications were added to the rating system guidance in Version 2 to incorporate annotations to address questions and comments Ecology received since the 2014 version was published (Hruby & Yahnke, 2023).

The jurisdictional status of a wetland can vary depending on the government agency and the statute regulations under consideration. For example, the CWA only applies to wetlands that meet specific criteria regarding connectivity to Waters of the U.S. and does not apply to isolated wetlands. Local and state wetland regulations are more broadly encompassing. Ecology regulates non-federally regulated wetlands by Administrative Order for compliance with the Water Pollution Control Act (Chapter 90.48 RCW). However, wetlands regulations generally exclude some features, such as artificially created stormwater features, for example.

## 5.3.2 Wetland Buffers

Wetlands in Washington are protected from surrounding land uses through buffer width requirements based on recommendations from Ecology. Similar to wetlands, buffers also provide functions that have ecological, sociological, and economic benefits. Wetland buffer functions include moderation of stormwater inputs, sediment removal, pollutant abatement, microclimate, habitat for wetland-dependent fauna, habitat connectivity, and disturbance screening (Sheldon et al. 2005). Buffer functions vary depending on a wide variety of factors such as the vegetation community, gradient, soil conditions, and adjacent land use intensity (Sheldon, et al., 2005).

In 2005, Sheldon et al. developed a synthesis of the science for wetlands in Washington which included the topic of buffer width efficacy. The synthesis includes a discussion of the topics of buffer widths relative to water quality functions, hydrologic maintenance, wildlife habitat, and disturbance barrier effectiveness. Due to the similarity of processes and functions, studies on stream buffer widths were compiled into the synthesis (Sheldon, et al., 2005). A detailed account of specific buffer functions as they relate to buffer widths can be found in Section 6.2.1.

### BUFFER APPROACHES

Ecology provides guidance for wetland buffers framed around several alternatives in Wetlands in Washington State - Volume 2: Guidance for Protecting and Managing Wetlands– Protecting and Managing Wetlands, Appendix 8-C (Granger, et al., 2005) and 2022 Ecology Guidance for Critical Area Ordinance Updates. Both guidance documents provide similar but slightly differing approaches, and both are considered to be consistent with BAS at this time.

Current Ecology wetland guidance documents outlines the following primary factors to consider when determining buffer widths (ECY, 2022):

- The wetland type and the functions needing protection (buffers filter sediment, excess nutrients, and toxics; screen noise and light; provide forage, nesting, or resting habitat for wetland-dependent species; etc.),
- The types of adjacent land use and their expected impacts, and
- The characteristics of the buffer area (slope, soils, vegetation).

Three wetland buffer alternatives are presented in the current Ecology guidance for CAO updates.

As buffer determination options are reviewed, it is important to note that, "buffer width recommendations are based on the assumption that the buffer area is well vegetated with *native species appropriate to the ecoregion*" (ECY, 2022). Those buffer options are:

Three BAS-based wetland buffer alternatives are referenced in the current Ecology guidance for CAO updates (ECY, 2022). Those buffer options are:

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

### FUNCTIONALLY DISCONNECTED BUFFER AREAS

In urban areas, standard buffer widths are sometimes interrupted by development. When a buffer area is functionally disconnected from a wetland, Ecology recommends providing clear direction on how buffer regulations address this condition by providing specific criteria. A distinction between minor and major developments is central to determining if a functional barrier is present. Minor developments, such as trails, accessory structures, and driveways for a single residence would not completely block wetland buffer functions. Significant developments associated with the complete loss of buffer functions include public infrastructure (paved roads, railroads), housing developments, or commercial structures. An interruption may impact all or just a portion of a buffer area (ECY, 2022).

### INFLUENCE OF BUFFERS ON HYDROLOGY

Wetland buffers can mediate the effects of surrounding land use impacts, with variable interactions depending on site conditions and landscape position. Development and impervious surfaces often result in runoff to surface waterbodies which negatively alters hydrologic regimes and introduces pollutants to waterways, these impacts are reduced by the presence of wetland buffers (Sheldon, et al., 2005; Hruby T., 2014). Infiltration of rainwater to soils in wetland buffers reduces surface flows and improves groundwater recharge. Vegetation slows the movement of surface runoff, allowing for greater time for infiltration to occur, which slows or desynchronizes hydrologic inputs into the wetland and potentially diverts them to other groundwater systems. Leaf and other vegetative litter on and in the soil also capture water and improve the soil's infiltration capacity (Castelle A. , et al., 1992a). Vegetation also intercepts rainwater and converts liquid water back to atmospheric vapor through evapotranspiration. Buffer characteristics that influence the performance of hydrologic maintenance are vegetation cover, soil infiltration capacity, rainfall intensity, and antecedent soil moisture conditions (Wong & McCuen, 1982).

Buffers also function to control erosion by slowing water flow and improving infiltration. Buffer vegetation can reduce erosion by capturing sediment before it enters the wetland, through soil stabilization by roots, and reduction in rain energy by both the vegetation canopy and organic material on the soil (Castelle A. , et al., 1992a). Vegetation composition and structure in buffers are important factors in the capability of a buffer to perform this function. Plants with fine roots are most effective at preventing erosion by binding the soil (McMillan, 2000).

### INFLUENCE OF BUFFERS ON WATER QUALITY

Buffers protect water quality in wetlands through the removal of sediment and suspended solids, nutrients, pathogens and toxic substances, and other pollutants (Castelle et al. 1992a; McMillan 2000; Sheldon et al. 2005). The ability of a buffer to improve water quality depends on several variables such as slope, vegetation composition, leaf and wood litter, soil type, the type of pollutant, size of the basin, and the fate of stormwater conveyance from adjacent land use (Desbonnet et al. 1994; McMillan 2000). Buffers are typically higher functioning when they have a structurally complex mix of trees, shrubs, and groundcovers, abundant downed wood and leaf litter, and low slopes (Hruby 2013). This is in-part facilitated by physical and biological processes, such as the retention, binding, and filtering of sediments and pollutants through wood or leaf litter, and the breakdown and uptake of pollutants by plants and microorganisms in the soil (Castelle et al. 1992a; Desbonnet et al. 1994; McMillan 2000). Buffer vegetation can reduce sediment input to the wetland through the stabilization of soils by roots, and reduction in runoff via rainwater interception and buildup of organic material on the soil (Castelle, et al. 1992a). Shading and wind reduction by buffer vegetation also influence water quality by maintaining cooler temperatures. Water temperature in wetlands can be critical to the survival of aquatic wildlife species, but more importantly from a water quality perspective, it helps maintain sediment-pollutant bonds, increases the water's dissolved oxygen capacity, and limits excessive algal growth (Castelle et al. 1992a; McMillan 2000; Sheldon et al. 2005).

Approximately 50% of overall pollution removal except nitrogen occurs in the first 16 ft (5 m) of buffer and 70% occurs at 115 ft (35 m) (Desbonnet, et al. 1994). For sediments and suspended solids, 60% removal is achieved with a 7 ft buffer (2 m), and 80% removal is achieved at 82 ft (25 m) (Desbonnet, et al. 1994). Phosphorus removal of 60% is achieved with a buffer of 39 ft (12 m), and 80% is achieved at 279 ft (85 m) (Desbonnet, et al. 1994). Analysis of a range of buffer widths by specific water quality function and identified the following effective buffers: 5 to 100 meters (16 to 330 feet) for sediment removal; 10 to 100 meters (33 to 330 feet) for nitrogen removal; 10 to 200 meters (33 to 656 feet) for phosphorus removal; and 5 to 35 meters (16 to 100 feet) for bacteria and pesticide removal (McMillan 2000; Sheldon, et al. 2005).

### INFLUENCE OF BUFFERS ON WILDLIFE HABITAT

Wetland buffers provide habitat for a wide variety of wildlife species and are particularly essential for wetland-dependent and wetland-associated species that require adjacent terrestrial habitat during their life cycle. They also provide habitat well suited for non-wetland-dependent species that prefer habitat edges, use the wetland as a source of drinking water, or use the protected buffer corridors for migrations and movements.

The current body of research includes a range of studies that assess how certain focal species utilize buffers at varying widths, following disturbance events or land use changes. One study in urban King County found that bird diversity was positively correlated with the percentage of wetland perimeter that has vegetated buffers, though only a minor increase in diversity was found with the tested buffer widths of 50, 100, and 200 feet (Milligan 1985). One literature summary reports an effective buffer range of 50 feet (15 m) for many bird species and up to 3,280 feet (1,000 m) for native amphibians (Azous and Horner 2010; Milligan 1985). Many studies recommend buffers between 150 and 300 feet with minimum buffer widths of 50 to 75 feet to provide general avian habitat (Desbonnet et al. 1994; ECY 1992). Wildlife corridors of at least 98 feet are recommended to connect wetlands by McMillan (2000), and Reichter (1997) recommends 490 feet as a minimum travel corridor. A synthesis by Sheldon et al. (2005) found that buffer widths for habitat protection range between 50 and 300 feet depending on factors including wetland habitat conditions, target species, buffer conditions, and surrounding land uses.

In addition to providing habitat for wetland-dependent and wetland-associated species, buffers provide a barrier between a wetland and the various vectors for human encroachment, including noise, light, trampling of vegetation, and the introduction of garbage and other pollutants. Buffer widths necessary to effectively reduce impacts vary by the intensity of the adjacent land use. Buffer widths of 49 to 98 feet can effectively screen low-intensity land uses, such as agriculture and low-density residential (Sheldon et al. 2005). High-intensity land use, such as high-density residential (more than 1 unit/acre), commercial, and industrial, require buffer widths of 98 to 164 feet (Sheldon et al. 2005). The buffer itself, and the functions that it provides, is influenced by the degree of human-related disturbance. Buffers less than 50 feet wide experienced the most loss of buffer function related to human disturbance, and this loss is related to a gradual reduction in buffer width as adjacent land uses encroach (Castille et al. 1992b).

### 5.3.3 Mitigation

#### MITIGATION SEQUENCING

Mitigation sequencing is the structured process of avoiding, minimizing, and mitigating all impacts to a particular resource. Lewis County has incorporated mitigation sequencing into existing wetland regulations according to LCC 17.38.080. This is consistent with federal directives to achieve no net loss of wetland functions and values. Mitigation sequencing is also required by the 2008 Wetlands Compensatory Mitigation Rule issued by the U.S. Environmental Protection Agency (EPA). and WAC § 197.11.768 (USEPA, 2008). Per current Ecology guidance for CAO updates, mitigation sequencing must be applied in the following order (ECY 2022):

> *Avoiding the impact altogether by not taking a certain action or parts of an action;*
>
> *Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts;*
>
> *Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;*
>
> *Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action;*
>
> *Compensating for the impact by replacing, enhancing, or providing substitute resources or environments; and/or*
>
> *Monitoring the impact and taking appropriate corrective measures.*

## COMPENSATORY MITIGATION

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

Ecology's recommendations for mitigation ratios for projects in Western Washington depend on the wetland category and type of mitigation action (Granger 2005, Modified 2008). Mitigation ratios for direct wetland impacts are increased to account for temporal losses (ECY 2022). When applying advanced mitigation, the Ecology-recommended ratios account for the wetland category and proposed mitigation actions (ECY 2021b).

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

Compensatory wetland mitigation methods in order of preference are (ECY 2021b):

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

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

Ecology recommends applying at least a one-to-one ratio to buffer impacts (ECY 2022). However, if buffer modifications exceed standard allowances, such as retaining at least 75 percent of the standard buffer width, then Ecology recommends evaluating indirect wetland impacts to determine appropriate compensatory mitigation (ECY 2021b).

## MONITORING

Evaluations of wetland mitigation outcomes found that most wetland mitigation does not fully replace impacted functions and falls short of the goal of no net loss (ECY, 2008; Johnston, Bird, Hogan, & MacIsaac, 2011). The goal of no net loss of wetland function cannot be achieved through mitigation alone but may be met through several factors, including adequate monitoring and maintenance and appropriate performance standards. Compensatory mitigation sites typically require performance standard monitoring for a 3- to 10-year period, to ensure that implemented sites provide the functions which were planned. There are few studies of long-term compliance with performance standards, and one assessment found a reduction in site compliance 8 to 20 years following installation (Van den Bosch & Matthews, 2017). NRC (2001) identifies factors that reduce the risk of mitigation failure, include; detailed functional assessment, high success standards, detailed mitigation plans, larger bonds with up-to-date market values, high replacement ratios, and greater expertise.

## 5.4 Climate Change Impacts & Mitigation

Climate change is predicted to significantly impact wetland ecosystems by altering hydrology, reducing biodiversity, disrupting carbon storage, modifying community composition, and increasing rates of disease (Aukema et al. 2017; Burkett and Kusler 2000; Lee et al. 2015). Altered hydrology and precipitation patterns from climate change can result in earlier drawdowns of wetlands during droughts, a process that will likely result in wetland loss where hydrologic conditions are significant and modify community composition (Lee et al. 2015). Wetlands may also experience greater polarity in seasonal water levels with increased ponding during wet seasons and decreased water levels during dry seasons (Halabisky 2017). Sea level rise is also expected to change the landscape of coastal wetlands, resulting in wetland loss, spatiotemporal changes to coastal wetland distribution, and shifts in community composition resulting from disturbance, climate change effects, and elevated salinity (Burkett & Kusler, 2000). Climate change impacts on biodiversity, as discussed in Section 6.4, are caused by a wide range of effects that modify habitats from historic baselines and reduce biodiversity (Aukema, Pricope, & Lopez-Carr, 2017). Furthermore, warming effects may result in a disruption of carbon storage, by reducing storage rates or even reverting some wetlands from carbon sinks to carbon sources, particularly in boreal peatlands (Burkett & Kusler, 2000).

Wetlands also provide functions that assist in the mediation of climate change impacts. Wetlands and wetland buffers, like riparian corridors, support a shaded and cool microclimate that provides refuge for wildlife from higher temperatures as well as wildlife corridors at a local or landscape scale (ASWM, 2015). Additionally, wetlands help offset climate change through carbon storage by protecting the remineralization of organic stocks and sequestering greenhouse gas emissions (Gallagher, Zhang, & Chuan, 2022). Carbon stocks in undisturbed wetlands are approximately twice as high as carbon storage in wetlands disturbed by human-driven land use changes. However, it is uncertain whether this is a causal relationship or influenced by patterns of human settlement in avoiding the wettest sites which are challenging to develop (Nahlik & Fennessy, 2016). Bogs and peatlands are important carbon sinks that could release hundreds of years of stored carbon if disturbed (Nahlik & Fennessy, 2016).

Although wetlands are dynamic by nature, the ability to adapt to change is limited. Alterations in stormwater runoff conditions and changes to seasonal wetland hydrologic cycles can reduce the ability of wetland soil bacteria and plants to retain, process, and sequester pollutants (USEPA, 2014). Climate change is impacting native plant species distribution; adaptative potential and climate tolerance for native plant species are being studied in the scientific community (Vose, et. al., 2012).

### 5.4.1 Strategies to Manage Climate Change Impacts on Wetlands

- Continue to encourage and incentivize direct wetland impact avoidance to maintain existing carbon storage.

- Continue to regulate wetland buffers to encourage and require width retention/limitations and enhancement with native vegetation. Both voluntary and required restoration planting should be paired with monitoring and maintenance that allows for dry-season irrigation and adaptive management.
- Continue to manage and regulate stormwater infrastructure to avoid and minimize discharges of untreated runoff to wetlands.
- Apply increased protections to bog wetlands and associated buffers to prevent stormwater impacts that could change pH and alter sensitive plant communities.
- Consider assisted migration for seed selection of native plants from locations that are better adapted to future climate conditions.

# 6. Fish and Wildlife Habitat Conservation Areas (FWHCAs)

## 6.1 Definition

Washington State defines fish and wildlife conservation as "land management for maintaining populations of species in suitable habitats within their natural geographic distribution so that the habitat available is sufficient to support viable populations over the long term and isolated subpopulations are not created" (WAC 365-190-130). Fish and Wildlife Habitat Conservation Areas (FWHCAs) are lands designated for this conservation action and are defined under WAC 365-190.130 and identified in the Lewis County Code (LCC) according to LCC 17.38. FWHCAs are separated into aquatic and wildlife habitats.

### 6.1.1 Aquatic habitat

The following resources are identified as aquatic habitat critical areas in LCC 17.38.465:

> *(1) Waters of the state as defined in RCW 77.55.011 and 90.56.010, but not including shorelines of the state as defined in RCW 90.58.010.*
>
> *(2) Naturally occurring ponds under 20 acres and their submerged aquatic beds that provide fish or wildlife habitat.*
>
> *(3) Lakes, ponds, streams, and rivers planted with game fish by a governmental or tribal entity.*

Streams and lakes are further classified in LCC 17.38.470 as follows:

> *(1) Streams and lakes are classified in accordance with the Washington State Department of Natural Resources (DNR) as provided in WAC 222-16-030, with the following revisions:*
>
> > *(a) "Type S water" means all waters identified as shorelines of the state under Chapter 90.58 RCW and the rules promulgated pursuant to Chapter 90.58 RCW, including periodically inundated areas of their associated wetlands. Type S waters are regulated entirely by the Lewis County shoreline master program.*

*(b) "Type F water" means segments of natural waters other than Type S waters, as defined by the ordinary high water mark and periodically inundated areas of their associated wetlands, except as regulated by LCC 17.38.220, or within lakes, ponds, or impoundments having a surface area of one-half acre or greater at seasonal low water and which in any case contain fish habitat, as well as riverine ponds, wall-based channels, and other channel features that are used by fish for off-channel habitat.*

*(c) "Type Np water" means all segments of natural waters within defined channels that are perennial nonfish habitat. Perennial streams are waters that do not go dry at any time during a year of normal rainfall. However, for the purpose of water typing, Type Np waters include the intermittent dry portions of the perennial channel below the uppermost point of perennial flow.*

*(d) "Type Ns water" means all segments of natural waters within defined channels that are not Type S, F, or Np waters. These are seasonal, nonfish 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. Ns waters must be physically connected by an aboveground channel system to Type S, F, or Np waters.*

*(2) Classification. Stream typing data from the Washington State Department of Natural Resources (DNR) is utilized to show the approximate location of streams and their types.*

*(a) Where a stream is shown on the DNR mapping, but no stream is present or the location is in error, the administrator may waive the requirements for additional studies after a qualified professional prepares a site investigation that details the existing stream conditions.*

*(b) Where a question about the correct stream type exists, Lewis County may consult with WDFW about the appropriate stream classification.*

### 6.1.2 Wildlife Habitat

Lewis County uses the following resources to identify wildlife habitat critical areas LCC 17.38.490:

*(1) Definitions and maps of wildlife habitat areas are based on the following documents:*

*(a) The United States Endangered Species Act of 1973, and species and critical habitat designed thereunder;*

*(b) The 1999 Washington Department of Fish and Wildlife Priority Habitats and Species List;*

*(c) The 1997 Management Recommendations for Washington's Priority Habitats;*

*(d) The list of best available science references maintained by the responsible official; and*

*(e) Associated GIS data files maintained by Lewis County GIS department.*

## STATE & FEDERAL DESIGNATED ENDANGERED, THREATENED, OR SENSITIVE SPECIES

The Washington Department of Fish and Wildlife (WDFW) lists priority habitats and species (PHS) by county. Cities and counties utilize the PHS List to designate and protect FWHCA under the Growth Management Act and Shoreline Management Act. Priority habitats are those with unique vegetation types or are significant to many species. There are thirteen types of priority habitat types located in Lewis County. Priority species include State Endangered, Threatened, Sensitive, and Candidate species and include species of recreational, commercial, or tribal importance. Table 2 includes a summary of the Lewis County PHS list. As WDFW notes, habitats, and species can change over time as distributions expand or contract. Lewis County includes habitat types that are known to be used or could potentially be used by bird and mammal species of interest, including those species with State or federal status and WDFW priority species.

The following locations are designated as fish and wildlife habitat conservation areas per LCC 17.38.420:

**Table 1.** Fish and wildlife habitat conservation area designations

| | Regulated Area |
|---|---|
| Aquatic Priority Habitat | Areas extending outward from the ordinary high-water mark on each side of a stream to the following distances[1, 2]:<br>(a) DNR Type F waters, 150 feet[3];<br>(b) DNR Type Np and Ns waters, 75 feet. |
| WDFW Priority Habitats and Species | Areas identified by and consistent with WDFW priority habitats and species criteria for federal or state endangered, threatened, or sensitive species. The county shall defer to WDFW in regard to classification, mapping, and interpretation of priority habitats and species. |
| Locally Important Habitat and Species | The following species of local importance and locally important habitat areas:<br>(a) Elk wintering habitat;<br>(b) Western brook lamprey;<br>(c) Pacific lamprey; and<br>(d) Freshwater mussels. |
| Designated Wildlife Areas | State natural area preserves, conservation areas, and state wildlife areas. No buffers shall be required adjacent to the areas since the preserves and conservation areas are assumed to encompass the land required for species preservation. |

[1] *Numbers shown within the table represent required "buffers." Aquatic habitat buffers may be modified per the standards in LCC 17.38.430.*

[2] *Type S streams, and lakes and ponds over 20 acres in size in Lewis County are regulated under the shoreline master program.*

[3] *Projects along Type F streams, which are less than 10 feet in width, may reduce their required buffer to 100 feet, when a qualified professional submits a report that details the width of the stream as it travels through the project site.*

**Table 2.** Lewis County priority species list (source: WDFW[20]).

| | Species/ Habitats | State Status | Federal Status |
|---|---|---|---|
| Habitats | Aspen Stands | | |
| | Biodiversity Areas & Corridors | | |
| | Herbaceous Balds | | |
| | Old-Growth/Mature Forest | | |
| | Oregon White Oak Woodlands | | |
| | West Side Prairie | | |
| | Riparian | | |
| | Freshwater Wetlands & Fresh Deepwater | | |
| | Instream | | |
| | Caves | | |
| | Cliffs | | |
| | Snags and Logs | | |
| | Talus | | |
| Fishes | Pacific Lamprey | | |
| | River Lamprey | Candidate | |
| | White Sturgeon | | |
| | Olympic Mudminnow | Sensitive | |
| | Leopard Dace | Candidate | |
| | Mountain Sucker | Candidate | |
| | Eulachon | | Threatened |
| | Bull Trout/ Dolly Varden | Candidate * | Threatened * |

[20] https://wdfw.wa.gov/species-habitats/at-risk/phs/list

| | Species/ Habitats | State Status | Federal Status |
|---|---|---|---|
| | Chinook Salmon | | Threatened (Upper Columbia Spring run is Endangered) |
| | Chum Salmon | | Threatened |
| | Coastal Res./ Searun Cutthroat | | |
| | Coho Salmon | | Threatened – Lower Columbia |
| | Rainbow Trout/ Steelhead/ Inland Redband Trout | Candidate ** | Threatened ** |
| Amphibians | Cascade Torrent Salamander | Candidate | |
| | Dunn's Salamander | Candidate | |
| | Larch Mountain Salamander | Sensitive | |
| | Van Dyke's Salamander | Candidate | |
| | Western Toad | Candidate | |
| Reptiles | Northwestern Pond Turtle (formerly Western Pond Turtle) | Endangered | |
| Birds | Marbled Murrelet | Endangered | Threatened |
| | Great Blue Heron | | |
| | Cavity-nesting ducks: Wood Duck, Barrow's Goldeneye, Common Goldeneye, Bufflehead, Hooded Merganser | | |
| | Western Washington nonbreeding concentrations of: Barrow's Goldeneye, Common Goldeneye, Bufflehead | | |
| | Harlequin Duck | | |
| | Waterfowl Concentrations | | |
| | Golden Eagle | Candidate | |
| | Northern Goshawk | Candidate | |
| | Mountain Quail | | |
| | Sooty Grouse | | |
| | Wild Turkey | | |
| | W WA nonbreeding concentrations of: Charadriidae, Scolopacidae, Phalaropodidae | | |

| | Species/ Habitats | State Status | Federal Status |
|---|---|---|---|
| | Band-tailed Pigeon | | |
| | Northern Spotted Owl (formerly called Spotted Owl) | Endangered | Threatened |
| | Vaux's Swift | | |
| | Black-backed Woodpecker | Candidate | |
| | Oregon Vesper Sparrow | Endangered | |
| | Slender-billed White-breasted Nuthatch | Candidate | |
| Mammals | Roosting Concentrations of: Big-brown Bat, Myotis bats, Pallid Bat | | |
| | Townsend's Big-eared Bat | Candidate | |
| | Western Gray Squirrel | Endangered | |
| | Mazama (Western) Pocket Gopher | Threatened | Threatened - glacialis, pugetensis, tumuli, yelmensis subspecies |
| | Cascade Red Fox | Endangered | |
| | Fisher | Endangered | |
| | Marten | | |
| | Wolverine | Candidate | Threatened |
| | Columbian Black-tailed Deer | | |
| | Mountain Goat | | |
| | Elk | | |
| Invertebrates | Blue-gray Taildropper | Candidate | |
| | Western Bumble Bee | Candidate | Candidate |
| | Johnson's Hairstreak | Candidate | |
| | Valley Silverspot | Candidate | |
| | Taylor's Checkerspot | Endangered | Endangered |

* Bull Trout only
** Steelhead only

## HABITATS AND SPECIES OF LOCAL IMPORTANCE

Lewis County currently recognizes four species of local importance. These include the following:

- Elk wintering habitat;
- Western brook lamprey;
- Pacific lamprey; and

- Fresh water mussels.

## 6.2 Functions and Values

FWHCA functions include the biological, chemical, and physical processes occurring on lands and ecosystems that influence wildlife. Since wildlife may include all species from the largest megafauna to microorganisms, these functions encompass a complex web of interacting ecological processes. At the highest level, FWHCAs provide wildlife with the habitat requirements necessary to survive and persist. This section discusses prominent functions that are relevant to land management and wildlife management. A discussion of the functions of certain habitat areas is also provided if relevant to a particular societal value other than wildlife (i.e., security).

FWHCA values are the range of societal, economic, and ecological benefits provided by these lands and the wildlife that may inhabit them. These include *indirect values* that include non-consumptive uses such as recreation, tourism, scientific research, option values (valuing future opportunities), and intrinsic existence values (Chardonnet, et al., 2002). They also include *direct values*, the consumptive and productive uses, such as commercial harvest, hunting, timber, and firewood (Chardonnet, et al., 2002). These values represent diverse public interests and attitudes toward wildlife issues which change over time (Teel, T.L. & Manfredo, 2010) .

### 6.2.1 Streams, Lakes and Ponds, and Riparian Areas

Streams, lakes, ponds, and their associated riparian areas provide critical habitat for a diversity of wildlife species and directly contribute to surface and subsurface hydrology as well as nutrient and energy exchange across the landscape (Quinn, T., Wilhere, & Krueger, 2020). The following section describes the functional attributes and impacts to these systems from natural ecological processes as well as land use activities including (1) land cover and impervious surfaces; (2) recruitment of large woody debris to aquatic areas; (3) shade, temperature, and microclimates; (4) stream migration and bank stability.

#### LAND COVER AND IMPERVIOUS SURFACE

Human development is well documented to negatively impact aquatic ecosystems and is often evaluated using landscape scale metrics such as impervious surface, and other land cover measures. Impervious surface is positively correlated with high flow volumes, daily streamflow variability and negatively correlated with groundwater recharge rates and summer low flow volumes (Burges et al. 1998; Cuo et al. 2009; Jones 2000, Konrad & Booth 2005). Other types of development also result in hydrological changes include soil compaction, draining, and ditching across the landscape, and logging (Booth & Jackson 2002; Moore & Wondzell 2005). Together, these landscape modifications have been documented to reduce rates of infiltration, evapotranspiration, and groundwater storage (Sheldon et al. 2005). As a result, flows become more synchronized and more variable and volatile (Sheldon et al. 2005).

A study assessing changes in forest canopy, stream flows, and stream bank erosion, found that unstable channels are expected to occur if forest retention is less than 40 percent within a watershed (Booth, Hartley, & Jackson, 2002). Increased erosion and bank instability coupled with a reduction of forest cover have been found to simplify stream morphology, leading to incised, wider, and straighter stream channels (Konrad & Booth, 2005). This less dynamic stream morphology is linked to accelerated water transport and reduced temporary instream flood storage capacity (Kaufmann & Faustini, 2012). Positive correlations have been found between spawner abundance and forested areas; negative correlations were found between spawner abundance and areas converted to agriculture or urban development (Pess, et al., 2002).

### RECRUITMENT OF LARGE WOODY DEBRIS TO AQUATIC AREAS

Large woody debris (LWD) plays a significant role in the geomorphic formation of stream channels by deflecting and redirecting stream flows and influencing sediment storage, transport, and deposition rates. These processes result in complex and diverse channel morphologies that include dam pools, plunge pools, riffles, glides, undercut banks, and side channels (Quinn, T., Wilhere, & Krueger, 2020). The creation of these features is also facilitated by variability in stream flow velocity which factors into scour, sediment deposition, and pool formation (Quinn, T., Wilhere, & Krueger, 2020). Large wood actuates the downward scour necessary for streams to create pools, which provides protective cover for fish in those pools (Quinn, T., Wilhere, & Krueger, 2020).

These processes result in complex and spatially heterogeneous stream habitats that support diverse communities of aquatic species. LWD and associated habitat complexities provide conditions suitable for rearing, and refugia from predators. In one study, the density of juvenile salmonids was found to be substantially higher in streams in which LWD was experimentally introduced (Roni, P. & Quinn, 2001). Similarly, streams containing large amounts of LWD supported populations of juvenile cutthroat trout and coho salmon five times greater than streams within the same river system that had been cleared of LWD (Fausch & Northcote, 1992).

The aggregation of LWD and associated entrapment of smaller branches, limbs, leaves, and other materials reduce flow conveyance in small streams and increase temporary flood storage (Dudley, S.J., Fischenich, & Abt, 1998). By retaining smaller organic debris, LWD provides substrate for microbes and algae, and prey resources for macroinvertebrates (Bolton, A. & Shellberg, 2001). The overall influence of LWD on biological processes is greater in smaller streams than in larger ones  (Harmon, M.E., et al., 1986). This is similar to the relationship with riparian areas, in which allochthonous inputs compose a greater proportion of small stream volume than large  streams and are more influential on biological processes (Vannote, et. al., 1980). In small channels, LWD provides a structural component in the stream that controls rather than responds to hydrologic and sediment transport processes (Gurnell, A.M., et.al., 2002). It follows that large wood is responsible for significant sediment storage in small channels, thereby increasing channel stability (May, C.L. & Gresswell, 2003; Nakamura & Swanson, 1993; Quinn, T., Wilhere, & Krueger, 2020). In a study where wood was experimentally removed from streams, increased sediment mobilization and reduced storage. LWD that partially blocks flow may also encourage hyporheic flow through the streambed substrate (Bilby, R.E. & Bisson, 1987; Poole & Berman, 2001; Wondzell, S.M. & Lanier, 2009).

Large wood recruitment is typically introduced to streams as a result of bank erosion, windthrow, landslides, debris flows, snow avalanches, and tree mortality due to fire, ice storms, insects, and disease (Swanson, F.J., Lienkaemper, & Sedell, 1976; Maser, et. al., 1988). Large woody debris can enter channels through individual trees falling into the stream, as well as through larger disturbances (Bragg, 2000). In a comparison of 51 streams with varying channel characteristics in mature forests of British Columbia, a study found that tree mortality was the most common entry mechanism of LWD where the source could be identified (Johnston, et. al., 2011). Streambank erosion and associated channel migration is also a common method of wood recruitment in large alluvial channels whereas, in smaller, steeper channels, LWD recruitment in smaller, steeper channels occurs primarily through slope instability and windthrow (May & Gresswell, 2003).

The probability of a tree entering the channel decreases with distance from the streambank (McDade, et. al., 1990; Grizzel, et al., 2000). Past research has found that most LWD originates within approximately 30 m (98 ft) of a watercourse (Murphy & Koski, 1989). In one study involving 51 streams surveyed in British Columbia, 90%of the LWD at most sites originated within 18 m (59 ft) of the channel (Johnston, et. al., 2011). May and Gresswell (2003) found that wood was recruited from distances farther from the stream channel in small, steep channels (80% from 50 m (164 ft) from the channel), compared to broad alluvial channels (80 percent from 30 m (98 ft) from the channel) because of the significance of hillslope recruitment in narrow valleys.

The likelihood of downstream transport of LWD is dependent on the length of wood relative to bankfull width of the stream (Lienkaemper & Swanson, 1986). Wood that is shorter than the average bankfull width is transported more readily downstream compared to wood that is longer than the bankfull width (Lienkaemper & Swanson, 1986). Therefore, large wood is rarely transported downstream from small channels less than 5 m (16 ft) in width (May, C.L. & Gresswell, 2003).

Beaver dams incorporate both small and large wood, and serve to slow water, retain sediment, and create pools and off-channel ponds used by rearing coho salmon and cutthroat trout (Naiman, Decamps, & Pollock, M., 1993; Pollock, et. al., 2004)). The removal of these structures throughout history has been linked to a significant reduction in coho salmon summer and winter rearing habitat in the nearby Stillaguamish River (Pollock, et. al., 2004). The Washington legislature states that "*beavers have historically played a significant role in maintaining the health of watersheds in the Pacific Northwest and act as key agents in riparian ecology*." They continue with "*The benefits of active beaver populations include reduced stream sedimentation, stream temperature moderation, higher dissolved oxygen levels, overall improved water quality, increased natural water storage capabilities within watersheds, and reduced stream velocities. These benefits improve and create habitat for many other species, including endangered salmon, river otters, sandhill cranes, trumpeter swans, and other riparian and aquatic species*." These statements are consistent with scientific evidence and recognize that beavers play an important role in stream ecosystems. Relocations and introductions to stream ecosystems can be beneficial wildlife management practices. Conditions for wild beaver release are provided in RCW 77.32.585. Related to this legislation, WDFW has instigated a beaver relocation program.

## SHADE, TEMPERATURE, AND MICROCLIMATE

Riparian vegetation influences stream temperatures and microclimate conditions such as air temperature, wind, light, and moisture. Factors affecting water temperature and microclimate include shade, orientation, relative humidity, ambient air temperature, wind, channel dimensions, groundwater, hyporheic exchange rates, and overhead cover (Quinn et al. 2020).

Salmon and other native freshwater fish require cool waters for migrating, rearing, spawning, incubation, and emergence, with summer maximum temperature recommendations ranging from 55-68°F (EPA 2003). Thermal tolerances differ by species; salmonids here have been studied frequently due to their cultural and economic importances, relative sensitivity to high temperatures, and narrow thermal tolerance (Quinn et al. 2020). Amphibians also have narrow thermal tolerances, and they are particularly sensitive to changes in microclimate conditions (Bury 2008). Several studies have documented significant increases in maximum stream temperatures associated with the removal of riparian vegetation (Beschta et al. 1987; Murray et al. 2000, Moore et al. 2005, Gomi et al. 2006). Considering the correlation between riparian vegetation and stream temperature, loss of vegetation presents a risk to the affected fish species. The importance of riparian vegetation in maintaining viable stream temperatures is clear in the literature (Quinn et al. 2020).

Several studies have considered the extent to which various riparian zone widths modulate stream temperature. In headwater streams in British Columbia, 10 m (33 ft) riparian zones generally minimized effects on stream temperature from timber harvest, although maximum daily temperatures reached 3.6°F higher than control streams (Gomi, Moore, & Dhakal, 2006). A comparative study of 40 small streams in the Olympic Peninsula found that mean daily maximum temperatures were 2.4°C higher in logged compared to unlogged watersheds, and that logged watersheds had greater diurnal fluctuations in water temperatures (Pollock M. , et. al., 2004). Another study of streams in Washington found that stream temperatures were most closely correlated with vegetation parameters associated with the riparian area, such as total leaf area and tree height, and that the effect of buffer width was less significant, particularly for buffers larger than 30 m (98 ft) (Sridhar, et. al., 2007). These findings are consistent with an earlier study relating angular canopy density, a proxy for shading, to riparian buffer width, which found that the correlation between shade and riparian buffer width increases up to around 30 m (98 ft) (Beschta, 1987). Therefore, for buffers less than 30 m (98 ft), buffer width is expected to be more closely related to shading and stream temperatures than buffers over 30 m (98 ft).

Riparian microclimate affects many ecological processes and functions, including plant growth, decomposition, nutrient cycling, succession, productivity, migration and dispersal of flying insects, soil microbe activity, fish and amphibian habitat (Brosofske, et. al., 1997). Riparian buffers necessary to maintain forest microclimate are controlled by edge effects, which tend to extend well into forested areas adjacent to clearings. However, riparian buffers ranging from 10-45 meters in width may minimize microclimate effects related to light, soil, and air temperatures. A study of small streams in Western Washington indicated that buffers greater than 45 m (147 ft) wide are generally sufficient to protect riparian microclimate in streams (Brosofske, et. al., 1997).

### STREAM MIGRATION AND BANK STABILITY

Streams migrate naturally which often results in complex natural geomorphology, floodplains, and heterogeneous ecosystems. One consequence of the erosive power of streams is damage to human-infrastructure. Bank stability is influenced by factors such as bank material, hydraulic forces, and vegetation (Ott, 2000). Riparian vegetation improves bank stabilization through root networks which encapsulate and anchor soil particles and rocks, thereby reducing soil movement. Vegetation also reduces the quantity of surface water runoff through rainwater capture and evapotranspiration. The effectiveness of bank stabilization is also dependent on the type of vegetation present. For example, woody vegetation tends to provide greater bank stability than herbaceous vegetation because woody vegetation has larger and firmer roots that extend deeper into the streambank (Wynn & Mostaghimi, 2007).

Bank stability is lower in urban watersheds because factors such as vegetation composition and hydraulic forces are degraded. The width of vegetated riparian buffers improves bank stability up to a distance of approximately 80 to 100 feet, after which diminishing returns limit marginal benefits (Castelle, Johnson, & Conolly, 1994).

### *Riparian Influence on Water Quality*

Water quality is characterized by several physical, chemical, and biological factors, including temperature, suspended sediment, nutrients, metals, pathogens, and other pollutants. These water quality parameters are influenced by riparian areas, and other terrestrial environments which control shade and runoff.

Conversion of natural environments to developed sites often results in a reduction of infiltration and an increase in surface flows, resulting in sediment and contaminants being transported more directly to receiving bodies, bypassing natural soil filtration and flow attenuation processes. Consequentially, urban areas tend to contribute a disproportionate amount of sediment and contaminants to receiving waters (Serrano, 1996). Heavy metals, bacterial pathogens, as well as PCBs, hydrocarbons, and endocrine-disrupting chemicals are aquatic contaminants that are commonly associated with urban and agricultural land uses.

The full suite of sublethal and indirect effects of urban contaminants and combinations of contaminants on aquatic organisms is under study. Likely some contaminants with potentially severe repercussions for fish and wildlife have yet to be identified. For example, research in the Puget Sound region had identified mature coho salmon that return to urban creeks and die before spawning, a condition called pre-spawn mortality (Feist et al. 2011, Sholz et al. 2011). After a prolonged investigation, the specific cause of the condition has been recently attributed to 6PPD-quinone, a breakdown product of tire wear (Tian et al., 2020). Coho pre-spawn mortality is also positively correlated with the relative proportion of roads, impervious surfaces, and commercial land cover within a basin (Feist et al. 2011

### *Sediment*

Sediment input to streams is supplied by bed and bank erosion, landslides, and upland erosion processes. These processes occur naturally but are acutely associated with and accelerated by forest practices and development activities. Other contaminants, including heavy metals and phosphorus, readily bond to suspended clay particles, and these contaminants are often transported with fine sediment in stormwater.

Excess inputs of fine sediments (e.g., silt and clay particles) into stream channels reduce habitat quality for certain species of fish, amphibians, and macroinvertebrates. Fine sediment adversely affects stream habitat by filling pools, embedding gravels, reducing gravel permeability, and increasing turbidity. In salmon-bearing streams, fine sediment fills interstitial spaces in redds, reducing the flow of oxygenated water to developing embryos and reducing egg-to-fry survival (Jensen et al. 2009). For example, highly turbid water can impair fertilization success in spawning salmonids and interfere with the respiration and reproduction of amphibians (Galbraith et al. 2006; Knutson et al. 2004). Fine sediments that settle out of the water column can smother gravel and cobble streambeds that are essential habitat for salmonid spawning and for benthic macroinvertebrates. These fine sediments fill interstitial spaces of gravel in redds, reducing the flow of oxygenated water to developing salmonid embryos and reducing egg-to-fry survival (Jensen et al. 2009).

Excessive sediment loads can significantly degrade water quality. Additionally, sediments tend to serve as a transport mechanism for other pollutants, carrying attached contaminants from upland sources to the stream channel. Suspended sediment can also cause gill abrasion in fish and interfere with foraging and predator avoidance (Quinn et al. 2020).

Vegetated riparian zones help stabilize stream banks by slowing and filtering overland flow, and temporarily storing sediment that is gradually released to both seasonal and perennial streams. Sediment filtration is also high within intermittent and ephemeral streams, presumably because of the high interface with vegetative structures and the flux in water surface elevation, which allows for sediment storage along the streambanks (Dietrich and Anderson 1998).

Upland clearing and grading can result in long-term increases in fine sediment inputs to streams (Gomi et al. 2005, Jackson et al. 2007). Numerous studies have investigated the effectiveness of varying widths of buffers at filtering sediment. These studies have typically found high sediment filtration rates in relatively narrow buffer areas without a significant improvement in sediment retention beyond 15 meters (Abu-Zreigh et al. 2004; Parkyn 2004; Sheridan et al. 1999; Wenger 1999; Yuan et al. 2009).

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

Additionally, studies on sediment retention in riparian zones are often based on a single storm event, rather than accounting for sediment accumulation over time. Two of the reviewed studies used Cesium-137 to track the location of sediment deposition over many years (Cooper et al. 1988; Lowrance et al. 1988; Wenger 1999). The findings of these studies suggest that riparian zones from 30-100 m (98-328 ft) or more may be necessary to provide long-term sediment retention and that studies of short-term sediment retention underestimate the riparian zone width needed for ongoing sediment filtration (Cooper et al. 1988; Lowrance et al. 1988; Wenger 1999).

In addition to riparian zone width, the slope, vegetation density, and sediment composition of a riparian area have a significant bearing on sediment filtration potential (Jin and Romkens 2001). A recent model of sediment retention in riparian zones found that a grass riparian zone as small as 4 m (13 ft) could trap up to 100% of sediment under specific conditions (i.e., 2% hillslope over fine sandy loam soil), whereas a 30 m (98 ft) grass riparian zone would retain less than 30% of sediment over silty clay loam soil on a 10% hillslope (Dosskey et al. 2008) (Figure 12). This study demonstrates the effects that soil type and hillslope have on sediment retention.

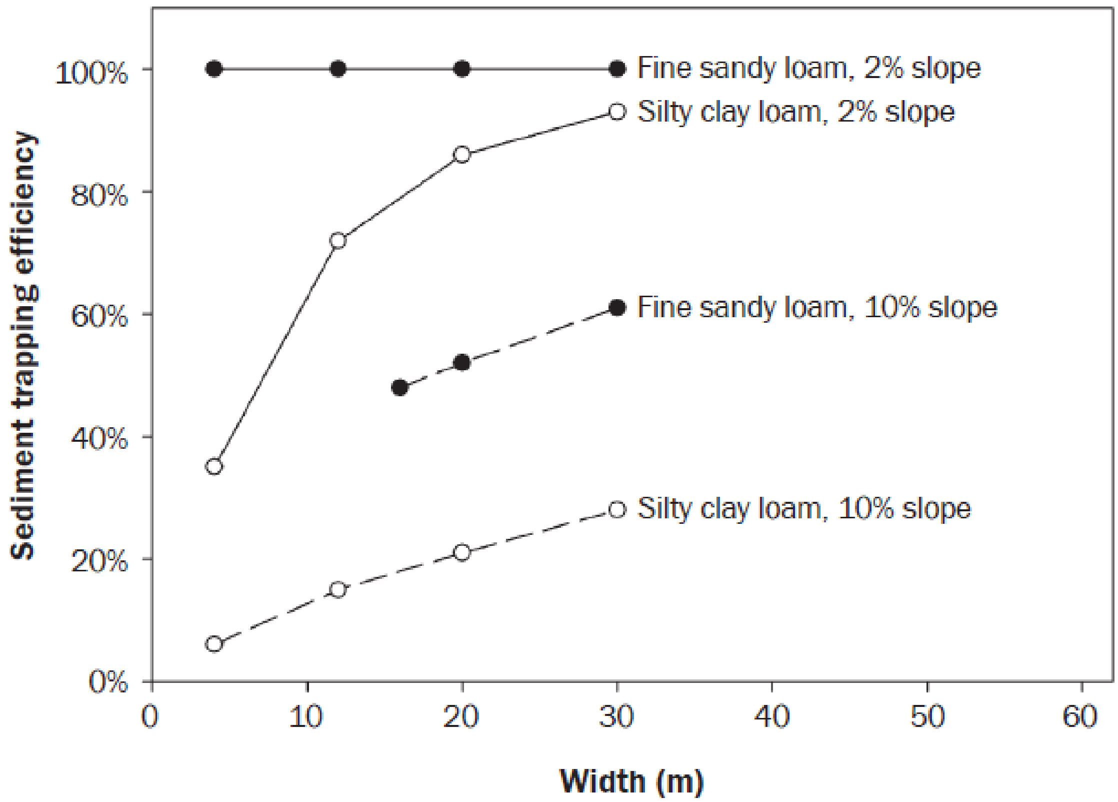


**Figure 12.** Sediment trapping efficiency related to soil type, slope, and buffer width. (Reproduced from Dosskey et al. 2008).

Multiple studies have found that larger particles tend to settle out within the first 3-6 m (10-20 ft) of the riparian zone, but finer particles that tend to degrade instream habitats, such as silt and clay, need a larger riparian zone, ranging from 15-120 m (49-394 ft), for significant retention (Parkyn 2004).

Vegetative composition within the buffer also affects sediment retention. Vegetation tends to become more effective at sediment and nutrient filtration several years after establishment for both grass and forested buffers (Dosskey et al. 2007). Thin-stemmed grasses may become overwhelmed by overland flow while dense, rigid-stemmed vegetation provides improved sediment filtration that is expected to continue to function better over successive storm events (Blanco-Canqui et al. 2004, Yuan et al. 2009).

### *Nutrients*

Established vegetation in a dense composition can provide effective sediment and nutrient filtration (Dosskey et al. 2007). Riparian zones can also reduce nitrogen pollution through nutrient uptake, assimilation by vegetation, and denitrification (Sobota et al. 2012). In excess concentrations, nitrogen and phosphorus can lead to poor water quality conditions, including reduced dissolved oxygen rates, increased pH, and eutrophication (Mayer et al. 2005, Mayer et al. 2007). Excessive amounts of nitrogen and phosphorus speed up eutrophication and algal blooms in receiving waters, which can deplete the dissolved oxygen in the water and result in poor water quality and fish kills (Dethier 2006; Heisler et al. 2008; Mayer et al. 2005).

Riparian zones can reduce nitrogen pollution through nutrient uptake, assimilation by vegetation, and through denitrification (Sobota et al. 2012). The rate of nitrogen removal from runoff varies considerably depending on local conditions, including soil composition, surface versus subsurface flow, riparian zone width, riparian composition, and climate factors (Mayer et al. 2005, Bernal et al. 2007, Mayer et al. 2007). Nutrient assimilation is also dependent on the location of vegetation relative to the nitrogen source, the flow path of surface runoff, and its position in the landscape (Baker et al. 2006).

Nutrients enter waterways through channelized runoff, groundwater flow, and overland flow. Nitrogen loading is often associated with agricultural activities, whereas low-density residential development has been found to result in nitrate levels comparable to a forested basin (Poor and McDonnell 2007).

Mayer et al. (2005, 2007) found that there was little relationship between riparian zone width and removal of subsurface nitrates. Subsurface nitrates were removed effectively regardless of riparian zone width. Conversely, nitrate removal from surface runoff is related to riparian zone width, and 50%, 75%, and 90% of surface nitrate removal was measured at widths of 27 m (88 ft), 81 m (266 ft), and 131 m (430 ft) respectively (Mayer et al. 2007). This suggests that surface water infiltration in the riparian zone should be a priority to promote effective nutrient filtration. Where soils are poorly drained and infiltration capacity is limited, the effectiveness of nutrient removal in riparian buffers may also be limited (Wigington et al 2003).

The size and species composition of the riparian zone buffer also affect the efficiency of nutrient removal, but studies are conflicting as to whether grass, wetland, herbaceous, or forested buffers are most effective at removing nutrients (Polykov 2005). Where nitrogen-fixing species predominate, such as red alder, these buffers tend to have higher soil nitrate concentrations (Monohan 2004).

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

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

### *Metals*

Although most metals can be toxic at high concentrations, cadmium, mercury, copper, zinc, and lead are particularly toxic even at low concentrations. Chronic and acute exposure to heavy metals have been found to impair, injure, and kill to aquatic plants, invertebrates, fish, and particularly salmonids (Grant and Ross 2002, Dethier 2006, Hecht et al. 2007, McIntyre et al. 2008, McIntyre et al. 2012). The toxicity of metals is influenced by a variety of factors including (Duffus et al 2002; Nagajyoti et al. 2010; Tchounwou et al 2012; Wang & Rainbow 2008):

- Properties of the metal
- Duration, frequency, and concentration of exposure
- The form and bioavilability of the metal at the time of exposure
- Environmental conditions including water chemistry and physical properties such as pH, temparature, and salinity
- Synergistic, additive, or antagonistic interactions of co-occurring contaminants
- Species sensitivity
- Life stage
- Physiological ability to detoxify and/or excrete the metal and,
- The condition of the exposed organism.

Metals are typically transported to the aquatic environment through fossil fuel combustion, industrial emissions, municipal wastewater discharge, and surface runoff. In general, heavy metals and hydrocarbons (e.g., leaked motor oil, polycyclic aromatic hydrocarbons) are found in road runoff, and these contaminants can reach the County's streams directly through existing stormwater systems. Stormwater systems that circumvent buffers limit the opportunity to filter runoff through adjoining soils and vegetation. Accordingly, stream buffers are typically underutilized for treatment of metals, hydrocarbons, and other pollutants found in typical stormwater runoff.

Copper brake pad dust has also been linked to chronically depressed Chinook salmon populations (U.S. EPA 2007). The U.S. EPA is working to reduce the use of copper and other heavy metals in motor vehicle brake pads through the *Copper-Free Brake Initiative* (U.S. EPA 2015a).

### *Pathogens*

Waterborne pathogens associated with human and animal wastes are a concern for direct and indirect human exposure. Fecal coliform bacteria, specifically E. coli, is typically used as an indicator of the possible or presumed presence of a suite of bacterial and viral pathogens. Fecal pollution tends to be positively correlated with human population densities and impervious surface coverage (Glasoe and Christy 2004). The main sources of fecal pollutants include municipal sewage systems, on-site sewage systems, stormwater runoff, marinas and boaters, farm animals, pets, and wildlife (Glasoe and Christy 2004). As municipal wastewater systems have improved treatment quality and capacity in recent years, increasingly, non-point source pollution, including septic systems, stormwater, wildlife, and pets, is responsible for fecal contaminants in surface water (Glasoe and Christy 2004).

### *Herbicides and Pesticides*

Commonly used herbicides, pesticides, and other pollutants may also affect aquatic communities, and the acute and chronic effects of these chemicals or combinations of chemicals are not always well understood. Additionally, effects documented in the laboratory may differ significantly from effects identified in a field setting (Relyea 2005, Thompson et al. 2004). The effects of these chemicals may be long-lasting, as has been observed for legacy pollutants such as polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) in salmon, seabirds, and marine mammals in Puget Sound

(Calambokidis et al. 1984, O’Neill et al. 1998, Ross et al. 2000, Wahl and Tweit 2000, Grant and Ross 2002, O’Neill et al. 2009).

Herbicides and pesticides may reach aquatic systems through several pathways, including surface runoff, erosion, subsurface drains, groundwater leaching, and spray drift. Narrow hedgerows have been found to limit 82-97 percent of the aerial drift of pesticides adjacent to a stream (Lazzaro et al. 2008). In runoff, herbicide retention in a buffer is dependent on the percentage of runoff that infiltrates the soil (Misra et al. 1996). A study of herbicides in simulated runoff found that 6-meter-wide vegetated buffers were sufficient to remove 100% of the tested herbicides (Otto et al. 2008). A meta-analysis found that filtration effectiveness increased logarithmically from 0.5 m to an asymptote at approximately 18 m (Zhang et al. 2010). In summary, relatively narrow vegetated buffers may be effective in limiting herbicides and pesticides from reaching aquatic habitats in surface runoff, erosion, and spray drift; however, these processes are best managed using best management practices in herbicide and pesticide applications to avoid contaminating groundwater (Reichenberger et al. 2007).

### *Pharmaceuticals*

Pharmaceuticals are another class of contaminants which have been demonstrated to have negative impacts on the health of humans and aquatic organisms. There are a wide range of pharmaceutical compounds and toxicological research is variable, with many that are poorly understood. Many commonly used pharmaceuticals are found in wastewater, particularly around more urban areas (Long et al. 2013). Many common pharmaceuticals have endocrine-disrupting properties, which can affect fertility and development in non-target aquatic species (Caliman and Gavrilescu 2009). The existing and potential population-scale effects of these chemicals in the environment are not yet well-understood (Mills and Chichester 2005, Caliman and Gavrilescu 2009).

## WILDLIFE HABITAT

The primary function of FWHCAs is the role they provide as habitat for fish and wildlife. All of the functions and processes listed above relate to habitat, and this section provides additional information on entire ecosystems rather than individual constituent parts.

Riparian ecosystems, including streams and associated riparian areas, including wetlands, provide important wildlife habitat due to the presence of unique structures and processes. Ecological resources important to species diversity and abundance include but are not limited to structural complexity, connectivity to other ecosystems, plentiful sources of food and water, and a moist moderate microclimate, though this depends on the scale and ecological context (Knutson and Naef 1997). Riparian ecosystems, depending on site-specific conditions, landscape position, and surrounding land use, will have some or all of these habitat features.

Aquatic ecosystems, including streams, lakes, and wetlands provide habitat for a broad range of fauna including invertebrates, reptiles and amphibians, anadromous and resident fish, birds, and mammals. Aquatic invertebrates that depend on stream and wetland ecosystems are important to aquatic trophic systems or food webs (Rosenberg and Danks 1987, Wissinger 1999, both in Sheldon et al. 2005). Native frogs and salamanders require wetlands for breeding. Buffer conditions, habitat interspersion, wetland hydroperiod, and emergent plants are all important factors that impact amphibian richness and abundance (Sheldon et al. 2005). Wetlands with surface connections to salmon-bearing streams can provide backwater refuge for anadromous fish if they also have ponded water at least 18 inches deep, low flow conditions, and cover such as overhanging or submerged plants (Sheldon et al. 2005). Waterfowl rely upon riparian ecosystems for all or part of their life cycle (Kauffman et al. 2001; Sheldon 2005). The suitability of habitat for birds is dependent on buffer condition and width, presence of snags or other perches, corridor connections, open water, and forest canopy cover (Sheldon et al. 2005). Water-associated mammals such as beaver and muskrat also seek out well-buffered vegetated corridors, interspersed habitats with open water, and a seasonally stable water level (Sheldon et al. 2005). According to a WDFW management recommendation plan conducted by Knutson and Naef (1997) a predominance of terrestrial vertebrate species in Washington are dependent on streams and riparian areas, including wetlands. Semlitsch and Bodie (2003) found that upland areas surrounding wetlands are core habitats for many semi-aquatic species, such as amphibians and reptiles.

Riparian and wetland ecosystems also support a diverse range of native plant species. Wetland characteristics that are correlated with plant richness are the hydroperiod, duration of flooding, and variation in water depths (Schueler 2000; Sheldon et al. 2005). Vegetated areas surrounding streams and wetlands perform several important functions that in turn protect their habitat functions.

Habitat fragmentation is a consequence of urbanization. As land is developed, continuous tracts of native habitat are reduced to patches, which become progressively smaller and more isolated. Ecological impacts of development are often overlooked and landscape-scale changes, particularly habitat fragmentation, alter the structure and function of those ecosystems (Dale et al. 2000).

The performance of stream and wetland habitat functions is affected to varying degrees by the width and/or character of the surrounding buffers. Habitat loss related to urbanization reduces wetland buffering and increases human encroachment. Disturbance vectors include but are not limited to habitat loss, habitat modification, noise, light, physical intrusion by equipment, people, pets, air and water pollution, and garbage. Each of these vectors can result in one or more of the following: disruption of essential wildlife activities, damage to native vegetation and invasion of non-native species, erosion, or fill, among others.

Cumulative impacts of direct and indirect riparian ecosystem alterations, including hydrologic changes, compromised water quality, and habitat fragmentation tend to reduce the habitat functions and values of wetlands and riparian areas (Sheldon et al. 2005, Azous and Horner 2010).

## 6.3 Key Protection Strategies

### 6.3.1 Streams, Lakes[21] and Ponds, and Riparian Areas

#### STREAM CLASSIFICATION

Flow conditions, fish habitat, seasonality, and accessibility for salmonids are commonly assessed to determine stream classifications. The DNR is encouraging all jurisdictions within the State to adopt the permanent water typing system upon completion of fish habitat water type mapping. The permanent system provides for four stream classes, Type S (water of the State), Type F (fish habitat present), Type Np (non-fish habitat stream with perennial flow), and Ns (non-fish habitat stream with seasonal flow). The water typing system is detailed in WAC 222-16-030.

[21] Lakes that exceed 20-acres are regulated separately under the Shoreline Master Program, therefore discussed BAS is focused on lakes smaller than this threshold.

## RIPARIAN MANAGEMENT ZONES

In 2020, the WDFW came out with new guidance (Rentz et al. 2020) for the protection of riparian areas. The guidance emphasizes a shift in terminology from the concept of "*stream buffers*" to "*riparian management zones*" (RMZs). An RMZ is defined as "…*a scientifically based description of the area adjacent to rivers and streams that has the potential to provide full function based on the SPTH [site potential tree height] conceptual framework*." Further, an RMZ is recommended to be regulated as a fish and wildlife habitat conservation area itself to protect its fundamental value, rather than as a buffer for rivers and streams (Rentz et al. 2020). Stream buffers are established in local critical areas ordinances based on the best available science and are intended to protect streams but may or may not provide full riparian function or a close approximation of them. To achieve full riparian function, the guidance recommends that RMZs be considered a delineable, regulatory critical area and that the guidance be applied to all streams and rivers, regardless of size and type.

WDFW's current recommendations for establishing RMZ widths are based primarily on a SPTH framework. The SPRH is defined as "…*the average maximum height of the tallest dominant trees (200 years or more) for a given site class.*" Exceptions may occur where the SPTH is less than 100 feet, in which case the agency recommends assigning an RMZ width of 100 feet at a minimum to provide adequate biofiltration and infiltration of runoff for water quality protection from most pollutants, but also in consideration of other habitat-related factors including shade and wood recruitment. A 100-foot-wide buffer is estimated to achieve 95% pollution removal and approximately 85% surface nitrogen (Rentz et al. 2020). WDFW recommends measuring RMZ widths from the outer edge of the CMZ, where present, or from the ordinary high-water mark where a CMZ is not present.

To apply their methodology, the WDFW has developed a web-based mapping tool for use in determining SPTH based on the 200-year site index. Modeled SPTH heights range from 75-231 feet. Where the SPTH is 100 feet or more, the agency recommends RMZ establishment within one SPTH, driven by the largest dominant tree species at any location. Acknowledging that establishing functional RMZs using the recommended methods may not be practical in many developed areas, WDFW recommends effective watershed management, preservation, and protection, resulting in nearly full restoration of riparian ecosystem habitat functions as is feasible within existing constraints. WDFWRMZ establishment and management recommendations are detailed in their *Riparian Ecosystems, Volume 2: Management Recommendations* document (Rentz et al. 2020). Examples of watershed-scale approaches include considering stormwater management adjacent to pollution-generating impervious surface areas and prioritizing impassable culverts on fish-bearing streams.

A graphical representation of the Forest Ecosystem Management Assessment Team (FEMAT) Curves are shown in Figure 13, conceptually similar to WDFW's recommendations for establishing the bounds of RMZs (Windrope et al 2020). The figure shows level of function of various riparian habitat attributes by distance to a stream. The SPTH is one point along a continuum of potential buffer widths, with the highest rates of return on all habitat functions except root strength generally occurring within the inner buffer.

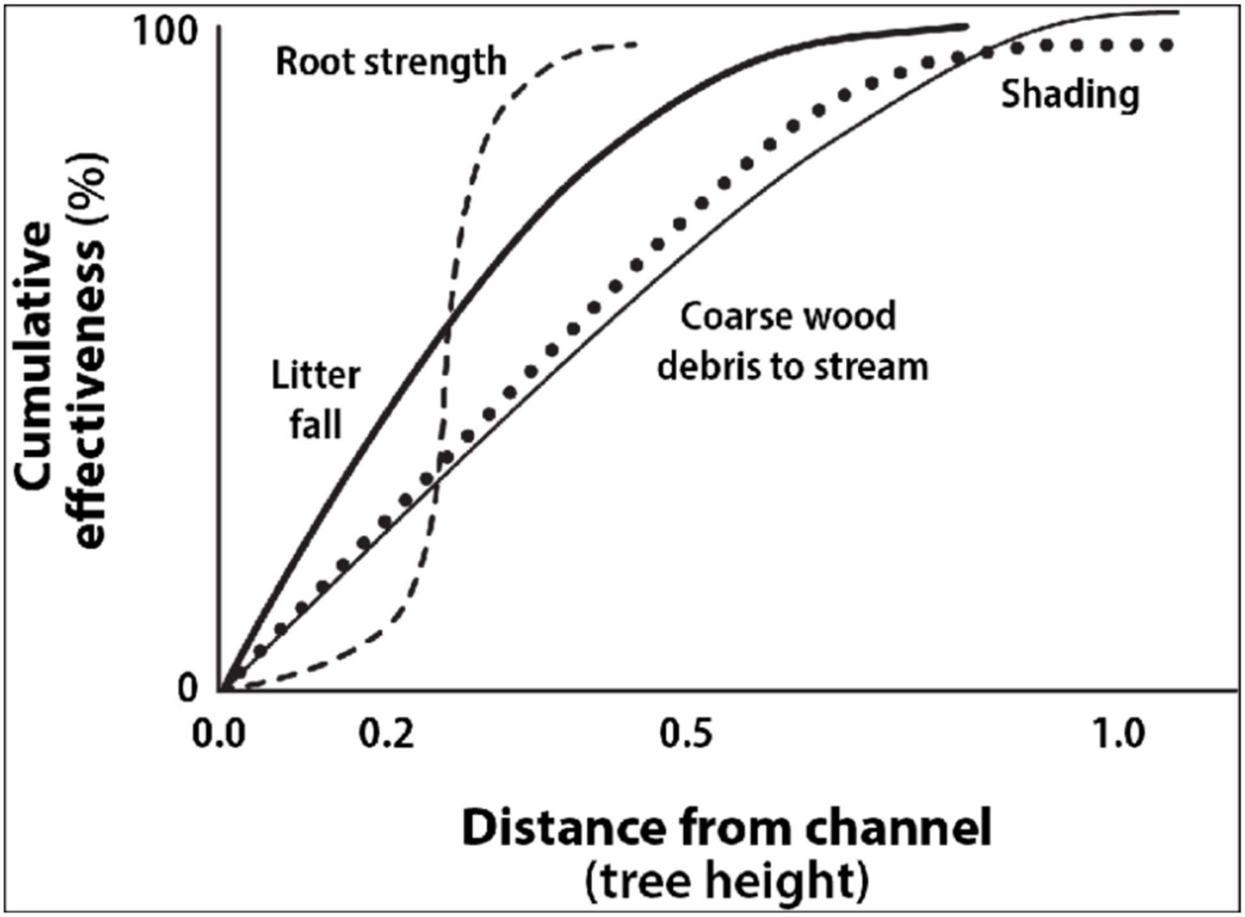


**Figure 13.** FEMAT Curves": a generalized conceptual model describing contributions of key riparian ecosystem functions to aquatic ecosystems as the distance from a stream channel increases. "Tree height" refers to average height of the tallest dominant tree (200 years old or greater); referred to as site-potential tree height (SPTH). Reproduced from FEMAT (1993).

Many of the scientific studies that examine the functions and values associated with riparian areas have been conducted in forested environments. However, there are fundamental differences between forested, agricultural, and urban areas, including land use and hydrology. Riparian studies often do not account for the contribution of engineering and public works projects, such as surface-water detention facilities, which can supplement natural riparian function in urban settings.

BAS-based literature points to a range of recommended management measures and buffer considerations to help maintain habitat functions for fish and wildlife. Effective methods to reduce impacts from urbanization and manage associated runoff can include the following:

- Limiting development densities and impervious surface coverage;
- Limiting vegetation clearing and retaining forest cover;
- Concentrating impact activities, particularly roads and pollutant sources, away from watercourses;
- Limiting the total area of roads and requiring joint use of new access roads;

- Protecting vegetation and limiting development on or near hydrologic source areas;
- Maintaining densely vegetated riparian buffers with native trees, shrubs, and groundcover species;
- Low impact development (LID);
- Municipal stormwater treatment;
- Public education.

In an analysis of riparian zone ordinances, Wenger and Fowler (2000) support using approaches that allow some flexibility in how policies are implemented on a parcel scale. Whereas variable-width policies provide greater flexibility and adaptability to address site-specific conditions, it is noted that fixed buffer widths are more easily established, require a lesser degree of scientific knowledge to implement, and generally require less time and money to administer (Castelle and Johnson 1998). Thus, although stream and riparian conservation measures should be based in best available science, some level of policy interpretation must be made by a local jurisdiction.

If fixed-width buffers are implemented, buffers should be sufficiently wide to ensure that riparian buffers are effective under a range of variable conditions. The ranges of effective buffer widths (as outlined in each subsection) based on each function that were previously discussed are summarized below in Table 3.

**Table 3.** Range of Effective Buffer Widths for Each Applicable Riparian Function.

| Function | Range of Effective Buffer Widths | Notes |
|---|---|---|
| Water quality: sediment | 4-30 m (13-98 feet), up to 120 m (394 feet) for fine sediment | Filtration is widely variable depending on slope and soils. |
| Water quality: nutrients | Subsurface flow: not dependent on buffer width<br><br>Surface flow: 15-131 m (49-430 feet) | In addition to buffer width, the rate of nutrient removal is dependent on infiltration, soil composition, and climate. Filtration capacity decreases with increasing loads, so best management practices that reduce nutrient loading will improve riparian function. |
| Water quality: metals | NA- Appropriate buffer width not established | Stormwater system improvements to slow and infiltrate runoff could help reduce metals entering aquatic systems. |
| Water quality: pathogens | NA- Appropriate buffer width not established | Minimizing the density of septic systems, maximizing the distance of septic systems from aquatic resource areas, and promoting pet waste management will help limit the transport of pathogens to aquatic systems. |

| Function | Range of Effective Buffer Widths | Notes |
|---|---|---|
| Water quality: herbicides | 6-18 m (20-59 feet) | Best management practices during application of herbicides and pesticides can help limit leeching to groundwater. |
| Water quality: pharmaceuticals | NA- Appropriate buffer width not established | Best management practices for disposal of pharmaceuticals may limit potential impacts. |
| Water quality: stream temperature | 10-30 m (33-98 feet) | Leaf cover is more closely related to stream temperature than buffer width. |
| Bank Stabilization | 10-30 m (33-98 feet) | Beyond 98 feet from the stream, buffers have little effect on bank stability. |
| Microclimate | (10-45 m) 33-150 feet | Most microclimate changes occur within 10-45 m (33 to 150 feet) from the edge, but microclimate effects extend over 240 m (790 feet) from the forest edge. |
| Invertebrates and Detritus | 30 m (98 feet) | Areas with 10 m (33 ft) buffers exhibit changes in invertebrate community composition. |
| Wildlife Habitat | 100 to 600 feet | Minimum width for supporting habitat varies among taxa, guides, and species. Functions include both corridor (travel and migration) and support of lifecycle stages, including breeding. |
| In-stream Habitat (large woody debris – LWD) | 18-50 m (59 to 164 feet) | Although most LWD is recruited from the area adjacent to the stream, tree-fall from beyond 1 SPTH may affect LWD loading. |

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

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

### FEMA FLOODPLAIN HABITAT ASSESSMENTS

In 2008, the National Marine Fisheries Service (NMFS) issued a Biological Opinion under Section 7 of the Endangered Species Act (ESA), which found that the implementation of the National Flood Insurance Program (NFIP) in the Puget Sound region jeopardized the continued existence of federally threatened salmonids and resident killer whales. As a result, NMFS established Reasonable and Prudent Alternatives to ensure that development within the Special Flood Hazard Area (100-year floodplain), floodway, Channel Migration Zone (CMZ), and riparian buffer zone do not adversely affect water quality, flood volumes, flood velocities, spawning substrate, or floodplain refugia for listed salmonids. Because the NFIP is implemented by the Federal Emergency Management Agency (FEMA) through participation by local jurisdictions that adopt and enforce floodplain management ordinances, FEMA has delegated responsibility to the local jurisdictions to ensure that development does not adversely affect listed species. Projects within FEMA-designated floodplains are required to prepare habitat assessments to ascertain their potential effects on federally-listed endangered species. In particular, floodplain storage volumes may not be decreased, nor base flood level elevations increased.

### 6.3.2 Endangered, Threatened, or Sensitive Species and Species of Local Importance

Effective BAS-based strategies can be applied to protect all Federal and State endangered or threatened species and WDFW-identified Priority Species and Habitats (PHS). Not all FWHCAs are water bodies or riparian areas associated with those water bodies. WDFW, USFWS, and NMFS provide information on species-specific management recommendations for certain species that can be used to guide management at the county level or site level. There is widely available information for high profile species, though many regulated species are poorly researched and lack specific management recommendations from state agencies. Where species-specific management recommendations are available from WDFW guidance documents, those should be followed or adapted to local regulations. Examples are Management Recommendations for Washington's Priority Species; Invertebrates (Larsen 2018); amphibians and reptiles (Larsen 1997); Birds (Larsen 2018); and mammals (WDFW 2010). General recommendations for management strategies to protect terrestrial habitat are listed below.

#### GENERAL TERRESTRIAL HABITAT MANAGEMENT RECOMMENDATIONS

- Existing high quality habitats should be retained because habitat loss is one of the most important factors influening biodiversity and loss of species .
- Generally, plan development to minimize fragmentation of native habitat, particularly large, intact habitat areas. Where large forest stands exist, manage for forest-interior species and avoid fragmentation.
- Manage agricultural development to limit fragmentation and edge; preserve vegetative structural diversity whenever possible in agricultural areas by retaining hedge rows and areas of native vegetation.
- Protect priority habitats that have a primary association with an ESA-list species or species of local importance by continuing to regulate for adherence to WDFW management recommendations and other applicable regulatory requirements.
- Control invasive species where needed on a site- and species-specific basis. Address invasive species specifically addressed in areas where environmental conditions tend to promote infestation, including created edges, roadways, and riparian zones where they are contiguous with developed areas that may act as a seed source.
- Maintain or provide habitat connectivity with vegetated corridors between habitat patches.
- Protect, maintain, and promote habitat features such as snags and downed wood.
- Manage for increase native vegetative cover in landscaping and discourage lawns.
- Plan habitat areas away from roads.
- Promote buffers of adequate width to support wildlife guilds in adjacent habitat.

- Identify existing habitat patches and corridors and maintain connectivity with vegetated corridors to limit fragmentation and edge habitat. Preserve habitat patches of at least moderate size 35 ha (86 ac) within developed areas.
- Promote restoration of FWHCAs, buffers, and other management zones through critical area regulations and public outreach. Encourage stewardship on a parcel by parcel and county-wide scale.

## 6.4 Climate Change Impacts & Mitigation

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

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

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

### 6.4.1 Strategies to manage climate change impacts to FWHCAs

The following actions or policies have been developed by the City of Redmond (2022) in collaboration with the University of Washington Climate Impacts Group, and have the potential to reduce negative climate change impacts on FWHCAs within Lewis County.

- Promote retention of significant trees and maintain tree replacement requirements.
- Encourage and incentivize enhancement and restoration of native forest patches throughout the County, particularly where connectivity to one or more FWHCAs is identified. Both voluntary and required restoration planting should be paired with monitoring and maintenance that allows for dry season irrigation and adaptive management.
- Encourage the use of local nursery plant stock grown under current conditions to increase resilience of plant communities considering climate stressors.

- Manage stormwater infrastructure to avoid and minimize discharges of increased and/or untreated runoff to streams and thereby offset the anticipated increase in intensive rainfall events. Promote the use of LIDs as a tool to effectively manage stormwater for minimal downstream impacts.
- Update and maintain regulations for habitats and species of local importance. This may include adding mapping resources to help identify the locations of potential habitats and species requiring protection and management.
- Prioritize protection of streams and riparian corridors to reduce the stresses of climate change on native fish species and anadromous fish, such as chinook salmon.

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