SCREENING-LEVEL EVALUATION FOR THE ECOLOGICAL RISK ASSESSMENT: PROBLEM FORMULATION STEP OF THE ASSESSMENT PROCESS

FINAL

Prepared for

LOTT Clean Water Alliance
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Acronyms

BAF	bioaccumulation factor
BCF	bioconcentration factor
BIRWP	Budd Inlet Reclaimed Water Plant
BITP	Budd Inlet Treatment Plant
BPA	bisphenol A
CAS	chemical abstracts service
COI	chemical of interest
COPEC	chemical of potential ecological concern
CSM	conceptual site model
DACT	2-Chloro-4,6-diamino-1,3,5-triazine
DBCP	dibromochloropropane
DEA	diethanolamine
DEET	N,N-Diethyl-m-toluamide
DF	detection frequency
ECx	concentration that causes a non-lethal effect in x% of an exposed population
Ecology	Washington State Department of Ecology
ECOSAR	Ecological Structure Activity Relationships
EDB	ethylene dibromide
EF	exceedance factor
EPA	US Environmental Protection Agency
EPI	Estimation Program Interface
ERA	ecological risk assessment
I-5	Interstate 5
LOEC	lowest-observed-effect concentration
LOTT	LOTT Clean Water Alliance
LWD	large woody debris
MATC	maximum acceptable toxic concentration

MWRWP	Martin Way Reclaimed Water Plant
NDMA	N-Nitroso dimethylamine
NOEC	no-observed-effect concentration
NSAID	nonsteroidal anti-inflammatory drug
NWR	National Wildlife Refuge
PBDE	polybrominated diephenyl
PFAS	per- and polyfluoralkyl substances
PFBA	perfluoro butanoic acid
PFNA	perfluoro-n-nonanoic acid
PFOA	perfluoro octanoic acid
PNEC	probable no-effect concentration
PPCP	pharmaceutical and personal care product
ROC	receptor of concern
RWIS	Reclaimed Water Infiltration Study
SMILES	Simplified Molecular-Input Line-Entry System
TCEP	tris(2-carboxyethyl)phosphine
TCPP	tris(chloropropyl)phosphate
TDCPP	tris(1,3-dichloro-2-propyl)phosphate
TMDL	total maximum daily load
TRV	toxicity reference value
TSCA	Toxic Substances Control Act
USFWS	US Fish and Wildlife Service
WDFW	Washington Department of Fish and Wildlife
Windward	Windward Environmental LLC
WRIA	Water Resource Inventory Area

1 Introduction

The LOTT Clean Water Alliance (LOTT) is a public, non-profit entity responsible for providing wastewater treatment and management for the Cities of Lacey, Olympia, and Tumwater in northern Thurston County, Washington. LOTT's long-range plan relies on the production and beneficial use of reclaimed water, including the infiltration of unused reclaimed water into groundwater, to meet the urban area's growing demand for wastewater management.

To address community questions about residual chemicals that may remain in reclaimed water, LOTT is undertaking a multi-year reclaimed water infiltration study (RWIS). The RWIS is intended to evaluate whether there are potential risks associated with the use of reclaimed water for groundwater replenishment caused by a targeted list of pharmaceutical chemicals or chemicals found in household and personal care products, herein referred to as "residual chemicals." One of the RWIS tasks (Task 3) involves conducting an ecological risk assessment (ERA), including a screening-level evaluation that applies conservative assumptions to identify those chemicals that warrant a more detailed evaluation. The results of the problem formulation, a component of the ERA, are presented in this document. The risk characterization step of the ERA will be conducted for chemicals warranting further evaluation based on the screening-level evaluation.

The problem formulation was conducted using a standard approach in accordance with both national and regional US Environmental Protection Agency (EPA) guidance (EPA 1998, 1997a, b).

This technical memorandum is organized into the following sections:

- Section 1 – introduction
- Section 2 – site description
- Section 3 – ecological setting and receptors
- Section 4 – identification of receptors of concern (ROCs)
- Section 5 – ecological conceptual site model (CSM)
- Section 6 – methods and results for the screen of chemicals of interest (COIs) to determine chemicals of potential ecological concern (COPECs)
- Section 7 – references

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2 Site Description

LOTT produces Class A reclaimed water at two facilities. At the Budd Inlet Treatment Plant/Budd Inlet Reclaimed Water Plant (BITP/BIRWP) in Olympia, final effluent already treated to meet advanced secondary standards is further treated through sand filtration and additional disinfection. Class A reclaimed water from this facility is used at a variety of sites in Olympia and Tumwater for irrigation and other non-potable purposes. The Martin Way Reclaimed Water Plant (MWRWP) is located north of Lacey, between the Woodland Creek and McAllister Creek drainages. MWRWP has produced reclaimed water from raw wastewater using membrane bioreactor technology since 2006. The majority of reclaimed water produced at MWRWP is used for groundwater recharge at two locations: the Hawks Prairie Ponds and Recharge Basins site in northeast Lacey, and the Woodland Creek Groundwater Recharge Facility located at the Woodland Creek Community Park in Lacey. The Hawks Prairie Ponds and Recharge Basins site is owned and operated by LOTT and is the primary study area for the RWIS. There, reclaimed water from MWRWP is conveyed through a series of five constructed wetland ponds before flowing into groundwater recharge basins (HDR 2017c). The site is open to the public, and the environs are equipped with educational information about reclaimed water, as well as a park-like setting with walking trails and benches.

From the recharge basins, reclaimed water infiltrates through the soil and into groundwater. Groundwater in the Shallow Aquifer at the Hawks Prairie site flows predominantly to the southwest, with Woodland Creek being a primary point of discharge (HDR 2017a). A portion of groundwater may migrate from the Shallow Aquifer to the Sea-Level Aquifer and Deep Aquifer, which from the Hawks Prairie site primarily flow toward McAllister Creek and Puget Sound, respectively. Because the Woodland Creek and McAllister Creek watersheds are downgradient of the Hawks Prairie Ponds and Recharge Basins, the habitat and associated ecological receptors at these two creeks are the basis for Sections 3 through 5 of this technical memorandum.

Woodland Creek flows south-to-north for approximately 11 miles through Thurston County, Washington (Figure 1). The headwaters are composed of a series of water bodies (Hicks Lake, Pattison Lake, Long Lake, Goose Pond, and Lake Lois) and form an intermittent stream until the Beatty Springs and College Creek convergence; there, the waters become a substantial perennial channel flowing northward into Henderson Inlet. Tributaries that contribute to the streamflow include College (at river mile 2.6), Eagle, Palm, Fox, Jorgensen, and Quail Creeks. The last mile of Woodland Creek is tidally influenced by Henderson Inlet.

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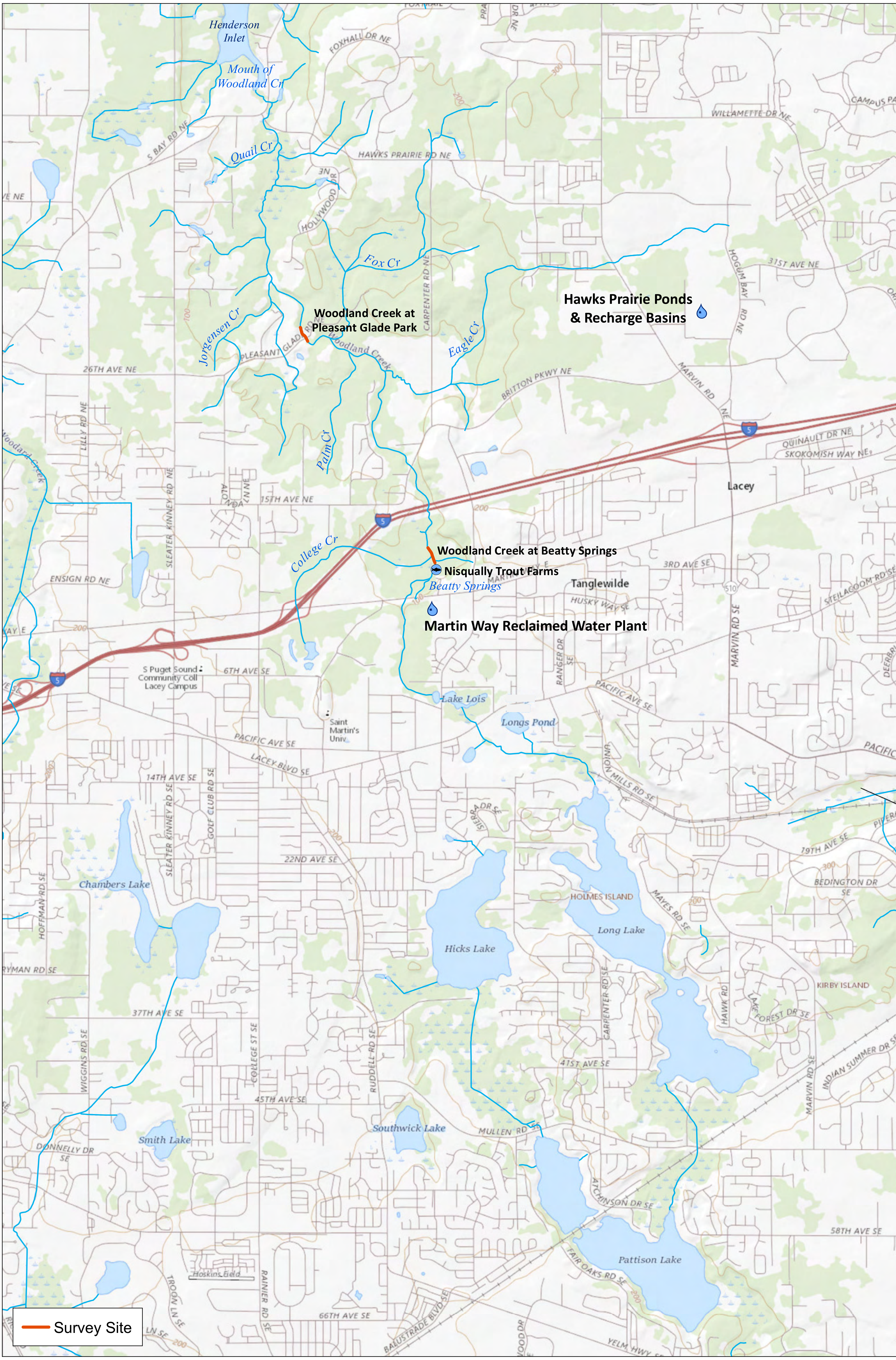

0 0.5 1 Miles

0 1 2 Kilometers

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Figure 1. Woodland Creek vicinity map

Prepared by craigh, 7/18/2019; W:\Projects\LOTT\GIS\Maps and Analyses\7076 Woodland Cr Basin.mxd

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McAllister Creek also flows south-to-north for approximately 6 miles through northeast Thurston County (Figure 2). The creek is fed by a series of springs, including McAllister,[1] Abbott, and Lodge Springs; numerous small seeps and springs along its left (west) bank; and drainage from adjacent agricultural fields and residential areas (Thurston County 1994). McAllister Springs, in turn, is fed largely by groundwater originating from Lake St. Claire, located approximately 1.5 miles south of McAllister Springs. The entirety of McAllister Creek flows through very low-elevation areas, and the creek is tidally influenced all the way to its source. McAllister Creek discharges to the Puget Sound via a broad estuarine lagoon located within the Nisqually National Wildlife Refuge (NWR).

[1] McAllister Springs was formerly the main source of drinking water for Olympia (Thurston County 1994).

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N

0 0.65 1.3 Miles

0 0.65 1.3 Kilometers

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Figure 2. McAllister Creek vicinity map

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3 Ecological Setting and Receptors

3.1 HABITAT

This section describes the habitats at Woodland and McAllister Creeks and the site surveys conducted at both watersheds.

3.1.1 Woodland Creek

The Woodland Creek watershed covers 29.7 square miles. The series of water bodies (Hicks, Pattison, Long, and Lois Lakes and Goose Pond) and associated wetland complexes at the headwaters of Woodland Creek are fed from groundwater (Figure 1). North of Lake Lois, Woodland Creek becomes an intermittent stream until it reaches Beatty Springs, just north of which Woodland Creek flows through the Nisqually Trout Farm. The confluence of Beatty Springs and College Creek forms a perennial stream with several other tributaries that continues to Henderson Inlet (Figure 1).

According to Thurston County (2007), 90% of the Woodland Creek basin lies within Lacey or Olympia urban growth areas. Land cover data from 2005 satellite imagery indicate that 28% of the watershed was given over to urban land uses at that time, with commercial and residential development expected to increase within the urban growth area boundaries in the then-near future. Using land cover data, the Thurston Regional Planning Council estimated that as of 2010, the watershed included 22% impervious surface area cover and 40% forest cover (Tabbutt and Ambrogi 2013). Land use designations within the watershed currently include moderate- and high-density residential, light industrial, and commercial, as well as some agricultural lands (HDR 2017b; Thurston County 2019). Land uses directly adjacent to Woodland Creek include natural; public park; open space; and rural-, low-, and moderate-density residential land (HDR 2017b; Thurston County 2019).

Most of Woodland Creek below Lake Lois (see Figure 1) is included on Washington State's 303(d) impaired waters list due to high levels of fecal coliform bacteria (Ecology 2017). An EPA-approved total maximum daily load (TMDL) plan for fecal coliform bacteria is in place to help restore the water body to more natural conditions. Woodland Creek is also included on the 303(d) impaired waters list for temperature, dissolved oxygen, and instream flow (Ecology 2019).

The Woodland Creek watershed accounts for 12% of the area within Water Resource Inventory Area (WRIA) 13. WRIA 13 is the most developed watershed in Thurston County and has the worst habitat condition (Thurston County 2013a).[2] However, portions of Woodland Creek north of Lacey have good habitat condition, and

[2] Habitat condition as designated using Washington Department of Fish and Wildlife (WDFW) habitat assessments.

Woodland Creek's riparian vegetation appears relatively unmodified despite encroaching development. An assessment of all streams within WRIA 13 rated Woodland Creek's invertebrate community as "good/fair-fair" using a benthic index of biotic integrity metrics averaged from 1999 to 2013 (City of Olympia 2018). A 2004 WRIA assessment described Woodland Creek and its associated tributaries as good salmonid spawning and rearing habitats with good estuary connectivity, fair fish passage, and good off-channel habitat (Thurston County 2004). Areas of Woodland Creek with high and moderate fish habitat resources were also identified in 2007 (Thurston County 2007), although it is possible that conditions have changed, since these data were published more than a decade ago.

Woodland Creek provides a hydrologic source for several wetland complexes within its reach that include scrub-shrub and forested wetlands and afford a variety of native vegetation. Woodland Creek contains an assortment of stream bed substrates, ranging from gravel and cobble to primarily coarse sand. Topography of the creek begins with rolling flat hills, which eventually become a shallow ravine setting before the creek reaches the estuary at the mouth of Henderson Inlet.

3.1.2 McAllister Creek

The McAllister Creek watershed covers 7.2 square miles (Thurston County 1994). The creek's drainage basin has a low gradient and low elevation, and the creek channel itself is tidally influenced all the way to its source (Thurston County 2013c). A series of springs and forested wetlands that serve as the headwaters of the creek is fed from groundwater (Figure 2). There are two small tributaries to McAllister Creek: Little McAllister Creek and Hartman Creek. While most of McAllister Creek has a relatively narrow floodplain, the portion of the creek north of Interstate 5 (I-5) has a much wider and more complex floodplain, as it merges with the Nisqually River floodplain and delta within the Nisqually NWR (Thurston County 2013c).

In 2009, land cover data from satellite imagery indicated that 21% of the McAllister Creek watershed south of I-5 was developed (i.e., covered by the built environment). Approximately 30% of the watershed (south of I-5) was covered by forest, 34% by scrub-shrub and understory vegetation, 11% by scrub-shrub/wetlands, and approximately 10% by grasses; an additional 5% was covered by wetlands, bare earth, tilled earth, or water (Thurston County 2013b).

Water quality in McAllister Creek is listed as "fair" and often does not meet water quality standards for fecal coliform, pH, and dissolved oxygen (Thurston County 2013c). Sources of water pollution to the creek include septic systems, agricultural runoff, and stormwater runoff. In 2002 and 2003, the Washington State Department of Ecology (Ecology) conducted a TMDL study for dissolved oxygen and fecal coliform bacteria within McAllister Creek (Ecology 2005). As water from many of the sampling locations did not meet fecal coliform bacteria water quality standards, a TMDL was established for McAllister Creek starting approximately 0.5 miles upstream from Martin

Way (at river mile 4.3). Dissolved oxygen levels in the creek were also found to be low, but this was attributed to natural conditions such as aquatic plant growth, low dissolved oxygen in groundwater discharging to the creek, physical conditions impeding aeration of the water, and influences from wetlands in the basin. Control of nutrient inputs to the creek was recommended, as was investigation into the high nitrate+nitrite nitrogen levels detected in groundwater.

The upper portion of McAllister Creek near McAllister Springs flows through forested and forested wetland habitats. The stream substrate in this reach of the creek consists of good-quality spawning gravels (Thurston County 1994).

Between its headwaters and the estuary, McAllister Creek runs through forested wetland habitat and agricultural/pasture and residential land, as well as under roadways; commercial development includes restaurants and gas stations concentrated around Martin Way East and the I-5 corridor (Figure 2). Dikes and tide gates[3] line the reach of the creek that flows through agricultural/pasture lands (primarily south of the Steilacoom Road Southeast bridge), and there is little riparian woody vegetation (Thurston County 1994, 2013c). Agricultural drainage ditches discharge to the creek on both sides in this area, and the stream bed substrate consists predominantly of muck and peat, with high organic matter content. Water in the creek in this area moves slowly due to influences from the tide, and there are no riffles or pieces of large woody debris (LWD).

North of the Steilacoom Road Southeast bridge, McAllister Creek flows past more agricultural/pasture land (to the east of the creek) and residential land (to the west of the creek). There is some forested riparian vegetation along this reach of the creek, particularly on the west side (Figure 2). At approximately river mile 4.3, McAllister Creek enters a series of diversion channels that convey the creek under Martin Way East and I-5; rip-rap lines the diversion channels through much of this area (Ecology 2005). There is some riparian vegetation in this reach of the creek but little overhanging vegetation. Land uses here include an RV park, restaurants, gas stations, an auto shop, and roadways. Stormwater from Martin Way East and I-5 discharges to McAllister Creek in this reach. The creek re-enters its natural channel north of I-5 as it enters the Nisqually NWR.

The majority of the McAllister Creek basin is located in the Nisqually WRIA (WRIA 11),[4] and its watershed is located immediately west of the Nisqually River watershed (Thurston County 2013c). The McAllister Creek delta joins the Nisqually River delta complex within a broad estuarine lagoon in the Nisqually NWR (Thurston County 1994). The lagoon contains a network of braided channels and extensive

[3] These dikes and gates are intended to prevent saltwater from flowing into adjacent pasture lands (Ecology 2005).

[4] A small portion of the basin is located within WRIA 13.

mudflats at low tide. The delta consists of thick deposits of alternating clay, silt, and sand layers and supports estuarine wetland plant communities, while the creek mouth is very sandy and supports eelgrass beds (Woo et al. 2017; Thurston County 1994).

There are natural runs of chum, coho, and Chinook salmon and steelhead and anadromous cutthroat trout in McAllister Creek; however, spawning occurs only in the upper reaches of the creek due to poor habitat conditions and influences of the salt wedge in the lower reaches of the creek (Ecology 2005). Invertebrate monitoring conducted in association with restoration efforts within the Nisqually NWR included the McAllister Creek delta. These studies found that eelgrass beds in the McAllister Creek delta supported high densities of crustaceans (such as copepods and amphipods), as well as polychaete and nematode worms (Woo et al. 2016 as cited in Woo et al. 2017). The delta of McAllister Creek was also found to be highly accessible to juvenile Chinook salmon (Thurston County 2013c).

3.2 SITE SURVEY RESULTS

A qualitative site survey was conducted at two locations along the perennially flowing segment of Woodland Creek and two locations along McAllister Creek[5] to confirm and/or supplement the available data.

The two survey sites at Woodland Creek—one near Beatty Springs downstream of the Nisqually Trout Farm, and one near Pleasant Glade Park downstream of Fox Creek—were selected because they were near groundwater discharge monitoring locations (HDR 2017b) and easy to access. Observations from the site surveys near Beatty Springs and in Pleasant Glade Park are presented in Section 3.2.1.

The two survey sites at McAllister Creek—one at the overpass along Steilacoom Road Southeast south of Salmon Lane Springs, and one at the overpass along Martin Road East south of I-5—were selected because they were the only publicly accessible locations along the creek. Access to McAllister Creek is restricted, as it runs through private residential and agricultural properties before entering the Nisqually NWR. Observations from the site surveys near the Steilacoom Road Southeast and Martin Road East overpasses are presented in Section 3.2.2.

3.2.1 Woodland Creek

3.2.1.1 Beatty Springs

A 500-ft section of Woodland Creek downstream of Beatty Springs and the Nisqually Trout Farm was surveyed on June 12, 2019, for vegetation and overstory density,

[5] Access to McAllister Creek was attempted from two locations north of I-5 but was restricted by the Nisqually NWR boundaries. The Nisqually NWR (north of I-5) and the Nisqually Reach Nature Center (north of the McAllister Creek outlet) were visited to gain access to the creek. Neither provided closer access to the creek than the two surveyed areas.

habitat, and wildlife presence. The survey site was located just north of where groundwater inputs from Beatty Springs and College Creek form the established perennial stream of Woodland Creek (Figure 1).

Woodland Creek near Beatty Springs is surrounded by dense woodland forest that provides a variety of habitats for aquatic and woodland species. Overstory density was measured with a densiometer at the 0-, 250-, and 500-ft points along the 500-ft section of the stream surveyed, resulting in an estimated 75 to 91% overstory density. Dominant vegetation observed during the site survey is presented in Table 3-1.

Table 3-1. Dominant vegetation observed at Woodland Creek near Beatty Springs

Vegetation Layer	Common Name	Scientific Name
Herbaceous	bedstraw	*Galium aparine*
	field horsetail	*Equisetum arvense*
	giant horsetail	*Equisetum telmateia*
	lily-of-the-valley	*Convallaria majalis*
	Pacific waterleaf	*Hydrophyllum tenuipes*
	slough sedge	*Carex obnupta*
	soft rush	*Juncus effusus*
	stinging nettle	*Urtica dioica*
	sword fern	*Polystichum munitum*
	western bracken fern	*Pteridium aquilinum*
Shrub	bittersweet nightshade	*Solanum dulcamara*
	Himalayan blackberry	*Rubus armeniacus*
	osoberry	*Oemleria cerasiformis*
	salmonberry	*Rubus spectabilis*
	snowberry	*Symphoricarpos albus*
	tall Oregon grape	*Mahonia aquifolium*
	vine maple	*Acer circinatum*
Tree	black hawthorn	*Crataegus douglasii*
	Douglas fir	*Pseudotsuga menziesii*
	Oregon ash	*Fraxinus latifolia*
	red alder	*Alnus rubra*
	western red-cedar	*Thuja plicata*

Although fish were not observed during the survey, instream features providing suitable fish habitat—such as aquatic vegetation, LWD, and pools and riffles—were commonly observed. The LWD was often complex, with several pieces and anchored within the shore, offering refuge and rearing habitats for various fish species. Surveys conducted by Johnson and Caldwell (1992) found a pool-to-riffle ratio of 41:59, another indicator of suitable fish habitat.

Several bird species, mostly inhabitants of woodland and/or riparian areas, were observed (i.e., seen or heard) during the site survey near Beatty Springs. While no birds of prey were observed during the site visit, a hawk feather (likely from a sharp-shinned [*Accipiter striatus*] or Cooper's hawk [*Accipiter cooperii*]) was found on the ground near Woodland Creek at the Beatty Spring site. Both of these hawk species inhabit forested areas and prey upon smaller birds (The Cornell Lab of Ornithology 2011). Table 3-2 presents the birds observed during the site visit to Woodland Creek near Beatty Springs.

Table 3-2. Birds observed at Woodland Creek near Beatty Springs

Common Name	Scientific Name
American crow	*Corvus brachyrhynchos*
American goldfinch	*Spinus tristis*
American robin	*Turdus migratorius*
Brown creeper	*Certhia americana*
Cedar waxwing	*Bombycilla cedrorum*
Chickadees	*Poecile* spp.
Song sparrow	*Melospiza melodia*
Spotted towhee	*Pipilo maculatus*
Swainson's thrush	*Catharus ustulatus*
Western wood-pewee	*Contopus sordidulus*

Other wildlife observed during the site visit included invertebrates such as midges (Order: Diptera), caddisflies (Order: Trichoptera), stoneflies (Order: Plecoptera), and pouch snails (*Physa* spp.). No vertebrates other than birds were observed, but tracks from common raccoon (*Procyon lotor*) and unidentified species of deer were present along the creek bed. Photos from the site survey near Beatty Springs are provided in Appendix A.

3.2.1.2 Pleasant Glade Park

A 500-ft section of Woodland Creek in Pleasant Glade Park was surveyed on June 12, 2019, for vegetation and overstory density, habitat, and wildlife presence. Woodland Creek in Pleasant Glade Park is surrounded by low-density residential properties. The surveyed area is located just downstream from Fox Creek below the Pleasant Glade Road Northeast bridge in a forested ravine with steep banks on both sides; the survey site provides habitat for both aquatic and woodland species (Figure 1). Overstory density was measured with a densiometer at the 0-, 250-, and 500-ft points along the 500-ft section of the stream surveyed, resulting in an estimated 94 to 98% overstory density. Dominant vegetation observed during the site survey is presented in Table 3-3.

Table 3-3. Dominant vegetation observed at Woodland Creek in Pleasant Glade Park

Vegetation Layer	Common Name	Scientific Name
Herbaceous	bedstraw	*Galium aparine*
	deer fern	*Blechnum spicant*
	herb Robert	*Geranium robertianum*
	jewelweed	*Impatiens capensis*
	Pacific bleeding heart	*Dicentra formosa*
	Pacific waterleaf	*Hydrophyllum tenuipes*
	reed canary-grass	*Phalaris arundinacea*
	stinging nettle	*Urtica dioica*
	sword fern	*Polystitchum mutinium*
	water parsley	*Oenanthe sarmentosa*
	western skunk cabbage	*Lysichiton americanus*
	youth-on-age	*Tolmiea menziesii*
Shrub	English ivy	*Hedera helix*
	English laurel	*Prunus laurocerasus*
	osoberry	*Oemleria cerasiformis*
	salmonberry	*Rubus spectabilis*
	vine maple	*Acer circinatum*
Tree	Douglas fir	*Psuedotsuga menziesii*
	Oregon ash	*Fraxinus latifolia*
	red alder	*Alnus rubra*
	western red cedar	*Thuja plicata*

Although fish were not observed during the survey, instream features providing suitable fish habitat—such as LWD; cobble, gravel, and sandy substrates for spawning; and pools and riffles—were commonly observed. LWD in Pleasant Glade Park, although less prevalent than at the Beatty Springs site, was composed of larger logs and root wads. Channel flow in Pleasant Glade Park was wider but included interstitial gravel and sand bars, large pools, and small islands. Surveys conducted by Johnson and Caldwell (1992) found a creek-wide pool-to-riffle ratio of 41:59, another indicator of suitable fish habitat.

Several bird species, mostly inhabitants of woodland and/or riparian areas, were observed (i.e., seen or heard) during the site survey. In addition, woodpecker holes were observed in a snag standing near the creek. Table 3-4 presents the bird species observed during the Woodland Creek in Pleasant Glade Park site visit.

Table 3-4. Birds observed at Woodland Creek at Pleasant Glade Park

Common Name	Scientific Name
American robin	*Turdus migratorius*
Chickadees	*Poecile* spp.
Evening grosbeak	*Coccothraustes vespertinus*
Pacific-slope flycatcher	*Empidonax difficilis*
Rufous hummingbird	*Selasphorus rufus*
Song sparrow	*Melospiza melodia*
Swainson's thrush	*Catharus ustulatus*
Western wood-pewee	*Contopus sordidulus*
Wilson's warbler	*Cardellina pusilla*
Woodpecker (holes)	na

na – not applicable

Other wildlife observed during the site visit included invertebrates such as midges and mosquitos (Order: Diptera), water striders (Order: Hemiptera), caddisflies (Order: Trichoptera), and stoneflies (Order: Plecoptera). Besides birds, vertebrate wildlife observed included the common garter snake (*Thamnophis sirtalis*) along the creek bank, unidentified chipmunks and squirrels in the riparian vegetation, and a muskrat (*Ondatra zibethicus*) swimming in the creek. Tracks from common raccoon were also present along the creek bed. Photos from the site survey in Pleasant Glade Park are provided in Appendix A.

3.2.2 McAllister Creek

3.2.2.1 Steilacoom Road Southeast

Due to private property restrictions and bends in the creek that limited the line-of-sight, only the 350-ft section of McAllister Creek that was visible from Steilacoom Road Southeast was surveyed on March 4, 2020. The survey site, which was surveyed for vegetation, habitat, and wildlife presence, was located at the overpass at Steilacoom Road Southeast, just south of Salmon Lane Springs (Figure 2).

McAllister Creek at the Steilacoom Road Southeast bridge crossing is surrounded by low-density residential properties and agricultural/pasture fields. The creek mostly runs through private properties and is flanked by intermittent narrow buffers of riparian vegetation, ornamental/landscape vegetation, and open farmland. Overstory density was not measured due to creek access limitations, but the entire section of the creek surveyed had little to no canopy cover, providing marginal to low wildlife habitat. Dominant vegetation observed during site survey is presented in Table 3-5.

Table 3-5. Dominant vegetation observed at McAllister Creek at the Steilacoom Road Southeast

Vegetation Layer	Common Name	Scientific Name
Herbaceous	English ivy	*Hedera helix*
	reed canary grass	*Phalaris arundinacea,*
	scouring rush	*Equisetum hyemale*
	Sword fern	*Polystitchum mutinium*
Shrub	English laurel	*Prunus laurocerasus*
	Himalayan blackberry	*Rubus armeniacus*
	osoberry	*Oemleria cerasiformis*
	salmonberry	*Rubus spectabilis*
Tree	bigleaf maple	*Acer macrophyllum*
	Douglas fir	*Psuedotsuga menziesii*
	red alder	*Alnus rubra*
	western red cedar	*Thuja plicata*

Fish, benthic invertebrates, and instream features were also not observed during the survey due to creek access limitations.

Several bird species—primarily ducks and inhabitants of developed, open woodland, and/or riparian areas—were observed (i.e., seen or heard) from the overpass during the survey at the Steilacoom Road Southeast site. Common goldeneyes (*Bucephala clangula*), common mergansers (*Mergus merganser*), and mallards (*Anas platyrhynchos*) were observed in the creek. A bald eagle (*Haliaeetus leucocephalus*) was observed in an adjacent agricultural field, and owl pellets were seen during the site visit. Table 3-6 presents the birds observed during the site visit to McAllister Creek at Steilacoom Road Southeast.

Table 3-6. Birds observed at McAllister Creek at the Steilacoom Road Southeast

Common Name	Scientific Name
American crow	*Corvus brachyrhynchos*
Anna's hummingbird	*Calypte anna*
Bald eagle	*Haliaeetus leucocephalus*
Black-capped chickadee	*Poecile atricapillus (Parus atricapillus)*
Common goldeneye	*Bucephala clangula*
Common merganser	*Mergus merganser*
Mallard	*Anas platyrhynchos*
Mourning dove	*Zenaida macroura*
Red-breasted nuthatch	*Sitta canadensis*
Red-shafted flicker	*Colaptes auratus*

Common Name	Scientific Name
Red-winged blackbird	*Haliaeetus leucocephalus*
Song sparrow	*Melospiza melodia*
Starling	*Sturnus vulgaris*
Steller's jay	*Cyanocitta stelleri*

Other wildlife observed during the site visit included an unidentified species of chipmunk and eastern gray squirrel (*Sciurus carolinensis*). The carcass of a long-tailed weasel (*Mustela frenata*) was discovered at the overpass, and an unidentified frog call was heard nearby. Photos from the site survey at Steilacoom Road Southeast are provided in Appendix A.

3.2.2.2 Martin Way East

An 800-ft section of McAllister Creek that was visible at Martin Way East was surveyed on March 4, 2020, for vegetation, habitat, and wildlife presence. The survey site was located at the overpass along Martin Way East, adjacent to a mixed business and commercial center to the south of I-5 and the Nisqually NWR (Figure 2).

McAllister Creek at the Martin Way East overpass is surrounded by an RV park and I-5 to the north, a mixed business and commercial center to the east, and agricultural fields to the south, west, and east. The creek runs through these private and commercial properties and under I-5 before discharging into the Nisqually NWR to the north. Intermittent, narrow buffers of riparian vegetation are present but the majority of the surveyed area is developed and provides little to no wildlife habitat. Although the overstory density could not be measured due to creek access limitations, no canopy cover was seen from Martin Way East based on visual observations of the surveyed area. Dominant vegetation observed during the site survey is presented in Table 3-7.

Table 3-7. Dominant vegetation observed at McAllister Creek at the Martin Way East

Vegetation Layer	Common Name	Scientific Name
Herbaceous	sedge (unidentified)	*Carex spp.*
	sword fern	*Polystitchum mutinium*
Shrub	Himalayan blackberry	*Rubus armeniacus*
	oceanspray	*Holodiscus discolor*
	osoberry	*Oemleria cerasiformis*
	Scotch broom	*Cytisus scoparius*
	tall Oregon grape	*Mahonia aquifolium*
	trailing blackberry	*Rubus ursinus*
Tree	black cottonwood	*Populus trichocarpa*
	Douglas fir	*Psuedotsuga menziesii*
	red alder	*Alnus rubra*

Fish, benthic invertebrates, and in-stream features could not be documented during the survey due to creek access limitations.

Few bird species—mostly those that inhabit developed, open woodland and/or riparian areas—were observed (i.e., seen or heard) from the overpass during the site survey at Martin Way East (Table 3-8). Among the bird species seen was a Cooper's hawk [*Accipiter cooperii*]), which was observed in the shrubs; this species inhabits forested areas and preys on smaller birds (The Cornell Lab of Ornithology 2011). The ability to hear birds was hindered at this site by traffic noise from Martin Way East.

Table 3-8. Birds observed at McAllister Creek at the Martin Way East

Common Name	Scientific Name
Brown creeper	*Certhia americana*
Common goldeneye	*Bucephala clangula*
Cooper's hawk	*Accipiter cooperii*
Red-breasted sapsucker	*Sphyrapicus ruber*
Red-shafted flicker	*Colaptes auratus*
Starling	*Sturnus vulgaris*
Steller's jay	*Cyanocitta stelleri*

No other wildlife was observed during the site visit, but tracks from common raccoon and an unidentified canine (possibly coyote) were present along the creek. Photos from the site survey at Martin Way East are provided in Appendix A.

3.3 Ecological Receptors

This section describes the primary ecological receptors of the Woodland Creek and McAllister Creek areas, including the benthic invertebrate community, fish, and aquatic-dependent birds, herptiles, and mammals. Aquatic-dependent birds, herptiles, and mammals are those that obtain prey dependent upon the aquatic environment for a least a portion of their life cycle. Information on ecological receptors was obtained from the most recently published sources available and supplemented with data from the 2019 and 2020 site surveys described in Section 3.2. Most of the data for species observed in Woodland Creek are from a site survey conducted more than 40 years ago (Dobos et al. 1977), so it should be noted that these data may not represent current conditions in the creek. Additionally, because site-specific wildlife data for McAllister Creek were not available, many of the species listed in wildlife inventories obtained from Thurston County (1994) and the US Fish and Wildlife Service (USFWS) (2005) are associated with the Nisqually NWR, where the creek discharges into Puget Sound.

3.3.1 Benthic invertebrate community

Dobos et al. (1977) provided the most complete benthic invertebrate community data for the Woodland Creek study area, which they collected from four survey sites.

Appendix B (Table B1) presents these benthic community data supplemented with data from Haub et al. (2018) and the site visit by Windward Environmental LLC (Windward) in June 2019. Thurston County (1994) provided the benthic invertebrate community data for the McAllister Creek study area.

3.3.2 Fish community

Appendix B (Table B2) provides a summary of the fish known to be or potentially present in Woodland and McAllister Creeks at some point throughout the year. A complete survey has not been conducted in Woodland Creek, so the list in Appendix B was derived from the species reported to be present by Dobos et al. (1977) and ESA Adolfson (2008) and known to occur in the greater Olympia drainage area (Haub et al. 2018). The list of fish species for McAllister Creek was reported by Thurston County (1994, 2013b) and USFWS (2005). No fish were observed during the Windward site visits in June 2019 and March 2020.

3.3.3 Aquatic-dependent birds

Appendix B (Table B3) presents a list of all bird species known to occur in the Woodland Creek basin as reported by Dobos et al. (1977), Haub et al. (2018), and Windward during the June 2019 site visit, and in the McAllister Creek basin as reported by Thurston County (1994, 2013b), USFWS (2005), and Windward's site visit in March 2020. Of the 240 species listed in Appendix B, 124 are considered to be aquatic dependent.

3.3.4 Aquatic-dependent herptiles

Aquatic-dependent herptiles (i.e., amphibians and reptiles) feed on aquatic vegetation or aquatic invertebrates. All aquatic-dependent herptile species known to be or potentially present in the Woodland Creek and McAllister Creek basins are listed in Appendix B (Table B4).

3.3.5 Aquatic-dependent mammals

Several mammals that may feed on aquatic prey (i.e., benthic invertebrates and fish) are known to be present in the Woodland Creek and McAllister Creek basins. Appendix B (Table B5) presents the 63 mammal species known to occur in the area, 12 of which are considered to be aquatic dependent.

3.3.6 Sensitive aquatic or aquatic-dependent species

Of all the ecological receptors known to be or potentially present in the Woodland Creek and McAllister Creek areas, 20 fish species (including 3 fish runs), 11 bird species, 1 reptile, 2 amphibians, 1 invertebrate, and 3 aquatic-dependent mammal species are listed as sensitive (Appendix B, Table B6). These species are considered sensitive because they are listed by the USFWS under the Endangered Species Act and/or by the

WDFW as either a species of concern (i.e., endangered, threatened, sensitive, or candidate) or a priority species that meets any of the following three criteria:

1. State-listed candidate species
2. Vulnerable aggregations
3. Species of recreational, commercial, and/or tribal importance

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4 Receptors of Concern

This section describes the representative ecological ROCs that will be evaluated in the risk characterization step of the ERA. Only those receptors that could be evaluated using water data (the only type of data available for this site) were considered as ROCs. Species for which direct water contact is the primary exposure route (aquatic plants, aquatic invertebrates, fish, and herptiles) are included as ROCs. In addition, bird and mammal species that consume primarily fish are included as ROCs, because chemical concentrations can be estimated in fish tissue using water concentrations and bioaccumulation factors (BAFs) or bioconcentration factors (BCFs).[6]

Because of the large number and variety of species potentially present in the study area, not all species can be evaluated individually in the risk characterization step. Instead, for aquatic species such as aquatic plants, invertebrates, fish, and herptiles that are exposed via direct contact with water, the general aquatic community will be evaluated using aquatic toxicity data available for a variety of species. For birds and wildlife, only one receptor from each group will be evaluated in the risk characterization step, as these receptors are expected to sufficiently represent other species. The belted kingfisher (*Megaceryle alcyon*) and northern river otter (*Lontra canadensis*) were selected as ROCs to represent piscivorous species of birds and mammals, respectively. Belted kingfisher is representative of other primarily piscivorous birds that may feed in Woodland and McAllister Creeks, such as great blue heron (*Ardea herodias*) or green heron (*Butorides virescens*). Northern river otter is considered representative of mink, the only other mammalian species that consumes primarily fish and could be present in Woodland and McAllister Creeks. Both species feed primarily on fish, although they may consume other types of aquatic organisms in smaller quantities (Prose 1985; Kelly et al. 2009). Belted kingfisher and northern river otter have been observed in Woodland Creek (Dobos et al. 1977) and McAllister Creek (Thurston County 1994; USFWS 2005) and are known to be present in the area (Haub et al. 2018). Exposure data for both species are readily available from EPA (1993) for evaluating uptake in a dietary model.

[6] A BAF allows for an estimation of uptake from direct contact with water as well as intake through the diet, whereas a BCF accounts for only uptake from direct contact with water. If a BAF is not available for a particular chemical, a BCF may be used instead.

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5 Conceptual Site Model

An ecological CSM is used to describe the pathways by which chemicals move from sources (i.e., surface water, tissue, sediment, and groundwater) to ecological receptors at a given site. A CSM is based on site-specific information about species known or assumed to be present at the site or similar systems and potential exposure pathways.

5.1 Potential Exposure Pathways

Figure 3 presents the CSM for this site, including exposure pathways for relevant ecological receptor groups. The most important exposure pathways for aquatic organisms in Woodland and McAllister Creeks are ingestion and direct contact. Exposure pathways are classified as one of the following for each ROC:

- **Complete and significant** – Pathway is complete (i.e., there is a direct link between the ROC and chemicals in reclaimed water via this pathway) and expected to be a significant source of exposure for the ROC.
- **Complete and insignificant** – Pathway is complete but not likely to significantly contribute to the exposure of the ROC.
- **Incomplete** – There is no direct pathway of exposure between the ROC and chemicals in reclaimed water.

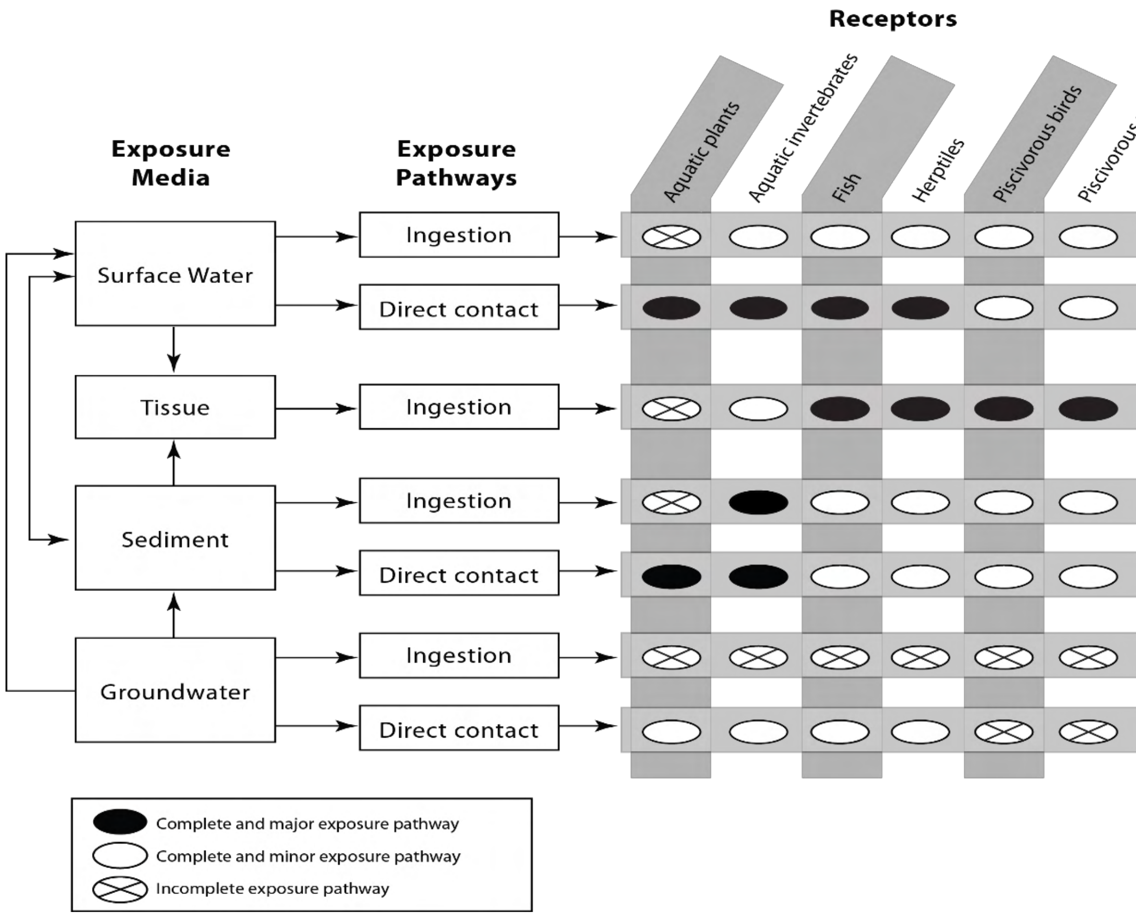

Figure 3. Exposure pathway model for Woodland and McAllister Creeks

5.2 Assessment Endpoints

For this problem formulation, assessment endpoints were identified as attributes of an ecological system to be protected (Table 5-1), based on the EPA (1998) definition of assessment endpoints as "explicit expressions of the actual environmental value that is to be protected, operationally defined by an ecological entity and its attributes." The assessment endpoints identified were the protection and maintenance of the aquatic community as a whole, of fish, and of aquatic-dependent bird and mammal (i.e., wildlife) populations residing in or feeding from Woodland or McAllister Creeks. Testable risk hypotheses were developed for all three assessment endpoints and were formulated into risk questions to be used in the risk characterization step of the ERA (Table 5-1). Based on these questions, the assessment endpoints will be addressed using measurement endpoints that involve the comparison of chemicals in surface water or fish tissue to ecological benchmarks derived from the scientific literature and calculated dietary doses. Only the chemicals identified in the screening-level evaluation will be addressed in the risk characterization step. Toxicity reference values (TRVs) used to characterize risk will represent concentrations associated with a 20% reduction in growth, reproduction, or survival, where data are available.[7]

Table 5-1. Assessment endpoints for Woodland and McAllister Creeks

Assessment Endpoint	Risk Question	Measurement Endpoint
Protection and maintenance of aquatic community populations in Woodland and McAllister Creeks	Are modeled concentrations of chemicals in surface water in Woodland and McAllister Creeks (predicted based on a fate and transport model) at levels that might adversely affect the aquatic community?	comparison of modeled concentrations in surface water to TRVs[a] for reduced survival, growth, or reproduction
Protection and maintenance of fish populations in Woodland and McAllister Creeks	Are modeled concentrations of chemicals in the tissues of fish (modeled using BAFs/BCFs) in Woodland and McAllister Creeks at levels that might adversely affect fish populations?	comparison of modeled concentrations in fish tissue to TRVs for reduced survival, growth, or reproduction[b]
Protection and maintenance of aquatic-dependent wildlife populations in Woodland and McAllister Creeks	Are modeled concentrations of chemicals in the tissues of prey (modeled using BAFs/BCFs) consumed by birds and mammals in Woodland and McAllister Creeks at levels that might adversely affect aquatic-dependent wildlife populations?[c]	comparison of calculated dietary doses to TRVs for reduced survival, growth, or reproduction[d]

[a] A water TRV is a concentration of a COI in water representing a toxicity threshold below which adverse effects are not expected to occur.

[b] A tissue TRV is a concentration of a COI in tissue representing a toxicity threshold below which adverse effects are not expected to occur.

[c] The tissue ingestion pathway is only complete for chemicals that bioaccumulate.

[d] A dietary TRV is a dose of a COI (i.e., an amount ingested daily on a body weight-normalized basis) representing a toxicity threshold below which adverse effects are not expected to occur.

BAF – bioaccumulation factor

BCF – bioconcentration factor

COI – chemical of interest

TRV – toxicity reference value

[7] In comparison, toxicity benchmarks used for the screening assessment are based primarily on concentrations associated with no effect or the geomean of the no-effect and lowest-effect concentrations (see Section 6.2).

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6 Selection of Chemicals of Potential Ecological Concern

This section describes the methods used to refine the list of COIs to a list of COPECs, which will be considered further. COPECs were selected by comparing the maximum concentrations of COIs in reclaimed water or porewater samples to conservative screening-level benchmarks. In addition, chemicals identified as persistent and bioaccumulative were selected as COPECs, as described in Section 6.2.3. The COIs for this evaluation were residual chemicals (i.e., pharmaceuticals, personal care products, and hormones),[8] organobromine compounds (polybrominated diephenyl ethers [PBDEs], ethylene dibromide [EDB], and dibromochloropropane [DBCP]), and per- and polyfluoralkyl substances (PFAS).

6.1 Available Data

COIs were analyzed in the following types of water samples collected from the vicinity of one or both LOTT wastewater treatment plants (MWRWP and BITP/BIRWP):[9]

- Effluent – Secondary effluent produced at BITP was sampled in November 2014 and February and August 2015 (HDR 2017c).
- Reclaimed water – Reclaimed water was sampled at MWRWP in November 2014 and February, May, and October 2015. Sampling took place at the MWRWP treatment plant, the inflow point to the Hawks Prairie wetland ponds, and the inflow point to the Hawks Prairie recharge basins. Reclaimed water from BITP/BIRWP was sampled at one location in November 2014 and February, May, and August 2015 (HDR 2017c). In addition, reclaimed water that bypassed the wetland ponds at MWRWP was sampled from January through October 2018 (HDR 2019).
- Porewater – Vadose zone porewater was collected from three depths at two locations within one of the Hawks Prairie recharge basins on a monthly basis from January through October 2018. Residual chemicals were analyzed in January, April, June, and August of the same year (HDR 2019).
- Groundwater – Groundwater was collected from domestic and municipal water wells in two study areas. In the Hawks Prairie area, 7 monitoring wells were

[8] The residual chemicals include 95 chemicals on the standard analyte list of the Eurofins-Eaton Analytical, Inc. laboratory in Monrovia, California. This list was developed to support reclaimed water projects in California and is currently used extensively throughout the United States on various projects. The list includes all analytes recommended by the California State Water Board for routine monitoring. See Appendix A of HDR (2017c) for a full list of residual chemicals analyzed.

[9] Untreated wastewater influent from MWRWP was sampled at the Martin Way Pump Station in November 2014 and February, May, and October 2015. Influent from BITP was sampled in November 2014 and February, May, and August 2015 (HDR 2017c). Influent data were not used to select COPECs.

sampled in 2013; 26 residential, public supply, and monitoring wells were sampled from April through June 2015, and 3 monitoring wells were resampled in May 2016. In the Tumwater area, 30 residential and public supply wells were sampled from August through September 2015 (HDR 2017a). In addition, groundwater was collected from 14 wells in the Hawks Prairie area during various sampling events from January through October 2018 (HDR 2019).

- Surface water – Surface water was collected from the Woodland Creek and Deschutes River watersheds during four sampling events in 2015. Sampling took place on the upper and lower sections of Woodland Creek, on the Deschutes River, and on associated tributaries. In addition, reference locations were sampled in the summer and winter of 2015 (HDR 2017b).

6.2 METHODS

This section describes the methods used to derive the screening-level benchmarks (Section 6.2.1), to compare those benchmarks to LOTT water quality data (Section 6.2.2), and to identify persistent and bioaccumulative chemicals (Section 6.2.3).

6.2.1 Derivation of screening-level benchmarks

Standard screening-level benchmarks are not available for the COIs evaluated for this study (with the exception of 4-nonylphenol, fipronil, and linuron), because these COIs are contaminants of emerging concern (EPA 2016). Therefore, screening-level benchmarks were derived by consulting a variety of resources, as available. Chronic toxicity values were used in all cases to better reflect what is known about the potential effects of long-term exposures. The primary sources of toxicity values were EPA's Ecological Structure Activity Relationships (ECOSAR) model (Mayo-Bean et al. 2017), Caldwell et al. (2012), Maruya et al. (2013), and ECOTOX (EPA 2018). These sources and the benchmarks derived from them are described in more detail in this section.
Table 6-1 provides the list of benchmarks selected for screening COIs detected in reclaimed water or porewater. A total of 29 literature-based benchmarks (27 for COIs detected in reclaimed water or porewater) were used (in parallel with ECOSAR-based benchmarks) for screening purposes. Appendix C, Table C1, also provides a tabular compilation of these benchmarks. Benchmarks were not derived for COIs that were not detected in any medium, and those COIs were not screened as part of this evaluation.

Table 6-1. Screening-level benchmarks for COIs detected in reclaimed water or porewater

COI Information				ECOSAR Information		Literature Information		
COI Name	COI Group	Use	CAS Registry No.	MATC/10 (ng/L)	Modeled Species	Benchmark (ng/L)	Endpoint	Notes
1,4-Dioxane	residual chemicals	non-PPCP	123-91-1	20,073,300	green algae	--		
1,7-Dimethylxanthine	residual chemicals	caffeine degradate	611-59-6	400	green algae	--		
2,4-Dichlorophenoxyacetic (2,4-D)	residual chemicals	herbicide	94-75-7	3,480,900	daphnid	79,000,000	NOEC	daphnia
4-Nonylphenol	residual chemicals	surfactant	104-40-5	600	fish	500	LOEC	Atlantic salmon, safety factor of 10; EPA's aquatic life criterion is 6,600 ng/L
4-tert-Octylphenol	residual chemicals	surfactant	140-66-9	1,900	fish	3,200	NOEC	zebrafish
Acesulfame-K	residual chemicals	sugar substitute	55589-62-3	151,701,20 0	green algae	--		
Acetaminophen	residual chemicals	analgesic	103-90-2	47,900	fish	9,200,000	NOEC	daphnia
Albuterol	residual chemicals	anti-asthmatic	18559-94-9	130,300	daphnid	--		
Amoxicillin	residual chemicals	antibiotic	26787-78-0	551,000	fish	--		
Atenolol	residual chemicals	beta blocker	29122-68-7	114,900	fish	19,000	EC10	duckweed (plant)
BPA	residual chemicals	plasticizer	80-05-7	22,700	green algae	120,000	NOEC	fathead minnow
Bromacil	residual chemicals	herbicide	314-40-9	500	green algae	--		

COI Information				ECOSAR Information		Literature Information		
COI Name	COI Group	Use	CAS Registry No.	MATC/10 (ng/L)	Modeled Species	Benchmark (ng/L)	Endpoint	Notes
Butalbital	residual chemicals	analgesic-NSAID	77-26-9	500	green algae	--		
Caffeine	residual chemicals	stimulant	58-08-2	400	green algae	--		
Carbadox	residual chemicals	antibiotic	6804-07-5	155,300	green algae	--		
Carbamazepine	residual chemicals	anti-seizure	298-46-4	13,000	green algae	875,000	NOEC	geometric mean of multiple results (daphnid and zebrafish)
Carisoprodol	residual chemicals	muscle relaxant	78-44-4	150,200	fish	--		
Chloramphenicol	residual chemicals	antibiotic	56-75-7	21,700	green algae	--		
Chloridazon	residual chemicals	herbicide	1698-60-8	36,700	green algae	--		
Clofibric Acid	residual chemicals	herbicide/ cholesterol drug	882-09-7	2,289,900	daphnid	40,000,000	NOEC	daphnia
Cotinine	residual chemicals	nicotine degradate	486-56-6	51,800	fish	--		
Cyanazine	residual chemicals	triazine herbicide	21725-46-2	7,100	green algae	--		
DACT	residual chemicals	triazine degradate	3397-62-4	5,400	daphnid	--		
DEA	residual chemicals	triazine degradate	111-42-2	2,323,400	daphnid	--		
DEET	residual chemicals	mosquito repellant	134-62-3	7,500	fish	--		
Dehydronifedipine	residual chemicals	blood pressure drug metabolite	67035-22-7	57,800	fish	--		

COI Information				ECOSAR Information		Literature Information		
COI Name	COI Group	Use	CAS Registry No.	MATC/10 (ng/L)	Modeled Species	Benchmark (ng/L)	Endpoint	Notes
Diazepam	residual chemicals	antianxiety	439-14-5	7,000	fish	--		
Dibromochloropropane	organobromine	antihelmintic	96-12-8	332,800	daphnid	--		
Diclofenac	residual chemicals	anti-inflammatory	15307-86-5	421,600	daphnid	1,500,000	NOEC	zebrafish
Dilantin	residual chemicals	anti-seizure	57-41-0	500	green algae	788,400	LOEC	zebrafish, safety factor of 10
Diltiazem	residual chemicals	vasodilator	42399-41-7	9,200	fish	--		
Diuron	residual chemicals	herbicide	330-54-1	9,300	green algae	--		
Erythromycin	residual chemicals	antibiotic	114-07-8	74,700	daphnid	--		
Estradiol – 17 beta	residual chemicals	estrogenic hormone	50-28-2	21,200	fish	2	PNEC	based on multiple species
Estrone	residual chemicals	estrogenic hormone	53-16-7	41,500	daphnid	6	PNEC	based on multiple species
Ethinyl estradiol – 17 alpha	residual chemicals	estrogenic hormone	57-63-6	17,500	fish	0.1	PNEC	based on multiple species
Fipronil	organobromine	insecticide	120068-37-3	16	fish	11	EPA chronic value	invertebrate benchmark
Flumequine	residual chemicals	antibiotic	42835-25-6	359,700	daphnid	--		
Fluoxetine	residual chemicals	antidepressant	54910-89-3	1,900	daphnid	--		
Gemfibrozil	residual chemicals	lipid regulator	25812-30-0	88,900	fish	851,900	NOEC	goldfish

COI Information				ECOSAR Information		Literature Information		
COI Name	COI Group	Use	CAS Registry No.	MATC/10 (ng/L)	Modeled Species	Benchmark (ng/L)	Endpoint	Notes
Ibuprofen	residual chemicals	analgesic-NSAID	15687-27-1	430,500	daphnid	1,000	NOEC	medaka
Iohexol	residual chemicals	x-ray contrast agent	66108-95-0	6,602,100	fish	--		
Iopromide	residual chemicals	x-ray contrast agent	73334-07-3	4,560,000	fish	--		
Ketorolac	residual chemicals	anti-inflammatory	74103-06-3	1,000	daphnid	--		
Lidocaine	residual chemicals	analgesic	137-58-6	17,200	fish	--		
Lincomycin	residual chemicals	antibiotic	154-21-2	126,000	fish	--		
Linuron	residual chemicals	herbicide	330-55-2	8,400	green algae	90	EPA chronic value	invertebrate benchmark
Lopressor	residual chemicals	beta blocker	51384-51-1	74,500	daphnid	--		
Meclofenamic acid	residual chemicals	anti-inflammatory	644-62-2	9,000	fish	no data		no suitable ECOTOX values
Meprobamate	residual chemicals	anti-anxiety	57-53-4	1,067,400	fish	--		
Metformin	residual chemicals	antidiabetic	657-24-9	1,898,100	daphnid	--		
Methylparaben	residual chemicals	preservative	99-76-3	152,000	daphnid	--		
Naproxen	residual chemicals	analgesic-NSAID	22204-53-1	1,573,700	daphnid	793	NOEC	fathead minnow
Nifedipine	residual chemicals	calcium blocker	21829-25-4	34,400	daphnid	--		

COI Information				ECOSAR Information		Literature Information		
COI Name	**COI Group**	**Use**	**CAS Registry No.**	**MATC/10 (ng/L)**	**Modeled Species**	**Benchmark (ng/L)**	**Endpoint**	**Notes**
NDMA	residual chemicals	degradate/impurity (fuel, food stuff, pesticides)	62-75-9	412,000	daphnid	--		
Norethisterone	residual chemicals	steroid hormone	68-22-4	493,000	daphnid	--		
OUST® (Sulfameturon,methyl)	residual chemicals	herbicide	74222-97-2	2,400	green algae	--		
Oxolinic acid	residual chemicals	antibiotic	14698-29-4	589,700	daphnid	--		
Pentoxifylline	residual chemicals	blood thinner	6493-05-6	600	green algae	--		
PFOA	PFAS	perfluoro surfactant	335-67-1	134,100	fish	16,000,000	NOEC	rainbow trout (plasma vitellogenin biomarker)
Perfluoro-1-butanesulfonic acid	PFAS	perfluoro surfactant	375-73-5	18,686,500	daphnid	--		no suitable ECOTOX values
PFBA	PFAS	perfluoro surfactant	375-22-4	7,684,500	daphnid	13,700,000	LOEC	zebrafish, safety factor of 10
Perfluoro-n-hexanoic acid	PFAS	perfluoro surfactant	307-24-4	1,130,600	daphnid	724,000,000	EC05	daphnia
PFNA	PFAS	perfluoro surfactant	375-95-1	40,500	fish	24,596,165,800	NOEC	daphnid; literature benchmark unrealistic because it exceeds solubility by six orders of magnitude.
Perfluoropentanoic acid	PFAS	perfluoro surfactant	2706-90-3	3,001,800	daphnid	100,000	LOEC	rotifer; safety factor of 10
Primidone	residual chemicals	anti-convulsant	125-33-7	42,700	fish	--		

COI Information				ECOSAR Information		Literature Information		
COI Name	COI Group	Use	CAS Registry No.	MATC/10 (ng/L)	Modeled Species	Benchmark (ng/L)	Endpoint	Notes
Quinoline	residual chemicals	pesticide	91-22-5	459,800	daphnid	--		
Salicylic acid	residual chemicals	skin-care agent	69-72-7	412,600	daphnid	--		
Simazine	residual chemicals	triazine herbicide	122-34-9	6,400	green algae	--		
Sucralose	residual chemicals	sugar substitute	56038-13-2	17,000	green algae	--		
Sulfadiazine	residual chemicals	sulfa antibiotic	68-35-9	14,800	daphnid	--		
Sulfadimethoxine	residual chemicals	sulfa antibiotic	122-11-2	6,600	daphnid	--		
Sulfamethoxazole	residual chemicals	sulfa antibiotic	723-46-6	8,600	daphnid	243,000	NOEC	geometric mean of multiple results (algae and zebrafish)
TCEP	residual chemicals	flame retardant	115-96-8	1,500	fish	--		
TCPP	residual chemicals	flame retardant	1067-98-7	1,100	fish	13,000,000	NOEC	daphnia
TDCPP	residual chemicals	flame retardant	13674-87-8	1,200	fish	--		
Testosterone	hormone	steroid hormone	58-22-0	148,100	daphnid	10,000	NOEC	daphnia
Theobromine	residual chemicals	caffeine degradate	83-67-0	400	green algae	--		
Theophylline	residual chemicals	anti-asthmatic	58-55-9	400	green algae	--		
Thiabendazole	residual chemicals	anthelminthic	148-79-8	6,600	daphnid	--		

COI Information				ECOSAR Information		Literature Information		
COI Name	COI Group	Use	CAS Registry No.	MATC/10 (ng/L)	Modeled Species	Benchmark (ng/L)	Endpoint	Notes
Triclosan	residual chemicals	antibacterial	3380-34-5	7,100	fish	15,100	NOEC	rainbow trout
Trimethoprim[a]	residual chemicals	antibiotic	23256-42-0	8,100	daphnid	--		

Note: COIs presented in Table 6-1 were detected in reclaimed water or porewater. Additional information about selected benchmarks is presented in Appendix C.

[a] ECOSAR modeling for trimethoprim was based on a compound excluding lactate ion. CAS registry number relates to the commercially available lactate salt.

BPA – bisphenol A
CAS – chemical abstracts service
COI – chemical of interest
DACT – 2-Chloro-4,6-diamino-1,3,5-triazine
DEA – diethanolamine
DEET – N,N-Diethyl-m-toluamide
ECx – concentration that causes a non-lethal effect in x% of an exposed population
ECOSAR -- Ecological Structure Activity Relationships
EPA – US Environmental Protection Agency
LOEC – lowest-observed-effect concentration
MATC – maximum acceptable toxic concentration
NDMA – N-Nitroso dimethylamine
NOEC – no observed effect concentration
NSAID – nonsteroidal anti-inflammatory drug
PFAS – per- and polyfluoralkyl substances
PFBA – perfluoro butanoic acid
PFNA – perfluoro-n-nonanoic acid
PFOA – perfluoro octanoic acid
PNEC – probable no-effect concentration
PPCP – pharmaceutical and personal care product
TCEP – tris(2-carboxyethyl)phosphine
TCPP – tris(chloropropyl)phosphate
TDCPP – tris(1,3-dichloro-2-propyl)phosphate

Chronic toxicity values were estimated using the ECOSAR model in EPA's Estimation Program Interface (EPI) Suite software (version 4.11). ECOSAR uses the chemical structure of a molecule to estimate its toxicity to aquatic organisms (Mayo-Bean et al. 2017).[10] ECOSAR estimates maximum acceptable toxic concentrations (MATCs) (referred to by the EPI Suite as "chronic values," or ChVs), which are the geometric means of the no-observed-effect concentration (NOECs) and the lowest-observed-effect concentration (LOECs). An MATC is an estimate of the lowest point at which an effect would be observed after chronic exposure to a given COI. For more complex molecules, several MATCs may be generated by ECOSAR for each organism. In such cases, the lowest (i.e., most protective) MATC among all freshwater species modeled by ECOSAR (i.e., green algae, daphnids, and fish) was used as the basis for the screening-level benchmark. Because of potential uncertainties associated with the use of a model rather than empirical data, a safety factor of 10 was applied to the lowest MATC derived from ECOSAR.

The steroid estrogen COIs included in this evaluation (i.e., estrone, 17-alpha ethinyl estradiol, and 17-beta estradiol) are potent endocrine-disrupting compounds (Adeel et al. 2017; Ebele et al. 2017), and their measured chronic toxicity values are substantially lower than those predicted by ECOSAR (Caldwell et al. 2012). As a result, literature-based probable no-effect concentration (PNEC) values for these compounds were used to screen COIs (in addition to ECOSAR-based benchmarks) (Caldwell et al. 2012). PNECs are conservative benchmarks based on a range of NOECs and species, so no safety factor was applied.

Values reported by Maruya et al. (2013) were also used because the authors compiled many relevant risk-based values for COIs, the toxicity data were readily available (in supplemental materials to the authors' report), and the values were recommended for use by a regulatory agency (in California). From among the available data compiled by Maruya et al. (2013), the highest available NOEC below an associated LOEC (from the same source study) was used. If an associated LOEC was not available, the geometric mean of NOECs was selected as the benchmark. When NOECs were unavailable in the literature, conservative ECx values (concentrations that cause a non-lethal effect in x% of an exposed population) or LOEC values were used. LOECs were divided by a safety factor of 10 to account for uncertainty in using an effect level (rather than a no-effect level), while an EC05 or EC10 was considered sufficiently conservative (and likely comparable to a NOEC or MATC) without applying a safety factor.[11]

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[10] Chemical structure was put into the EPI Suite interface using Simplified Molecular-Input Line-Entry System (SMILES) values, which were obtained for each COI from the National Institutes of Health PubChem database (NIH 2019).

[11] LOEC/10 values were used for 4-nonylphenol and triclocarban, an EC05 was used for perfluoro-n-hexanoic acid, and an EC10 was used for atenolol.

For eight COIs,[12] ECOSAR identified MATC values as relatively uncertain, so these COIs were evaluated further. Specifically, this situation applied to cases in which the mechanism of action assumed by ECOSAR was narcosis, which may have resulted in unrealistically high MATCs. To address this uncertainty, data were exported from the ECOTOX database. From the available data, the highest available chronic NOEC that was less than an effect level (e.g., LOEC or EC10) was selected as a screening-level benchmark, if possible. LOEC and EC05 values were also selected from ECOTOX when NOECs were unavailable. Prior to selecting ECOTOX values, several types of data were excluded: effect levels greater than 50%, values missing a reported endpoint, values missing a reported exposure duration, and unbounded values.[13] Despite searching, no benchmark values could be derived from ECOTOX for two COIs: meclofenamic acid and perfluoro-1-butanesulfonic acid (which is also included in the LOTT database as the conjugate base perfluoro-1-butanesulfonate). ECOSAR values were still used to screen these COIs.

6.2.2 Comparison to screening-level benchmarks

COI concentrations reported in the LOTT database were screened against the benchmarks described in Section 6.2.1 (Table 6-1 and Appendix C). COIs that were identified for analysis but were not detected in any medium were excluded from the comparison to benchmarks. Exceedance factors (EFs) were calculated by dividing the measured concentration by the associated benchmark value. If a COI concentration exceeded either an ECOSAR- or literature-based benchmark (EF > 1), then the COI was identified as a COPEC. Although Table 6-1 (as well as tables in Section 6.3) includes only COI benchmarks that were detected in reclaimed water or porewater, concentrations, benchmarks, and benchmark screening results are also provided for chemicals that were detected in other media (but not reclaimed water or porewater); data related to chemicals not detected in reclaimed water or porewater are provided in Appendix C.

6.2.3 Identification of persistent and bioaccumulative compounds

COPECs were also identified by evaluating whether a COI was persistent and bioaccumulative. Persistent and bioaccumulative COIs were retained as COPECs regardless of whether they exceeded screening-level benchmarks, because the screening-level benchmarks were for exposure via water, not food. Because dietary exposure might be an important exposure route for persistent and bioaccumulative COIs, it will be evaluated as part of the risk characterization step for those COPECs

[12] The eight COIs were 2,4-D, clofibric acid, diclofenac, perfluoro butanoic acid, perfluoro-1-butanesulfonate, perfluoro-n-hexanoic acid, perfluoro-n-nonanoic acid, and perfluoropentanoic acid.

[13] An unbounded LOEC was reported when there was significant toxicity measured at the lowest tested concentration, and an unbounded NOEC was reported when there was no significant toxicity measured at the highest concentration tested.

retained based on persistence and bioaccumulation potential. The evaluation described herein is limited to COIs detected in reclaimed water or porewater, although Appendix C describes additional COIs that were detected in other media.

Models in EPA's EPI Suite can predict chemical fate parameters for a given chemical, such as its water solubility, octanol-water partitioning coefficient (K_{ow}), BAF, and environmental half-life. Using the ranking methods from Toxic Substances Control Act (TSCA) guidance (EPA 2012), half-lives and BAFs were used to determine whether each COI was persistent and bioaccumulative. Per TSCA methods, a COI is assigned a score depending on its degree of persistence and bioaccumulation potential. If a COI's estimated BAF or BCF is between 1,000 and 5,000, it is given a bioaccumulation score of two; if the BAF or BCF is 5,000 or higher, the COI is given a bioaccumulation score of three. In this evaluation, BAFs were used instead of BCFs, because BAFs account for uptake from both water and diet, whereas BCFs account for uptake from water only. The highest (i.e., most conservative) BAF among the trophic levels was used to evaluate bioaccumulation potential.[14] Then, if the half-life in any environmental medium exceeds two months, the COI is given a persistence score of two, or if the half-life exceeds six months, it is given a score of three. Per TSCA guidance, chemicals with combined bioaccumulation and persistence scores of three or four are assigned a "moderate" ranking, and chemicals with scores of five or six are assigned a "high" ranking. For this evaluation, COIs with a high ranking were classified as COPECs. PFAS are bioaccumulative (despite having relatively low K_{ow} values) (Cheng and Ng 2018); therefore, all PFAS detected in reclaimed water or porewater were classified as COPECs regardless of the BAF estimates made by EPI Suite.

6.3 Results

The results of the benchmark screen for reclaimed water and porewater are provided in Table 6-2. Of the COIs considered, 82 were detected in reclaimed water or porewater, and 8 had EFs > 1: 4-nonylphenol, 17-alpha ethinyl estradiol, 17-beta estradiol, fipronil, sucralose, tris(chloropropyl)phosphate (TCPP), tris(1,3-dichloro-2-propyl)phosphate (TDCPP), and theobromine. All eight of these COIs have been classified as COPECs for further consideration. The full data screen (including COIs detected in other media) is provided in Appendix C, Tables C2 and C3.

[14] All trophic levels were considered relevant for the screening-level evaluation. In addition, BAFs that considered biotransformation (i.e., metabolism) were used, because they were most relevant for net bioaccumulation. Because many of the COIs are pharmaceuticals or the metabolic byproducts thereof, it is reasonable to expect that many COIs will be biotransformed by other biota.

Table 6-2. Results of COPEC screening process, COIs detected in reclaimed water or porewater

COI	N	DF (%)	Max Detected Conc. (ng/L)	ECOSAR-based Benchmark (ng/L)	Literature-based Benchmark (ng/L)	No. Exceeding ECOSAR-based Benchmark	No. Exceeding Literature-based Benchmark	ECOSAR-based EF (Max.)	Literature-based EF (Max.)	Max. EF > 1?
1,4-Dioxane	49	100	850	20,073,300	--	0	--	0.000042	--	no
1,7-Dimethylxanthine	50	20	45	400	--	0	--	0.11	--	no
2,4-Dichlorophenoxyacetic acid (2,4-D)	50	32	160	3,480,900	79,000,000	0	0	0.000046	0.000002	no
4-Nonylphenol[a]	55	53	510,000	600	500	17	18	850	1000	yes
4-tert-Octylphenol	50	6	130	1,900	3,200	0	0	0.068	0.041	no
Acesulfame-K	50	88	13,000	151,701,200	--	0	--	0.000086	--	no
Acetaminophen	50	40	160	47,900	9,200,000	0	0	0.0033	0.000017	no
Albuterol	50	20	11	130,300	--	0	--	0.000084	--	no
Amoxicillin	50	2	33	551,000	--	0	--	0.00006	--	no
Atenolol	50	76	230	114,900	19,000	0	0	0.002	0.012	no
BPA	53	5.7	28	22,700	120,000	0	0	0.0012	0.00023	no
Bromacil	50	6	14	500	--	0	--	0.028	--	no
Butalbital	50	86	54	500	--	0	--	0.11	--	no
Caffeine	50	14	76	400	--	0	--	0.19	--	no
Carbadox	50	2	14	155,300	--	0	--	0.00009	--	no
Carbamazepine	50	100	850	13,000	875,000	0	0	0.065	0.00097	no
Carisoprodol	50	86	110	150,200	--	0	--	0.00073	--	no
Chloramphenicol	50	2	24	21,700	--	0	--	0.0011	--	no
Chloridazon	50	8	62	36,700	--	0	--	0.0017	--	no
Clofibric acid	50	22	120	2,289,900	40,000,000	0	0	0.000052	0.000003	no
Cotinine	50	48	130	51,800	--	0	--	0.0025	--	no
Cyanazine	50	6	9.3	7,100	--	0	--	0.0013	--	no

COI	N	DF (%)	Max Detected Conc. (ng/L)	ECOSAR-based Benchmark (ng/L)	Literature-based Benchmark (ng/L)	No. Exceeding ECOSAR-based Benchmark	No. Exceeding Literature-based Benchmark	ECOSAR-based EF (Max.)	Literature-based EF (Max.)	Max. EF > 1?
DACT	50	6	12	5,400	--	0	--	0.0022	--	no
DEA	50	4	20	2,323,400	--	0	--	0.0000086	--	no
DEET	50	78	500	7,500	--	0	--	0.067	--	no
Dehydronifedipine	50	6	8.7	57,800	--	0	--	0.00015	--	no
Diazepam	50	4	9.3	7,000	--	0	--	0.0013	--	no
Dibromochloropropane	15	6.7	11	332,800	--	0	--	0.000033	--	no
Diclofenac	50	36	260	421,600	1,500,000	0	0	0.00062	0.00017	no
Dilantin	50	62	130	500	788,400	0	0	0.26	0.00016	no
Diltiazem	50	18	370	9,200	--	0	--	0.04	--	no
Diuron	50	62	100	9,300	--	0	--	0.011	--	no
Erythromycin	50	18	48	74,700	--	0	--	0.00064	--	no
Estradiol - 17 beta	65	6.2	35	21,200	2	0	4	0.0017	18	yes
Estrone	65	7.7	1.9	41,500	6	0	0	0.000046	0.32	no
Ethinyl estradiol – 17 alpha	65	17	64	17,500	0.1	0	11	0.0037	640	yes
Fipronil	12	50	51	15.8	11	3	3	3.2	4.6	yes
Flumeqine	50	8	98	359,700	--	0	--	0.00027	--	no
Fluoxetine	50	52	210	1,900	--	0	--	0.11	--	no
Gemfibrozil	50	44	710	88,900	851,900	0	0	0.008	0.00083	no
Ibuprofen	50	26	320	430,500	1,000	0	0	0.00074	0.32	no
Iohexol	50	88	14,000	6,602,100	--	0	--	0.0021	--	no
Iopromide	50	54	540	4,560,000	--	0	--	0.00012	--	no
Ketorolac	50	6	18	1,000	--	0	--	0.018	--	no
Lidocaine	50	60	550	17,200	--	0	--	0.032	--	no
Lincomycin	50	12	76	126,000	--	0	--	0.0006	--	no

COI	N	DF (%)	Max Detected Conc. (ng/L)	ECOSAR-based Benchmark (ng/L)	Literature-based Benchmark (ng/L)	No. Exceeding ECOSAR-based Benchmark	No. Exceeding Literature-based Benchmark	ECOSAR-based EF (Max.)	Literature-based EF (Max.)	Max. EF > 1?
Linuron	50	10	7.9	8,400	90	0	0	0.00094	0.088	no
Lopressor	50	78	900	74,500	--	0	--	0.012	--	no
Meclofenamic acid	50	12	300	9,000	--	0	--	0.033	--	no
Meprobamate	50	82	390	1,067,400	--	0	--	0.00037	--	no
Metformin	50	56	2,600	1,898,100	--	0	--	0.0014	--	no
Methylparaben	50	4	48	152,000	--	0	--	0.00032	--	no
Naproxen	50	8	32	1,573,700	793	0	0	0.00002	0.04	no
Nifedipine	50	2	20	34,400	--	0	--	0.00058	--	no
NDMA	49	51	8.2	412,000	--	0	--	0.00002	--	no
Norethisterone	50	4	5.9	493,000	--	0	--	0.000012	--	no
OUST® (Sulfameturon,methyl)	35	2.9	11	2,400	--	0	--	0.0046	--	no
Oxolinic acid	50	6	64	589,700	--	0	--	0.00011	--	no
Pentoxifylline	50	8	9.9	600	--	0	--	0.017	--	no
PFOA	51	90	31	134,100	16,000,000	0	0	0.00023	0.0000019	no
Perfluoro-1-butanesulfonic acid	102	80	27	18,686,500	--	0	0	0.0000014	--	no
PFBA	51	5.9	17	7,684,500	13,700,000	0	--	0.0000022	0.0000012	no
Perfluoro-n-hexanoic acid	51	96	81	1,130,600	724,000,000	0	0	0.000072	0.00000011	no
PFNA	51	2	5.7	40,500	24,596,165,800	0	0	0.00014	2.3E-10	no
Perfluoropentanoic acid	48	96	150	3,001,800	100,000	0	0	0.00005	0.0015	no
Primidone	50	90	930	42,700	--	0	--	0.022	--	no
Quinoline	50	20	28	459,800	--	0	--	0.000061	--	no
Salicylic acid	35	2.9	130	412,600	--	0	--	0.00032	--	no
Simazine	50	8	7.7	6,400	--	0	--	0.0012	--	no
Sucralose	50	100	470,000	17,000	--	47	--	28	--	yes

COI	N	DF (%)	Max Detected Conc. (ng/L)	ECOSAR-based Benchmark (ng/L)	Literature-based Benchmark (ng/L)	No. Exceeding ECOSAR-based Benchmark	No. Exceeding Literature-based Benchmark	ECOSAR-based EF (Max.)	Literature-based EF (Max.)	Max. EF > 1?
Sulfadiazine	50	4	300	14,800	--	0	--	0.02	--	no
Sulfadimethoxine	50	6	39	6,600	--	0	--	0.0059	--	no
Sulfamethoxazole	50	72	700	8,600	243,000	0	0	0.081	0.0029	no
TCEP	50	94	240	1,500	--	0	--	0.16	--	no
TCPP	50	86	1,300	1,100	13,000,000	4	0	1.2	0.0001	yes
TDCPP	50	70	2,000	1,200	--	5	--	1.7	--	yes
Testosterone	50	8	31	148,100	10,000	0	0	0.00021	0.0031	no
Theobromine	50	26	490	400	--	1	--	1.2	--	yes
Theophylline	35	26	160	400	--	0	--	0.4	--	no
Thiabendazole	50	32	600	6,600	--	0	--	0.091	--	no
Triclosan	50	42	130	7,100	15,100	0	0	0.018	0.0086	no
Trimethoprim	50	18	97	8,100	--	0	--	0.012	--	no

[a] Data for 4-nonylphenol include “semi-quantitative” measurements reported for wastewater (in addition to fully quantitative measurements).

BPA – bisphenol A
COI – chemical of interest
COPEC – chemical of potential ecological concern
DACT – 2-Chloro-4,6-diamino-1,3,5-triazine
DEA – diethanolamine
DEET – N,N-Diethyl-m-toluamide
DF – detection frequency
EF – exceedance factor
ECOSAR -- Ecological Structure Activity Relationships
NDMA – N-Nitroso dimethylamin
PFBA – perfluoro butanoic acid
PFNA – perfluoro-n-nonanoic acid
PFOA – perfluoro octanoic acid
TCEP – tris(2-carboxyethyl)phosphine
TCPP – tris(chloropropyl)phosphate
TDCPP – tris(1,3-dichloro-2-propyl)phosphate

The results of the persistence and bioaccumulation screen are provided in Table 6-3. Of the COIs detected in reclaimed water or porewater, six were assigned a score of five or six (per the BAF and half-life benchmarks described in Section 6.2.3): perfluoro octanoic acid (PFOA), perfluoro-n-nonanoic acid (PFNA), diclofenac, gemfibrozil, meclofenamic acid, and triclosan. Of these COIs, meclofenamic acid, PFOA, and PFNA were assigned scores of six. Three other persistent and bioaccumulative compounds were detected in other media—perfluoro-n-heptanoic acid, perfluoro octanesulfonic acid, and nonylphenol monoethoxylate—but only the six COIs listed above were detected in reclaimed water or porewater. Diclofenac and gemfibrozil have relatively low estimated half-lives in water (38 days); however, their half-lives are much longer in solid media (75 days in soil and 340 days in sediment). PFNA and PFOA are the most persistent COIs, each expected to have half-lives of 180 days in water. PFNA and meclofenamic acid are likely the most bioaccumulative among the six COIs, with BAFs of 27,180 and 111,900, respectively. The four additional PFAS detected in reclaimed water or porewater (perfluoro-1-butanesulfonic acid, perfluoro butanoic acid [PFBA], perfluoro-n-hexanoic acid, and perfluoropentanoic acid) were also considered COPECs because of their known bioaccumulative potential.

Table 6-3. Results of persistence and bioaccumulation screen, COIs detected in reclaimed water or porewater

COI	Estimated Half-life (days)[a]				Estimated BAF[a]	Persistence Score[b]	Bioaccum. Score[b]	Total Score ≥ 5?[b]
	Air	Water	Soil	Sediment				
1,4-Dioxane	0.98	15	30	140	0.9649	3	1	no
1,7-Dimethylxanthine	0.19	15	30	140	0.9606	3	1	no
2,4-Dichlorophenoxyacetic acid (2,4-D)	1.6	38	75	340	68.75	3	1	no
4-Nonylphenol	0.21	15	30	140	752.1	3	1	no
4-tert-Octylphenol	0.25	38	75	340	816.2	3	1	no
Acesulfame-K	0.19	15	30	140	0.9415	3	1	no
Acetaminophen	0.6	15	30	140	1.032	3	1	no
Albuterol	0.079	15	30	140	1.056	3	1	no
Amoxicillin	0.077	38	75	340	1.155	3	1	no
Atenolol	0.077	38	75	340	0.992	3	1	no
BPA	0.13	38	75	340	172.8	3	1	no
Bromacil	0.51	38	75	340	7.099	3	1	no
Butalbital	0.21	38	75	340	2.272	3	1	no
Caffeine	0.55	15	30	140	0.9759	3	1	no
Carbadox	1.1	38	75	340	0.9411	3	1	no
Carbamazepine	0.034	38	75	340	19.3	3	1	no
Carisoprodol	0.31	38	75	340	4.128	3	1	no

COI	Estimated Half-life (days)[a]				Estimated BAF[a]	Persistence Score[b]	Bioaccum. Score[b]	Total Score ≥ 5?[b]
	Air	Water	Soil	Sediment				
Chloramphenicol	0.35	60	120	540	1.269	3	1	no
Chloridazon	0.26	38	75	340	2.195	3	1	no
Clofibric acid	1.4	38	75	340	37.96	3	1	no
Cotinine	0.41	38	75	340	0.9664	3	1	no
Cyanazine	1.2	180	360	1,600	10.87	3	1	no
DACT	91	60	120	540	1.003	3	1	no
DEA	0.12	8.7	17	78	0.9415	3	1	no
DEET	0.42	38	75	340	13.3	3	1	no
Dehydronifedipine	7.3	60	120	540	8.58	3	1	no
Diazepam	1.1	38	75	340	57.64	3	1	no
Dibromochloropropane	25	38	75	340	24.81	3	1	no
Diclofenac	0.065	38	75	340	1,539	3	2	yes
Dilantin	1	38	75	340	4.51	3	1	no
Diltiazem	0.059	60	120	540	9.894	3	1	no
Diuron	0.98	38	75	340	12.39	3	1	no
Erythromycin	0.027	180	360	1,600	12.33	3	1	no
Estradiol – 17 beta	0.087	38	75	340	50.49	3	1	no
Estrone	0.085	38	75	340	17.11	3	1	no
Ethinyl estradiol – 17 alpha	0.085	60	120	540	19.93	3	1	no
Fipronil	0.11	180	360	1,600	241.8	3	1	no
Flumequine	0.31	60	120	540	3.797	3	1	no
Fluoxetine	0.29	60	120	540	489	3	1	no
Gemfibrozil	0.13	38	75	340	1,396	3	2	yes
Ibuprofen	0.9	15	30	140	437	3	1	no
Iohexol	0.15	60	120	540	0.9402	3	1	no
Iopromide	0.16	60	120	540	0.9404	3	1	no
Ketorolac	0.053	15	30	140	22	3	1	no
Lidocaine	0.098	60	120	540	7.405	3	1	no
Lincomycin	0.038	38	75	340	0.9754	3	1	no
Linuron	1	60	120	540	39.7	3	1	no
Lopressor	0.073	38	75	340	8.04	3	1	no
Meclofenamic acid	0.12	60	120	540	27,180	3	3	yes
Meprobamate	0.55	38	75	340	1.049	3	1	no
Metformin	0.097	15	30	140	0.9417	3	1	no
Methylparaben	0.97	15	30	140	3.972	3	1	no
Naproxen	0.093	15	30	140	131.8	3	1	no

COI	Estimated Half-life (days)[a]				Estimated BAF[a]	Persistence Score[b]	Bioaccum. Score[b]	Total Score ≥ 5?[b]
	Air	Water	Soil	Sediment				
Nifedipine	0.043	38	75	340	6.168	3	1	no
NDMA	4.2	38	75	340	0.95	3	1	no
Norethisterone	0.059	60	120	540	74.34	3	1	no
OUST® (Sulfameturon,methyl)	0.3	38	75	340	1.313	3	1	no
Oxolinic acid	0.084	38	75	340	1.355	3	1	no
Pentoxifylline	0.35	38	75	340	1.01	3	1	no
PFOA	21	180	360	1,600	7,674	3	3	yes
Perfluoro-1-butanesulfonic acid	76	180	360	1,600	7.321	3	1	no
PFBA	21	60	120	540	14.91	3	1	no
Perfluoro-n-hexanoic acid	21	180	360	1,600	281.6	3	1	no
PFNA	21	180	360	1,600	111,900	3	3	yes
Perfluoropentanoic acid	21	60	120	540	64.9	3	1	no
Primidone	0.31	38	75	340	1.114	3	1	no
Quinoline	0.92	15	30	140	6.306	3	1	no
Salicylic acid	0.82	15	30	140	11.96	3	1	no
Simazine	0.97	60	120	540	11.36	3	1	no
Sucralose	0.2	38	75	340	0.9424	3	1	no
Sulfadiazine	0.38	38	75	340	0.9841	3	1	no
Sulfadimethoxine	0.053	38	75	340	4.51	3	1	no
Sulfamethoxazole	0.053	38	75	340	1.472	3	1	no
TCEP	0.49	60	120	540	3.465	3	1	no
TCPP	0.15	60	120	540	49.14	3	1	no
TDCPP	0.59	180	360	1,600	113.1	3	1	no
Testosterone	0.091	38	75	340	163.9	3	1	no
Theobromine	0.57	15	30	140	0.9448	3	1	no
Theophylline	0.55	15	30	140	0.9727	3	1	no
Thiabendazole	0.16	15	30	140	21.76	3	1	no
Triclosan	0.66	60	120	540	1,647	3	2	yes
Trimethoprim	0.053	60	120	540	1.229	3	1	no

[a] Estimated using EPI Suite software; highest BAF among all trophic levels (including biotransformation factor to account for metabolism).

[b] Scoring system based on TSCA guidance (EPA 2010), described in Section 6.2.3.

BAF – bioaccumulation factor

BPA – bisphenol A

COI – chemical of interest

DACT – 2-Chloro-4,6-diamino-1,3,5-triazine

PFBA – perfluoro butanoic acid

PFNA – perfluoro-n-nonanoic acid

PFOA – perfluoro octanoic acid

TCEP – tris(2-carboxyethyl)phosphine

DEA – diethanolamine
DEET – N,N-Diethyl-m-toluamide
EPI – Estimation Program Interface
NDMA – N-Nitroso dimethylamine
TCPP – tris(chloropropyl)phosphate
TDCPP – tris(1,3-dichloro-2-propyl)phosphate
TSCA – Toxic Substances Control Act

The following 18 COIs were selected as COPECs for further consideration: 4-nonylphenol, 17-alpha ethinyl estradiol, 17-beta estradiol, fipronil, sucralose, TCPP, TDCPP, PFOA, perfluoro-1-butanesulfonic acid, PFBA, perfluoro-n-hexanoic acid, PFNA, perfluoropentanoic acid, diclofenac, gemfibrozil, meclofenamic acid, theobromine, and triclosan. A chemical's identification as a COPEC does not imply that environmental exposures to it cause ecological risks, only that such risks have the potential to exist. Further study is needed to understand the potential for ecological risks from environmental exposures to the COPECs. Similarly, persistence and bioaccumulation does not imply ecological risk, only that such COPECs have the potential to be taken up in biota. Further study of the possible effects of the accumulation of persistent and bioaccumulative COPECs in biota tissues is warranted.

6.4 Uncertainty Analysis

The purpose of this section is to provide an evaluation of uncertainties associated with the screening process and results described in earlier sections of Section 6. The following sources of uncertainties are evaluated:

- If a chemical was not detected in any water matrix sampled by LOTT, no benchmark was developed using ECOSAR or compiled from the literature. In some cases, COIs might have been present but below detection limits. In such instances, it is possible that a COI might be toxic at an undetectable concentration.
- EPA and the European Union conducted a large-scale verification study to compare ECOSAR model predictions with empirical data and found ECOSAR to accurately predict acute toxicity thresholds (within one order of magnitude) 71 to 82% of the time for daphnid and fish receptors, respectively (EPA 1994). EPA (2007) recommends using ECOSAR (i.e., using the best available information about chemical structure-activity relationships) to make inferences about COI toxicity thresholds when little or no toxicity data are available. Examples of how ECOSAR has been applied to screen and prioritize chemicals of emerging concern are shown in Howard and Muir (2010), Sanderson et al. (2003), and Diamond et al. (2011). There is uncertainty associated with the use of ECOSAR model predictions rather than experimentally derived data. To protect against false negatives (i.e., COIs screening out when they should be

identified as COPECs), the chronic MATC predicted by ECOSAR for each COI was used, and the lowest MATC was divided by 10.[15]

- ECOSAR has the potential to underestimate the toxicity (i.e., predict a higher chronic value) of pharmaceutical hormones. Literature-based screening-level benchmarks (Caldwell et al. 2012) were much lower than ECOSAR-based values for estrogenic compounds (i.e., 17-alpha ethinyl estradiol, 17-beta estradiol, and estrone). The lower literature-based screening-level benchmarks were used to screen estrogenic hormones.
- In cases where literature-based NOECs were not available for screening purposes, PNEC, EC05, EC10, and LOEC values were used. PNECs were used only for estrogenic COIs. LOECs can be associated with any level of effect, depending heavily on the experimental design from which the LOEC was derived. To account for potentially high effect levels, LOEC values were divided by a safety factor of 10 for the screen. EC05 and EC10 values are probably more conservative than LOECs, because the lowest observed effect usually affects more than 5 to 10% of the test population (EPA 2013).
- When ECOSAR does not recognize a chemical class,[16] the model provides only a narcosis effect prediction, which the ECOSAR output indicates is potentially non-conservative. In these cases, literature-based values were compiled and used, as available, providing an appropriately conservative bias in the screening process. Suitable literature-based values were not found for meclofenamic acid or perfluoro-1-butanesulfonic acid, so the screen of those two COIs was potentially less conservative than the screen for other COIs.
- Several PFAS benchmarks exceeded the chemical's solubility in water (Appendix C, Table C1). The use of those benchmarks was conservative because it is not possible under normal circumstances (i.e., in the absence of a carrier solvent) for aqueous-phase PFAS concentrations to exceed saturation. PFOA and PFNA were included as COPECs on the basis of persistence and bioaccumulation.

  Several ECOSAR-based benchmarks relied on acute-to-chronic ratios to estimate chronic values from results measured in a short-term (acute) exposure, because no suitable chronic data existed from which to derive the benchmark (Appendix C, Table C1). This approach introduced uncertainty associated with extrapolation. The method for deriving acute-to-chronic ratios is described by EPA (1976).

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[15] Throughout this document, the word "conservative" is used to describe assumptions or decisions that reduced the probability of a false negative screening outcome.

[16] ECOSAR "classes" correspond to the modes or mechanisms of toxic action corresponding to chemical structures or moieties.

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7 Summary

Residual chemicals that may remain in reclaimed water after wastewater treatment are being evaluated as part of a multi-year study by LOTT to assess potential ecological risks associated with using reclaimed water for groundwater replenishment. COIs for the study include those found in pharmaceuticals and household and personal care products. This document presents the results of the screening-level evaluation, which identified COIs that will be further evaluated in the risk characterization step of the ERA.

The maximum concentration of each detected COI was compared to a conservative screening-level benchmark. Each COI was also evaluated based on its potential to be persistent and bioaccumulative. COIs were considered to be COPECs for further evaluation in the risk characterization step if they were detected in reclaimed water or porewater at concentrations greater than screening-level benchmarks (Table 7-1), or if they were considered to be highly persistent and bioaccumulative (Table 7-2).

Table 7-1. COPECs retained based on benchmark exceedances

COPEC	Chemical Use Category	Max. Detected Conc. (ng/L)	Screening-level Benchmark (ng/L)	Risk Characterization Approach
4-nonylphenol	surfactant	510,000	500	For the aquatic community, compare modeled concentrations in surface water to screening-level benchmarks and TRVs.
17-alpha ethinyl estradiol	estrogenic hormone	64	0.1	
17-beta estradiol	estrogenic hormone	35	2	
Fipronil	insecticide	51	11	
Sucralose	sugar substitute	470,000	17,000	
TCPP	flame retardant	1,300	1,100	
TDCPP	flame retardant	2,000	1,200	
Theobromine	alkaloid in chocolate and coffee	490	400	

COPEC – chemical of potential ecological concern
TCPP – tris(chloropropyl)phosphate
TDCPP – tris(1,3-dichloro-2-propyl)phosphate
TRV – toxicity reference value

Table 7-2. COPECs retained based on bioaccumulation potential

COPEC	Chemical Use Category	Persistence and Bioaccumulation Score	Risk Characterization Approach
Chemicals with persistence and bioaccumulation score ≥ 5			For fish receptors, compare modeled concentrations in fish tissue to TRVs. For belted kingfisher and river otter, compare calculated dietary doses to TRVs.
Diclofenac	anti-inflammatory	5	
Gemfibrozil	lipid regulator	5	
Meclofenamic acid	anti-inflammatory	6	
PFOA	perfluoro surfactant	6	
PFNA	perfluoro surfactant	6	
Triclosan	antibacterial	5	
Additional PFAS chemicals[a]			
Perfluoro-1-butanesulfonic acid	perfluoro surfactant	4	
PFBA	perfluoro surfactant	4	
Perfluoro-n-hexanoic acid	perfluoro surfactant	4	
Perfluoropentanoic acid	perfluoro surfactant	4	

[a] All PFAS detected in reclaimed water or porewater were considered to be COPECs because PFAS are known to be highly bioaccumulative.

COPEC – chemical of potential ecological concern
PFAS – per- and polyfluoralkyl substances
PFBA – perfluoro butanoic acid
PFNA – perfluoro-n-nonanoic acid
PFOA – perfluoro octanoic acid
TRV – toxicity reference value

COPECs retained based on benchmark exceedances (Table 7-1) will be evaluated in the risk characterization step by deriving a surface water concentration from a groundwater fate and transport model being developed for the study. Chemicals with modeled concentrations that exceed the screening-level benchmark will be compared to surface water TRVs derived from the literature representing concentrations associated with a 20% reduction in growth, reproduction, or survival.

COPECs retained based on bioaccumulation potential (Table 7-2) will be evaluated in the risk characterization step in one of two ways:

1. A fish tissue concentration will be derived for each chemical using a BAF or BCF. The modeled fish tissue concentration will be compared to a fish tissue TRV derived from the literature representing a concentration associated with a 20% reduction in growth, reproduction, or survival.
2. Dietary exposure will be calculated for aquatic-dependent wildlife (i.e., belted kingfisher and river otter) using BAFs or BCFs to estimate chemical concentrations in prey and dietary exposure assumptions from the literature.

Calculated dietary doses will be compared to dietary TRVs derived from the literature representing doses associated with a 20% reduction in growth, reproduction, or survival.

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Appendix A. Site Visit Photos from Woodland and McAllister Creeks

Photo No.:	1
Date:	06/12/19

Description:
Below Nisqually Trout Farm, Woodland Creek at Beatty Springs

Photo No.:	2
Date:	06/12/19

Description:
Below Nisqually Trout Farm, Woodland Creek at Beatty Springs

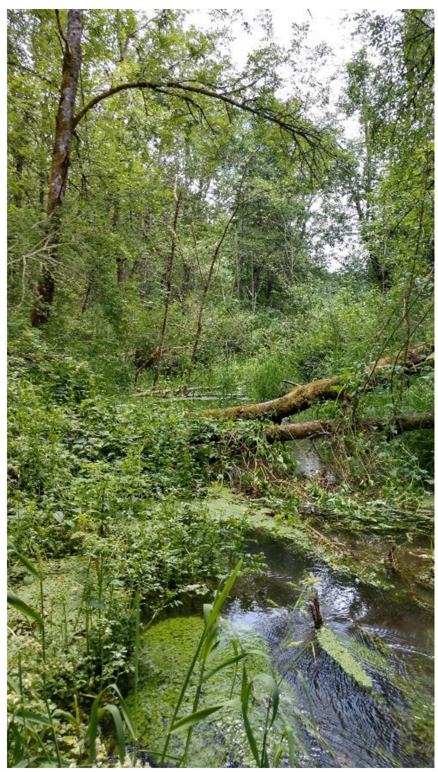

Photo No.:	3
Date:	06/12/19

Description:
Caddisfly larva (Order Tricoptera), Woodland Creek at Beatty Springs

Photo No.:	4
Date:	06/12/19

Description:
Woodland Creek at Beatty Springs

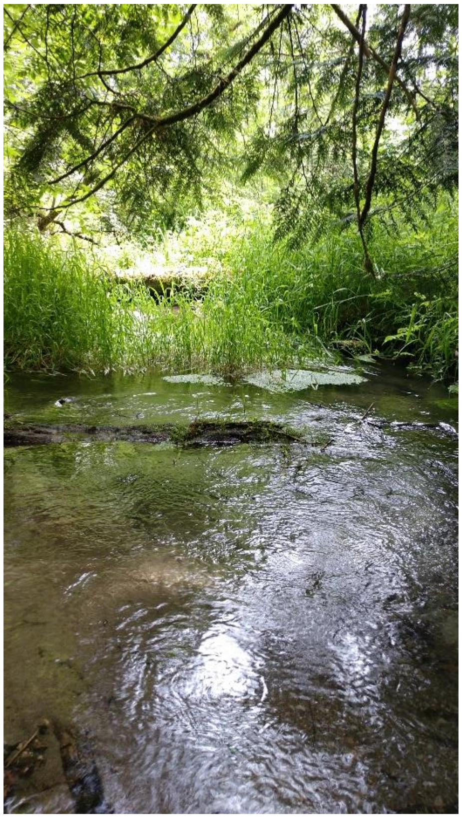

Photo No.:	5
Date:	06/12/19

Description:
Woodland Creek at Beatty Springs

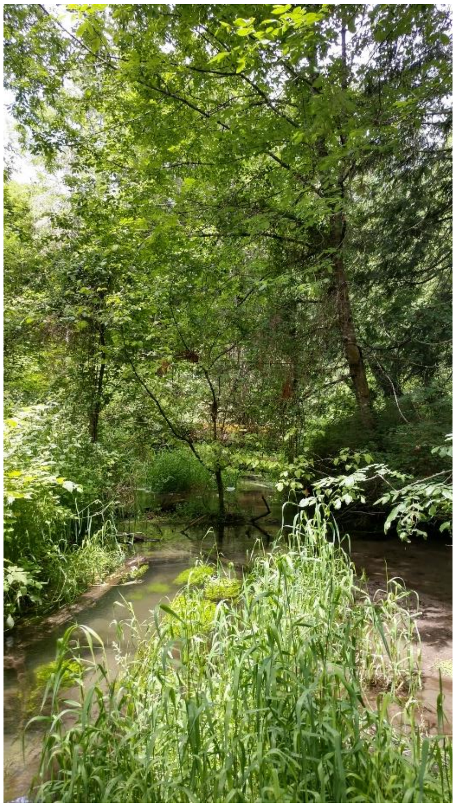

Photo No.:	6
Date:	06/12/19

Description:
Woodland Creek at Pleasant Glade Park

Photo No.:	7
Date:	06/12/19

Description:
Raccoon tracks, Woodland Creek at Pleasant Glade Park

Photo No.:	8
Date:	06/12/19

Description:
Woodland Creek at Pleasant Glade Park

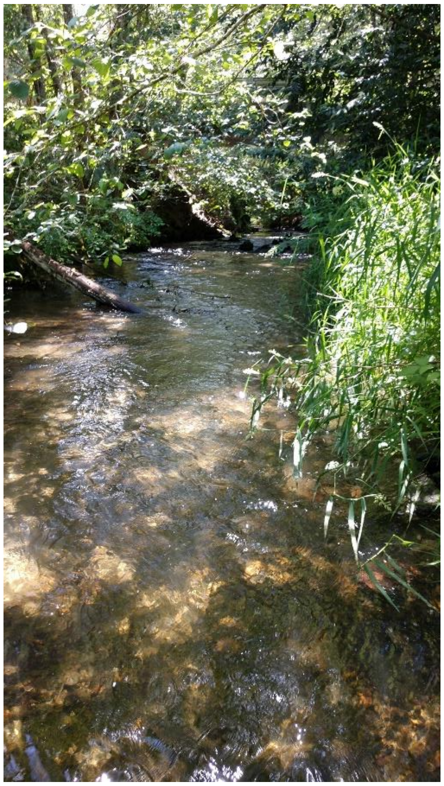

Photo No.:	9
Date:	06/12/19

Description:
Stonefly larva (Order Plecoptera), Woodland Creek at Pleasant Glade Park

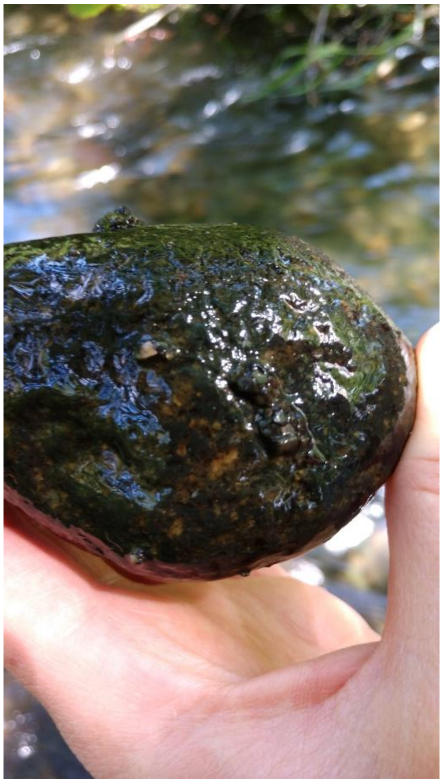

Photo No.:	10
Date:	06/12/19

Description:
Woodland Creek at Pleasant Glade Park

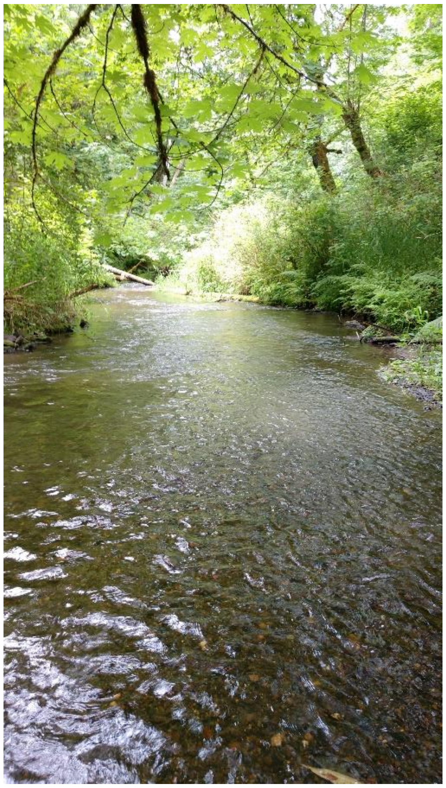

Photo No.:	11
Date:	06/12/19
Description: Woodland Creek at Pleasant Glade Park	

Photo No.:	12
Date:	06/12/19
Description: Large woody debris, Woodland Creek at Pleasant Glade Park	

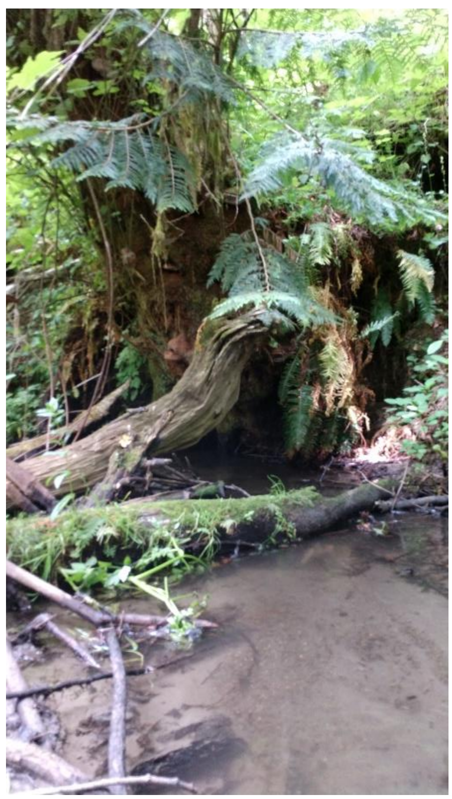

Photo No.:	13
Date:	06/12/19

Description:
McAllister Creek at the bridge crossing on Steilacoom Road Southeast, looking south

Photo No.:	14
Date:	06/12/19

Description:
McAllister Creek at the bridge crossing on Steilacoom Road Southeast, looking north

Photo No.:	15
Date:	03/04/20

Description:
McAllister Creek at the bridge crossing on Martin Way East, looking south

Photo No.:	16
Date:	03/04/20

Description:
McAllister Creek at the bridge crossing on Martin Way East, looking north

Photo No.:	17
Date:	03/04/20

Description:
Canine (likely coyote) and raccoon tracks along the left bank of McAllister Creek near the bridge crossing on Martin Way East

Photo No.:	18
Date:	03/04/20

Description:
Looking southwest from the Nisqually Estuary Boardwalk Trail (within the Nisqually National Wildlife Refuge) toward the mouth of McAllister Creek and the forested bluff west of the creek

APPENDIX B. ECOLOGICAL RECEPTORS

Table B1. Benthic invertebrates potentially present in Woodland Creek and McAllister Creek

Invertebrate Group	Scientific Name	Woodland Creek	McAllister Creek	Source[a]
Amphipoda	*Hyalella* spp.	yes	yes	Dobos et al. (1977); Woo et al. (2017)
Coleoptera (beetles)	*Hydaticus* spp.	yes	nd	Dobos et al. (1977)
	Zaitzevia spp.	yes	nd	
Copepoda	*Canthocamptus* spp.	yes	yes	Dobos et al. (1977); Woo et al. (2017)
Decapoda (crayfish, shrimp, crabs)	*Pacifastacus leniusculus*	yes	nd	Haub et al. (2018)
	Hemigrapsus oregonensis	nd	yes	Thurston County (1994)
	Epialtus productus	nd	yes	
	Upogebia pugettensis	nd	yes	
	Neotrypaea californiensis	nd	yes	
Diptera – Chironomidae (midges)	*Tanytarsus* spp. (formerly *Calopsectra* spp.)	yes	nd	Dobos et al. (1977); Windward 2019 site survey
	Hemerodromia spp.	yes	nd	
	Metriocnemus spp.	yes	nd	
	Palpomyia spp.	yes	nd	
	Pentaneura spp.	yes	nd	
Ephemeroptera (mayflies)	family *Baetidae*	yes	nd	Dobos et al. (1977)
	Paraleptophlebia spp.	yes	nd	
Hydrachnidia (water mites)	family *Hygrobatidae*	yes	nd	Dobos et al. (1977)
	family *Libertiidae*	yes	nd	
	family *Sperchonidae*	yes	nd	
Isopoda (water sowbugs)	*Asellus* spp.	yes	nd	Dobos et al. (1977)

Table B1. Benthic invertebrates potentially present in Woodland Creek and McAllister Creek

Invertebrate Group	Scientific Name	Woodland Creek	McAllister Creek	Source[a]
Mollusca (clams and snails)	*Physa* spp.	yes	nd	Dobos et al. (1977); Windward 2019 site survey
	family *Sphaeriidae*	yes	nd	
	Macoma inconspicua	nd	yes	Thurston County (1994)
	Macoma nasuta	nd	yes	
	Mya arenaria	nd	yes	
	Mytilus edulis	nd	yes	
	Leukoma staminea	nd	yes	
	Cryptomya californica	nd	yes	
Odonata (damselflies)	*Coenagrionidae*	nd	yes	USFWS (2005)
Oligochaeta (annelid worms)	not identified	yes	yes	Dobos et al. (1977); Woo et al. (2017)
Polychaeta (paddle-footed annelids)	*Lumbrineris* spp.	nd	yes	Thurston County (1994)
	Nephtys spp.	nd	yes	
	Neanthes virens	nd	yes	
	family *Polynoidae*	nd	yes	
	family *Phyllodocidae*	nd	yes	
	Glycera americana	nd	yes	

Table B1. Benthic invertebrates potentially present in Woodland Creek and McAllister Creek

Invertebrate Group	Scientific Name	Woodland Creek	McAllister Creek	Source[a]
Plecoptera (stoneflies)	*Allocapnia* spp.	yes	nd	Dobos et al. (1977); Windward 2019 site survey
	Alloperla spp.	yes	nd	
	family *Nemouridae*	yes	nd	
	family *Peltoperlidae*	yes	nd	
	Isogenus spp.	yes	nd	
Trichoptera (caddisflies)	*Glossosoma* spp.	yes	nd	Dobos et al. (1977); Windward 2019 site survey
	Hydropsyche spp.	yes	nd	
	Limnephilus spp.	yes	nd	
	Rhyacophila spp.	yes	nd	
	Phryganeidae	nd	yes	USFWS (2005)

[a] Sources for Woodland Creek include Dobos et al. (1977), ESA Adolfson (2008), Haub et al. (2018), Windward 2019 site survey, and Woo et al. (2017); sources for McAllister Creek include Thurston County (1994), Thurston County (2013), and USFWS (2005).

nd – no data

USFWS – US Fish and Wildlife Service

Windward – Windward Environmental LLC

Table B2. Fish potentially present in Woodland Creek and McAllister Creek

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source[a]
American shad	*Alosa sapidissima*	nd	yes	USFWS (2005)
Arrow goby	*Clevelandia ios*	nd	yes	USFWS (2005)
Bay goby	*Lepidogobius lepidus*	nd	yes	USFWS (2005)
Bay pipefish	*Syngnathus leptorhynchus*	nd	yes	USFWS (2005)
Black crappie	*Pomoxis nigromaculatus*	nd	yes	USFWS (2005)
Blacktip poacher	*Xeneretmus latifrons*	nd	yes	USFWS (2005)
Bluegill	*Lepomis macrochirus*	yes	nd	Haub et al. (2018)
Brown bullhead	*Ameiurus nebulosus*	yes	yes	Haub et al. (2018); USFWS (2005)
Brown rockfish	*Sebastes auriculatus*	nd	yes	USFWS (2005)
Buffalo sculpin	*Enophrys bison*	nd	yes	USFWS (2005)
Bull trout	*Salvelinus confluentus*	nd	yes	USFWS (2005)
Butter sole	*Pleuronectes isolepsis*	nd	yes	USFWS (2005)
Cabezon	*Scorpaenichthys marmoratus*	nd	yes	USFWS (2005)
Calico sculpin	*Clinocottus embryum*	nd	yes	USFWS (2005)
Chinook salmon	*Oncorhynchus tshawytscha*	yes	yes	ESA Adolfson (2008); Haub et al. (2018); Thurston County (2013); USFWS (2005)
Chum salmon	*Oncorhynchus keta*	yes	yes	Dobos et al. (1977); ESA Adolfson (2008); Haub et al. (2018); Thurston County (2013); USFWS (2005)
C-O sole	*Pleuronichthys coenosus*	nd	yes	USFWS (2005)
Coastrange sculpin	*Cottus aleuticus*	nd	yes	USFWS (2005)
Coho salmon	*Oncorhynchus kisutch*	yes	yes	Dobos et al. (1977); ESA Adolfson (2008); Haub et al. (2018); Thurston County (2013); USFWS (2005)
Copper rockfish	*Sebastes caurinus*	nd	yes	USFWS (2005)

Table B2. Fish potentially present in Woodland Creek and McAllister Creek

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source[a]
Crescent gunnel	*Pholis laeta*	nd	yes	USFWS (2005)
Cutthroat trout	*Oncorhynchus clarkii*	yes	yes	Dobos et al. (1977); ESA Adolfson (2008); Haub et al. (2018); Thurston County (2013); USFWS (2005)
Dace	*Leuciscus leuciscus*	yes	nd	Haub et al. (2018)
Dolly varden	*Salvelinus malma*	nd	yes	USFWS (2005)
Dover sole	*Microstomus pacificus*	nd	yes	USFWS (2005)
English sole	*Pleuronectes vetulus*	nd	yes	USFWS (2005)
Flathead sole	*Hippoglossoides elassodon*	nd	yes	USFWS (2005)
Great sculpin	*Myoxocephalus polyacanthocephalus*	nd	yes	USFWS (2005)
Grunt sculpin	*Rhamphocottus richardsoni*	nd	yes	USFWS (2005)
High cockscomb	*Anoplarchus purpurescens*	nd	yes	USFWS (2005)
Kelp greenling	*Hexagrammos decagrammus*	nd	yes	USFWS (2005)
Kokanee	*Oncorhynchus nerka*	yes	yes	Haub et al. (2018); Thurston County (2013);USFWS (2005)
Largemouth bass	*Micropterus salmoides*	yes	yes	Haub et al. (2018); USFWS (2005)
Large-scale sucker	*Catostomus macrocheilus*	yes	yes	Haub et al. (2018); USFWS (2005)
Longnose dace	*Rhinichythys cataractae*	nd	yes	USFWS (2005)
Manacled sculpin	*Synchirus gilli*	nd	yes	USFWS (2005)
Mountain whitefish	*Prosopium williamsoni*	nd	yes	USFWS (2005)
Northern clingfish	*Gobiesox meandricus*	nd	yes	USFWS (2005)
Northern spearnose poacher	*Agonopsis vulsa*	nd	yes	USFWS (2005)
Olympic mud minnow	*Novumbra hubbsi*	yes	nd	Haub et al. (2018)

Table B2. Fish potentially present in Woodland Creek and McAllister Creek

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source[a]
Pacific cod	*Gadus macrocephalus*	nd	yes	USFWS (2005)
Pacific hake	*Merluccius productus*	nd	yes	USFWS (2005)
Pacific herring	*Clupea harengus*	nd	yes	USFWS (2005)
Pacific lamprey	*Lampetra tridentata*	nd	yes	USFWS (2005)
Pacific sand lance	*Ammodytes personatus*	yes	yes	Haub et al. (2018); USFWS (2005)
Pacific sanddab	*Citharichthys sordidus*	nd	yes	USFWS (2005)
Pacific snake prickleback	*Lumpenus sagitta*	nd	yes	USFWS (2005)
Pacific staghorn sculpin	*Leptocottus armatus*	nd	yes	USFWS (2005)
Pacific tomcod	*Microgadus proximus*	nd	yes	USFWS (2005)
Padded sculpin	*Artedius fenestralis*	nd	yes	USFWS (2005)
Painted greenling	*Oxylebius pictus*	nd	yes	USFWS (2005)
Penpoint gunnel	*Apodichthys flavidus*	nd	yes	USFWS (2005)
Pile perch	*Rhacochilus vacca*	nd	yes	USFWS (2005)
Pink salmon	*Oncorhynchus gorbuscha*	nd	yes	Thurston County (2013); USFWS (2005)
Plainfin midshipman	*Porichthys notatus*	nd	yes	USFWS (2005)
Prickly sculpin	*Cottus asper*	nd	yes	USFWS (2005)
Pumpkinseed	*Lepomis gibbosus*	nd	yes	USFWS (2005)
Pygmy poacher	*Odontopyxis trispinosa*	nd	yes	USFWS (2005)
Quillback rockfish	*Sebastes maliger*	nd	yes	USFWS (2005)
Rainbow trout/steelhead	*Oncorhynchus mykiss*	yes	yes	Dobos et al. (1977); ESA Adolfson (2008); Haub et al. (2018); Thurston County (2013); USFWS (2005)
Red Irish lord	*Hemilepidotus hemilepidotus*	nd	yes	USFWS (2005)

Table B2. Fish potentially present in Woodland Creek and McAllister Creek

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source[a]
Reticulate/riffle sculpin	*Cottus perplexus/gulosus*	nd	yes	USFWS (2005)
Rex sole	*Errex zachirus*	nd	yes	USFWS (2005)
Ringtail snailfish	*Liparis rutteri*	nd	yes	USFWS (2005)
River lamprey	*Lampetra ayresi*	nd	yes	USFWS (2005)
Rock greenling	*Hexagrammos lagocephalus*	nd	yes	USFWS (2005)
Rock sole	*Pleuronectes bilineata*	nd	yes	USFWS (2005)
Rockweed gunnel	*Apodichthys fucorum*	nd	yes	USFWS (2005)
Roughback sculpin	*Chitonotus pugetensis*	nd	yes	USFWS (2005)
Sablefish	*Anoplopoma fimbria*	nd	yes	USFWS (2005)
Saddleback gunnel	*Pholis ornata*	nd	yes	USFWS (2005)
Sailfin sculpin	*Nautichthys oculofasciatus*	nd	yes	USFWS (2005)
Sand sole	*Psettichthys melanostictus*	nd	yes	USFWS (2005)
Sculpin	*Cottus* spp.	yes	nd	Dobos et al. (1977); Haub et al. (2018)
Sharpnose sculpin	*Clinocottus acuticeps*	nd	yes	USFWS (2005)
Shiner perch	*Cymatogaster aggregata*	nd	yes	USFWS (2005)
Shorthead sculpin	*Cottus confusus*	nd	yes	USFWS (2005)
Silverspotted sculpin	*Blepsias cirrhosus*	nd	yes	USFWS (2005)
Slender cockscomb	*Anoplarchus insignis*	nd	yes	USFWS (2005)
Smoothhead sculpin	*Artedius lateralis*	nd	yes	USFWS (2005)
Soft sculpin	*Psychrolutes sigalutes*	nd	yes	USFWS (2005)
Speckled sanddab	*Citharichthys stigmaeus*	nd	yes	USFWS (2005)
Spiny dogfish	*Squalus acanthias*	nd	yes	USFWS (2005)

Table B2. Fish potentially present in Woodland Creek and McAllister Creek

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source[a]
Spotted ratfish	*Hydrolagus colliei*	nd	yes	USFWS (2005)
Starry flounder	*Platichythys stellatus*	nd	yes	USFWS (2005)
Striped seaperch	*Embiotoca lateralis*	nd	yes	USFWS (2005)
Sturgeon poacher	*Agonus acipenserinus*	nd	yes	USFWS (2005)
Surf smelt	*Hypomesus pretiosus*	yes	yes	Haub et al. (2018); USFWS (2005)
Tadpole sculpin	*Psychrolutes paradoxus*	nd	yes	USFWS (2005)
Three-spine stickleback	*Gasterosteus aculeatus*	yes	yes	Dobos et al. (1977); Haub et al. (2018); USFWS (2005)
Tidepool sculpin	*Oligocottus maculosus*	nd	yes	USFWS (2005)
Torrent sculpin	*Cottus rhotheus*	nd	yes	USFWS (2005)
Tubenose poacher	*Pallasina barbata*	nd	yes	USFWS (2005)
Tube-snout	*Aulorhynchus flavidus*	nd	yes	USFWS (2005)
Walleye pollock	*Theregra chalcogrammus*	nd	yes	USFWS (2005)
Western brook lamprey	*Lampetra planeri*	yes	yes	Haub et al. (2018); USFWS (2005)
White sturgeon	*Acipenser transmontanus*	nd	yes	USFWS (2005)
White-spotted greenling	*Hexagrammos stelleri*	nd	yes	USFWS (2005)
Yellow perch	*Perca flavescens*	yes	yes	Haub et al. (2018); USFWS (2005)

[a] Sources for Woodland Creek include Dobos et al. (1977), ESA Adolfson (2008), and Haub et al. (2018); sources for McAllister Creek include Thurston County (2013) and USFWS (2005).

nd – no data

USFWS – US Fish and Wildlife Service

Windward – Windward Environmental LLC

Table B3. Birds in the Woodland Creek and McAllister Creek areas

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source[a]
American avocet	*Recurvirostra americana*	nd	yes	USFWS (2005)
American bittern	*Botaurus lentiginosus*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
American coot	*Fulica americana*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
American crow	*Corvus brachyrhynchos*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005); Windward 2019 site survey; Windward 2020 site survey
American golden plover	*Pluvialis dominica*	nd	yes	Thurston County (1994); USFWS (2005)
American goldfinch	*Spinus tristis (Carduelis tristis)*	yes	yes	Thurston County (1994); USFWS (2005); Windward 2019 site survey
American kestrel	*Falco sparverius*	yes	yes	Dobos et al. (1977); Thurston County (1994)
American pipit	*Anthus rubescens*	nd	yes	USFWS (2005)
American robin	*Turdus migratorius*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005); Windward 2019 site survey
American white pelican	*Pelecanus erythrorhynchos*	nd	yes	USFWS (2005)
American wigeon	*Anas americana*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Ancient murrelet	*Synthliboramphus antiquus*	nd	yes	Thurston County (1994); USFWS (2005)
Anna 's hummingbird	*Calypte anna*	nd	yes	Thurston County (1994); Windward 2020 site survey
Audubon's warbler	*Setophaga coronata*	yes	nd	Dobos et al. (1977)
Baird 's sandpiper	*Calidris bairdii*	nd	yes	Thurston County (1994); USFWS (2005)
Bald eagle	*Haliaeetus leucocephalus*	yes	yes	Dobos et al. (1977); Thurston County (1994); Thurston County (2013); USFWS (2005); Windward 2020 site survey
Band-tailed pigeon	*Patagioenas fasciata (Columba fasciata)*	nd	yes	Thurston County (1994); Thurston County (2013)
Bank swallow	*Riparia riparia*	nd	yes	USFWS (2005)

Table B3. Birds in the Woodland Creek and McAllister Creek areas

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source[a]
Barn owl	*Tyto alba*	nd	yes	Thurston County (1994); USFWS (2005)
Barn swallow	*Hirundo rustica*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Barrow's goldeneye	*Bucephala islandica*	nd	yes	Thurston County (1994); USFWS (2005)
Belted kingfisher	*Megaceryle alcyon*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Bewick's wren	*Thryomanes bewickii*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Black brant	*Branta bernicla nigricans*	nd	yes	Thurston County (1994)
Black scoter	*Melanitta nigra*	nd	yes	Thurston County (1994); USFWS (2005)
Black swift	*Cypseloides niger*	nd	yes	USFWS (2005)
Black-bellied plover	*Pluvialis squatarola*	nd	yes	Thurston County (1994); USFWS (2005)
Black-billed magpie	*Pica hudsonia*	nd	yes	USFWS (2005)
Black-capped chickadee	*Poecile atricapillus (Parus atricapillus)*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005); Windward 2020 site survey
Black-headed grosbeak	*Pheucticus melanocephalus*	nd	yes	Thurston County (1994); USFWS (2005)
Black-headed gull	*Larus ridibundus*	nd	yes	USFWS (2005)
Black-necked stilt	*Himantopus mexicanus*	nd	yes	USFWS (2005)
Black-throated grey warbler	*Setophaga nigrescens (Dendroica nigrescens)*	nd	yes	Thurston County (1994); USFWS (2005)
Blue grouse	*Dendragapus obscurus*	yes	yes	Dobos et al. (1977); Thurston County (1994)
Blue-winged teal	*Anas discors*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Bohemian waxwing	*Bombycilla garrulus*	nd	yes	Thurston County (1994)
Bonaparte's gull	*Chroicocephalus philadelphia*	nd	yes	Thurston County (1994); USFWS (2005)
Brandt's cormorant	*Phalacrocorax penicillatus*	nd	yes	Thurston County (1994); USFWS (2005)

Table B3. Birds in the Woodland Creek and McAllister Creek areas

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source[a]
Brant	*Branta bernicla*	nd	yes	USFWS (2005)
Brewer's blackbird	*Euphagus cyanocephalus*	nd	yes	Thurston County (1994); USFWS (2005)
Brown creeper	*Certhia americana*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005); Windward 2019 site survey; Windward 2020 site survey
Brown pelican	*Pelecanus occidentalis*	nd	yes	USFWS (2005)
Brown-headed cowbird	*Molothrus ater*	nd	yes	USFWS (2005)
Bufflehead	*Bucephala albeola*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
California gull	*Larus californicus*	nd	yes	Thurston County (1994); USFWS (2005)
California quail	*Callipepla californica*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Canada goose	*Branta canadensis*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Canvasback	*Aythya valisineria*	nd	yes	Thurston County (1994); USFWS (2005)
Caspian tern	*Hydroprogne caspia (Sterna caspia)*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Cassin's vireo	*Vireo cassinii*	nd	yes	USFWS (2005)
Cedar waxwing	*Bombycilla cedrorum*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005); Windward 2019 site survey;
Chestnut-backed chickadee	*Poecile rufescens (Parus rufescens)*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Chipping sparrow	*Spizella passerina*	nd	yes	Thurston County (1994); USFWS (2005)
Cinnamon teal	*Anas cyanoptera*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Cliff swallow	*Petrochelidon pyrrhonota*	nd	yes	Thurston County (1994); USFWS (2005)
Common bushtit	*Psaltriparus minimus*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)

Table B3. Birds in the Woodland Creek and McAllister Creek areas

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source[a]
Common goldeneye	*Bucephala clangula*	nd	yes	Thurston County (1994); USFWS (2005); Windward 2020 site survey
Common loon	*Gavia immer*	nd	yes	Thurston County (1994); USFWS (2005)
Common merganser	*Mergus merganser*	nd	yes	Thurston County (1994); USFWS (2005); Windward 2020 site survey
Common murre	*Uria aalge*	nd	yes	Thurston County (1994); USFWS (2005)
Common nighthawk	*Chordeiles minor*	nd	yes	Thurston County (1994); USFWS (2005)
Common raven	*Corvus corax*	nd	yes	Thurston County (1994)
Common snipe	*Gallinago gallinago*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Common tern	*Sterna hirundo*	nd	yes	Thurston County (1994); USFWS (2005)
Common yellowthroat	*Geothlypis trichas*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Cooper's hawk	*Accipiter cooperii*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005); Windward 2020 site survey
Double-crested cormorant	*Phalacrocorax auritus*	nd	yes	Thurston County (1994); USFWS (2005)
Downy woodpecker	*Picoides pubescens*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Dunlin	*Calidris alpina*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Eared grebe	*Podiceps nigricollis*	nd	yes	Thurston County (1994); USFWS (2005)
European widgeon	*Anas penelope*	nd	yes	Thurston County (1994); USFWS (2005)
Evening grosbeak	*Coccothraustes vespertinus*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Fox sparrow	*Passerella iliaca*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Franklin's gull	*Larus pipixcan*	nd	yes	Thurston County (1994); USFWS (2005)
Gadwall	*Mareca strepera* *(Anas strepera)*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)

Table B3. Birds in the Woodland Creek and McAllister Creek areas

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source[a]
Glaucous gull	*Larus hyperboreus*	nd	yes	Thurston County (1994); USFWS (2005)
Glaucous-winged gull	*Larus glaucescens*	nd	yes	Thurston County (1994); USFWS (2005)
Golden-crowned kinglet	*Regulus satrapa*	nd	yes	Thurston County (1994); USFWS (2005)
Golden-crowned sparrow	*Zonotrichia atricapilla*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Goshawk	*Accipiter gentilis*	nd	yes	Thurston County (1994); USFWS (2005)
Great blue heron	*Ardea herodias*	yes	yes	Dobos et al. (1977); Haub et al. (2018); Thurston County (1994); USFWS (2005)
Great egret	*Ardea alba*	nd	yes	Thurston County (1994); USFWS (2005)
Great horned owl	*Bubo virginianus*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Greater scaup	*Aythya marila*	nd	yes	Thurston County (1994); USFWS (2005)
Greater yellowlegs	*Tringa melanoleuca*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Green heron	*Butorides virescens*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Green-winged teal	*Anas carolinensis*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Gyrfalcon	*Falco rusticolus*	yes	yes	Dobos et al. (1977); USFWS (2005)
Hairy woodpecker	*Picoides villosus*	nd	yes	Thurston County (1994); USFWS (2005)
Harris' sparrow	*Zonotrichia querula*	nd	yes	Thurston County (1994); USFWS (2005)
Heerman's gull	*Larus heermanni*	nd	yes	Thurston County (1994); USFWS (2005)
Hermit thrush	*Catharus guttatus*	nd	yes	Thurston County (1994); USFWS (2005)
Herring gull	*Larus argentatus*	nd	yes	Thurston County (1994); USFWS (2005)
Hooded merganser	*Lophodytes cucullatus*	nd	yes	Thurston County (1994); USFWS (2005)
Horned grebe	*Podiceps auritus*	nd	yes	Thurston County (1994); USFWS (2005)

Table B3. Birds in the Woodland Creek and McAllister Creek areas

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source[a]
Horned lark	*Eremophila alpestris*	nd	yes	USFWS (2005)
House finch	*Haemorhous mexicanus (Carpodacus mexicanus)*	nd	yes	Thurston County (1994); USFWS (2005)
House wren	*Troglodytes aedon*	nd	yes	USFWS (2005)
Hutton's vireo	*Vireo huttoni*	nd	yes	Thurston County (1994); USFWS (2005)
Killdeer	*Charadrius vociferus*	nd	yes	Thurston County (1994); USFWS (2005)
Laysan albatross	*Phoebastria immutabilis*	nd	yes	USFWS (2005)
Lazuli bunting	*Passerina amoena*	nd	yes	USFWS (2005)
Leach's storm-petrel	*Oceanodroma leucorhoa*	nd	yes	USFWS (2005)
Least sandpiper	*Calidris minutilla*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Lesser scaup	*Aythya affinis*	nd	yes	Thurston County (1994); USFWS (2005)
Lesser yellowlegs	*Tringa flavipes*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Lewis' woodpecker	*Melanerpes lewis*	nd	yes	USFWS (2005)
Lincoln's sparrow	*Melospiza lincolnii*	nd	yes	Thurston County (1994); USFWS (2005)
Long-billed dowitcher	*Limnodromus scolopaceus*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Long-billed marsh wren	*Cistothorus palustris*	yes		Dobos et al. (1977)
Long-eared owl	*Asio otus*	nd	yes	USFWS (2005)
MacGillivray's warbler	*Geothlypis tolmiei*	nd	yes	Thurston County (1994);
Mallard	*Anas platyrhynchos*	yes	yes	Dobos et al. (1977); Haub et al. (2018); Thurston County (1994); USFWS (2005); Windward 2020 site survey
Marbled godwit	*Limosa fedoa*	nd	yes	Thurston County (1994)
Marbled murrelet	*Brachyramphus marmoratus*	nd	yes	Thurston County (1994); USFWS (2005)

Table B3. Birds in the Woodland Creek and McAllister Creek areas

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source[a]
Marsh wren	*Cistothorus palustris*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Merlin	*Falco columbarius*	nd	yes	Thurston County (1994); USFWS (2005)
Mew gull	*Larus canus*	nd	yes	Thurston County (1994); USFWS (2005)
Mountain quail	*Oreortyx pictus*	yes	yes	WDFW (2019) (PHS); USFWS (2005)
Mourning dove	*Zenaida macroura*	nd	yes	Thurston County (1994); USFWS (2005); Windward 2020 site survey
Nashville warbler	*Vermivora ruficapilla*	nd	yes	USFWS (2005)
Northern bobwhite	*Colinus virginianus*	nd	yes	USFWS (2005)
Northern harrier	*Circus cyaneus*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Northern mockingbird	*Mimus polyglottos*	nd	yes	USFWS (2005)
Northern oriole	*Icterus bullockii*	nd	yes	Thurston County (1994); USFWS (2005)
Northern pintail	*Anas acuta*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Northern pygmy-Owl	*Glaucidium gnoma*	nd	yes	USFWS (2005)
Northern rough-winged swallow	*Stelgidopteryx serripennis*	yes	yes	Haub et al. (2018); USFWS (2005)
Northern shoveler	*Anas clypeata*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Northern shrike	*Lanius excubitor*	nd	yes	Thurston County (1994); USFWS (2005)
Oldsquaw	*Clangula hyemalis*	nd	yes	Thurston County (1994); USFWS (2005)
Olive-sided flycatcher	*Contopus cooperi*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Orange-crowned warbler	*Leiothlypis celata* *(Vermivora celata)*	nd	yes	Thurston County (1994); USFWS (2005)
Oregon junco	*Junco hyemalis*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)

Table B3. Birds in the Woodland Creek and McAllister Creek areas

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source[a]
Osprey	*Pandion haliaetus*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Pacific-slope flycatcher	*Empidonax difficilis*	yes	yes	USFWS (2005); Windward 2019 site survey
Parasitic jaeger	*Stercorarius parasiticus*	nd	yes	Thurston County (1994); USFWS (2005)
Pectoral sandpiper	*Calidris melanotos*	nd	yes	Thurston County (1994); USFWS (2005)
Pelagic cormorant	*Phalacrocorax pelagicus*	nd	yes	Thurston County (1994); USFWS (2005)
Peregrine falcon	*Falco peregrinus*	nd	yes	Thurston County (1994); USFWS (2005)
Pied-billed grebe	*Podilymbus podiceps*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Pigeon guillemot	*Cepphus columba*	nd	yes	Thurston County (1994); USFWS (2005)
Pileated woodpecker	*Dryocopus pileatus*	nd	yes	Thurston County (1994); USFWS (2005)
Pine siskin	*Spinus pinus* *(Carduelis pinus)*	nd	yes	Thurston County (1994); USFWS (2005)
Prairie falcon	*Falco mexicanus*	nd	yes	USFWS (2005)
Purple finch	*Haemorhous purpureus* *(Carpodacus purpureus)*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Purple martin	*Progne subis*	nd	yes	Thurston County (1994)
Red crossbill	*Loxia curvirostra*	nd	yes	USFWS (2005)
Red knot	*Calidris canutus*	nd	yes	Thurston County (1994); USFWS (2005)
Red-breasted merganser	*Mergus serrator*	nd	yes	Thurston County (1994); USFWS (2005)
Red-breasted nuthatch	*Sitta canadensis*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005); Windward 2020 site survey
Red-breasted sapsucker	*Sphyrapicus ruber*	nd	yes	USFWS (2005); Windward 2020 site survey
Red-eyed vireo	*Vireo olivaceus*	nd	yes	Thurston County (1994); USFWS (2005)
Redhead	*Aythya americana*	nd	yes	Thurston County (1994);

Table B3. Birds in the Woodland Creek and McAllister Creek areas

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source[a]
Red-necked grebe	*Podiceps grisegena*	nd	yes	Thurston County (1994); USFWS (2005)
Red-necked phalarope	*Phalaropus lobatus*	nd	yes	USFWS (2005)
Red-shafted flicker	*Colaptes auratus*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005); Windward 2020 site survey
Red-shouldered hawk	*Buteo lineatus*	nd	yes	USFWS (2005)
Red-tailed hawk	*Buteo jamaicensis*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Red-throated loon	*Gavia stellata*	nd	yes	Thurston County (1994); USFWS (2005)
Red-winged blackbird	*Agelaius phoeniceus*	yes	yes	Dobos et al. (1977); Haub et al. (2018); Thurston County (1994); USFWS (2005); Windward 2020 site survey
Rhinoceros auklet	*Cerorhinca monocerata*	nd	yes	Thurston County (1994); USFWS (2005)
Ring-billed gull	*Larus delawarensis*	nd	yes	Thurston County (1994); USFWS (2005)
Ring-necked duck	*Aythya collaris*	nd	yes	Thurston County (1994); USFWS (2005)
Ring-necked pheasant	*Phasianus colchicus*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Rock dove	*Columba livia*	nd	yes	Thurston County (1994); USFWS (2005)
Rough-legged hawk	*Buteo lagopus*	nd	yes	Thurston County (1994); USFWS (2005)
Rough-winged swallow	*Stelgidopteryx ruficollis*	nd	yes	Thurston County (1994)
Ruby-crowned kinglet	*Regulus calendula*	nd	yes	Thurston County (1994); USFWS (2005)
Ruddy duck	*Oxyura jamaicensis*	nd	yes	Thurston County (1994); USFWS (2005)
Ruffed grouse	*Bonasa umbellus*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Rufous hummingbird	*Selasphorus rufus*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005); Windward 2019 site survey
Sage sparrow	*Amphispiza belli*	nd	yes	USFWS (2005)
Sanderling	*Calidris alba*	nd	yes	Thurston County (1994); USFWS (2005)

Table B3. Birds in the Woodland Creek and McAllister Creek areas

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source[a]
Sandhill crane	*Grus canadensis*	nd	yes	Thurston County (1994); USFWS (2005)
Savannah sparrow	*Passerculus sandwichensis*	nd	yes	Thurston County (1994); USFWS (2005)
Saw-whet owl	*Aegolius acadicus*	nd	yes	Thurston County (1994)
Screech owl	*Megascops asio*	yes	yes	Dobos et al. (1977); Thurston County (1994);
Semipalmated plover	*Charadrius semipalmatus*	nd	yes	Thurston County (1994); USFWS (2005)
Sharp-shinned hawk	*Accipiter striatus*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Sharp-tailed sandpiper	*Calidris acuminata*	nd	yes	Thurston County (1994); USFWS (2005)
Short-billed dowitcher	*Limnodromus griseus*	nd	yes	USFWS (2005)
Short-eared owl	*Asio flammeus*	nd	yes	Thurston County (1994); USFWS (2005)
Short-tailed shearwater	*Puffinus tenuirostris*	nd	yes	USFWS (2005)
Slaty-backed gull	*Larus schistisagus*	nd	yes	USFWS (2005)
Snow bunting	*Plectrophenax nivalis*	nd	yes	Thurston County (1994); USFWS (2005)
Snow goose	*Chen caerulescens*	nd	yes	Thurston County (1994); USFWS (2005)
Snowy owl	*Bubo scandiacus (Nyctea scandiaca)*	nd	yes	Thurston County (1994); USFWS (2005)
Solitary sandpiper	*Tringa solitaria*	nd	yes	Thurston County (1994)
Song sparrow	*Melospiza melodia*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005); Windward 2019 site survey; Windward 2020 site survey
Sora	*Porzana carolina*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Spotted sandpiper	*Actitis macularius*	nd	yes	Thurston County (1994); USFWS (2005)
Spotted towhee	*Pipilo maculatus*	yes	yes	Dobos et al. (1977); USFWS (2005); Windward 2019 site survey
Starling	*Sturnus vulgaris*	nd	yes	Thurston County (1994); USFWS (2005); Windward 2020 site survey

Table B3. Birds in the Woodland Creek and McAllister Creek areas

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source[a]
Steller's jay	*Cyanocitta stelleri*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005); Windward 2020 site survey
Surf scoter	*Melanitta perspicillata*	nd	yes	Thurston County (1994); USFWS (2005)
Swainson's thrush	*Catharus ustulatus*	yes	yes	Thurston County (1994); USFWS (2005); Windward 2019 site survey
Thayer's gull	*Larus thayeri*	nd	yes	Thurston County (1994); USFWS (2005)
Townsend's solitaire	*Myadestes townsendi*	nd	yes	USFWS (2005)
Townsend's warbler	*Setophaga townsendi (Dendroica townsendi)*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Tree sparrow	*Spizelloides arborea*	nd	yes	Thurston County (1994); USFWS (2005)
Tree swallow	*Tachycineta bicolor*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Trumpeter swan	*Cygnus buccinator*	nd	yes	USFWS (2005)
Turkey vulture	*Cathartes aura*	nd	yes	Thurston County (1994); USFWS (2005)
Varied thrush	*Ixoreus naevius*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Vaux's swift	*Chaetura vauxi*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Vesper sparrow	*Pooecetes gramineus*	nd	yes	Thurston County (1994); USFWS (2005)
Violet-green swallow	*Tachycineta thalassina*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Virginia rail	*Rallus limicola*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Wandering tattler	*Tringa incana*	nd	yes	Thurston County (1994);
Warbling vireo	*Vireo gilvus*	nd	yes	Thurston County (1994); USFWS (2005)
Western bluebird	*Sialia mexicana*	nd	yes	USFWS (2005)
Western flycatcher	*Empidonax difficilis*	yes	yes	Dobos et al. (1977); Thurston County (1994)

Table B3. Birds in the Woodland Creek and McAllister Creek areas

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source[a]
Western grebe	*Aechmophorus occidentalis*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Western gull	*Larus occidentalis*	nd	yes	USFWS (2005)
Western kingbird	*Tyrannus verticalis*	nd	yes	Thurston County (1994); USFWS (2005)
Western meadowlark	*Sturnella neglecta*	nd	yes	Thurston County (1994); USFWS (2005)
Western sandpiper	*Calidris mauri*	nd	yes	Thurston County (1994); USFWS (2005)
Western scrub-jay	*Aphelocoma californica*	nd	yes	Thurston County (1994); USFWS (2005)
Western tanager	*Piranga ludoviciana*	nd	yes	Thurston County (1994); USFWS (2005)
Western wood-pewee	*Contopus sordidulus*	yes	yes	Thurston County (1994); USFWS (2005); Windward 2019 site survey
Whimbrel	*Numenius phaeopus*	nd	yes	Thurston County (1994); USFWS (2005)
Whistling swan	*Cygnus columbianus*	nd	yes	Thurston County (1994); USFWS (2005)
White-crowned sparrow	*Zonotrichia leucophrys*	nd	yes	Thurston County (1994); USFWS (2005)
White-fronted goose	*Anser albifrons*	nd	yes	Thurston County (1994); USFWS (2005)
White-tailed kite	*Elanus leucurus*	nd	yes	Thurston County (1994); USFWS (2005)
White-throated sparrow	*Zonotrichia albicollis*	nd	yes	Thurston County (1994); USFWS (2005)
White-winged scoter	*Melanitta fusca deglandi*	nd	yes	Thurston County (1994); USFWS (2005)
Willet	*Catoptrophorus semipalmatus*	nd	yes	USFWS (2005)
Willow flycatcher	*Empidonax traillii*	nd	yes	Thurston County (1994); USFWS (2005)
Wilson's phalarope	*Phalaropus tricolor*	nd	yes	Thurston County (1994); USFWS (2005)
Wilson's warbler	*Cardellina pusilla*	yes	yes	Thurston County (1994); USFWS (2005); Windward 2019 site survey
Winter wren	*Troglodytes hiemalis*	yes	nd	Dobos et al. (1977)
Winter wren	*Troglodytes troglodytes*	nd	yes	Thurston County (1994); USFWS (2005)

Table B3. Birds in the Woodland Creek and McAllister Creek areas

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source[a]
Wood duck	*Aix sponsa*	yes	yes	ESA Adolfson (2008); Thurston County (1994); Thurston County (2013); USFWS (2005)
Yellow warbler	*Setophaga petechia (Dendroica petechia)*	nd	yes	Thurston County (1994); USFWS (2005)
Yellow-bellied sapsucker	*Sphyrapicus varius*	nd	yes	Thurston County (1994)
Yellow-billed loon	*Gavia adamsii*	nd	yes	USFWS (2005)
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	nd	yes	Thurston County (1994); USFWS (2005)
Yellow-rumped warbler	*Setophaga coronata (Dendroica coronata)*	nd	yes	Thurston County (1994); USFWS (2005)

Bold indicates aquatic-dependent species.

a Sources for Woodland Creek include Dobos et al. (1977), ESA Adolfson (2008), Haub et al. (2018), and Windward 2019 site survey; sources for McAllister Creek include Thurston County (1994), Thurston County (2013), USFWS (2005), and Windward 2020 site survey.

nd – no data

PHS – priority habitats and species

USFWS – US Fish and Wildlife Service

WDFW – Washington Department of Fish and Wildlife

Table B4. Herptiles in the Woodland Creek and McAllister Creek areas

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source [a]
Bullfrog	*Lithobates catesbeianus*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Chorus frog	*Pseudacris triseriata*	yes	nd	Haub et al. (2018)
Common garter snake	*Thamnophis sirtalis*	yes	yes	Dobos et al. (1977); Haub et al. (2018); Thurston County (1994); Windward 2019 site survey
Long-toed salamander	*Ambystoma macrodactylum*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Northern alligator lizard	*Elgaria coerulea*	yes	yes	Dobos et al. (1977); Thurston County (1994)
Northwest salamander	*Ambystoma gracile*	yes	yes	Haub et al. (2018); USFWS (2005)
Olympic salamander	*Rhyacotriton olympicus*	yes	nd	Dobos et al. (1977)
Pacific giant salamander	*Dicamptodon spp.*	yes	nd	Dobos et al. (1977)
Pacific tree frog	*Pseudacris regilla*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Red-legged frog	*Rana draytonii*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
Rough-skinned newt	*Taricha granulosa*	yes	yes	Dobos et al. (1977); Haub et al. (2018); Thurston County (1994); USFWS (2005)
Western fence lizard	*Sceloporus occidentalis*	yes	nd	Dobos et al. (1977)
Western garter snake	*Thamnophis elegans*	yes	nd	Dobos et al. (1977)
Western pond turtle	*Actinemys marmorata*	nd	yes	Thurston County (1994); USFWS (2005)
Western red-backed salamander	*Plethodon vehiculum*	nd	yes	USFWS (2005)
Western toad	*Anaxyrus boreas*	yes	yes	Dobos et al. (1977); Haub et al. (2018); Thurston County (1994)

Bold indicates aquatic-dependent species.

[a] Sources for Woodland Creek include Dobos et al. (1977), Haub et al. (2018), and Windward 2019 site survey; sources for McAllister Creek include Thurston County (1994) and USFWS (2005).

nd – no data

USFWS – US Fish and Wildlife Service

Windward – Windward Environmental LLC

Table B5. Mammals in the Woodland Creek and McAllister Creek areas

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source [a]
American beaver	*Castor canadensis*	yes	yes	Haub et al. (2018); Thurston County (1994); USFWS (2005)
American red squirrel	*Tamiasciurus hudsonicus*	yes	nd	Dobos et al. (1977)
Big brown bat	*Eptesicus fuscus*	yes	nd	Dobos et al. (1977)
Black rat	*Rattus rattus*	nd	yes	USFWS (2005)
Black-tailed deer	*Odocoileus hemionus*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Bobcat	*Lynx rufus*	nd	yes	USFWS (2005)
Bushytailed woodrat	*Neotoma cinerea*	yes	yes	Dobos et al. (1977); USFWS (2005)
Coast mole	*Scapanus orarius*	nd	yes	USFWS (2005)
Columbian mouse	Peromyscus oreas	nd	yes	USFWS (2005)
Common raccoon	*Procyon lotor*	yes	yes	Dobos et al. (1977); Haub et al. (2018); Thurston County (1994); USFWS (2005); Windward 2019 site survey; Windward 2020 site survey
Coyote	*Canis latrans*	nd	yes	Thurston County (1994); USFWS (2005)
Creeping vole	*Microtus oregoni*	nd	yes	USFWS (2005)
Deer mouse	*Peromyscus maniculatus*	yes	yes	Haub et al. (2018); Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Douglas' squirrel	*Tamiasciurus douglasii*	nd	yes	USFWS (2005)
Dusky shrew	*Sorex monticolus*	yes	nd	Dobos et al. (1977)
Eastern cottontail rabbit	*Sylvilagus floridanus*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Eastern gray squirrel	*Sciurus carolinensis*	nd	yes	USFWS (2005); Windward 2020 site survey
Golden-mantled ground squirrel	*Callospermophilus lateralis*	yes	nd	Dobos et al. (1977)
Gray squirrel	*Sciurus carolinensis*	yes	nd	Dobos et al. (1977)
Harbor seal	*Phoca vitulina*	nd	yes	Thurston County (1994); USFWS (2005)
Hoary bat	*Lasiurus cinereus*	yes	yes	Dobos et al. (1977), USFWS (2005)

Table B5. Mammals in the Woodland Creek and McAllister Creek areas

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source [a]
House mouse	*Mus musculus*	nd	yes	Thurston County (1994); USFWS (2005)
Little brown myotis	Myotis lucifugus	nd	yes	USFWS (2005)
Long-eared myotis	Myotis evotis	nd	yes	USFWS (2005)
Long-tailed vole	*Microtus longicaudus*	yes	yes	Haub et al. (2018); USFWS (2005)
Long-tailed weasel	*Mustela frenata*	yes	yes	Thurston County (1994); USFWS (2005); Windward 2020 site survey
Masked shrew	*Sorex cinereus*	nd	yes	Thurston County (1994); USFWS (2005)
Mink	*Mustela vison*	yes	yes	Dobos et al. (1977); Haub et al. (2018); Thurston County (1994); Thurston County (2013); USFWS (2005)
Mountain beaver	*Aplodontia rufa*	nd	yes	Thurston County (1994); USFWS (2005)
Mountain lion	*Felis concolor*	nd	yes	USFWS (2005)
Muskrat	*Ondatra zibethicus*	yes	yes	Dobos et al. (1977); Haub et al. (2018); Thurston County (1994); USFWS (2005); Windward 2019 site survey
Northern flying squirrel	*Glaucomys sabrinus*	nd	yes	Thurston County (1994); USFWS (2005)
Northern river otter	*Lontra canadensis*	yes	yes	Dobos et al. (1977); Haub et al. (2018); Thurston County (1994); USFWS (2005)
Northern water shrew	*Sorex palustris*	yes	nd	Dobos et al. (1977)
Norway rat	*Rattus norvegicus*	nd	yes	USFWS (2005)
Nutria	*Myocastor coypus*	yes	nd	Haub et al. (2018)
Opossum	*Didelphis virginiana*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Oregon vole	*Microtus oregoni*	nd	yes	Thurston County (1994)
Pacific jumping mouse	*Zapus trinotatus*	nd	yes	Thurston County (1994); USFWS (2005)
Pacific shrew	*Sorex pacificus*	yes	nd	Dobos et al. (1977)
Pacific water shrew	*Sorex bendirii*	nd	yes	USFWS (2005)

Table B5. Mammals in the Woodland Creek and McAllister Creek areas

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Source [a]
Porcupine	*Erethizon dorsatus*	nd	yes	Thurston County (1994); USFWS (2005)
Red fox	*Vulpes vulpes*	yes	yes	Dobos et al. (1977); USFWS (2005)
Short-tailed weasel	*Mustela erminea*	nd	yes	USFWS (2005)
Shrew-mole	*Neurotrichus gibbsi*	nd	yes	Thurston County (1994); USFWS (2005)
Silver haired bat	*Lasionycteris noctivagans*	yes	yes	Dobos et al. (1977); USFWS (2005)
Skunk (unidentified)	*Mephitus* spp.	yes	nd	Dobos et al. (1977)
Snowshoe hare	*Lepus americanus*	yes	yes	Dobos et al. (1977); USFWS (2005)
Spotted skunk	*Spilogale gracilis*	yes	nd	Dobos et al. (1977)
Striped skunk	*Mephitis mephitis*	nd	yes	Thurston County (1994); USFWS (2005)
Townsend's big-eared bat	*Plecotus townsendii*	nd	yes	USFWS (2005)
Townsend's chipmunk	*Tamias townsendii*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Townsend's mole	*Scapanus townsendii*	yes	yes	Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Townsend's vole	*Microtus townsendii*	yes	yes	Haub et al. (2018); Dobos et al. (1977); Thurston County (1994); USFWS (2005)
Trowbridge's shrew	*Sorex trowbridgii*	yes	yes	Dobos et al. (1977); USFWS (2005)
Vagrant shrew	*Sorex vagrans*	nd	yes	Thurston County (1994); USFWS (2005)
Weasel (unidentified)	*Mustela* spp.	yes	nd	Dobos et al. (1977)
Western gray squirrel	*Sciurus griseus*	nd	yes	Thurston County (1994); USFWS (2005)
Western red-backed vole	*Clethrionomys californicus*	nd	yes	USFWS (2005)
Western spotted skunk	*Spilogale gracilis/putorius*	nd	yes	Thurston County (1994); USFWS (2005)
White-footed mouse	*Peromyscus leucopus*	yes	nd	Dobos et al. (1977)
White-tailed deer	*Odocoileus virginianus*	nd	yes	USFWS (2005)
Yuma myotis (bat)	*Myotis yumanensis*	yes	yes	USFWS (2005); Windward 2019 site survey

Bold indicates aquatic-dependent species.

Note: Only species documented in published sources are listed. Anecdotal evidence suggests that Douglas squirrel (*Tamiasciurus douglasii*) are also present in the Woodland Creek area.

[a] Sources for Woodland Creek include Dobos et al. (1977), Haub et al. (2018), and Windward 2019 site survey; sources for McAllister Creek include Thurston County (1994), Thurston County (2013), USFWS (2005), and Windward 2020 site survey.

nd – no data

USFWS – US Fish and Wildlife Service

Windward – Windward Environmental LLC

Table B6. Aquatic-dependent sensitive species potentially present in the Woodland Creek and McAllister Creek areas

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Potential Site Use	USFWS Status	WDFW Status
Bald eagle	*Haliaeetus leucocephalus*	yes	yes	occurrence	recovery	not listed
Brown rockfish	*Sebastes auriculatus*	nd	yes	occurrence	none	priority species[b,c]
Bull trout	*Salvelinus confluentus*	nd	yes	occurrence	threatened	SOC candidate and priority species[a,b,c]
Chinook salmon	*Oncorhynchus tshawytscha*	yes	yes	occurrence/ migration	threatened	SOC candidate and priority species[a,b,c]
Chum salmon	*Oncorhynchus keta*	yes	yes	occurrence	threatened	SOC candidate and priority species[a,b,c]
Coho salmon	*Oncorhynchus kisutch*	yes	yes	breeding area	SOC	SOC candidate and priority species[a,b,c]
Common loon	*Gavia immer*	nd	yes	breeding area/migration	none	SOC and priority species[a,b]
Copper rockfish	*Sebastes caurinus*	nd	yes	occurrence	none	SOC candidate and priority species[a,b,c]
Cutthroat trout	*Oncorhynchus clarki*	yes	yes	occurrence	none	priority species[c]
English sole	*Pleuronectes vetulus*	nd	yes	breeding area	none	SOC candidate and priority species[a,b,c]
Fall Chinook salmon	*Oncorhynchus tshawytscha*	yes	nd	occurrence/ migration	threatened	SOC candidate and priority species[a,b,c]
Fall chum salmon	*Oncorhynchus keta*	yes	nd	occurrence	threatened	SOC candidate and priority species[a,b,c]
Great blue heron	*Ardea herodias*	yes	yes	breeding area	none	priority species[b]
Harbor seal	*Phoca vitulina*	nd	yes	haul-out areas	none	priority species[b]
Little brown myotis	Myotis lucifugus	nd[d]	yes	communal roost	under review	priority species[b]
Marbled murrelet	*Brachyramphus marmoratum*	nd	yes	occurrence	threatened	SOC and priority species[a,b]
Mountain quail	*Oreortyx pictus*	yes	nd	occurrence	none	priority species[c]

Table B6. Aquatic-dependent sensitive species potentially present in the Woodland Creek and McAllister Creek areas

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Potential Site Use	USFWS Status	WDFW Status
Native littleneck clam	*Leukoma staminea*	nd	yes	occurrence	none	priority species[b,c]
Olympic mudminnow	*Novumbra hubbsi*	yes	nd	occurrence	none	SOC and priority species[a]
Pacific cod	*Gadus macrocephalus*	nd	yes	breeding area	none	priority species[b,c]
Pacific hake	*Merluccius productus*	nd	yes	breeding area	none	priority species[c]
Pacific herring	*Clupea harengus*	nd	yes	breeding area	none	SOC candidate and priority species[a,b,c]
Pacific lamprey	*Lampetra tridentata*	nd	yes	occurrence	none	SOC candidate and priority species[a,b,c]
Pink salmon	*Oncorhynchus gorbuscha*	nd	yes	occurrence	none	priority species[b,c]
Quillback rockfish	*Sebastes maliger*	nd	yes	occurrence	none	priority species[c]
Rainbow trout/Winter steelhead	*Oncorhynchus mykiss*	yes	yes	occurrence/ migration	threatened	SOC candidate and priority species[a,c]
Red knot	*Calidris canutus rufa*	nd	yes	occurrence/ migration	threatened	not listed
Red-legged frog	*Rana draytonii*	yes	yes	occurrence	threatened	not listed
River lamprey	*Lampetra ayresi*	nd	yes	occurrence	none	SOC candidate and priority species[a,b,c]
Rock sole	*Pleuronectes bilineata*	nd	yes	breeding area	none	priority species[c]
Sandhill crane	*Grus canadensis*	nd	yes	breeding area	none	SOC and priority species[a]
Snow goose	*Chen caerulescens*	nd	yes	occurrence	none	priority species[b,c]
Sockeye salmon	*Oncorhynchus nerka*	yes	yes	occurrence	threatened	SOC candidate and priority species[a,b,c]
Surfsmelt	*Hypomesus pretiosus*	yes	nd	breeding area	none	priority species[b,c]
Trumpeter swan	Cygnus buccinator	nd	yes	occurrence	none	SOC candidate and priority species[a,b,c]

Table B6. Aquatic-dependent sensitive species potentially present in the Woodland Creek and McAllister Creek areas

Common Name	Scientific Name	Woodland Creek	McAllister Creek	Potential Site Use	USFWS Status	WDFW Status
Walleye pollock	*Theregra chalcogrammus*	nd	yes	breeding area	none	SOC candidate and priority species[a,b,c]
Western grebe	*Aechmophorus occidentalis*	yes	yes	breeding area/migration	none	SOC candidate and priority species[a,b]
Western pond turtle	*Actinemys marmorata*	nd	yes	occurrence	under review	SOC and priority species[a]
Western toad	*Anaxyrus boreas*	yes	yes	occurrence	none	SOC candidate and priority species[a]
White sturgeon	*Acipenser transmontanus*	nd	yes	occurrence	endangered	SOC candidate and priority species[a,b,c]
Winter steelhead	*Oncorhynchus mykiss*	yes	nd	occurrence/ migration	threatened	SOC candidate and priority species[a,c]
Wood duck	*Aix sponsa*	yes	yes	breeding area	none	priority species[c]
Yuma myotis (bat)	*Myotis yumanensis*	yes	yes	communal roost	none	priority species[b]

Source: WDFW (2019) and USFWS (2019)

[a] Priority species designation based on Criterion 1 (state-listed and candidate species).

[b] Priority species designation based on Criterion 2 (vulnerable aggregations).

[c] Priority species designation based on Criterion 3 (species of recreational, commercial, and/or tribal importance).

[d] Little brown myotis is not documented in the literature as being present in Woodland Creek basin, nor was it observed during the Windward site visit; however, information from the WDFW PHS List suggests that it may be present in the Woodland Creek area.

PHS – priority habitat and species

SOC – species of concern

WDFW – Washington Department of Fish and Wildlife

USFWS – US Fish and Wildlife Service

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