Thurston County Voluntary Stewardship Program Work Plan

Appendix J – Critical Area Functions and Agricultural Activities

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1 Critical Area Functions and Agricultural Activities

The following section outlines some of the complex relationships between primary functions and values of critical areas and potential effects (both positive and negative) from agricultural activities. The VSP statute requires the workgroup to "create measurable benchmarks that, within ten years after the receipt of funding, are designed to result in (i) the protection of critical area functions and values and (ii) the enhancement of critical area functions and values through voluntary, incentive-based measures" (RCW 36.70A.720 (e)), as well as maintaining and improving the long-term viability of agricultural activities. In order to meet this requirement and the goals of VSP it is important to understand (i) what the primary functions and values of critical areas are, (ii) what the relationship to agricultural activities is, and (iii) what the effects of conservation practices on critical area functions and values are.

Summary of Critical Area Functions and Values

The following table provides a summary of the primary functions and values provided by each critical area. The primary functions and values identified for each critical area fall into four main categories: water quality, hydrology, soil health, and wildlife habitat. All five critical areas provide most of these key functions and values, however the functions and values provided by critical areas are not limited to these four main types.

Critical Area Primary Functions

Critical Area	Primary Functions			
	Water Quality	*Hydrology*	*Soil Health*	*Wildlife Habitat*
Fish and Wildlife Habitat Conservation Areas	✓	✓	✓	✓
Wetlands	✓	✓	✓	✓
Critical Aquifer Recharge Areas	✓	✓		✓
Frequently Flooded Areas	✓	✓	✓	✓
Geologically Hazardous Areas	✓	✓	✓	✓

1.1 Critical Areas and Agricultural Activities – The Relationship

The relationship between critical areas and agriculture is complex and impacts can flow in both directions. Critical areas can affect agricultural activities and viability just as agricultural activities can impact the functions and values of critical areas. This relationship can be mutually beneficial. Agricultural activities and conservation practices may have positive impacts to critical areas and the protection and enhancement of critical areas may also support agricultural activities. For example, protecting aquifer recharge areas can assure clean water for agricultural operations and enhancing habitat areas for beneficial wildlife such as pollinators, which can in turn increase the productivity of crops. The table below summarizes the impacts and relationship between certain common agricultural activities and critical areas.

Summary of Agricultural Activities and Potential Critical Area Impacts

Agricultural Activity	Aquifer Recharge Areas	Wetlands	Fish and Wildlife Habitats	Geologic Hazard Areas	Frequently Flooded Areas
Building access roads and other impervious surfaces	Can decrease water infiltration and recharge	Can change surface water - temp and chemicals	Can cause loss of habitat and connectivity, changes to surface water hydrology	Can increase erosion	Can create changes in water infiltration and fine sediment
Fencing	Can reduce potential contamination	Can reduce nutrient loads	Can inhibit movement	Can decrease erosion	
Irrigation	Can contribute to changes to groundwater flow and water table, transport of nutrients, pathogens, etc.	Can reduce water available, accumulation of salts and selenium in soil	Can contribute to a decrease in-stream flow/quantity available for wildlife		Can contribute to changes to stormflow volume, decreases in-stream flow
Clearing vegetation and harvesting crops	Can cause loss of filtration function	Can contribute to loss of filtration, temp control from shading	Can contribute to loss of habitat, food and cover	Can increase erosion, decreases slope stability	Can contribute to channel erosion, sedimentation
Pesticide and fertilizer use	Can contribute to excess nutrients and chemicals in groundwater, water quality degradation-short term and long term	Can contribute to excess nutrients and chemicals in surface water, water quality degradation	Can cause increases in mortality, absorption by amphibians, loss of beneficial insects, loss of native vegetation		
Altering hydrology: ditches/ponds	Can cause changes in groundwater flow/quantity	Can contribute to changes in surface water flow/quantity	Can cause loss and degradation of habitat	Can change natural water course and increase/decrease natural sedimentation rates	Can increase flows at certain times
Flood control: dikes and armoring banks	Can be designed to clean and infiltrate into aquifer (i.e. LOTT recharge ponds)	Can either lose or potentially increase wetlands in floodplains	Can contribute to loss of habitat structure and complexity	Can cause channel and bank erosion, reduced bank stability. Changes in natural flow paths and sediments	Can cause changes to storm flow, channel erosion. Permanently change erosion/sediment ation

Planting more land/replanting		Can cause changes in water use and level fluctuations	Can contribute to loss or simplification of habitat	Can cause soil erosion, alteration of steep slopes	Can cause sedimentation
Livestock and grazing	Can cause compaction of soil/less infiltration	Can contribute excess nutrients/waste and impact to wetland form and structure	Can cause loss of cover and forage, trampling burrows	Can cause increases in nutrient/pathogen and sediment rich flow volumes	Can cause sedimentation, reduce bank stability
Fish Hatcheries	Can cause changes in stream flow volumes for water used for riparian aquaculture	Can cause changes in nutrient loads and overall water volumes in streams and aquifers	Can introduce pathogens and excess nutrients to native fish and habitats, escaped fish compete with native fish for resources and interbreed with local stocks		
Change of agricultural use (i.e. from grazing to crops, etc.)	Can cause changes infiltration rates, groundwater flow, etc.	Can contribute to changes in surface water flow/quantity	Can contribute to changes in habitat, food, cover	Can cause changes in erosion and introduction of more or less sediments	Can cause changes in infiltration, fine sediment, storm flow, and channel erosion

1.1.1 Critical Aquifer Recharge Areas

Critical Aquifer Recharge Areas (CARAs) provide protection to areas with a critical recharging effect on aquifers used for drinking water supplies. CARAs affect groundwater quality, hydrology, and fish and wildlife habitat through groundwater infiltration and recharging lakes, wetlands, and streams.

<u>Primary Functions and Values</u>

- Fish and Wildlife Habitat
  - Many ecosystems and their functions depend on groundwater, including terrestrial vegetation, river base flow systems and aquatic habitats, wetlands, terrestrial fauna, and estuarine and nearshore ecosystems (Bergkamp & Cross, 2006). Groundwater commonly is an important source of surface water and recharges in-stream flows at critical periods for fish and wildlife habitat.
  - Recharge sufficient to maintain the normal water level elevations and soil moisture requirements of plants' root-zones, both for wetlands plants and for upland plants.
- Water Quality

  - Underground aquifers and wells are the primary source of drinking water in Thurston County.[1]
  - Infiltration through the soil column improves groundwater quality.
- Hydrology
  - Protect Minimum Instream Flow requirements (MIFs) for the five Water Resource Inventory Area (WRIA) covering 100% of Thurston County by supplying groundwater recharge needs for meeting the year-round base flows defined by:
    - Nisqually River (1981): Chapter 173-511 WAC (WRIA 11)
    - Deschutes River (1980): Chapter 173-513 WAC (WRIA 13)
    - Kennedy-Goldsborough (1984): Chapter 173-514 WAC (WRIA 14)
    - Chehalis River (1976): Chapter 173-522 WAC (WRIAs 22 and 23)

  - Recharge sufficient to meet public supply and private supply well requirements, including both senior permitted water rights and permit-exempt uses.
  - Recharge sufficient to meet the irrigation requirements of farmers.

<u>Agricultural impacts</u>

- Water Quality
  - Direct and indirect effects on rates and composition of groundwater (Böhlke, 2002).
  - Water quality degradation from salt-mobilization, salinization in waterlogged areas, and fertilizer leaching: dissolution and transportation of fertilizers and associated materials (Scanlon, et al., 2007).
  - Agricultural activities can affect the concentrations of inorganic chemicals (i.e. nitrate contamination) in aquifers. Increases in pesticides, fertilizers, and other organic compounds impact water quality and can have a wide variety of impacts on aquatic ecosystems.
  - Changes in agricultural practices and the use of BMPs such as nutrient management and lined lagoons can reduce potential contamination to aquifers (Thurston County, 2009).
- Hydrology
  - Recharge sufficient to maintain the normal water level elevations and soil moisture requirements of plants' root-zones, for both irrigated and non-irrigated crops.
  - Hydrological alterations related to irrigation and drainage: irrigation based on surface water has been shown to reduce streamflow and raise water tables. Groundwater-fed irrigation has lowered water tables and reduced streamflow (Scanlon, Jolly, & Zang, 2007). However, in Thurston County a unique geological setting often allows aquifers to recharge rapidly, which leads more commonly to issues with contamination.

1.1.2 Wetlands

"Wetlands" are areas that are inundated or saturated by surface water or by groundwater at an elevation, frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated or near-saturated soil

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[1] More information on drinking water and wells is available at: http://www.co.thurston.wa.us/health/ehdw/index.html

conditions for at least a part of normal years. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands do not include those artificial wetlands intentionally created from non-wetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after 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 non-wetland areas to mitigate conversion of natural wetlands, if permitted by the county or city. Wetlands can help reduce erosion and sedimentation, provide filtration and produce cleaner water, retain water to reduce flooding, and provide fish and wildlife habitat.

<u>Primary Functions and Values</u>

- Hydrology
    - Water storage and retention reducing flooding and maintaining water regimes, groundwater discharge/recharge, maintaining and protecting water quality, and providing clean potable water (Thurston County, 2005).
    - Soil moisture at the elevations needed for plant survival and growth.
- Wildlife Habitat
    - Biodiversity protection: freshwater ecosystems cover only 1% of the Earth's surface but they hold more than 40% of the world's species and 12% of all animal species. Wetlands are considered amongst the most productive ecosystems in the world (EPA, 2013).
    - Habitat functions: wetlands provide food, water, and shelter for numerous species of birds, fish, mammals, reptiles, and amphibians and they serve as breeding/spawning grounds, nursery and rearing habitat, as well as cover and refuge. Migratory birds depend on wetlands, and many endangered and threatened animal species require wetlands for their survival (Novitzki, Smith, & Fretwell, 1997).
- Soil Health
    - Sediment retention and erosion control: wetlands and their associated riparian zones contribute to healthy streams by suppressing the erosional processes that move sediment, mechanically filtering and/or storing upland sediments before they can enter stream channels, and dissipating energy (slows down the force of water), encouraging the deposition of sediments carried in the water (May, 2003).
- Water Quality
    - Retention of nutrients and other substances: wetlands provide biogeochemical functions that can improve water quality, including preventing eutrophication (high concentrations of nutrients) and removing toxic substances from human activities or preventing toxic substances from reaching groundwater supplies or other sources for drinking water, which can also reduce drinking water treatment costs (Thurston County, 2005; Department of Ecology, 2005).
    - Wetlands reduce sedimentation of surface water, provide water filtration, and moderate water temperatures.
- Climate change mitigation
    - Wetlands can function as carbon sinks and play critical roles in mitigating the effects of climate change.

- Ecosystem services/economic and social values
    - Provide natural flood prevention infrastructure that has lower costs than building structures that serve the same functions. Other functions include cultural, aesthetic or recreational values (Earth Economics, 2010).

Agricultural Impacts

- Hydrology
    - Direct impacts to the hydrologic function such as a change in flow from dredging or the partial filling of a wetland has a primary effect on flood storage and secondary effects on water quality. In turn, changes in both these functions alter vegetation, potentially changing a wetland's value to wildlife (Hruby, 2013).
    - Clearing of vegetation, including riparian and wetland conversion, or location of agriculture related structures in riparian and wetland critical areas can result in changes in storm flow volume, peak flow intensity and frequency, surface and channel erosion, reduced bank stability, and sedimentation, which impacts fish and their habitats in numerous ways including suffocation, as well as loss of habitat structure and complexity (King County, 2004).
- Water Quality
    - Excess nutrients and pesticides transported to surface water, wetland soils and vegetation.
        - Twenty-three pesticides were detected in waterways in the Puget Sound Basin, including 17 herbicides, many of which are commonly used in agricultural activities (Aktar et al., 2009).
        - Pesticides can bio-accumulate through aquatic food chains (build up within the tissues of organisms) and contribute to amphibian extinctions (Hruby, 2013).
        - Thurston County Best Available Science (BAS) report for wetlands (2005) found that 100 foot buffers provides 80% sediment removal except on steep slopes and adjacent to tilled fields where 300 feet may be needed. 100 feet was also found to provide 80% nonpoint source pollution and fecal removal. However, 200 feet was needed for some pesticides, and 600 feet was necessary for removing pesticides and animal waste/nutrients from croplands.
    - Agricultural activities can contribute considerable quantities of (mostly fine) sediment to streams. Loss of permanent vegetation, regular tilling of the soil, and sloughing of ditch and channelized stream banks all contribute to sedimentation (King County, 2004).
    - Poorly placed and designed roads can also increase sediment loads.

- Wildlife Habitat
    - Altering wetland hydrology also impacts vegetation and wildlife habitat. Loss of vegetation can result in decreased wildlife habitat availability and/or suitability of habitat for fauna, resulting in decreased species diversity and population size.

1.1.3 Frequently Flooded Areas

"Frequently flooded areas" (FFAs) are lands in the floodplain subject to at least a one percent or greater chance of flooding in any given year or areas within the highest known recorded flood elevation, or within areas subject to flooding due to high (shallow) ground water. This includes all areas within unincorporated Thurston County identified on flood insurance rate maps prepared by the Federal

Insurance Administration. Frequently flooded areas may include special flood hazard areas as defined in Chapter 14.38 TCC or high (shallow) ground water flood hazard areas, where high (shallow) ground water forms ponds on the ground surface, or may overlap with other critical areas, such as streams, rivers, lakes, coastal areas, and wetlands. FFAs provide temporary flood water storage and conveyance, riparian habitat and other wildlife benefits, can improve or degrade soil health based on vegetative conditions, can improve water quality, and recharge groundwater and maintain stream flows.

Primary Functions and Values

- Soil Health
    - Floodplain connectivity is critical to a properly functioning riparian ecosystem. Flooding is an essential ecological interaction between the river channel and its associated floodplain. Floodwaters carry sediment, organic material, nutrients, and organisms that can replenish the soils in the floodplain.
    - Supports moisture content in soils, reduces rate of erosion, and supports plant growth that can increase organic inputs to soil.
- Wildlife Habitat
    - Floodplain connectivity with streams and rivers is recognized as a necessary habitat element for the survival of wild salmon populations (Thurston County, 2005).
    - Flooding creates, maintains, and modifies important features of the stream channel and floodplain by creating and filling pools, oxbows, side channels, and backwater areas, and redistributing sediment and organic matter to create/erode islands, bars, and stream banks.
    - Flooding can recruit large woody material into the stream channel and floodplain, which influences channel morphology. Trees falling into the channel and floodplain become large woody debris, influencing channel morphology and creating high quality, diverse habitat for fish rearing, spawning, migration and refuge. This material also provides habitat for benthic invertebrates, an important component of the aquatic food chain.
    - Migration of species: flooding allows for foraging and reproduction outside of the river channel.
    - High diversity of aquatic and terrestrial plants and animals result from regular flooding coupled with diverse habitat.
    - Disturbance can cause abrupt changes in habitat conditions and alter hydrologic and nutrient cycling processes. Given time and without obstruction, a natural, unimpeded, meandering channel can swing and shift across its valley, resulting in a complete reworking of the floodplain (Thurston County, 2004).
    - Inundation of floodplains and wetlands provides important wildlife habitat and connects and increases available habitats (i.e. pools and bars).
- Hydrology
    - Stores and retains surface water in the floodplain, reducing velocities and modifying discharge rates. Floodwater retention and discharge can help to recharge groundwater and maintain stream base flows.
    - Biologically important parameters that change following flooding and channel activities include water temperature, turbidity, flow velocity, variable water depths, hydrologic

regime, a decrease or change in vegetation, changes in storage of organic matter and sediment, and changes in the size and stability of channel substrate (Thurston County, 2004).

- Water Quality
    - Riparian areas and vegetated floodplains filter pollutants, hold underlying soil in place, reduce erosion and provides a place for new sediment deposition to settle out. Regular flooding flushes and maintains healthy habitats in river pools and can reduce algal blooms.
    - Moderates water temperature by shallow groundwater infiltration, cooler groundwater recharge from aquifers back to streams, and by vegetation that can provide shade.

Agricultural Impacts

- Hydrology
    - Common agricultural activities that can degrade water flow processes include: impervious surfaces, forest clearing, filling and draining/diking wetlands and floodplains, roads and associated storm drainage systems, and removal of riparian vegetation (Thurston County, 2013).
    - Removal of vegetation, compaction of soils, and the installation of drainage networks associated with roads combine to increase surface water runoff during and immediately after storms, while reducing groundwater recharge and evapotranspiration. This results in quick water level rise to storms and decreased base flow during dry periods (King County, 2004).
    - As impervious surfaces and ditches increase the rate and magnitude of the in-stream storm response, channel-forming flows occur more frequently, which can promote downstream bank erosion, channel widening, and incision.
    - Changes in water infiltration from tilling or compaction of soils and alteration of surface and groundwater flows can result in increased surface flows and issues with flooding and erosion as well as decreased groundwater flows and aquifer recharge rates (King County, 2004).
    - Altering hydrology can increase flows at critical times (i.e. peak storm flow season) and lead to overall changes in the in-stream habitat conditions. Channelization greatly limits the functions of a stream and its associated floodplain as well as any potential benefits of a functional riparian corridor, channel migration zone, and floodplain.
    - Agricultural activities, particularly when implemented with conservation practices such as riparian forest zones and cover crops, can improve the functions of frequently flooded areas by reducing the volume of floodwaters and providing storage capacity at peak flows. Vegetation both in the riparian zone and along the floodplain slows water and removes energy from floodwaters, reducing impacts from flooding (i.e. scouring and stream bank erosion).
- Water quality
    - Loss of riparian vegetation reduces bank stability, and increases channel erosion and sedimentation. Loss of vegetation and harvesting crops in the floodplain can also increase soil erosion and sedimentation in nearby streams and lakes.

  - Water flowing over impervious surfaces, fields, and agricultural use areas can pick up excess nutrients, pathogens and contaminants, which have a negative impact on the aquatic ecosystem biota and can also reduce the safety of water for drinking and recreational uses (Thurston Regional Planning Council, 2013).
- Wildlife Habitat
  - Agricultural activities and development in riparian areas and floodplains can result in the reduction in diversity and complexity of habitat, which affects the amount and types of wildlife that can be sustained. Increased impervious surfaces and decreased vegetative cover increases the volume of water flow, scouring of channels, and reduction or loss of the functions associated with flooding and channel migration, including the loss of wildlife habitat food and cover, vegetation, and woody debris recruitment.
  - Activities in the floodplain can change stormwater flows and contribute pollutants to water bodies, which impacts our water quality and quantity as well as aquatic habitat. These impacts can degrade fish populations even at low levels of development (Washington State Department of Ecology and Washington State Department of Transportation, 2001).

1.1.4 Fish and Wildlife Habitat Conservation Areas

"Fish and wildlife habitat conservation areas" (FWHCAs) are areas that serve a critical role in sustaining needed habitats and species for the functional integrity of the ecosystem, and which, if altered, may reduce the likelihood that the species will persist over the long term. These areas may include, but are not limited to, rare or vulnerable ecological systems, communities, and habitat or habitat elements including seasonal ranges, breeding habitat, winter range, and movement corridors; and areas with high relative population density or species richness. These also include locally important habitats and species. FWHCAs provide water quality, hydrology, soil health, and habitat functions. Streams provide a key habitat and riparian vegetation functions as a source of organic materials, habitat structures and cover, streambank stabilization, and shade to help regulate water temperatures. Habitats of local importance may support sensitive species throughout their lifecycles, or are areas that are of limited availability, or high vulnerability to alteration. FWHCAs, especially riparian areas, help to improve water quality, affect hydrology, contribute to soil health, and provide a variety of habitats.

<u>Primary Functions and Values</u>

- Wildlife Habitat
  - FWHCAs support sensitive and important species lifecycles, provide spawning, rearing, and migratory habitat for fish, and nesting and rearing habitat, food and cover for riparian and upland wildlife species. Riparian areas also supply organic inputs, such as leaf fall, insects and large wood to aquatic habitat.
  - Browsing or grazing by ungulates (i.e. herbivores such as deer and elk) can change plant communities and alter the functions of ecosystems (Augustine & McNaughton, 1998; Hobbs, 1996).
  - Seed-dispersing wildlife species can influence forest succession and regeneration (Duncan & Chapman, 1999).

    - Carnivore predation can influence populations of ungulate prey species. Predators regulate the impacts of grazing animals, improve the overall fitness of prey populations by culling the weak, sick, and old animals, and foster biological diversity and ecological stability (Scott, 2011).
    - Rodents can serve to disseminate beneficial mycorrhizal fungi (Li et al., 1986).
    - Ecological functions of organisms support the trophic structure of ecosystems (i.e. food webs and nutrient cycling). More biodiverse systems generally have wider arrays of ecological functions (Marcot & Vander Heyden, 2001).
    - Invertebrates play central functional roles, including as food sources, fostering wood decay, and creating snags and down wood (Marcot & Vander Heyden, 2001).
- Hydrology
    - Wildlife species can act as "environmental engineers" by altering landscapes and ecosystem processes, such as the creation of wetlands from beaver dams (Jones, 1996). Wetlands created by wildlife can also provide protection from flooding and climate extremes.
    - FWHCAs provide areas to store and retain water to reduce flooding and support stream base flows.
- Soil and Crop Health
    - Pollinators support plant diversity and agricultural production. The reproduction of many crops and wild plants is dependent on pollination, primarily through native pollinators such as wasps, bees and flies, managed honey bee colonies, as well as birds, bats, and others.
        - More than one-third of the world's crops require pollination (Abrol, 2012).
    - Plants provide the foundation of net primary production, provide many kinds of physical habitat structures, and support soil structures and soil health, as well as fertile crops.
    - Vegetative cover reduces the rate of soil erosion and provides wind breaks.
- Water Quality
    - Provides water filtration. Plants and invertebrates in FWHCAs help filter water and detoxify soils.
    - Riparian vegetation reduces sedimentation, stabilizes streambanks, and moderates water temperature by providing shade.

<u>Agricultural Impacts</u>

- Water Quality
    - Pesticides and nutrient loads related to agricultural uses can deteriorate surface and ground water quality, which directly or indirectly impacts many wildlife species including birds, fish, amphibians, and beneficial insects.
    - Soil erosion from agricultural activities can cause sedimentation of surface waters, which can reduce the diversity and populations of stream invertebrates.
    - Soil erosion and sedimentation deteriorates and reduces fish habitat and survival.
        - Unlike the wildlife generalists that often thrive in agricultural habitats, salmonids are specialists and require relatively rigorous conditions to carry out their life cycle. Small, persistent changes in water quality, temperature, habitat

structure, or even distribution within a watershed can have severe consequences for salmon survival.

- Wildlife Habitat
    - Agriculture and fish and wildlife habitat areas have complex interactions that vary from negative impacts on fish and wildlife habitat and biodiversity to beneficial impacts for some habitats and species.
    - Habitat loss due to conversion of native plant communities and rare habitat types (e.g. prairie and oak woodland) to agricultural activities, loss of biodiversity due to habitat simplification, habitat degradation from introduction of non-native plant and animal species, and the hazing/killing of wildlife that may be considered nuisance by agricultural operators.
    - Dissection, fragmentation, substitution, and loss of habitat from conversion to cropland or agricultural building structures, roads/tracks. Spatial processes have distinctive attributes, and each exerts significant effects on a range of ecological characteristics from habitat structure to biodiversity to erosion to water chemistry (King County, 2004).
    - Migration patterns, reproductive success, exposure to invading species and predators, are modified as populations are split and isolated. As habitats shrink, they are no longer capable of supporting and sustaining viable populations.
    - Agricultural habitats support a high diversity of wildlife species in Oregon and Washington (over 300 species) as a result of the broad distribution of agricultural areas and the wide variety of land uses, crops, and habitat conditions (Edge, 2001).
        - Many bird species depend on open habitat such as grasslands and pastures and over-wintering waterfowl populations rely on agricultural lands for habitat, food, and forage.
    - Pesticides and herbicides commonly used in agriculture directly and indirectly impact populations of pollinators, which can threaten the availability of pollination for agriculture as well as wildlife flora (Abrol, 2012).
    - Pasture, specifically in vernally flooded riparian areas, can provide important habitat for the threatened Oregon Spotted Frog (OSF) in areas that it is found in Thurston County.
    - Effects of grazing vary among sites and are likely to depend on a suite of factors including but not limited to timing, intensity, duration, and how these factors interact with seasonal habitat use patterns.
        - Cause-and effect information is lacking and an understanding of the variation among sites is central to managing impacts.
        - Potential impacts of grazing on OSF can be considered in at least three categories (Cushman & Pearl, 2007):
            - Direct trampling of Oregon Spotted Frog,
            - Impacts on vegetation and related secondary effects
            - Water quality changes (i.e. bacterial loads and nitrogenous wastes)
- Hydrology
    - Out-of-stream water consumption/irrigation can reduce the quantity of water available in-stream for wildlife habitat.
    - Senior water rights permit holders may be impaired.

1.1.5 Geologic Hazard Areas

"Geologic hazard areas" (GHAs) are those areas that are susceptible to erosion, landsliding, earthquake, volcanic lahar, liquefaction or other geological events. In the VSP context, GHAs can primarily impact soil erosion risks from wind and water. The focus for GHAs is on reducing landslide risks and the rate of erosion for soil conservation and to reduce the risk of erosion effects on other functions such as surface water quality, water infiltration into soil to improve groundwater conditions, and to soil health.

Primary Functions and Values

- Hydrology
  - Landslides over time can be beneficial to the hydrology of streams and beaches, such as the addition of Large Woody Debris (LWD) that provide stream channel stability.
  - Erosion and sedimentation can impact the rate of groundwater infiltration.
- Wildlife habitat
  - Deposits of LWD that can originate from landslides are important to the natural function and health of aquatic areas and provide nutrients, shelter from predators to fish and amphibians, some shade, and serves to stabilize stream channels and beach environments.
  - Erosion and sediment deposition from material being carried downslope maintains the functions of riverine, riparian, and marine habitats (Thurston County, 2011).
  - Erosion increases sediment inputs to streams and wetlands and impacts aquatic habitats.
- Water Quality
  - In the short term, landslides and erosion can have negative impacts by introducing excess sediments, nutrients, and contaminants into surface waterbodies.
  - Lahars can impact water quality and are gravity-controlled volcanic flows that are channeled into valleys and typically grow in size as they move downslope by picking up (and later depositing) sediment, water, and organic materials (King County, 2004).
- Soil Health
  - Landslides and volcanic activity, such as ash and lahars, can form a blanket-like deposit on the soil surface that can damage or kill vegetation/ruin crops and contaminate surface water in the short-term. However, over time these deposits of nutrients and sediments can be beneficial to soil health.
  - Erosion can reduce soil depth and impact soil health.

Agricultural Impacts

- Landslides and erosion are often caused or exacerbated by human activities, including increases in surface water runoff, altering rates and locations of precipitation infiltration, excavation and fill activities, and the construction of drainage systems (Thurston County, 2011).
  - Removal of vegetation and land development can have a dramatic effect on the stability of slopes and increase land slide hazards (Shipman, 2010).
  - NOTE: In general, most agricultural activities in Thurston County are not typically located within landslide hazard areas and may be only indirectly capable of causing or exacerbating slide risks, depending on the types of agricultural practices.

- Hydrology
  - As impervious surfaces increase and native vegetation decreases, the volume and rate of runoff tends to increase, which results in an increase in erosion potential within the basin.
  - One of the primary causes of landslides is slope saturation by water (USGS, 2004). Irrigation from groundwater sources can result in changes to the water table, increased soil saturation and erosion, and reduced slope stability, particularly if surface irrigation occurs on slopes.
  - Increases in surface water runoff, altering rates of precipitation infiltration (impervious surfaces), excavation and fill activities, and the construction of drainage systems can all lead to increased erosion and landslide hazards (Shipman, 2010).
- Wildlife Habitat
  - Steep slope and shoreline stabilization methods directly impact aquatic wildlife habitats and populations such as forage fish and surf smelt which are sensitive to changes in sedimentary processes. This in turn negatively impacts the threatened and endangered marine species that depend on forage fish for a large part of their diets. Armoring structures also negatively affects the habitat of many state priority species (Thurston County, 2011).
    - Shoreline armoring can actually result in higher rates of erosion.
    - Nonstructural or soft stabilization techniques that rely on practices such as vegetative plantings, sand fill, bioengineering and gravel berms have many advantages over hard armoring techniques. They maintain important shoreline habitat and functions rather than destroy them, and protect marine bluffs by reducing wave energy and absorbing storm surge and flood waters. They also are less costly than structural stabilization.

2 Summary of Conservation Practice Effects on Critical Area Functions

The following table summarizes conservation practices that are commonly utilized by agricultural operators in Thurston County and their effects on the primary critical area functions and values, more detail on these practices can be found following this table. The Natural Resources Conservation Service provides technical guides as the primary scientific references for conservation practices. These technical guides include reports, matrices and diagrams on the environmental and economic effects of each conservation practice.[2]

Summary of Conservation Practice Effects on Critical Area Functions

Conservation Practice	Critical Area Functions			
	Water Quality	*Hydrology*	*Soil Health*	*Wildlife Habitat*
Access control	Can reduce potential contamination and pathogen transport	Can increase infiltration to aquifers	Can reduce compaction and	Can facilitate movement and can increase population health and

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[2] More information on NRCS Conservation Practices, technical guides, and documentation of physical effects is available at: https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/cp/ncps/?cid=nrcs143_026849

Conservation Practice	Critical Area Functions *Water Quality*	*Hydrology*	*Soil Health*	*Wildlife Habitat*
		by reducing compaction	increases soil organic matter and quality	biodiversity, improves aquatic habitat
Conservation crop rotation	Can reduce nutrients, pesticides, contaminants, and sediments to ground or surface water	Can reduce volume of water runoff	Can reduce wind and water erosion and increases soil quality and organic matter	Can provide habitat from crop residue: food and cover
Conservation cover	Can increase uptake of nutrients, reduce sedimentation and contaminants, increase quality of runoff water and receiving waters	Can filter sediment from shallow flood waters and reduce volume of water run off	Can increase organic matter, reduces wind and water erosion, and increases carbon storage	Can reduce non-native invasive species and increase wildlife food and cover and biodiversity
Cover Crop	Can reduce water and wind erosion, sedimentation and associated contaminants, and uptake excess nutrients	Can reduce volume of water runoff	Can improve soil moisture, organic matter, increases balanced plant nutrients, and minimizes soil compaction	Can enhance pollinator and wildlife habitat food and cover, suppresses weed pressure and breaks pest cycles
Early successional habitat management				Can improve early successional wildlife habitat and increases populations and biodiversity
Fencing and livestock exclusions	Can reduce source of nutrients, pathogens and contaminants, and soil erosion		Can reduce compaction	Can protect and/or enhance habitats and improve riparian and stream conditions
Integrated Pest Management	Can prevent or minimize pesticides leaving the site and contamination of ground and surface water, reduces water and wind erosion		Can reduce pesticide residue in the soil and improve soil condition	Can protect and increase beneficial species and non-target species such as pollinators
Irrigation Water Management	Can reduce runoff of potentially contaminated agricultural chemicals, nutrients, and/or pathogens	Can increase amount of water for other purposes and use potential	Can avoid soil mineralization and salt build-up, manages plant and soil microclimates, improves biomass and soil quality	Can improve water availability for seepage into other critical areas and wildlife habitat
Nutrient and manure management	Can improve water quality, reduce nutrients to ground and surface water, decrease noxious		Can optimize timing and quantity of nutrient application to crop production,	Can improve water quality for fish and wildlife, increase stream/lake fauna

Conservation Practice	Critical Area Functions *Water Quality*	*Hydrology*	*Soil Health*	*Wildlife Habitat*
	algal growth, increases dissolved oxygen		increase crop growth and vigor	
Prescribed grazing	Can reduce impacts and source of nutrients, pathogens, contaminants, and sediment	Can introduce micro-topography that can trap some surface flow	Can reduce erosion and compaction and increase soil quality, increase plant productivity	Can introduce micro-topography, increase early successional habitat and biodiversity
Residue and tillage management – reduced till and no-till	Can reduce sedimentation and nutrient loads	Can improve soil porosity and water infiltration	Can reduce sheet and rill erosion, increase soil organic matter, soil carbon, and crop production	Can increase wildlife food and cover, habitat diversity, and upland wildlife
Riparian forest zones	Can increase filtration and uptake of nutrients, reduces sediment, increases shade and reduces stream temp	Can intercept precipitation, slow runoff, increase retention of flood waters	Can provide soil stability, increases carbon storage and denitrification of soil nitrates	Can provide wildlife habitat, cover, and refuge, increase leaf/debris fall and large woody debris in streams and stream fauna
Riparian herbaceous cover	Can decrease erosion and associated sedimentation, compaction, and pesticide runoff, increase uptake of soil nutrients, increase shade, improve temp	Can increase water storage on floodplains, dissipates stream energy and traps sediment, enhances stream bank protection	Can increase root biomass, soil organic matter and carbon storage, decreases soil erosion	Can increase plant biomass, detritus in streams, fish and wildlife biodiversity, decrease habitat fragmentation and invasive species
Shellfish and aquaculture management	Can prevent shoreline erosion	Can prevent loss of shoreline or damage to banks		Can prevent wildlife entanglement and facilitates movement
Vegetated Filter Strips	Increases filtration, reduces sediment, pathogens, and contaminants to ground and surface waters	Increases infiltration, slows runoff and increases retention of flood waters	Traps sediment, decreases contaminants, increases soil organic matter, soil quality, and nutrient cycling by soil organisms	Provides wildlife habitat, cover, and refuge, improves water quality and aquatic habitat, increases biodiversity
Wetland wildlife habitat management	Can maintain and/or improve wetland habitat functions, improve surface and ground water quality			Can provide wildlife habitat and cover, increases habitat quality, increase migratory bird and other populations

2.1 Conservation Practice Effects on Critical Area Functions

With the implementation of natural resource management and conservation practices, the relationship between agricultural activities and critical areas can lead to greater mutual benefits. Conservation practices, in this context, are methods to control, prevent, and reduce pollution, protect critical area functions and values, and may enhance the functions of critical areas and maintain and improve agricultural operations.

The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) has been working to control nonpoint source (NPS) pollution for decades and maintains standards for the implementation of over 150 different conservation practices. NRCS conservation practices can be implemented to ensure that landowners operate in a profitable yet environmentally responsible manner.

NRCS conservation practices are developed from Land Grant University research with State and Federal agency input. These practices under-go review every 5 years and are vetted through the USDA Agricultural Research Service (ARS).

Studies have shown that NRCS conservation practices can be effective at helping to control nonpoint source pollution issues and reduce the impacts of agricultural activities on critical area functions and values (Best, 2004; EPA, 2010; EPA, 2009; Lizotte, Knight, Locke, & Bingner, 2014; Stang et al., 2016; Tomer & Locke, 2011; Yuan, Locke & Bingner, 2008). For example, Tomer and Locke (2011) reviewed USDA watershed studies and the challenges of identifying water quality benefits in fourteen relatively large agricultural watersheds with varying crop systems, landscapes, climate, and water quality concerns. They found that conservation practices improved water quality by reducing pollution concerns and summarized some important lessons learned:

> 1) The need to target placement of conservation practices at critical sources of contaminants using the best available data and with flexible policies that allow stakeholders to respond to new information on pollution sources;
>
> 2) Sediment in streams originated more from bank and channel erosion than from soil erosion, thus practices that attenuate surface runoff as well as erosion are more effective;
>
> 3) The effects of practice implementation are masked by timing lags in which several years may be required to see impacts, historical legacies of pre-conservation (i.e. pre-1950) agricultural practices, and shifting climate; and
>
> 4) The need for a comprehensive approach in water quality management strategies that considers inherent trade-offs among contaminants and utilizes a set of targeted conservation practices rather than focusing on single contaminants.

The ARS Conservation Effects Assessment Project maintains a clearinghouse of research on the topic of conservation practice and program effects on critical area functions and values.[3]

When implemented according to the Stewardship Plans, conservation practices protect and provide benefits to critical area functions and values (e.g. improved water quality), including those outlined in the summary table below, as well as many other beneficial impacts to both the overall environmental health of the watershed and the enhancement of agricultural operations.

The VSP Individual Stewardship Plans primarily utilize the conservation practice standards of the Natural Resources Conservation Service (NRCS). More information on specific conservation practices and Field Office Technical Guides (FOTGs) for Thurston County can be found at https://efotg.sc.egov.usda.gov/ by clicking Washington → Thurston County → Section IV → Washington Conservation Practices.

However, these are not the only conservation practices that can be used in a Stewardship Plan. For example, aquaculture and shellfish agricultural operations may implement other best management practices to minimize adverse impacts on environmental resources and enhance the sustainability of aquaculture.

The following conservation practices are specifically selected as options for common practices to be applied for agricultural operations under the VSP in Thurston County. However, this is not an exhaustive list and there are many other options for conservation practices and specific tools that can be discussed with the technical assistance provider during the development of each site-specific Stewardship Plan.

- **Access Control** (NRCS Code 472) is a temporary or permanent barrier constructed to exclude animals, people, or vehicles from the site. It can also be a non-barrier, use-regulating activity such as posting of signs, patrolling or permits. The purpose of controlling access is to achieve and maintain desired resource conditions by monitoring and managing the intensity of use by animals, people, vehicles, and/or equipment from an area. The barriers should be designed to facilitate wildlife movement around, under, or over them and can increase target species wildlife habitat and improve the health of wildlife populations and biodiversity. This practice can reduce pathogen transport to surface water and improve water quality by also reducing soil erosion from the site.
- **Conservation Crop Rotation** (NRCS Code 328) is a simple and cost-effective practice that involves a planned sequence of at least two different crops grown on the same ground over a period of time. This practice also often includes leaving crop residue cover on the soil surface and a tillage system that will produce sufficient and timely quantities of biomass or crop residue, which in conjunction with other practices in the management system, will reduce sheet, rill and wind erosion. No-till is one of the most effective conservation tillage practices for reducing soil erosion and improving soil and water quality. The crop residue cover increases infiltration rates and reduces the volume of agricultural runoff and contaminants associated with sediment loss. Farmers benefit from conservation crop rotation and conservation tillage through reduced

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[3] More information on the Conservation Effects Assessment Project and literature reviews are available at: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/ceap/

production costs and therefore have the potential for increased profit margins. Wildlife also benefit from the reduced runoff, cleaner water, and increased availability of habitat, food, and cover.

- **Conservation Cover** (NRCS Code 327) is a permanent vegetation cover established and maintained to reduce sheet, rill and wind erosion, and sedimentation to improve ground and surface water quality, as well as enhance wildlife, pollinator and beneficial wildlife habitat. This practice does not apply to critical area plantings or plantings for forage production. Benefits have been documented to waterfowl species from farm programs that provided incentives to landowners for planting undisturbed grass cover as an alternative to annual crops (Reynolds et al., 2001).
- **Cover Crop** (NRCS Code 340). Cover crops are generally grasses, legumes, and forbs grown as winter annuals to reduce erosion from wind and water, maintain and increase soil health and organic matter content, reduce water quality degradation, suppress weeds, improve soil moisture efficiency, and minimize soil compaction. Cover crops are established quickly after the growing season to provide an early dense cover prior to the onset of winter, then harvested or ploughed under in spring as a green manure.
- **Early successional habitat development/management** (NRCS Code 647) is intended to manage the harvest of vegetation and plant succession to develop and maintain the early successional habitat to benefit desired wildlife species, such as the Oregon Spotted Frog. Management is designed to achieve the desired plant community structure and plant species diversity. Grazing cattle at the right time of year (i.e. when the soil is not so wet as to increase compaction and standing water) as well as mowing can reduce invasive reed canary grass populations which border critical wetland habitat (Cushman & Pearl, 2007). Grazing can also be beneficial to maintain disturbance regimes and restore heterogeneity that early successional prairie species (including many native wildflower, butterfly, and bird species of concern) are dependent upon. Studies have shown that grazing and mowing can enhance impacted grassland ecosystems and promote a shifting mosaic of habitat types that maintain biodiversity and agricultural productivity (Collins et al., 1998; Fuhlendorf et al., 2006).
- **Fencing and livestock exclusions** (NRCS Code 382) is a constructed barrier to animals and people to assist with source reduction, recovery of damaged habitats, and protection and enhancement of other conservation practices by providing a means to control movement of animals and people, including vehicles. Fencing materials, type, and design installed to meet the management objectives of the individual stewardship plan. Based on site-specific challenges and the management objectives the fences may be permanent, portable, or temporary. Height, size, spacing, and type of materials used should provide the desired management of people and animals of concern. Riparian fencing and reductions in stocking rates have generally proven to be effective measures for the improvement of riparian and stream conditions.
- **Integrated Pest Management** (NRCS Code 595) involves site-specific implementation of diverse methods of pest controls, pest prevention, pest avoidance, and suppression paired with monitoring to reduce on-site and off-site risks from unnecessary pesticide applications, particularly to at-risk ecosystems. Several activities fall under the umbrella of Integrated Pest Management, including maintaining a diverse and healthy community of pest-resistant plant species, cleaning equipment after use in an infested area, monitoring pest populations, and using suppression techniques that minimize risk to non-target species and water quality.

- **Irrigation Water Management** (NRCS Code 449) is a process of determining and controlling the volume frequency, and application rate of irrigation water. This practice is designed to improve irrigation water use efficiency, minimize irrigation induced soil erosion, decrease degradation of surface and groundwater resources, manage salts in the crop root zone, manage air, soil, or plant micro-climates, and reduce energy use. The irrigation system is adapted to site conditions (soil, slope, crop grown, climate, water quality and quantity, air quality, etc.) for the efficient application of water to meet the intended purposes.
- **Nutrient and Manure Management** (NRCS Code 590) involves adaptively managing the amount (rate), source, placement (method of application), and timing of plant nutrients and soil amendments. When applied in proper quantities and at appropriate times, nutrients help achieve optimum crop yields. However, improper storage and application of nutrients (especially nitrogen, phosphorus, and potassium) can cause water quality problems locally and downstream (EPA, 2013), as well as issues for livestock health and safety. A Nutrient Management Plan (NMP) for nitrogen, phosphorous, and potassium must be developed when nutrients are applied. A nutrient budget must be developed for nitrogen, phosphorous, and potassium that considers all potential sources of nutrients.
    - Use **soil tests** to determine actual site-specific nutrient needs.
    - Manure tests are used to determine manure nutrient content. And correctly plan manure application rates.
    - Used with conservation tillage and other erosion-control practices to minimize loss of phosphorus that is attached to the soil.
    - Application timing is planned in accordance with soil test data to provide nutrients to crops at the appropriate time.
    - Manure Storage takes place in an appropriate storage/treatment structure (e.g. lined lagoons). Gutters and downspouts are installed to channel storm drainage away from areas receiving animal waste and to prevent nutrient transport in surface water.
- **Prescribed Grazing** (NRCS Code 528). When grazing is used as a management tool, a prescribed grazing plan must be developed to specifically meet the intent and natural resource objective(s). Prescribed grazing manages the harvest of vegetation by varying the intensity and duration of grazing or browsing animals to benefit native plant community health, forage quality, water quality, riparian function, and improve the quantity and quality of food and/or cover for wildlife habitat and species of concern habitat.
- **Residue and Tillage Management, Reduced Till and No-Till** (NRCS Codes 345 and 329) limits soil disturbance to manage the amount, orientation and distribution of crop and plant residue on the soil surface year-round. These conservation practices reduce sheet, rill and wind erosion, excess sediments in surface waters, tillage-induced particulate emissions, maintains or increases soil quality and organic matter content, reduces energy use, increases water use and precipitation storage efficiency, and provides food and escape cover for wildlife. A study by Moore and Palmer (2005) found that high macroinvertebrate richness values in streams may be due to widespread use of agricultural Best Management Practices (BMPs) in the area of the study, including no-till farming and the implementation of woody and herbaceous riparian areas, which may alleviate many acute stressors caused by agricultural cultivation.
- **Riparian Forest (NRCS Code 391) and Herbaceous Cover** (NRCS Code 390) serve as habitat corridors, which should consist of native vegetation wherever possible. Ranging from primarily forested areas to herbaceous cover in the transitional zone between upland and aquatic habitats, they can improve water quality, maintain water temperatures to improve aquatic

habitat, enhance pollen, nectar, and nesting habitat, reduce excess amounts of sediments, dissipate stream energy (reduce flood damage), sequester carbon, and increase floodwater storage. Riparian zones are established using plants that are appropriate for the conditions of the specific site (including soils, hydrology, vegetation, slope, and species of importance), and for its intended purpose. A range of riparian widths is used to protect multiple riparian functions and values (May, 2003).

- **Shellfish and Aquaculture Management** (NRCS Code 706) uses environmentally sound management and sustainable aquaculture practices to minimize adverse impacts of shellfish farming on water, plant, animal and human resources and enhance the sustainability of aquaculture. One of the primary objectives of shellfish and aquaculture management is to minimize or eliminate aquaculture marine debris using regular monitoring and collection of tideland debris as well as self-reporting items found. Another objective is to thoroughly secure aquaculture gear to prevent wildlife entanglement and prevent navigational hazards. Common management practices include:
    - Gear cycling – Used to reduce, clean, or remove biofouling organisms and other waste from bivalve production areas. Fouled gear is brought on shore, air dried, and cleaned in an approved off-site location.
    - Rack replacement – Replaces existing oyster racks with new racks built and installed to the appropriate height and spacing to allow for wildlife movement under and around racks.
    - Oyster bed restoration or enhancement/replenishment – Successful oyster growth occurs on beds that have a firm substrate. This practice improves the substrate to increase production.
    - Shoreline protection – Prevent the loss of land or damage to banks of streams, lakes, reservoirs, or estuaries (does not apply to ocean fronts). Vegetation and bioengineering treatments are used to stabilize low risk areas.
- **Vegetated Treatment Areas** (NRCS Code 635) and filter strips (NRCS Code 393) consist of a strip or area of herbaceous vegetation for the treatment of agricultural waste and to remove contaminants from surface water flow. This practice addresses four types of pollutants in agricultural runoff: sediment, sediment-adsorbed pollutants in surface runoff, dissolved pollutants in surface runoff, and dissolved pollutants in groundwater. The effectiveness of this practice to remove these various pollutants from agricultural runoff depends on many factors: pollutant type and load, field shape and slope, type and density of vegetation, soil structure, drainage, etc. In general, this practice is designed primarily for pollutant removal to improve water quality by using vegetation to reduce the loading of nutrients, organics, pathogens, and other contaminants, but do not provide for other critical riparian functions such as organic matter recruitment, temperature control, or wildlife habitat. These filter strips are designed with substantial but infrequent storm runoff in mind. Vegetation species (generally grasses, legumes, and/or forbs) are selected based on suitability for site conditions and ability to attain significant density for treatment in an appropriate timeframe. Livestock are excluded from these filter strip areas.
- **Wetland Wildlife Habitat Management** (NRCS Code 644) is implemented to maintain, develop, or improve wetland habitat for waterfowl, shorebirds, fur-bearers, or other wetland dependent or associated plants and animals. A habitat evaluation or appraisal, approved by the NRCS state office, shall be used to identify habitat-limiting factors in the planning area. Implementation of this practice removes or reduces limiting factors in their order of significance, as indicated by results of the habitat evaluation. Native plants are used wherever possible and invasive plant

species are controlled on the site. Application of this practice alone, or in combination with other supporting and facilitating practices (i.e. early successional habitat development and management, prescribed burning, etc.), shall result in a conservation system that will enable the planning area to meet or exceed the NRCS minimum quality criteria for wildlife habitat.

Site-Specific Management

A sound, scientifically-defensible approach to promoting conservation management to protect or enhance critical area functions and values while also promoting agricultural viability must recognize the attributes of the farmed landscape—soils, slopes, crop types, the management practices employed on the farm, and the sensitivity of the feature to be protected or conserved. In this way, the technical assistance provider assists the agricultural producer in developing cost-effective and context-sensitive solutions that can be reasonably implemented to improve agricultural operations, prevent or minimize negative impacts, and protect or enhance critical area functions and values.