Curley Creek
Watershed Assessment and Protection and Restoration Plan

November 27, 2017
FINAL REPORT

EPA

THE SUQUAMISH TRIBE

Natural Systems Design

ICF INTERNATIONAL

Funded by:

This project has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreement #00J99801 (Puget Sound Tribal Capacity Building) and EPA Puget Sound Implementation Grant Number 12EPA PSP436 to the Suquamish Tribe. The contents of this document do not necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ACKNOWLEDGMENTS

The Curley Creek Watershed Assessment and Restoration Plan benefited greatly from the participation and technical input provided by the following individuals during site visits, workshops, and review of draft reports:

Won Yang (landowner)
Butch Ashby and family (landowner)
Steve Childers (landowner)
Karen Williamson (landowner)
Brittany Gordon (WDFW)
Chris Waldbillig (WDFW)
Carin Anderson (Kitsap Conservation District)
Kathy Peters (Kitsap County)
David Nash (Kitsap County)
Kirvie Mesebeluu-Yobech (Kitsap County)
Zack Holt (City of Port Orchard)
Scott Pascoe (Great Peninsula Conservancy)
Jonathan Decker (Great Peninsula Conservancy)
Jamie Glasgow (Wild Fish Conservancy)
Marty Ereth (Pierce County)
Brenda Padgham (Bainbridge Island Land Trust)
Colin Hume (Washington State Dept. of Ecology)
Jeanette Dorner (Mid Sound Salmon Enhancement Group)
Sarah Heerhartz (Hood Canal Salmon Enhancement Group)
Marian Berejekian (formerly with Kitsap County)

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1. INTRODUCTION

1.1 Overview

This report describes the watershed processes and habitat conditions for salmonids in the Curley Creek Watershed, including a watershed protection and restoration plan. The project goal was to develop strategies and actions that will protect and restore watershed, riparian, floodplain and stream processes and habitat conditions for salmonids. The project area for this assessment encompasses the approximately 15 square mile watershed (including Curley Creek, Long Lake, Salmonberry Creek, and their tributaries), the estuary, and nearshore areas of Yukon Harbor extending into adjacent drift cells north and east from the estuary. The assessment describes the most significant factors that adversely impact salmonid habitat and populations within the Curley Creek watershed as well as those that maintain ecosystem functions and improve habitat and the stream's resilience to external changes (e.g., increased peak flows associated with urbanization and climate change). An underlying assumption of this assessment is that by protecting and restoring the habitat-forming processes most important to salmonids, a group of regional keystone species (for this assessment we include chum, coho, and chinook salmon, and steelhead and cutthroat trout), other native aquatic and riparian plant and animal species are also likely to benefit from these same recommended strategies and actions.

1.2 Salmonid Recovery Context

The Curley Creek watershed is located within the West Sound Watersheds Lead Entity. Lead Entities were created by the Washington State Legislature (RCW 77.85) in 1999 to solicit, develop, prioritize, and find funding for habitat protection and restoration projects that would advance salmon recovery. The Lead Entity model is meant to encourage a grass roots approach where partnerships and local community relationships thrive and contribute to sustaining long term commitments to salmon recovery. In each Lead Entity, the identification, prioritization, and implementation of protection and restoration projects follows a recovery strategy. Strategies provide the social and scientific framework for prioritizing geographic areas, specific salmon populations and life history phases, and types of habitat restoration and protection actions.

Geographically, the West Sound Watersheds Lead Entity covers the east portion of Water Resource Inventory Area (WRIA) 15, excluding Vashon and Maury Islands. This area includes the east portion of the Kitsap Peninsula in addition to the Key and Gig Harbor Peninsulas and the islands of Anderson, Fox, McNeil, Bainbridge, Ketron, Herron, Blake, and Raft. Local government jurisdictions include the cities of Gig Harbor, Port Orchard, Bremerton, Poulsbo, and Bainbridge Island, and Kitsap, Mason and Pierce counties.

The strategy for West Sound Watersheds as originally developed, adopted a multi-species, ecosystem approach meant to prioritize actions that result in the biggest benefit for abundance, productivity, diversity, and spatial structure of our salmon populations. The Curley Creek watershed supports populations of coho salmon, chum salmon, steelhead, and cutthroat trout, with the nearshore area supporting chinook salmon. The strategy has been refined and supplemented over time by more detailed recovery planning efforts occurring locally and regionally. In 2005, the National Oceanic and Atmospheric Administration approved a recovery plan for Puget Sound Chinook salmon, a species listed as threatened under the Federal Endangered Species Act. Three chapters of the Puget Sound Chinook recovery plan add to the original watershed strategy: the watershed chapters for East Kitsap and the South Sound, and the Nearshore Chapter. Streams, including Curley Creek, in the West Sound Watersheds area, do not support spawning of independent populations of Puget Sound Chinook salmon. Consequently, the recovery plan chapters focus on strategies and actions in the nearshore environment, important rearing habitat for juvenile Puget Sound Chinook salmon (as well as other species of salmon) belonging to designated independent populations from all over the Sound. These nearshore strategies were further refined in 2017 when Kitsap County completed a nearshore tool that integrates several ecosystem attributes to rank the benefits of restoration and protection projects.

The Lead Entity has also taken several steps to refine freshwater strategies, including a phased project to delineate all fish bearing streams and human-made migration barriers (water-typing), for most of the West Sound Watersheds area and a separate project estimating the habitat intrinsic potential for the East Kitsap Distinct Independent Population (DIP) of Puget Sound Steelhead (listed as threatened in 2007). In 2012, the West Sound Watersheds Council proposed a near term action to complete watershed specific assessments, including development of strategies and site specific actions to protect and restore 3 high priority salmon recovery watersheds (based on salmon abundance, productivity, diversity, and spatial structure). These assessments included Chico Creek (completed in 2014), Blackjack Creek (due for completion at the end of 2017), and Curley Creek. This assessment proposes strategies and actions for Curley Creek. Finally, the West Sound Watersheds Council hopes to begin work on a recovery chapter for the East Kitsap Steelhead DIP in 2017.

1.3 Approach and Report Framework

The Open Standards Framework is utilized in this assessment to identify protection and restoration actions. The general framework applies the following steps: (1) Identifying ecosystem components, (2) Developing key ecological attributes and indicators, and (3) Identifying pressures and contributing factors. This approach will be used to describe significant factors that adversely impact salmonid habitat or, conversely, those factors necessary to maintain ecosystem functions and improve resilience to external disturbance such as land use or climate change. Key terms utilized in the Open Standards Framework are defined below.

Ecosystem Components are the specific species, habitats, or processes that are the focus of protection and restoration actions.

Key Ecological Attributes (KEA) are characteristics of an ecological component that are being evaluated. KEAs may be patterns of biological structure and composition, ecological processes, environmental regimes, or other environmental constraints.

Indicators are specific metrics that can be measured and tracked to assess changes in response to land use change or other disturbance.

Pressures are factors delivering direct stresses to ecosystem components.

Population growth in the region and conversion of forestlands to agricultural and residential land uses are the primary drivers affecting aquatic habitats in the watershed. Population trends and land use/land cover data are synthesized from existing data sources in Section 2.

Section 3 of this report evaluates Ecosystem Components and KEAs used for assessment of habitat conditions in the Curley Creek watershed. An indicator (or group of indicators) was identified for each KEA and assessed using existing information from available data or previous studies to evaluate the relative impacts of pressures and contributing factors. No field data were collected or produced for this study other than a brief field reconnaissance with visits to select locations in the watershed as summarized in Appendix A. A synthesis of the existing data sources compiled and reviewed for the assessment is attached as Appendix B.

Salmonid distributions and population status was summarized based on existing data sources and information provided by staff from the Suquamish Tribe Fisheries Department. Species evaluated include coho salmon, chum salmon, steelhead trout, Chinook salmon, and cutthroat trout. Life history characteristics, abundance, and distribution of each species are discussed in Section 4.

Two collaborative workshops were held to discuss the pressures affecting KEAs in the Curley Creek Watershed and develop strategies for protection and restoration. These strategies are discussed in Section 5 of the report. Section 6 then discusses recommended actions linked to specific reaches or locations within the watershed. The report concludes in Section 7 with a synthesis of data gaps identified over the course of the assessment and recommendations for future work.

1.4 Study Area

The Curley Creek Watershed is located near the City of Port Orchard in southeastern Kitsap County. The watershed drains an area encompassing 15 square miles (Figure 1-1). Geologic units that underlie the watershed are primarily glacial deposits from the most recent glaciation that overrode the Kitsap Peninsula approximately 15,000 years ago. Topography is relatively flat with just over 400 feet of vertical relief. Long Lake, located near the center of the watershed, stretches nearly 2 miles in length and has a surface area of 320 acres (0.5 square mile). The watershed is divided into three subbasin areas: (1) Curley Creek and tributaries entering downstream of Long Lake; (2) Salmonberry Creek, which is the largest inflow to Long Lake; and (3) Long Lake, including tributary inflows to Long Lake other than Salmonberry Creek.

Curley Creek originates at the outlet of Long Lake, flows northeasterly for approximately 3 miles, and discharges into Yukon Harbor. The channel below the lake outlet is unconfined with relatively low gradient (0.2%) to the crossing at Sedgwick Road. Below Sedgwick Road the channel is confined in a ravine flanked by steep hillslopes and gradient steepens to about 1% (Figure 1-2). Tributary inflows downstream of the lake outlet account for an area of 4.3 square miles. Banner Creek (stream number 15.0186 in WDFW stream catalog) drains an area of 0.7 square miles to the south of Curley Creek and flows through a confined ravine at an average channel gradient of 5% prior to joining Curley Creek approximately 4,000 feet upstream of the estuary at Yukon Harbor. A second unnamed tributary (15.0187 in WDFW stream catalog) to the north of Curley Creek, drains a similar sized area (0.8 square miles), is relatively unconfined with channel gradient of 1% in the upper sections, then enters a more confined reach with channel gradient of 3% over the lower mile to the junction with Curley Creek. Additional tributaries draining into Curley Creek between Long Lake and Yukon Harbor are smaller, shorter, and steeper channels that may provide habitat for cutthroat trout but less likely for salmon or steelhead.

Salmonberry Creek is the largest inflow to Long Lake with a contributing subbasin area of 5.2 square miles. Salmonberry Creek has a broad valley bottom that was carved by an outwash channel draining the receding glacier. As such, Salmonberry Creek is underfit for its valley and flanked by broad, floodplain wetlands along much of its length. The channel profile is relatively flat upstream of the lake with gradient ranging between 0.1 and 0.5% (Figure 1-2). The valley narrows near the stream crossing at Sedgwick Road from what may be an old landslide deposit and the channel steepens to

0.6% through the more confined segment. Channel gradient flattens to 0.1% as the valley widens upstream of Salmonberry Road before gradually steepening as the channel rises toward the headwater area to the north. Cool Creek, the largest tributary to Salmonberry Creek, drains an area of 0.9 square miles, crosses under Phillips Road and joins with Salmonberry Creek approximately 1.5 miles upstream of the lake.

The Long Lake subbasin captures runoff from tributaries to the south and east of Long Lake. The majority of shoreline areas around Long Lake are heavily developed with residential properties behind which steep hillslopes rise up to the surrounding upland plateau. The largest tributary, shown on some maps as Upper Curley Creek, drains northerly through a ravine at a gradient of 6% before crossing Mullenix Road and discharging to the southern end of Long Lake. Two smaller fish bearing tributaries flow parallel to Upper Curley Creek and discharge into the embayment at the southern end of Long Lake. A large wetland complex occupies a low-lying depression at the southeast corner of Long Lake in a broad, low-relief valley carved by an outwash channel that drained southeasterly into the Ollalla Valley during the last glacial recession. The upland plateau to the east of Long Lake is pockmarked with numerous wetlands and includes a large (approximately 1 square mile) forested area managed as Banner Forest Heritage Park. Two channels drain southward off the plateau and discharge to the wetland complex at the southeast corner of the lake. Another channel drains westerly and discharges to Long Lake approximately midway along the eastern shoreline.

Land use activities, including timber harvest, agriculture, and residential development, have fragmented forests, and altered ecological conditions and function in the Curley Creek watershed during the past 150 years. Forests covering the watershed were cleared for timber during the late 19th and early 20th centuries. Much of the low-gradient valley bottoms in Salmonberry Creek and the segment of Curley Creek below the lake outlet were channelized and drained for agricultural use. Current Land use in the Curley Creek Watershed is primarily rural residential. However, urbanization is occurring within parts of the watershed including the Port Orchard Urban Growth Area (UGA) that covers areas of Cool Creek and other tributaries draining the upland between Salmonberry Creek and the city of Port Orchard (Figure 1-1).

Additional detail of study area conditions based on limited field reconnaissance covering parts of the watershed are discussed in attached memoranda (Appendix A).

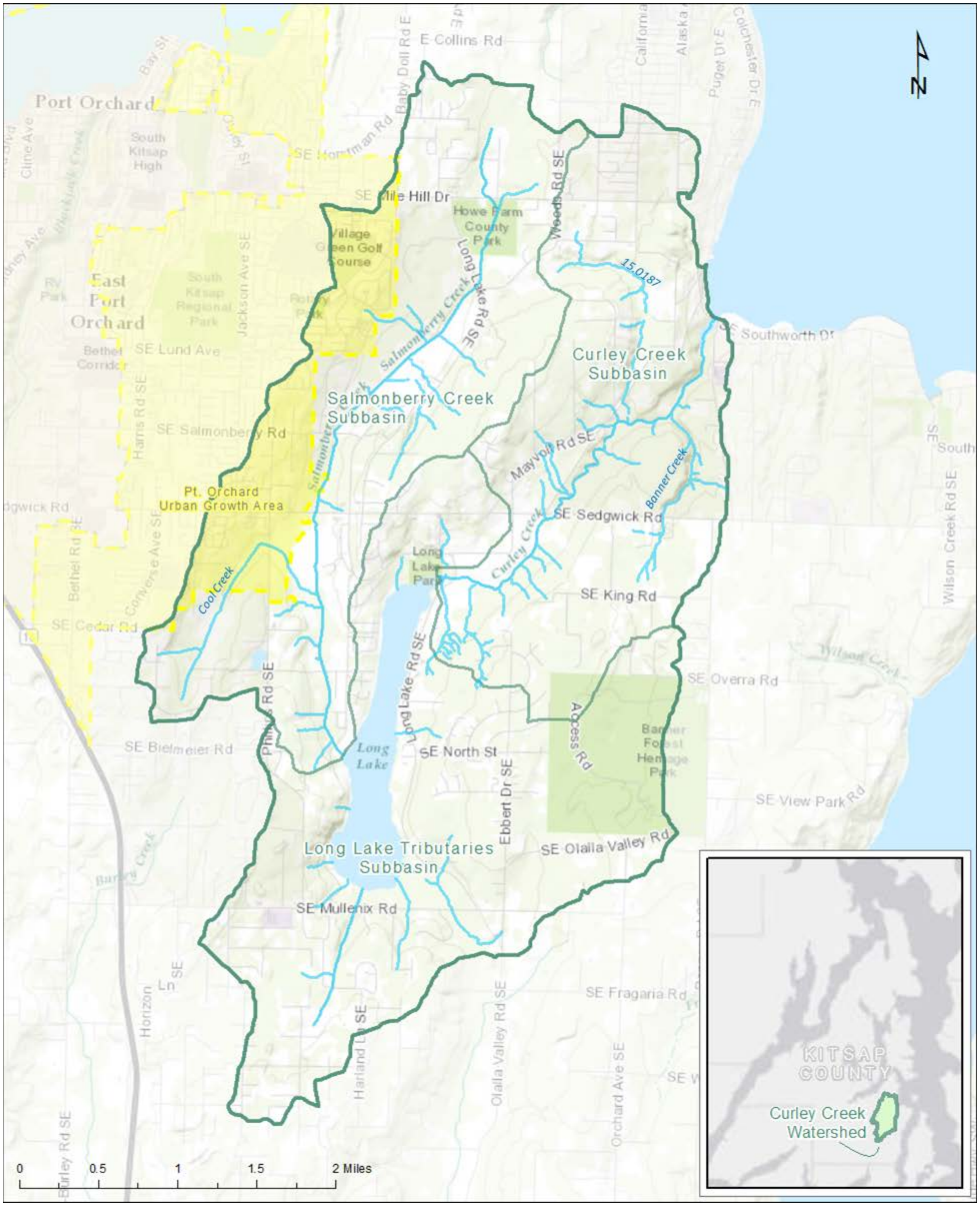

Figure 1-1. Reference map of the Curley Creek Watershed.

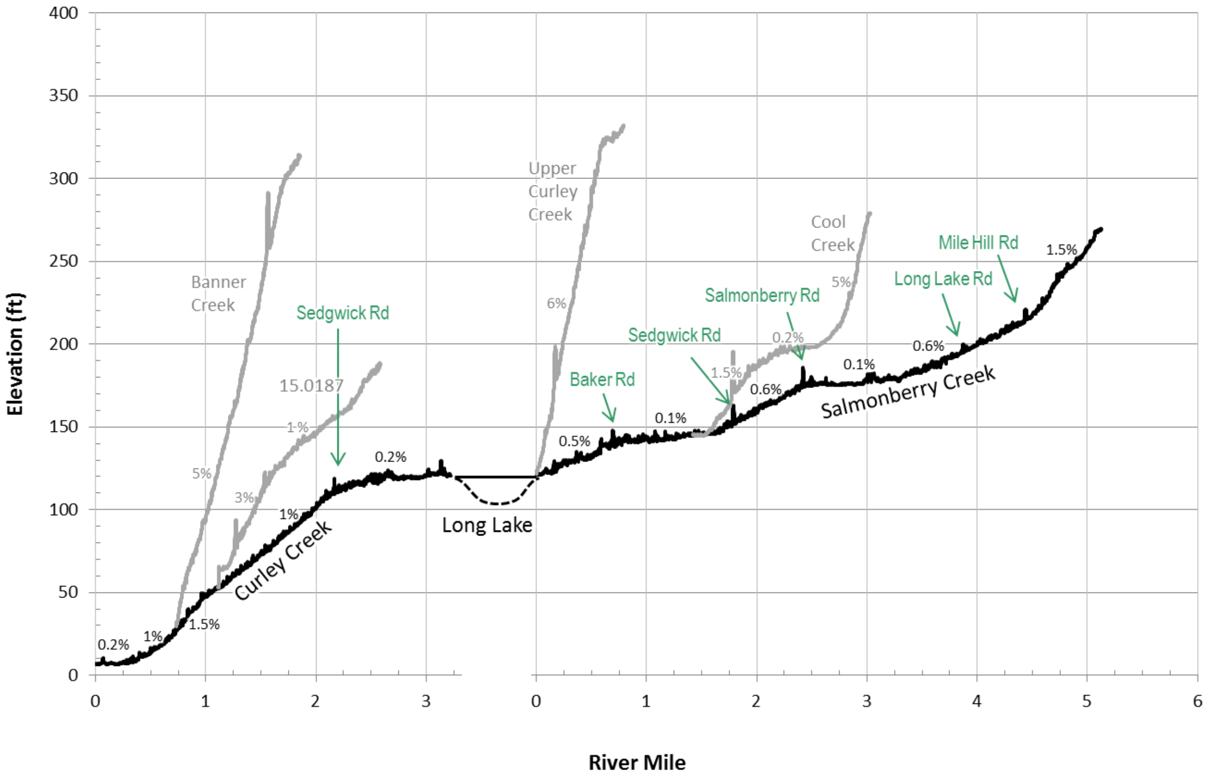

Figure 1-2. Longitudinal profile of Curley Creek and key tributary channels derived from lidar DEM.

2. LAND USE CHARACTERISTICS AND TRENDS

2.1 Land Cover Mapping

Existing data of land use and land cover types were evaluated using GIS tools to assess current watershed conditions and potential trends that could affect salmonid habitat conditions in the Curley Creek Watershed. The Regional Land Cover Classification Scheme from NOAA Office for Coastal Management Coastal Change Analysis Program (C-CAP) was used to assess existing land cover characteristics. Data from the most recent classification is mapped below in Figure 2-1. Summary statistics derived from the 2011 C-CAP land use data are presented in Table 2-1. Table 2-2 describes the land cover classification scheme utilized in the C-CAP data.

Across the watershed approximately 60% of the land (5,803 acres) is forested, ranging from 52% of the Salmonberry Creek subbasin to 68% of the Curley Creek subbasin. These forests include deciduous, evergreen, and mixed forest types.

Approximately 24% of the watershed (2,306 acres) is developed. Developed areas are associated with greater extent of impervious surfaces as indicated in Figure 2-2. Just under 10 acres of the Curley Creek Watershed are classified as high intensity development. Low intensity development and developed open space characterize the majority of developed areas in the watershed. Low intensity development is described as parcels with 21-49% of the parcel covered by constructed material. Sixty percent (1,381 acres) of the total developed land in the watershed is classified as low intensity developed. Developed open space refers to parcels with 20% or less of the parcel covered by constructed material. Approximately 31% (716 acres) the total developed land in the watershed is classified as developed open space. The remaining 9% of the developed lands are medium intensity developed. This indicates that the vast majority of development in the watershed is characterized by parcels where less than 50% of the total parcel contains areas with constructed materials. This development pattern is relatively constant throughout the watershed subbasins. The Salmonberry Creek subbasin is the most heavily developed of the three subbasins with nearly all of the lands within the watershed characterized as high intensity development (6.9 of the 9.8 total acres) located in the subbasin. Medium intensity development (50-79% of the parcel covered by constructed material) characterizes 4% of the land in the Salmonberry Creek subbasin.

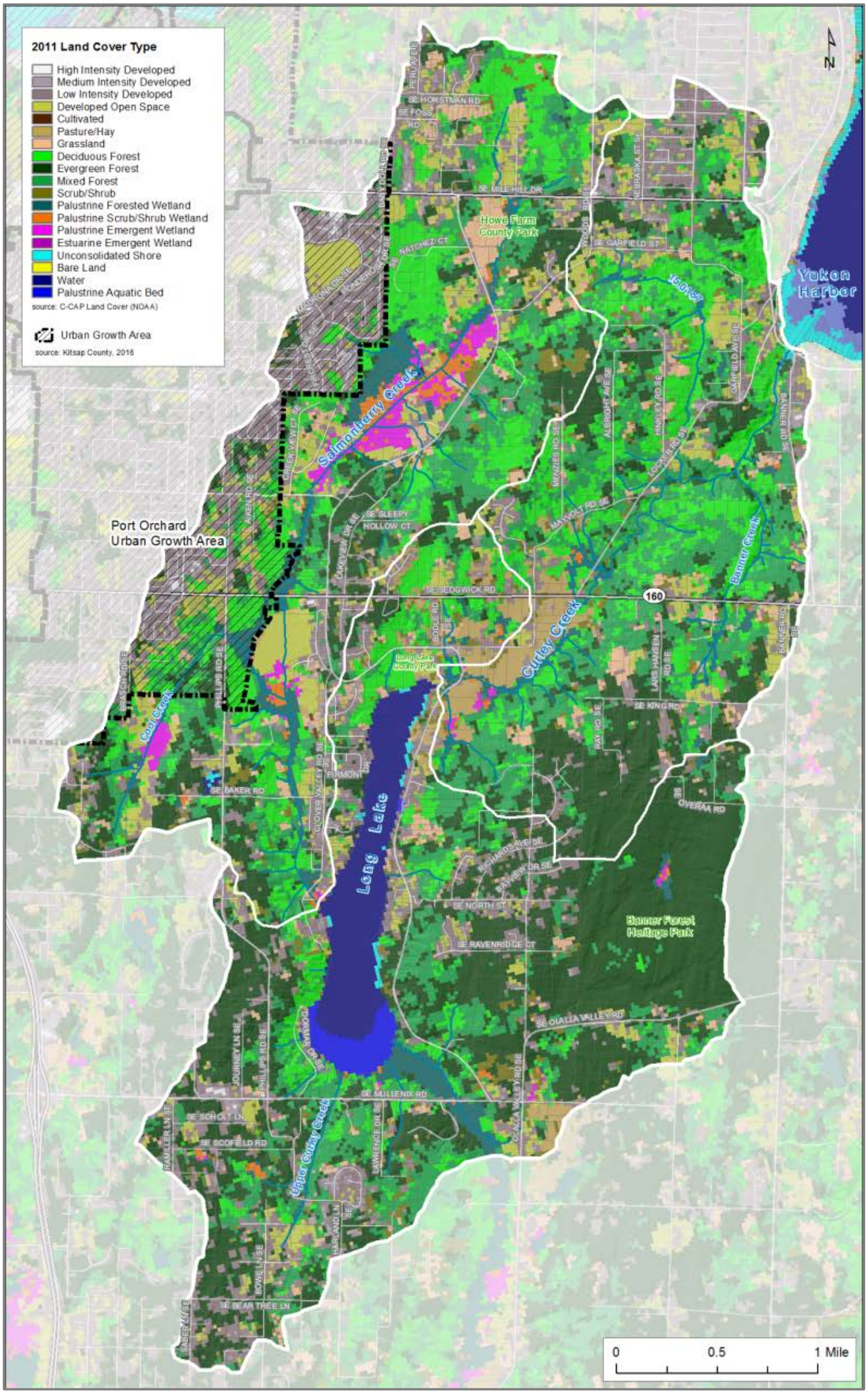

Figure 2-1. Map of land cover types Curley Creek Watershed derived from 2011 Landsat Imagery (C-CAP Landcover Atlas).

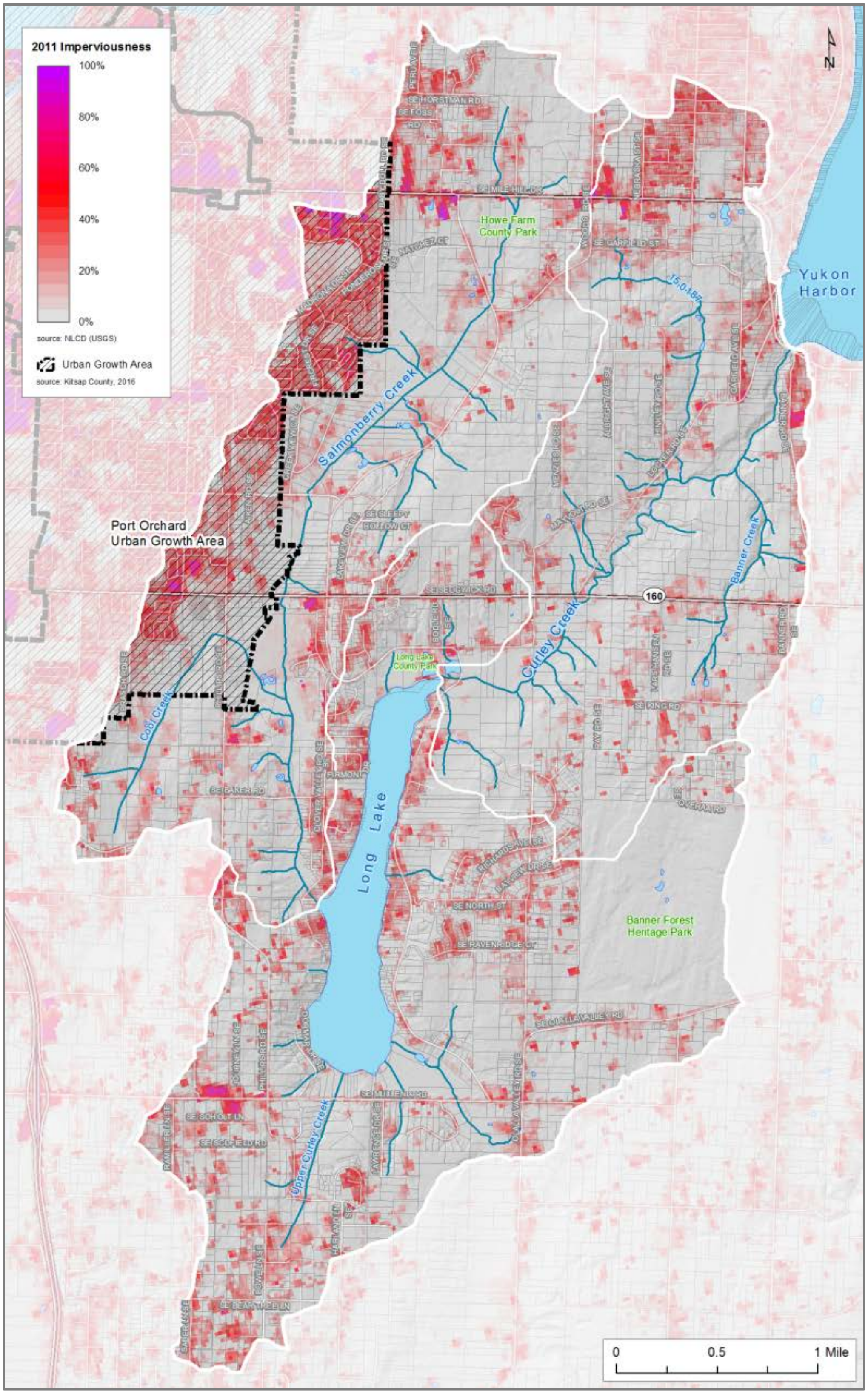

Figure 2-2. Map of impervious surface in the Curley Creek Watershed derived from 2011 Landsat Imagery (USGS National Landcover Database 2011).

Table 2-1. Land cover classification within subbasins areas of the Curley Creek Watershed (C-CAP 2011 Landcover Atlas)

LAND COVER CLASSIFICATION[1]	CURLEY CREEK		SALMONBERRY CREEK		LONG LAKE		TOTAL	
	Acres	%	Acres	%	Acres	%	Acres	%
High Intensity Developed	1.1	0%	6.9	0%	1.8	0%	9.8	0%
Medium Intensity Developed	29.1	1%	116.7	4%	52.7	1%	198.5	2%
Low Intensity Developed	323.2	12%	555.1	17%	502.8	14%	1,381.1	14%
Developed Open Space	184.5	7%	394.4	12%	137.4	4%	716.3	7%
Subtotal – Developed Land	**538**	**20%**	**1,073**	**33%**	**695**	**19%**	**2,306**	**23%**
Cultivated Crops	0.0	0%	1.3	0%	0.9	0%	2.2	0%
Pasture/Hay	100.5	4%	10.9	0%	85.1	2%	196.5	2%
Subtotal – Agricultural Land	**101**	**4%**	**12**	**0%**	**86**	**2%**	**199**	**2%**
Grassland	85.4	3%	138.9	4%	68.5	2%	292.8	3%
Subtotal –Grassland	**85**	**3%**	**139**	**4%**	**69**	**2%**	**293**	**3%**
Deciduous Forest	546.6	20%	590.0	18%	289.9	8%	1,426.5	15%
Evergreen Forest	577.5	21%	525.3	16%	1,455.2	40%	2,558.0	26%
Mixed Forest	726.9	27%	579.1	18%	512.4	14%	1,818.4	19%
Subtotal – Forest Land	**1,851**	**68%**	**1,694**	**52%**	**2,258**	**62%**	**5,803**	**60%**
Scrub/Shrub	80.0	3%	90.9	3%	108.7	3%	279.7	3%
Subtotal – Scrub Land	**80**	**3%**	**91**	**3%**	**109**	**3%**	**280**	**3%**
Palustrine Forested Wetland	63.4	2%	150.7	5%	76.5	2%	290.5	3%
Palustrine Scrub/Shrub Wetland	7.8	0%	53.6	2%	10.7	0%	72.0	1%
Palustrine Emergent Wetland	5.3	0%	85.6	3%	4.2	0%	95.1	1%
Palustrine Aquatic Bed[2]	0.0	0%	0.4	0%	58.2	2%	58.7	1%
Subtotal – Wetlands / Aquatic Bed	**77**	**2%**	**290**	**10%**	**150**	**4%**	**516**	**6%**
Unconsolidated Shore	4.0	0%	1.6	0%	10.4	0%	16.0	0%
Water	0.7	0%	4.0	0%	254.1	7%	258.8	3%
Subtotal - Barren Land and Water	**5**	**0%**	**6**	**0%**	**265**	**7%**	**275**	**3%**
Total	**2,736**	**100%**	**3,305**	**100%**	**3,630**	**100%**	**9,671**	**100%**

Notes:

[1] The following NOAA Regional Land Cover Classification Scheme classifications were not identified in the Curley Creek Watershed: Unclassified, Estuarine Forested Wetland, Estuarine Scrub/Shrub Wetland, Estuarine Emergent Wetland, Bare Land, Estuarine Aquatic Bed, Tundra, Snow/Ice.

[2] Palustrine Aquatic Bed is included in the sub-total for wetlands because it includes areas where vegetation cover is greater than 80% and thus more similar to this land cover than open water for the purposes of this study.

Table 2-2. Regional Land Cover Classification Scheme – Subset of Designated Land Uses that are found in the Curley Creek Watershed Analysis Area[1] (modified from NOAA)

GROUP	CLASS	DESCRIPTION
Developed Land	High Intensity Developed	Constructed materials: 80 – 100% of the total cover. Vegetation: less than 20% of the landscape. Common characteristics: heavily built-up center.
	Medium Intensity Developed	Constructed materials: 50 – 79% of the total cover. Common characteristics: multi- and single-family housing.
	Low Intensity Developed	Constructed materials: 21 – 49% of the total cover. Common characteristics: single-family housing, especially in rural areas.
	Developed Open Space	Constructed materials: less than 20% of the total cover. Common characteristics: managed grasses or low-lying vegetation for recreation, erosion control or aesthetic.
Agricultural Land	Cultivated Crops	Crop Vegetation: More than 20% of total vegetation. Areas intensely managed for annual crop production.
	Pasture/Hay	Pasture/Hay Vegetation: More than 20% of total vegetation. Planted for livestock grazing or production of seed or hay crops.
Grassland	Grassland	Grammanoid or herbaceous vegetation: More than 80% of total vegetation. Not subject to intensive management, may be used for grazing.
Forest Land	Deciduous Forest	Trees: dominated by trees >5m tall that cover more than 20% of vegetation cover. More than 75% shed foliage seasonally.
	Evergreen Forest	Trees: dominated by trees >5m tall that cover more than 20% of vegetation cover. More than 75% do NOT shed foliage.
	Mixed Forest	Trees: dominated by shrubs <5m tall that cover more than 20% of vegetation cover. Mix of coniferous and broad-leaved evergreens.
Scrub Land	Scrub/Shrub	Trees: dominated by shrubs <5m tall that cover more than 20% of vegetation cover. Shrubs, young trees, or stunted growth trees.
Wetlands / Aquatic Bed	Palustrine Forested Wetland	Tidal and nontidal wetlands dominated by woody vegetation >5m tall. Salinity due to ocean-derived salts below 0.5%. Vegetation cover >20%.
	Palustrine Scrub/Shrub Wetland	Tidal and nontidal wetlands dominated by woody vegetation <5m tall. Salinity due to ocean-derived salts below 0.5%. Vegetation cover >20%.
	Palustrine Emergent Wetland	Tidal and nontidal wetlands dominated by persistent emergent vascular plants, mosses, lichens. Salinity due to ocean-derived salts below 0.5%. Vegetation cover >80%.
	Palustrine Aquatic Bed[2]	Tidal and nontidal wetlands and deepwater habitats, salinity due to ocean-derived salts below 0.5%. Vegetation includes plants that grow and form continuous cover principally on or at the surface of the water (algal mats, detached floating mats, rooted vascular plant assemblages). Vegetative cover >80%.
Barren Land / Water	Unconsolidated Shore	Includes silt, sand, gravel subject to inundation and redistribution due to water. Substrates lack continuous vegetation.
	Water	Open water, generally <25% cover of vegetation or soil.

Notes:
[1] The following NOAA Regional Land Cover Classification Scheme classifications were not identified in the Curley Creek Watershed: Unclassified, Estuarine Forested Wetland, Estuarine Scrub/Shrub Wetland, Estuarine Emergent Wetland, Bare Land, Estuarine Aquatic Bed, Tundra, Snow/Ice.
[2] Palustrine Aquatic Bed is included in the sub-total for wetlands because it includes areas where vegetation cover is greater than 80% and thus more similar to this land cover than open water for the purposes of this study.

2.2 Recent Land Cover Change

WDFW has used advances in digital imaging to monitor land-use patterns to help understand changes in ecosystem components, highlight potential threats, and increase the ability to monitor the effectiveness of land use plans and legislation. WDFW has analyzed aerial imagery (1 m resolution National Agriculture Inventory Program data) for 2006, 2009, 2011, and 2013 using a process called High Resolution Change Detection (HRCD) to track vegetation changes in several water resource inventory areas (WRIAs) in the Puget Sound Basin. The process has been tested and demonstrates the ability to accurately detect changes on parcels as small as 0.25 acre (Pierce, 2011).

Polygon areas mapped as changed land cover types in the HRCD analysis between 2006 and 2013 are shown in the map series attached as Appendix C. The WDFW HRCD dataset indicates that more than 170 acres across the Curley Creek watershed (nearly 2% of the watershed area) have transitioned from forested landcover to human dominated landcover between 2006 and 2013 (Table 2-3). More recent data, using 2015 aerial imagery, have not been published to date but visual review of 2016 imagery suggests development pressures and tree clearing have continued and perhaps accelerated since the 2013 imagery used in the HRCD analysis.

Table 2-3. Cumulative area mapped as change in land use (primarily development and tree removal) between 2006 and 2013.

DISTURBED AREA PER WATERSHED SUBBASIN (ACRES)									
		Curley Creek		Salmonberry Creek		Long Lake and Tributaries		Watershed (Total)	
		Acres	%	Acres	%	Acres	%	Acres	%
	Total Area	2,736		3,305		3,630		9,671	
Time Period	2006-2009	25.11	0.9%	26.15	0.8%	35.03	1.0%	86.29	0.9%
	2009-2011	6.71	0.2%	17.16	0.5%	20.35	0.6%	44.22	0.5%
	2011-2013	6.84	0.3%	14.5	0.4%	21.58	0.6%	42.92	0.4%
	2006-2013	**38.66**	**1.4%**	**57.81**	**1.7%**	**76.96**	**2.1%**	**173.43**	**1.8%**

2.3 Land Use and Zoning

The Puget Sound region is experiencing rapid population growth and communities across the region are adopting policies and making infrastructure investments in order to absorb the growth. The population of Kitsap County has grown steadily over recent decades and growth estimates project additional growth over future decades (Figure 2-3). The 2016 Kitsap County Comprehensive Plan Update is intended to direct the majority of population growth (76 to 84%) to the Urban Growth Areas (UGAs). The buildable lands analysis estimated that total existing buildable land supply has the capacity to accommodate another 113,252 residents, while the county forecasts 80,483 additional residents by 2036 (Kitsap County, 2016).

The cities and UGAs are the focus areas for future development and the 2016 Comprehensive Plan identifies multiple strategies to encourage growth in the UGAs and preserve the natural landscape in rural areas. To encourage concentrated growth, the strategies increase transportation options, improve access to public services, implement minimum density requirements, and designate mixed-use areas to encourage growth to concentrate in existing urbanized corridors. To preserve the character and ecosystem services of rural areas, rural development strategies include providing a different level of governmental services to the urban and rural areas and adopting zoning that discourages dense development with a maximum permissible density of one dwelling unit per five acres in rural areas (Kitsap County, 2016).

Figure 2-4 shows land use designations and the urban growth area for the Curley Creek Watershed. Land use within the Curley Creek watershed is primarily characterized by rural development with 76% of the land zoned for 1 dwelling unit per 5 or 10 acres (Appendix B of 2016 Comprehensive Plan [Kitsap County, 2016]). Approximately 1,113 acres of the 3,630 acre Salmonberry subbasin (30%) are designated as part of the unincorporated UGA that borders the Port Orchard city limits (approximately 11.5% of the watershed is within the Port Orchard UGA).

Table 2-4 provides a breakdown of land use designation by subbasin for the Curley Creek watershed as designated by the 2016 Kitsap County Comprehensive Plan. The majority of the Curley Creek watershed is located in an unincorporated section of the county and zoned for rural land uses.

- Within the **Curley Creek subbasin** 91% is zoned for restricted rural-type development. About 7% of the subbasin, near Yukon Harbor, is designated as ‘a limited area of more intense rural development-I’. The remaining 2% of land is occupied by parks or other public facilities.
- Development in the **Salmonberry Creek subbasin** is relatively denser with 73% zoned as rural residential or rural protection and 19% zoned as urban low-density residential (1 to 9 dwelling units per acre). The relatively high density zoning in the Salmonberry Creek subbasin is due to the fact that 30% of the land is within the UGA that extends east from Port Orchard. Recently a portion of the Salmonberry Creek subbasin along the southern edge of the UGA has been re-classified from low-density residential to a ‘rural protection area’. This is likely due to the fact that this area currently has a narrow riparian corridor.
- The primary land use designations in the **Long Lake subbasin** are also rural residential and rural protection, which account for 78% of the land. A large portion of the land (13%) is parkland that includes most of the Banner Forest Heritage Park and several other smaller

public facilities.[1] The remaining portion of the subbasin is covered by the waters of Long Lake.

Despite the fact that most of the land areas in the Curley Creek Watershed are zoned for relatively low density, actual density of development is substantially higher in much of the watershed as land parcels were divided prior to establishment of current zoning policy. For example, average parcel size among parcels classified as "Rural Protection" in the Comprehensive Plan is 2.5 acres whereas the proposed zoning density is 1 Dwelling Unit (DU) per 10 Acres (AC). Among parcels designated as "Rural Residential", average parcel size is 1.8 acres, whereas the proposed zoning density is 1 DU / 5 AC. Undeveloped lands within these two zoning categories average 3.3 acres and 2.7 acres, respectively. As such, potential development build out could be more than double the zoning density of the land use designations in the Comprehensive Plan. The presence of parcels smaller than the designated zoning classification is distributed relatively uniformly throughout the watershed and not necessarily focused in particular areas.

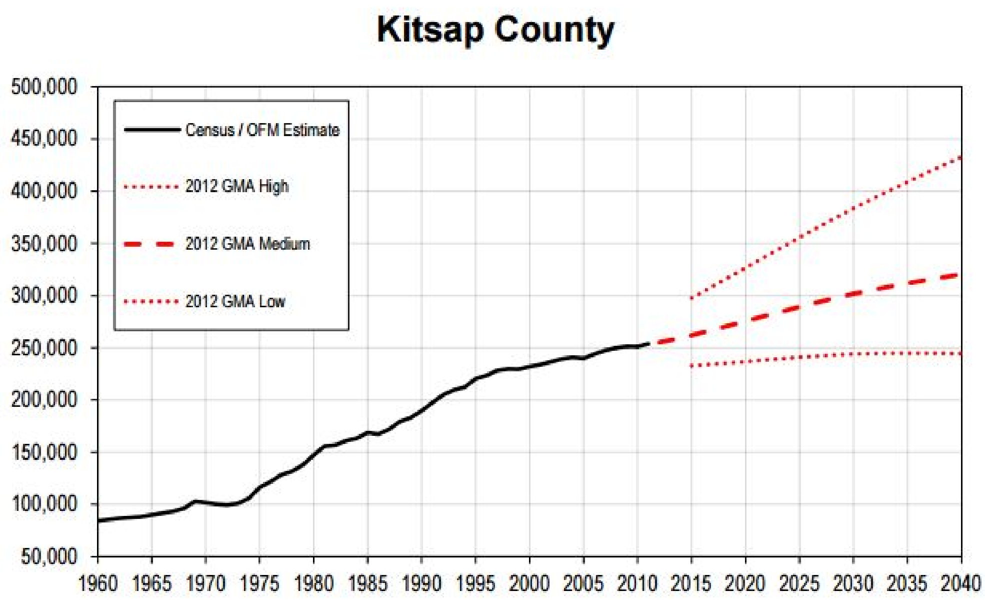

Figure 2-3. Growth Management Act Population Projections for Kitsap County (OFM 2012).

[1] Parks are assigned a "public facility" land use classification.

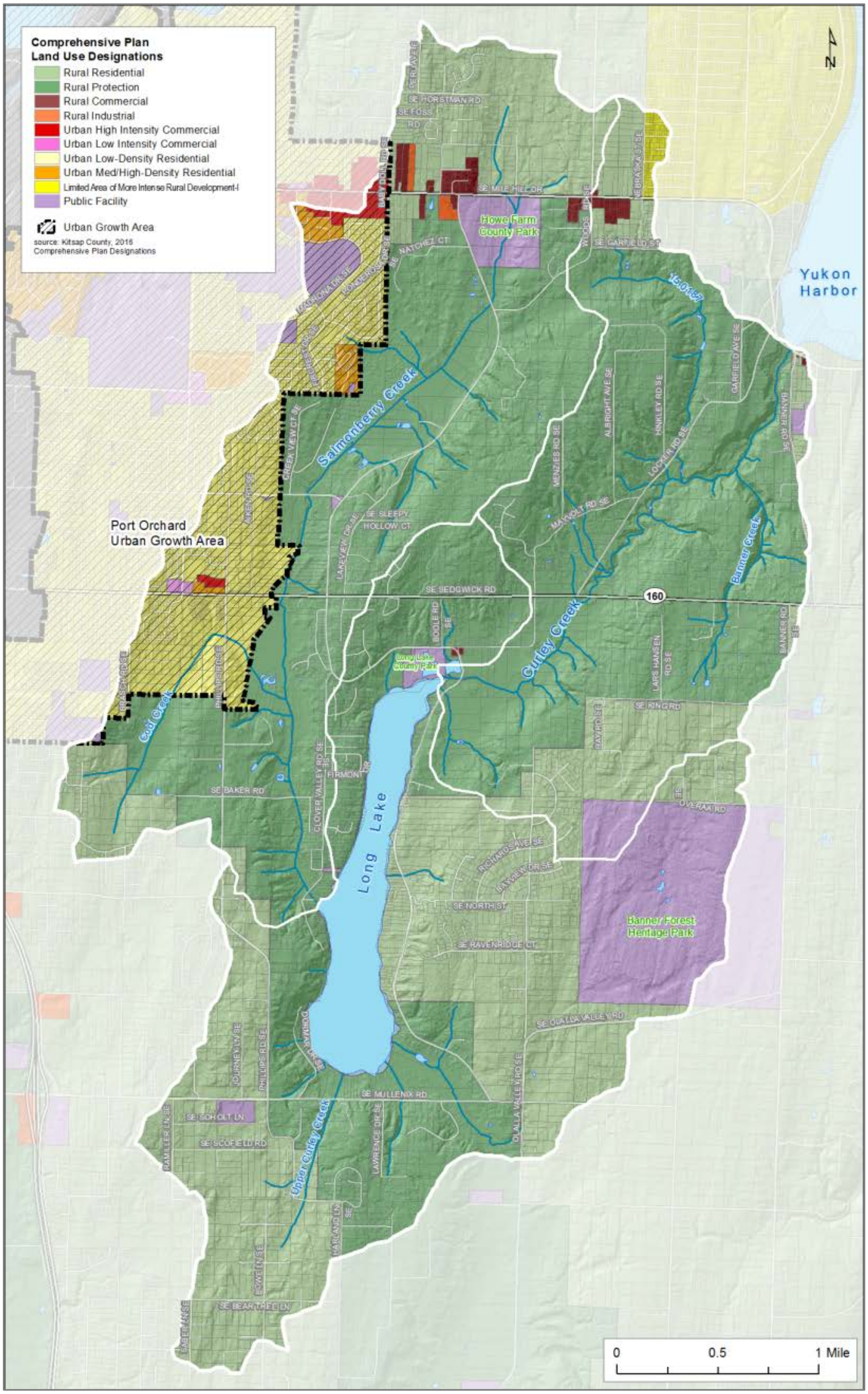

Figure 2-4. Map of land use designations in Kitsap County's Comprehensive Plan (amended 2016).

Table 2-4: Land Use Designations by Subbasin (Based on Comp Plan Designations)

Density	Land Cover Classification	Curley Creek		Long Lake		Salmonberry Creek		Total - Watershed	
		Acres	%	Acres	%	Acres	%	Acres	%
1 du / 5 acres	Rural Residential	509	19%	1,723	47%	610	18%	2,841	29%
1 du / 10 acres	Rural Protection	1,960	72%	1,112	31%	1,818	55%	4,890	51%
Not applicable	Rural Commercial	13	0%	2	0%	40	1%	55	1%
Not applicable	Rural Industrial	-	0%	-	0%	11	0%	11	0%
	Urban High-Intensity Commercial/Mixed Use	-	0%	-	0%	28	1%	28	0%
1 to 9 du / acre	Urban Low-Density Residential	-	0%	-	0%	614	19%	614	6%
	Urban Medium/High-Density Residential	-	0%	-	0%	42	1%	42	0%
	Urban Low-Intensity Commercial/Mixed Use	-	0%	-	0%	6	0%	6	0%
	Limited Area of More Intense Rural Development-I	192	7%	-	0%	-	0%	192	2%
Not applicable	Public Facility	61	2%	471	13%	137	4%	669	7%
Not applicable	Lake	1	0%	328	9%	0.07	0%	330	3%
	Total	**2,736**	**100%**	**3,635**	**100%**	**3,305**	**100%**	**9,676**	**100%**

Note: All acres are rounded to the nearest whole acre.

3. ECOSYSTEM COMPONENTS AND KEY ECOLOGICAL ATTRIBUTES

3.1 Ecosystem Component: Stream Channels

3.1.1 KEA Hydrologic Regime

The Hydrologic Regime KEA is characterized by the quantity, timing, and variability of streamflow. Stream channels in the Curley Creek watershed have a rainfall-dominated flow regime characterized by a seasonal pattern with highest flows corresponding to the period of greatest precipitation between October and April followed by a gradual recession of base flows through the spring and summer, and annual minimum flows in August or September (Figure 3-1). Mean annual precipitation is approximately 49 inches with a relatively uniform distribution over the watershed. Snowfall is infrequent, and melts relatively quickly when present.

The relatively flat, hummocky topography of the glacially sculpted landscape includes many depressional areas occupied by lakes and wetlands. These are important areas of surface water storage that act to attenuate flood routing, increase groundwater recharge, and increase summer base flows. Long Lake inundates 320 acres near the center of the watershed and moderates inflow to Curley Creek from the surrounding tributaries and uplands draining to the lake. Other water bodies providing surface storage include wetland complexes surrounding Long Lake, wetlands in Banner Forest Heritage Park, and Lake Amelia. Broad, low gradient valley bottoms along much of Salmonberry Creek and the segment of Curley Creek between Long Lake and Sedgwick Road provide important floodplain areas affecting hydrologic processes.

Key Parameters and Watershed Pressures

The natural flow regime plays a critical role in regulating both physical and biological processes that sustain ecological integrity within the stream corridor (Poff et al., 1997). Riparian plants, aquatic insects, and fish all have specific adaptations to the natural flow regime of a given stream (Lytle and Poff, 2004). Pacific salmon, for example, have life history characteristics (e.g., migration, spawning, egg incubation, and juvenile rearing) that are adapted to a specific range of suitable habitat conditions which are affected by hydrologic regime (Waples et al., 2008). As such, human activities that alter flow regimes and shift prevailing conditions outside of the natural range and variability pose a threat to the long term resilience of native salmonid populations.

Kitsap water resource area (WRIA) 15 has an Instream Resources Protection rule to provide for preservation and protection of environmental and recreational values and water quality (WAC 173-515). In Curley Creek, the instream flows set by Ecology range from 40 cfs during winter months to 5 cfs in later summer. Based on these values, Curley Creek is now closed to additional consumptive appropriations between June 15 and October 15. Salmonberry Creek is closed year-round to new consumptive uses.

Increased imperviousness in urbanizing areas of the watershed typically reduces rates of infiltration and groundwater recharge and increases the relative proportion of precipitation delivered to the drainage network as surface runoff. Expansion of road networks in the watershed increase drainage density through construction of roadside ditches that intercept shallow groundwater and increase runoff to streams. Collectively, these impacts lead to increased flashiness in the hydrologic regime with greater magnitude of peak flows during winter storm events and a corresponding decrease in summer low flows. Impacts to the high flow regime due to urbanization are most pronounced in the headwater tributaries downstream of urbanizing areas.

Land use impacts that affect hydraulic routing also have important impacts to hydrologic regime. The key process driving this impairment is disconnection of floodplain areas due to channelization of the stream network and channel incision. Floodplains provide important storage areas that collect flood waters overtopping the channel bank during flood events and slowly return flow back to the channel network. This process attenuates peak flood magnitudes and increases opportunities for groundwater recharge, contributing additional baseflow to the channel network during summer. The broad valley bottoms along Salmonberry Creek and the section of Curley Creek between Long Lake and Sedgwick Road are important areas for floodplain storage that have been affected by past clearing of riparian forest, removal of wood jams from the channel, and construction of ditches to channelize streams. In addition, historic and ongoing removal of beaver from these floodplain areas and throughout parts of the Curley watershed has profound effects on water storage and salmonid habitat with implications for both peak and low flows. These impacts collectively reduce hydraulic resistance and result in down-cutting of the stream channel (incision). This leads to less frequent connectivity between the channel and floodplain, greater flood peaks and limited opportunities for flood flows to infiltrate (less recharge). There is substantial overlap with the effect of these land use impacts on hydrologic regime with other KEAs. As such, specific indicators to monitor floodplain connectivity are listed below under KEAs for Wetland Conditions, Riparian Conditions, and Stream Structure.

Indicators

Indicators used to track and evaluate hydrologic regime include: (1) direct measurements of streamflow, and (2) indirect measures based on land cover characteristics derived from GIS data (Table 3-1).

There is one active streamflow gaging station in the watershed operated by Kitsap Public Utility District downstream of Long Lake on Curley Creek at Sedgwick Road. The period of record spans from 2011 to present. This record is insufficient to assess historical streamflow trends but provides useful information to characterize the existing hydrologic regime and can be used to monitor future trends. USGS collected episodic low flow measurements of Curley Creek (13 field measurements) and Salmonberry Creek (10 field measurements) during the period 1948-1959 but there are no continuous flow data recorded at these sites. Cummins (1976), used these data along with continuous flow data from other streams in Kitsap County to estimate a mean August streamflow of approximately 6 cfs for Curley Creek. This estimate is not substantially different from flow measurements recorded at the KPUD gage in the recent period (2012-present).

Streamflow metrics characterizing the low flow (7 day low flow) and high flow (annual maximum flow) components of the hydrologic regime should be tracked at the KPUD gage over time to evaluate potential changes in response to land use impacts in the watershed. Low flows in Puget Sound streams typically occur in late August or September, however, review of several hydrographs at the KPUD gage show a rapid drop in flow as shown for June 2016 in Figure 3-1. We interpret this as effects of beaver activity near the outlet of Long Lake that plugs the channel where constricted at the bridge crossing for Long Lake Road. Stream flows can drop substantially low (from near 10 cfs to less than 1 cfs) in the segment of Curley Creek downstream due to the effect of the beaver dams. The hydrologic effect of beaver dams at Long Lake Road is augmented by road fill effectively blocking any opportunity for flow to spill laterally around the beaver dams. As such, water backs up and increases storage in Long Lake until the beaver dam is either breached or removed by management action.

A third metric, T_{Qmean}, is included to monitor the variability of flows. T_{Qmean} is the fraction of time that daily flow exceeds the mean annual flow and varies inversely with the level of development in a watershed (Konrad and Booth, 2002). Urbanizing watersheds are typically characterized by an increase in flashiness (brief stormflow periods with high peak flows and rapid rates of recession) and thus low T_{Qmean} relative to an undeveloped watershed. Annual T_{Qmean} reported by KPUD for the period 2012-2016 ranged from 0.34 to 0.44.

Total Impervious Area (TIA) provides an index of land use changes affecting infiltration, recharge, and surface runoff from urbanizing areas. GIS analysis of imperviousness in the Curley Creek Watershed revealed an average TIA of 8% across the watershed (Table 3-2). Areas with more intensive development and greater amount of imperviousness are mapped in Figure 2-1 and Figure 2-2. The area of greatest imperviousness is located in the Port Orchard Urban Growth Area (UGA) which contributes runoff to several first order streams in the Salmonberry Creek subbasin. The portion of the UGA overlapping the Salmonberry Creek subbasin had a TIA of 22% in 2011 and is increasing with ongoing development.

A second GIS based indicator representing watershed conditions is the percent forest cover. Forest cover averaged across the Curley Creek Watershed is 63% of the land area (Table 3-2). The Salmonberry Creek subbasin has slightly less forest cover (57%) compared to other subbasins due to clearing for agricultural use in the broad valley bottom and from urbanizing areas such as the UGA. Hydrologic models of developing rural areas show that even a watershed with 65% forest cover and 4% effective impervious area can produce changes in hydrologic regime with peak flows at a 2-year recurrence interval (anticipated to be exceeded every other year, on average) that are equivalent in magnitude to what was a 10-year recurrence interval flood in the predeveloped (forested) condition (Booth et al., 2002).

In general, the GIS-based indicators of hydrologic regime (Impervious Area and Forest Cover) are rated as "Fair" in each of the three primary subbasins as the loss of forest cover and extent of impervious surface are at a magnitude beginning to impact hydrologic processes. Localized areas within the watershed, such as tributaries downstream of more intense development in the UGA are likely to be "Poor" given the relative change in land cover and potential degradation to hydrologic processes.

The only segment of the watershed that can be evaluated based on streamflow metrics is Curley Creek downstream of the lake given the lack of streamflow data representing other parts of the watershed, in particular Salmonberry Creek. Even Curley Creek cannot be evaluated with data representing unaltered conditions given the short period of record. We have classified high flow, low flow and variability indicators as "Fair" in Curley Creek based on knowledge of watershed conditions and past impacts to floodplain processes that are important for attenuating flows.

Climate Change Considerations

Average annual temperatures are projected to continue rising over future decades with potential implications on hydrologic regime in Pacific Northwest streams. The most pronounced changes are expected to occur in watersheds that have a substantial snowmelt contribution to streamflow where a greater proportion of winter precipitation is anticipated to fall as rain as opposed snow (Elsner et al., 2009). Lowland streams with a historically rainfall-dominated flow regime are less sensitive to climate impacts on streamflow. Changes to the seasonal pattern and timing of streamflow in the

Curley Creek Watershed from climate change are expected to be relatively minor. There is, however, potential for changes in streamflow extremes, affecting both high and low flows. Peak flows could be affected by a projected increase in the frequency and severity of heavy rainfall events with intensification of winter atmospheric river events (Warner et al., 2015). Summer low flows could decrease given projections for increased evapotranspiration with warmer average temperature. There are no quantitative data estimating the potential magnitude of these effects in the Curley Creek Watershed.

Data gaps

A key data gap identified in the watershed is the lack of streamflow gaging information in the Salmonberry Creek watershed. Given current zoning in the Comprehensive Plan, the primary area of concern for hydrologic impacts to urbanization is within and draining from the UGA. As such, stream gaging stations are recommended for Cool Creek and Salmonberry Creek to monitor the hydrologic regime. Further analysis of potential changes in hydrologic regime under future climate change scenarios would also benefit watershed stakeholders.

Figure 3-1. Annual hydrograph for water year 2016 with mean daily flow in Curley Creek near Sedgwick Road (Kitsap Public Utility District).

Table 3-1. Indicators for hydrologic regime in stream channels.

COMPONENT: SMALL CHANNELS		
KEA	**INDICATOR(S)**	**INDICATOR DESCRIPTION**
Hydrologic Regime	7-day low flow	Average flow measured during the 7 consecutive days of lowest flow during a given water year
	Annual maximum flow	Peak instantaneous flow during a given water year
	T_{Qmean}	Fraction of time that daily flow exceeds the mean annual flow
	Total Impervious Area	Relative subbasin area with impervious land cover such as pavement
	Percent forested cover	Relative subbasin area of upland forests and forested wetlands
Supporting Information		
Streamflow metrics for Curley Creek near Sedgwick Road (Station CU) collected by Kitsap Public Utility District		Data available for the period WY 2012-2016
GIS landcover data derived from Landsat Imagery C-CAP Land Cover Atlas (NOAA) National Land Cover Database (USGS)		Produced at 5-year intervals, most recent data from 2011, 30-meter resolution
Data Gaps		
Continuous streamflow measurement in Salmonberry Creek and other tributary streams. Analysis of climate change impacts on hydrologic regime.		

Table 3-2. Estimated percent of watershed area with impervious surface by subbasin (USGS, National Landcover Database 2011).

SUBBASIN	AREA (SQ MI)	TOTAL IMPERVIOUS AREA	FOREST COVER
Curley Creek	4.2	6%	70%
Salmonberry Creek	5.2	10%	57%
Long Lake Tributaries	5.7	6 %	65%
Total	15.1	8%	63%

3.1.2 KEA Sediment Dynamics

Key Parameters and Watershed Pressures

Sediment dynamics of stream channels such as Curley Creek are characterized by the rates of sediment supply, transport, and deposition. Implications of sediment dynamics on habitat in the Curley Creek Watershed include:

- Potential for increased sediment from upland source areas due to land use change,
- Decrease in floodplain storage due to channelization, removal of beaver and beaver dams, incision, and loss of floodplain connectivity,
- Decreased production of sediment from channel migration due to channelization and bank armoring,
- Changes in sediment transport and storage due to loss of large wood and removal of beavers in channel network, and,
- Increase in sediment production due to incision and gully erosion along first order tributaries following wood removal and/or increase in peak flows.

Alterations to the sediment regime disrupt the relative balance between sediment inputs and outputs, which drive changes in channel morphology, substrate composition, and affect the distribution of habitat types (pool/riffle/run) in the stream network. Maps of geologic hazards show hillslope areas most sensitive to increases in runoff where gully erosion and excess sediment production are a concern (Figure 3-2).

Indicators

Indicators for monitoring the sediment regime are listed in Table 3-3. The substrate can be monitored through sediment sampling at select channel locations and quantified by a pebble count analysis to derive a grain size distribution. Key metrics such as median grain size can be derived from these distributions for comparison to literature reviews of habitat preferences for different life history stages. Historic impacts to riparian forests and intentional removal of logjams have generally increased sediment transport capacity and led to a coarsening of the channel substrate. Hydraulic changes associated with management actions such as wood placement can be monitored to record changes in grain size characteristics such as the median grain size (D50). Channel surveys are recommended to establish a baseline for evaluation of patterns of channel aggradation or incision.

No quantitative data are available to characterize sediment dynamics in the Curley Creek Watershed. We assume some impairment to the substrate composition and bed armoring (both rated as "Fair") in all subbasins given known reductions in wood loading and potential impacts to the high flow regime due to land use change. Channel stability was rated as "Poor" given evidence of channel incision were noted in all subbasins during field reconnaissance.

Table 3-3. Indicators for sediment dynamics in stream channels.

COMPONENT: SMALL CHANNELS		
KEA	**INDICATOR(S)**	**INDICATOR DESCRIPTION**
Sediment Dynamics	Substrate composition	Distribution of sediment classes relative to habitat suitability for different life history stages (e.g., spawning, incubation, rearing)
	Channel Stability	Patterns of aggradation or incision reflecting an imbalance between sediment supply and transport capacity
Supporting Information		
Field reconnaissance of select areas (Appendix B)		
Data Gaps		
Sediment grain size information Channel surveys to monitor changes (aggradation or incision)		

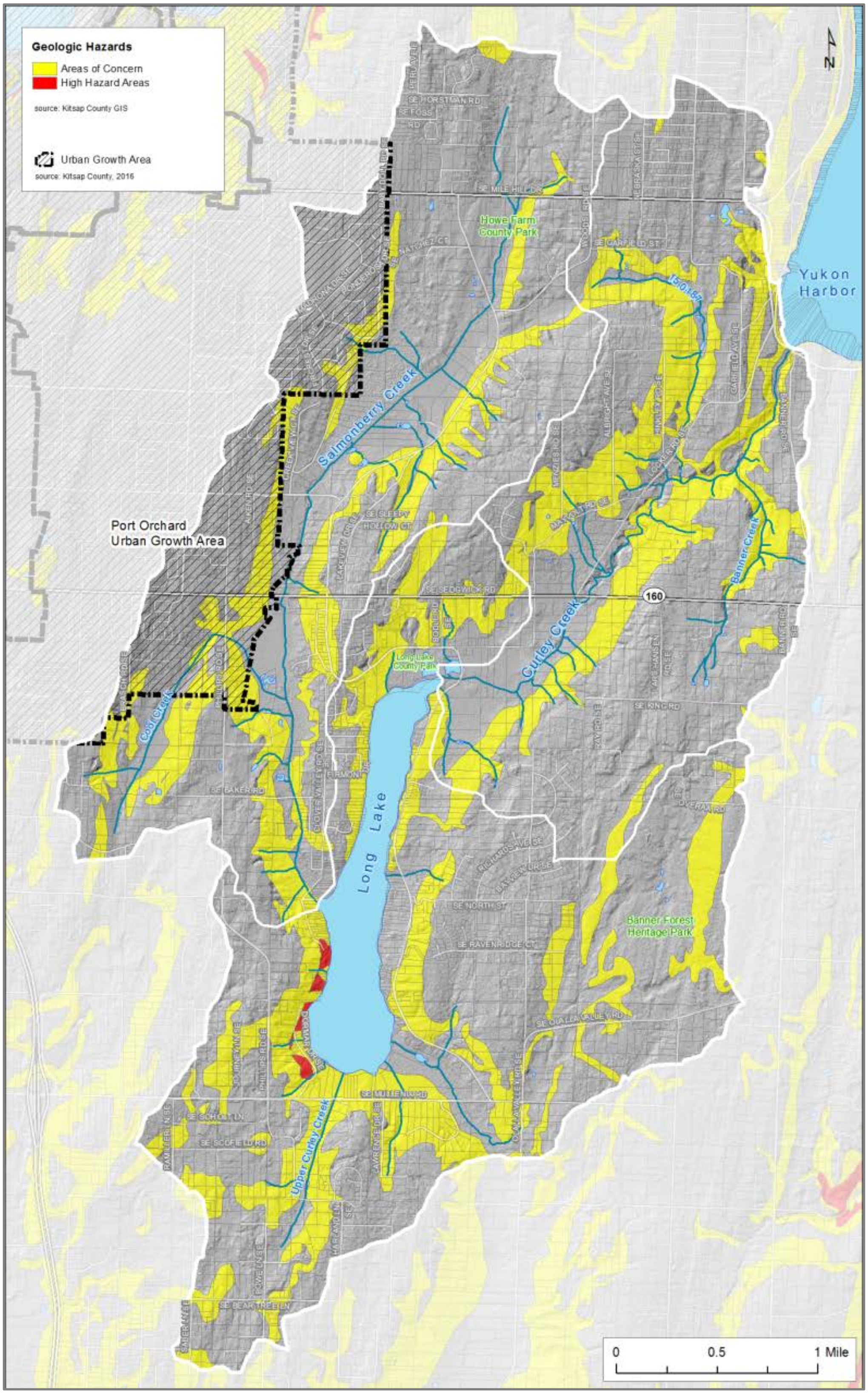

Figure 3-2. Map of geologic hazard areas in the Curley Creek Watershed (Kitsap County GIS). Note that many headwater tributaries are within "Areas of Concern" for slope stability and potentially susceptible to land use impacts.

3.1.3 KEA Water Quality

This assessment reviewed existing data and information to identify water quality conditions in small stream channels in the Curley Creek watershed and identify impairments to water quality indicators. This section evaluates the effect of known impairments on salmonid stream channel habitat and survival by subbasin. The assessment of water quality is guided by the standards published by the Washington Department of Ecology (2012a). The current EPA-approved Water Quality Assessment (Washington Department of Ecology, 2012b) fulfills the State's obligation under sections 303(d) and 305(b) of the Clean Water Act. Washington DOE water quality categories are shown in Table 3-4.

The Suquamish Tribe has conducted continuous water temperature monitoring during summer in the Curley Creek watershed going back to 2003 (Table 3-5). Data are available for three stations in the watershed (Figure 3-3). The lower Salmonberry station was in place from June-Sept in 2015, 2016 and 2017, and the middle Salmonberry station was deployed in late July-Sept 2016. Two additional stations (Curley at Sedgwick Rd, and Cool Creek at Phillips Rd) were deployed in Spring 2017 to collect continuous temperature data through summer.

Water temperature data were summarized for the entire period of monitoring and the 7-day average of daily maximum (7DADM) for "Core Summer Habitat" criteria. The "Core Summer Habitat" standard under WAC 173-201A-600 is 7DADM water temperature less than 16C from June 15-September 15. Water temperature was classified from poor to very good based on the number of 7-day periods the 7DADM exceeded 16C and number of days the daily maximum temperature exceeded 20C. The 20C daily maximum criteria was an arbitrary value to delineate conditions above optimum growth and approaching lethal for juvenile salmonids, in particular coho (Hicks 2000). Conditions were classified "poor" if the 7DADM exceeded 16C most days during the period and maximum daily temperature was greater than 20C. Conditions were classified "fair" if the 7DADM exceeded 16C most days during the period but maximum daily temperature did not exceed 20C. Conditions were classified "good" if the 7DADM did not exceed 16C during the period.

Existing water quality impairments identified by Washington DOE for the Curley Creek watershed small channels are listed below by subbasin and reach. Bacteria, dissolved oxygen and temperature were the common impairments across the watershed.

Subbasin: Curley Creek

Curley Creek immediately downstream of Long Lake outlet:

- Bacteria – Category 4b (has a water pollution control plan in place), declining condition trend from 2004 to 2014

Curley Creek at Sedgwick Road:

- Bacteria – Category 4b, declining condition trend 2004 to 2012 and improving condition trend in 2014
- Dissolved Oxygen – Category 5 (impaired), declining condition trend 2004 to 2008 and stable trend 2008 to 2014
- Temperature (>16C) – Category 5, stable trend 2004 to 2012, declining condition trend 2014

Curley Creek downstream of Banner Creek (Tributary 15.0186):

- Bacteria – Category 4b, stable trend 2004 to 2012 and improving condition trend in 2014

- Dissolved Oxygen – Category 5, stable trend 2004 to 2014
- Temperature (>16C) – Category 5, stable trend 2004 to 2014

Water quality parameters that are Category 5 in Curley Creek are Dissolved Oxygen, and Temperature. The listing for fecal coliform bacteria was based on samples collected from 2013-2014 and was likely associated with source areas in the Long Lake subbasin. Ongoing monitoring of fecal coliform bacteria by the Kitsap County Health District shows that bacteria levels in Curley Creek meet health standards and indicate a stable trend (Kitsap Public Health District, 2012).

Maximum observed water temperature in Curley Creek consistently exceeded 20C each summer (Table 3-5 and Figure 3-4), and the 7DADM exceeded 20C in 9 of the 11 years of monitoring data. The 7DADM water temperature exceeded the Core Summer Habitat standard of 16C on 87% to 100% of the days from June 15 to September 15. During June-Sept 2017, the Suquamish Tribe deployed an additional temperature monitoring station on Curley Creek, just upstream of Sedgwick Road. The 2017 temperature data shows that the Curley (Sedgwick Rd) station had consistently slightly warmer temperatures than the downstream Curley station, likely because it is closer to Long Lake (which warms considerably in summer) and the station is just downstream of a more open and degraded riparian corridor that further exposes the channel to solar radiation.

Subbasin: Long Lake Tributaries

Tributaries entering Long Lake (excluding Salmonberry Creek) are not evaluated for water quality impairments. Water temperature of tributaries flowing into Long Lake is of particular interest. These tributaries may provide thermal refugia during the summer for juvenile coho or steelhead that may be rearing in the lake following spring, fall or winter migrations.

Subbasin: Salmonberry Creek

Water quality in Salmonberry Creek is degraded from 100-150 years of agricultural land use, and more recently with residential development in the contributing watershed. Parameters that have violated DOE water quality standards are:

- Dissolved oxygen – Category 5, stable trend 2004 to 2014
- Bacteria – Category 4b, declining condition trend 2004 to 2012 and improving condition n 2014

Temperature monitoring data collected in Salmonberry Creek a short distance upstream of Long Lake (lower station) by the Suquamish Tribe are available for summer months in 2015 through 2017. In summer 2016 and 2017 the Suquamish Tribe deployed a second monitoring station in Salmonberry Creek about midway up the watershed, just downstream of Salmonberry Road. In June-Sept 2017, the Tribe deployed an additional temperature monitoring station in lower Cool Creek, just downstream of Phillips Road.

Maximum observed water temperature and the 7DADM in lower Salmonberry Creek exceeded 20C in 2015 (Table 3-5 and Figure 3-5). Water temperature was slightly cooler in 2016 with a maximum observed of 20.5C and a maximum 7DADM of 18.5C. The 7DADM water temperature exceeded the Core Summer Habitat standard of 16C from June 15 to September 15 on 84%, 73%, and 82% of the days in 2015, 2016, and 2017 respectively.

Conclusions

Water temperature at the middle Salmonberry Creek station in late summer 2016 and during summer 2017 was slightly warmer than the lower station (Figure 3-6). This is not surprising given the contribution of cooler water from Cool Creek that joins Salmonberry Creek upstream of the lower station (Stream temperature data for Cool Creek from June-Sept 2017 shows this tributary never exceeded the 7DADM of 16C throughout the summer), and also likely an effect of more functional riparian shading downstream of the middle station. This suggests an opportunity to reduce water temperature across the entire length of Salmonberry Creek with improved riparian condition and the priority protection action to protect Cool Creek instream flows and the relatively intact riparian corridor in this stream and lower Salmonberry Creek.

There appears to be a partial warming effect on water temperature in Curley Creek from Long Lake through most of the summer, based on a comparison of water temperature at the monitoring stations in Curley Creek and lower Salmonberry Creek in 2015, 2016, and 2017 (Figure 3-7). Maximum water temperature in Salmonberry Creek in 2015-2017 tended to be cooler most days than at the Curley Creek station. The exception was a two week period from about mid-August when water temperature in Curley Creek was slightly cooler in 2015, which coincided with rain storms during that time. It is unclear why Salmonberry water temperatures did not show the same response.

Long Lake does not fully explain the relatively high summer water temperatures in Curley Creek. Tributary inflows to Long Lake may also be warm, and water temperatures are high in Salmonberry Creek upstream of the lake. In 2016 (a relatively "average" summer in terms of average air temps over the 2003-2016 period), the Curley station exceeded the 7DADM water temperature of 16C on 87% of the days between June 15 and September 15. The lower Salmonberry station exceeded the 7DADM standard of 16C on 73% of the days and the middle Salmonberry Creek station exceeded the 7DADM on 78% of the days between July 24-and September 15. Similarly, in summer 2017, 82% of days exceeded in lower Salmonberry, and 94% of days exceeded in middle Salmonberry.

Data Gaps

With the exception of Salmonberry Creek, the lack of water temperature observations in tributaries entering Long Lake is a significant data gap in the analysis. These tributaries may provide cool water refugia for juvenile coho and steelhead entering the lake prior to the summer.

A watershed-wide temperature monitoring project with multiple stations running for several years would provide an important assessment of cool water areas to protect and warming reaches that could be restored. Climate change will likely have a significant impact on water temperature across the watershed as seen by conditions in 2015, which may represent air temperatures for "average" conditions with future climate. Protecting instream flow and intact riparian corridors, and restoring degraded riparian corridors has the potential to improve resiliency of stream habitat in the watershed under future climate conditions.

Indicators

<table>
<tr><th colspan="3">Ecosystem Component: Small Channels</th></tr>
<tr><th>KEA</th><th>Indicator(s)</th><th>Indicator Description</th></tr>
<tr><td rowspan="2">Water Quality</td><td>7-day average of daily maximum (7DADM)</td><td>The 7DADM stream temperature is calculated using the average of the daily maximum water temperature of three days prior, the same day, and three days after on a rolling basis.</td></tr>
<tr><td>DOE Water Quality Assessment Indicators (bacteria, dissolved oxygen, and temperature)</td><td>303(d) listing indicator</td></tr>
</table>

<table>
<tr><th colspan="2">Supporting Information</th></tr>
<tr><td>Suquamish Tribe Temperature monitoring stations in Curley Creek and Salmonberry Creek</td><td>May through October temperature records with temperature measured every 30 minutes</td></tr>
<tr><td>Kitsap County</td><td>• Long Lake Restoration Project
• Long Lake Integrated Aquatic Vegetation Management Plan
• Long Lake Area Sanitary Survey Project
• 2014-2015 Priority Area Work List Pollution Identification and Correction Program</td></tr>
<tr><td>Washington Department of Ecology</td><td>• Water Quality Assessment and 303(d) List</td></tr>
<tr><td colspan="2">Data Gaps: water temperature monitoring in a few key tributaries and upper Salmonberry Creek</td></tr>
</table>

Indicator Bins for Water Quality by Subbasin

Subbasin	Indicator	Condition		
		Poor	Fair	Good
All	7 DADM Temperature	Does not meet Core Summer Salmonid Habitat criteria for 7 DADM of 16 C and daily maximum is greater than 20C most days	Does not meet Core Summer Salmonid Habitat criteria for 7 DADM of 16 C but daily maximum is less than 20C most days	Meets Core Summer Salmonid Habitat criteria for 7DADM of 16 C all days.
	WDOE Water Quality Assessment Indicators	Category 5 (303(d) listed)	Category 2, 3 and 4 with improving trend	Category 1 and stationary trend

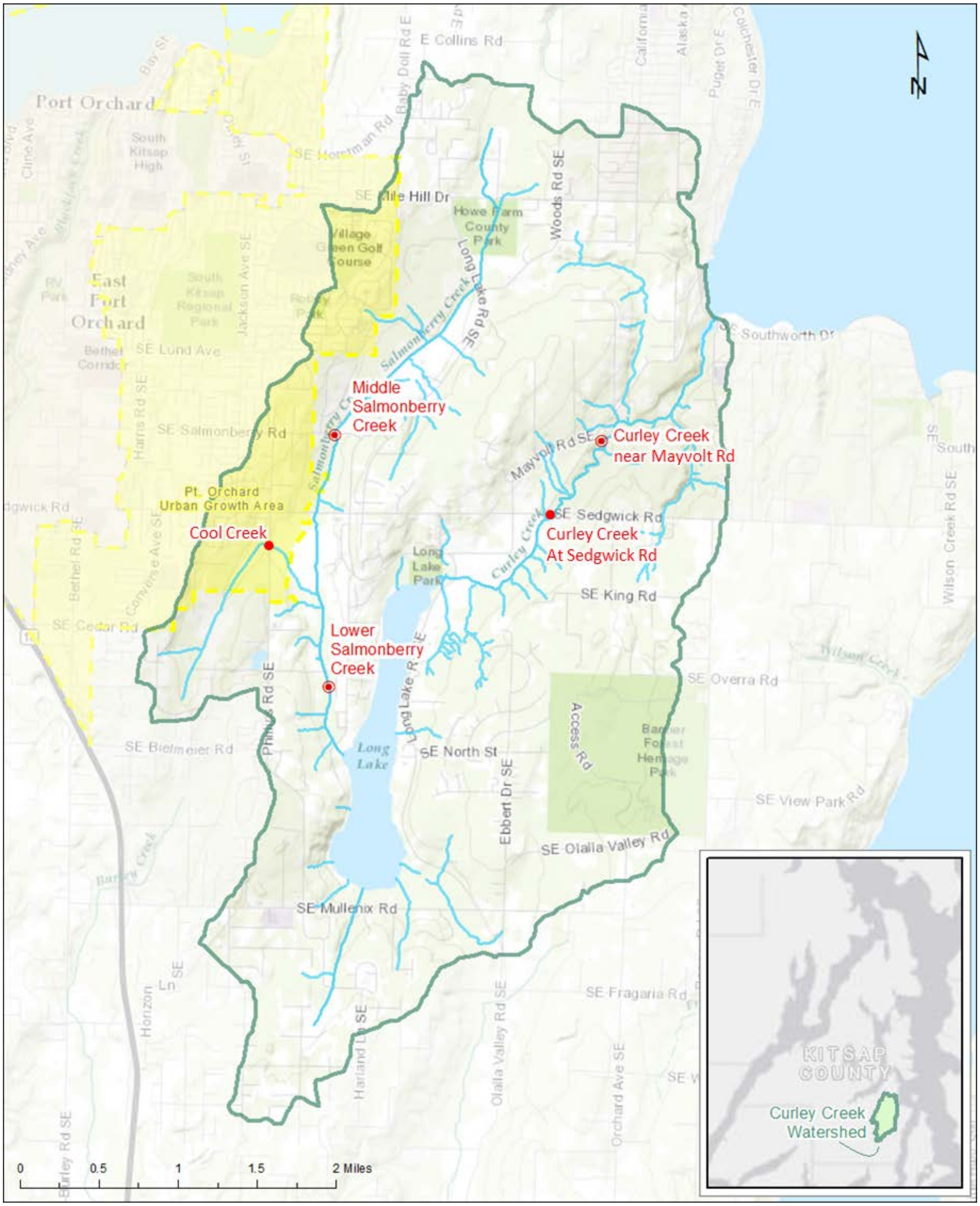

Figure 3-3. Suquamish Tribe water temperature monitoring stations. Stations in Cool Creek at Phillips Road and Curley Creek at Sedgwick Road added in 2017 (data not included in this report).

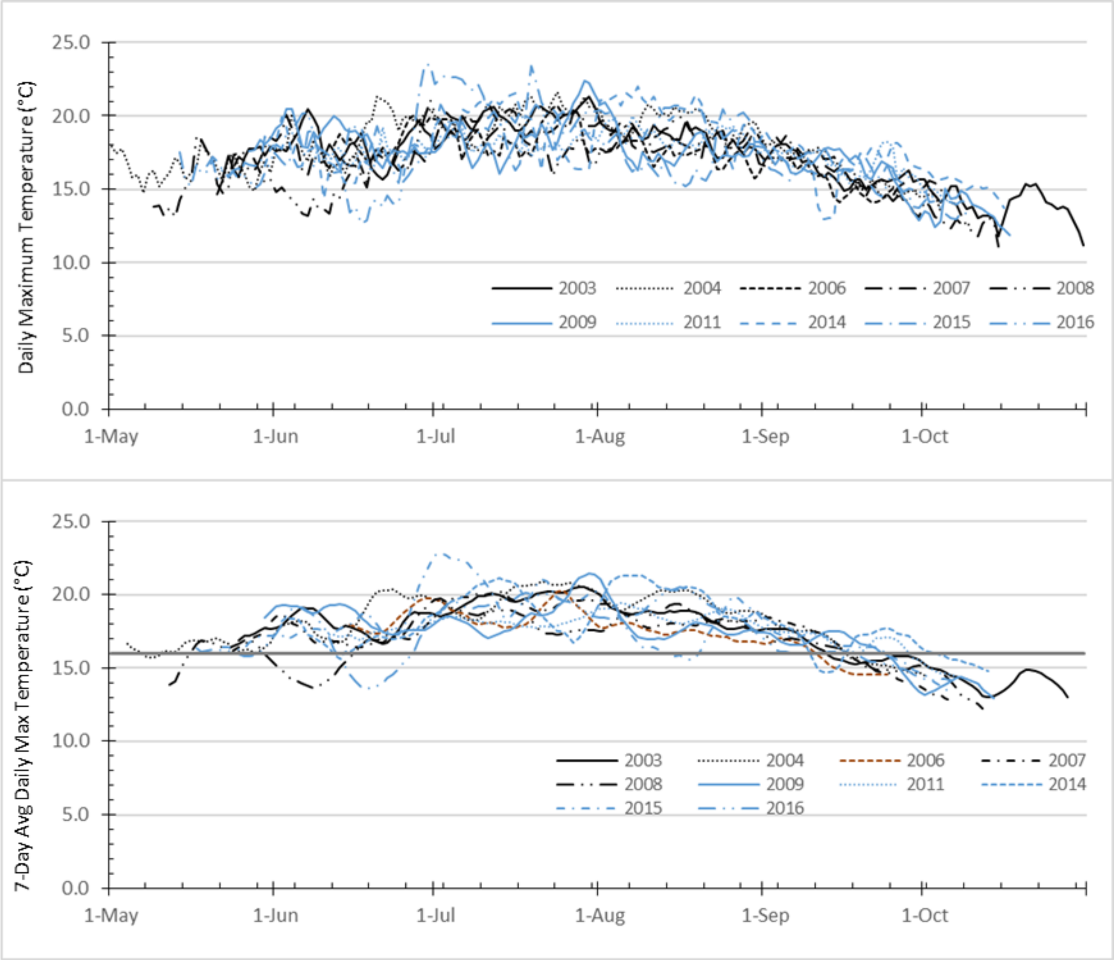

Figure 3-4. Time series plots of daily maximum temperature (top) and 7-day average of daily maximum (7DADM) water temperature monitoring data for Curley Creek. Data for 2017 not included (source: Suquamish Tribe).

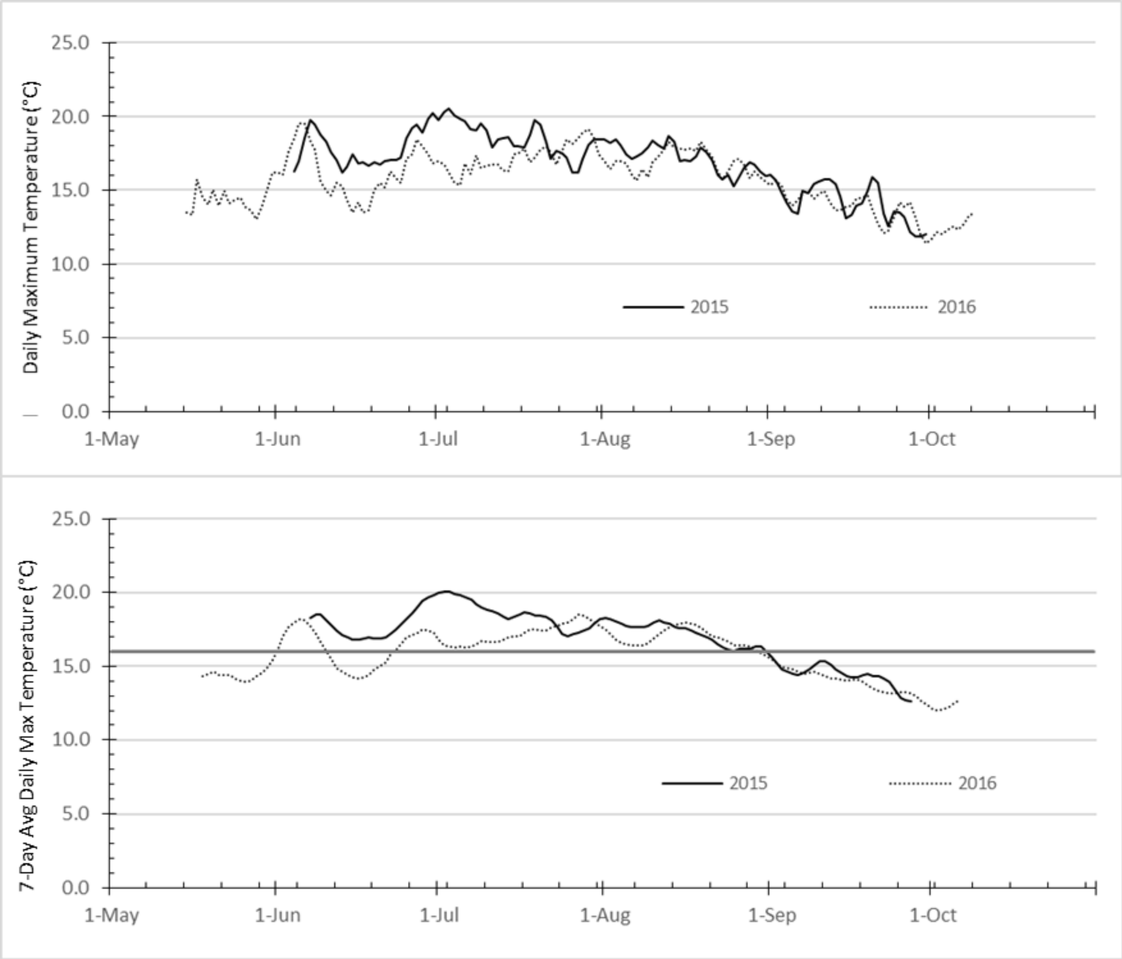

Figure 3-5. Time series plots of daily maximum temperature (top) and 7-day average of daily maximum (7DADM) water temperature monitoring data for lower Salmonberry Creek station (source: Suquamish Tribe). Water temperature monitoring at the middle Salmonberry Creek station commenced July 21, 2016 (Table 4.1.3.2 and Figure 4.1.3.4). Based on comparison of water temperature at the lower station, it is clear the late start missed periods of warm temperatures in June and the first half of July. The maximum observed water temperature was 19.6C measured soon after the probe was installed. The 7DADM did not exceed 20C, but was slightly warmer than the downstream station in 2016. The 7DADM water temperature exceeded the Core Summer Habitat standard of 16C on 78% of the days from July 21 to September 15. Data from 2017 not included in this graph.

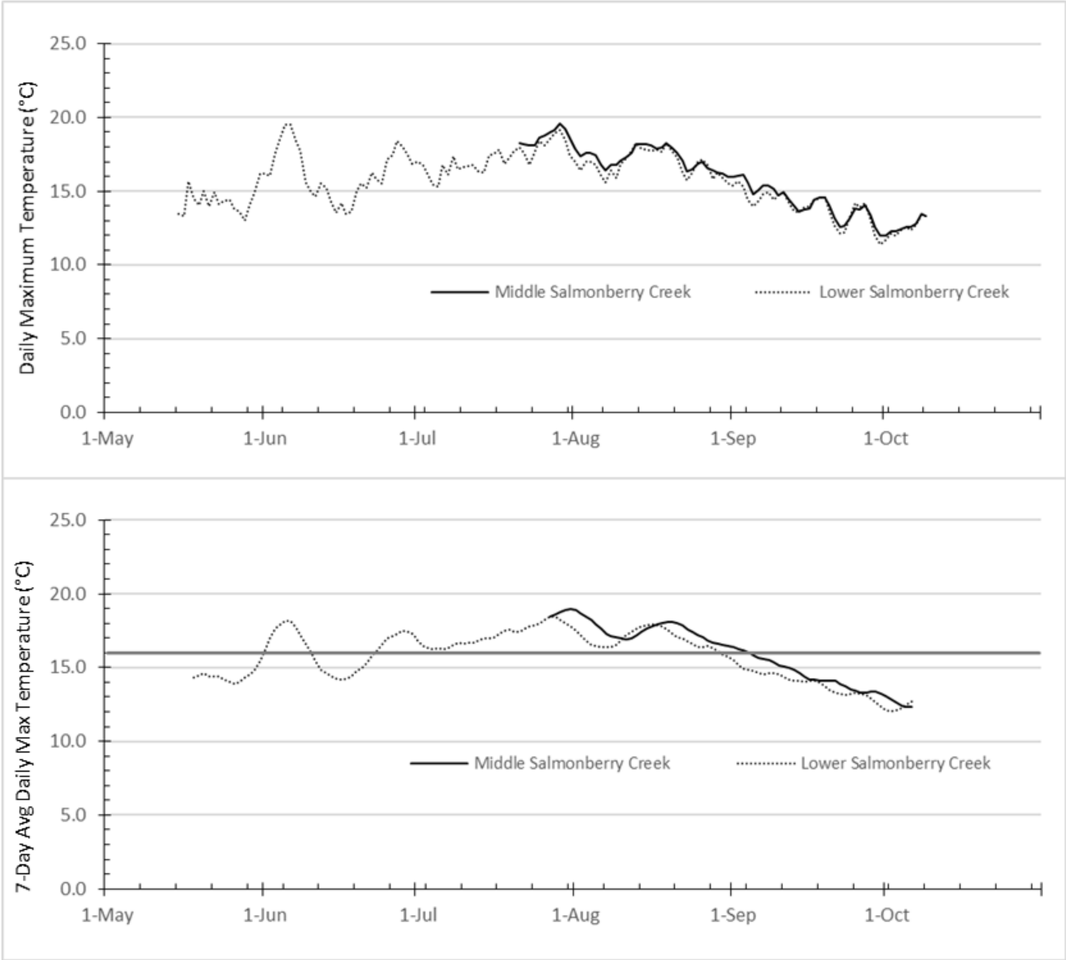

Figure 3-6. Time series plots of daily maximum temperature (top) and 7-day average of daily maximum (7DADM) water temperature monitoring data for Lower and Middle Salmonberry Creek stations in 2016 (source: Suquamish Tribe).

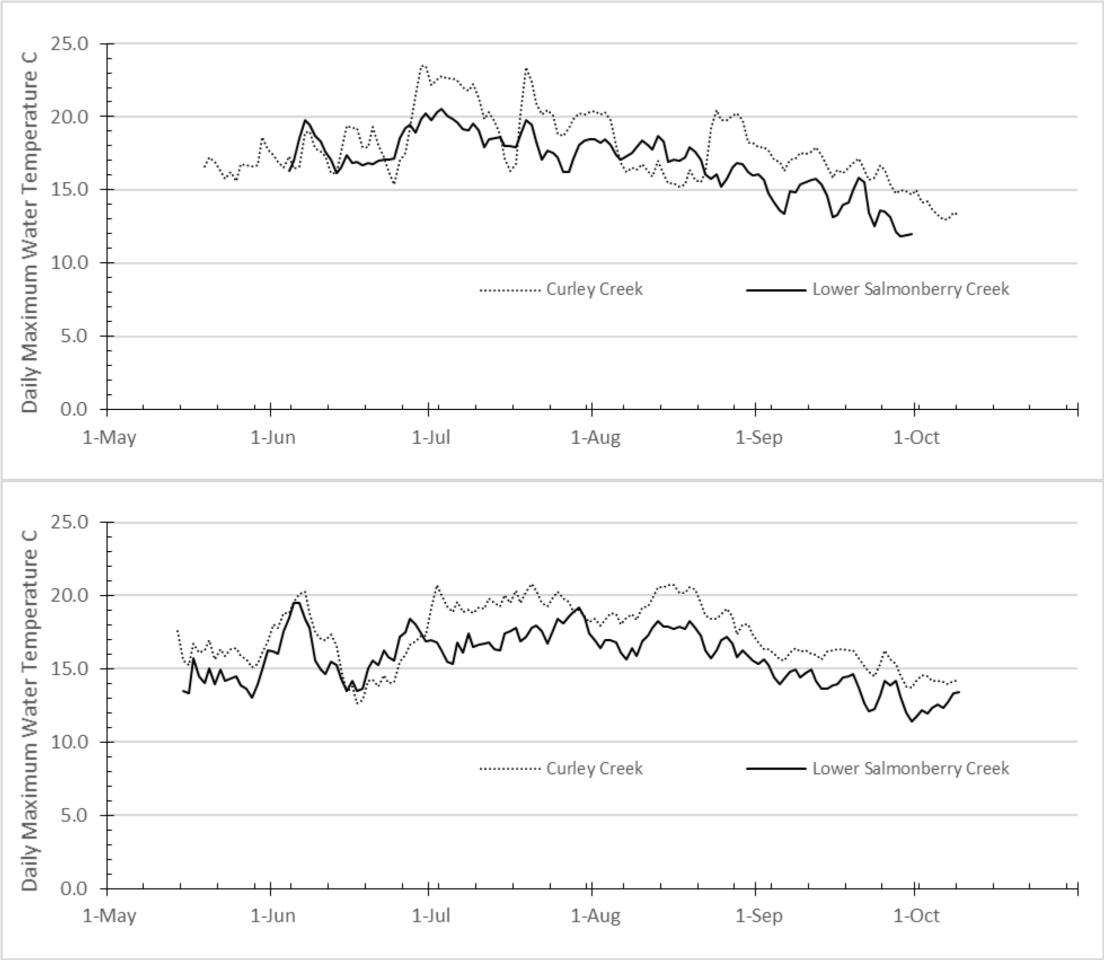

Figure 3-7. Daily maximum water temperatures at the Curley Creek and Lower Salmonberry stations in 2015 (top) and 2016 (bottom).

Table 3-4. Washington DOE water quality assessment categories (DOE 2012a).

Category	Description (DOE modified descriptions)
Category 1	Meets tested standards for clean waters
Category 2	These are waters of concern, there is some evidence of a water quality problem, but not enough to require production of a water quality improvement project
Category 3	Insufficient data to meet minimum requirements
Category 4a	Polluted waters not requiring a total maximum daily load (TMDL), but one is in place
Category 4b	Polluted waters not requiring a TMDL, has a pollution control program
Category 4c	A water body impaired by a non-pollutant that cannot be addressed through a TMDL
Category 5	Polluted water body that requires a TMDL or WQI project, these are traditionally known as the 303(d) list.

Table 3-5. Water temperature metrics for Curley Creek small channels.

Station Name and Coordinates (decimal degrees)	Year	Period of Record	Daily Maximum (C)	7 Day Average Daily Maximum (C)	# Days June 15 to September 15 7DADM > 16C	Percent of Days Monitored 7DADM >16C
Subbasin: Curley Creek						
Curley (47.512, -122.561)	2003	5/22 - 10/31	21.3	20.6	90	97%
	2004	5/1 - 10/4	21.6	20.9	93	100%
	2006	6/12 - 9/27	20.7	20.3	88	95%
	2007	5/21 - 10/10	20.9	20.2	93	100%
	2008	5/9 - 10/15	21.1	19.7	92	99%
	2009	5/27 - 10/17	22.4	21.5	93	100%
	2011	6/8 - 10/17	20.0	19.4	93	100%
	2014	5/30 - 10/16	22.0	21.3	87	94%
	2015	5/19 - 10/9	23.5	22.8	87	94%
	2016	5/14 - 10/9	20.8	20.5	81	87%
	2017	5/2 - 10/1	22.3	21.0	92	99%
Curley (Sedgwick Rd) (47.505, - 122.567)	2017	6/3 - 10/1	23.3	21.6	93	100%
Subbasin: Salmonberry Creek						
Lower Salmonberry (47.489, -122.597)	2015	6/4 - 9/30	20.5	20.1	78	84%
	2016	5/15 - 10/9	19.5	18.5	68	73%
	2017	5/2 - 10/1	18.4	17.9	76	82%
Middle Salmonberry (47.512, -122.597)	2016	7/21 - 10/9	19.6	19.0	40	78%
	2017	5/2 - 10/1	19.9	19.5	87	94%
Cool Creek (47.502, -122.605)	2017	5/2 - 10/1	15.4	15.0	0	0%

3.1.4 KEA Wetland Conditions and Functions

Wetlands provide rearing, breeding, and foraging habitat functions for fish and wildlife, as well as water quality/erosion and sediment reduction functions. They also provide transitions between aquatic and terrestrial habitats. As a key ecological attribute, wetlands affect downstream hydrologic functions by reducing and holding floodwaters and maintaining seasonal base flow in adjacent streams. Indicators of wetland condition and function at a watershed scale include wetland extent, landscape context, vegetation richness and diversity, and characteristics that enhance wildlife habitat including structural components such as snags, downed wood, and buffer conditions (Table 3-6).

Wetland extent was assessed based on a combination of land cover information derived from the Regional Land Cover Classification Scheme from NOAA Office for Coastal Management Coastal Change Analysis Program (C-CAP) (Chapter 2) for the land cover classifications within the subbasins of the Curley Creek watershed, the Ecology Modeled Wetland Inventory, and the Kitsap County wetland inventory (which includes National Wetland Inventory data). Wetland condition and function was assessed qualitatively based on the limited field reconnaissance conducted on October 9, 2015, and best professional judgement based on observable wetland conditions.

Wetland Extent and Condition

The Curley Creek watershed includes approximately 516 acres of land classified as wetland (Table 2-1), the majority of which (290.5 acres) is forested wetland. These wetlands are characterized by a diverse mixture of native species, typically deciduous trees such as red alder, willow (*Salix* spp.), and black cottonwood (*Populus balsamifera*), with an often dense understory of salmonberry (*Rubus spectabalis*), red osier-dogwood (*Cornus sericea*), red elderberry (*Sambucus racemosa*), Indian plum (*Oemleria cerasiformis*), and various ferns and deciduous groundcover species. Coniferous trees such as western red cedar (*Thuja plicata*) and Sitka spruce (*Picea sitchensis*) also occur sporadically in the forested wetlands of the Curley Creek watershed, although most were logged out early in the last century and are slow to regenerate; observed cedars tended to be 6-12 inches in diameter, indicating trees only a few years to decades old. Observed spruce trees were very widely scattered but larger, typically 16 to 24 inches in diameter, particularly in the forested areas along Salmonberry Creek.

Forested wetlands typically support snags and downed wood which contribute to their wildlife habitat functions, particularly for cavity nesting wildlife species such as wood duck, pileated woodpecker, and mammals such as raccoon. Forested wetlands within the riparian zone also provide large wood to stream channels, although typically not the coniferous species which tend to persist the longest in the stream.

Scrub-shrub wetlands occupy 72 acres of the watershed, most of which is located in the Salmonberry subbasin. These wetlands are willow dominated, with Douglas spirea/hardhack (*Spirea douglasii*), another common species contributing to dense wildlife habitat and good structure to slow flood flows and prevent erosion. The watershed supports 95 acres of emergent wetlands and 58.7 acres of aquatic bed wetland, both of which can provide important amphibian habitat. These wetlands tend to be dominated by a diverse mixture of herbaceous species, including slough sedge (*Carex obnupta*) in the emergent wetlands and native species such as pond lilies (*Nuphar* spp., *Nymphaea* spp.), as well as invasive species such as Eurasian water milfoil (*Myriophyllum spicatum*) in the aquatic bed areas. Reed canarygrass (*Phalaris arundinacea*), English ivy (*Hedera helix*), and Himalayan blackberry (*Rubus armeniacus*) were the three invasive species most frequently noted in the watershed, with reed canarygrass being the most common, particularly in the open emergent wetland areas along

Salmonberry Creek. These introduced species adversely impact ecological functions by displacing the native species and altering the structure and function of wetland habitats.

Wetland condition in the Curley Creek subbasin was generally considered “Good” (Table 3-16), based on a diversity of wetland types (forested, scrub-shrub, and emergent), the prevalence of native plant species, the landscape context, and generally good buffer condition along the stream. Over half of the total wetland area within the watershed is located within the Salmonberry Creek subbasin (290 acres) (Table 2-1). Much of this wetland is located along the mainstem of the creek north of SE Baker Road. These wetlands were generally rated as in “Fair” condition, with the proximity of adjacent development, a prevalence of invasive plant species, and hydrologic and land use modifications more common than in the other subbasins. The southern end of Long Lake also supports a large wetland area at the confluence of the Long Lake tributaries and the lakeshore. Long Lake tributary wetlands were generally rated as in “Fair” condition, with the proximity of adjacent development more common than in the other subbasins. Less information regarding wetland conditions in this subbasin also contributed to a conservative ”Fair” rating.

Nearly half (239 acres, 46%) of the 516 acres of wetland in the watershed occur within the riparian corridor, mostly along Curley Creek and its tributaries and Salmonberry Creek. These wetlands are largely forested along Curley Creek, with scrub-shrub and emergent wetlands more common along Salmonberry Creek.

Potential Wetland Loss

The loss of wetlands can be a stressor to the ecosystem components considered in this watershed assessment. The extent and function of floodplain wetlands in the Curley Creek watershed has been diminished by logging of mature riparian forests, intentional removal of logjams, channelization of streams, and historical reductions in beaver populations. These factors collectively simplify the stream corridor, lower the water table, and disconnect floodplain wetland features.

Between 2010 and 2013, the Washington State Department of Ecology created a Modeled Wetlands Inventory intended to better map wetlands on a regional level to determine the status and trends in wetland change over time and determine if the goal of no net loss of wetlands is being achieved in Washington State. The Modeled Wetlands Inventory was created by extracting the wetland land cover classifications from the overall land cover layer derived from 30-meter resolution Landsat data analyzed according to the Coastal Change Analysis Program (C-CAP) protocol. Part of this effort included identifying areas that have a high potential to be wetland, but have an observed land cover (via the satellite data) of ‘pasture/hay’ or ‘cultivated’. These areas were classified as ‘potentially disturbed wetlands’. The determination that these locations may have been wetland in the past was based on compilation of data derived from multiple sources, including:

- National Wetland Inventory
- SSURGO Soils data (hydric soils and hydric soil inclusions)
- NAIP aerial ortho-imagery
- Elevation data, including LiDAR where available
- Landsat Thematic Mapper imagery – multiple dates
- Local wetland data layers

The Department of Ecology Modeled Wetland Inventory identifies approximately 94 acres of potentially disturbed wetlands within the watershed. There are 516 acres of the watershed that are currently identified as wetlands or palustrine aquatic bed land cover (Table 2-1). GIS map layers showing the wetlands identified in 2011 C-CAP land cover atlas, potentially disturbed wetlands from the Modeled Wetland Inventory, and wetland polygons from Kitsap County GIS are overlaid in Appendix D. Such areas may present an opportunity for restoration, particularly where they occur within the riparian zone such as along Salmonberry and Cool creeks. Riparian wetland functions, if restored, have the potential to improve both water quality and instream habitat conditions (such as food chain support) for salmonids.

Table 3-6. Indicators for Wetland Condition and Function.

ECOSYSTEM COMPONENT: SMALL CHANNELS		
KEA	**INDICATOR(S)**	**INDICATOR DESCRIPTION**
Wetland condition and function	Extent and landscape context of wetlands	Acres of wetlands within the watershed by subbasin; location relative to riparian corridor
	Vegetation richness and potential to provide wildlife habitat	Diversity of native plant species and structure provided by communities (forested, scrub-shrub, emergent) and special habitat features such as downed wood and snags and buffer conditions.
Supporting Information		
Derived from inventory information, qualitative observations and BPJ	Land cover information derived from the Regional Land Cover Classification Scheme from NOAA Office for Coastal Management Coastal Change Analysis Program (C-CAP)	
Ecology Modeled Wetland Inventory,	Kitsap County wetland inventory (which includes National Wetland Inventory data)	
Data Gaps: Mapped extent and accuracy of 'disturbed' wetland data not field verified		

3.1.5 KEA Riparian Conditions and Functions

The riparian corridor provides an important linkage across the landscape between terrestrial influences and aquatic habitat conditions. The species, diversity, density, structure, and width of the riparian corridor all affect the influence of riparian conditions on stream habitat conditions and on the integrity and resiliency of aquatic communities. Riparian corridor trees shade the streams, provide allochthonous organic matter that feeds benthic invertebrates, resist erosion, slow flood flows, and provide the source of most large wood recruitment to streams (Décamps et al., 2009). Clearing and fragmentation of the riparian corridor reduces LWD recruitment, altering habitat forming processes and the quantity and quality of pools. Alterations in tree and shrub species diversity and community composition changes the frequency, nature, and seasonality of allochthonous organic material input to the stream. Consequent changes in benthic invertebrate communities affect foraging opportunities and the bioenergetics of juvenile salmonids rearing in streams and estuaries. Clearing and development of the riparian zone negatively affects riparian functions, including stream temperatures, wildlife habitat, sediment retention, and possibly also groundwater recharge (Haring, 2000; Naiman and Bilby, 2001; Baird et al., 2005).

In the Curley Creek watershed, the riparian corridor encompasses the majority of the mapped floodplain of Salmonberry Creek and Curley Creek, and much of the undeveloped land along Cool Creek and the tributaries to Long Lake. Nearly all the Curley Creek watershed, including the riparian zones, has been harvested for timber at least one time since the mid-late 1800's and large portions, particularly in the Salmonberry Creek subbasin, have been cleared for agriculture and rural development. This has created a patchwork of widely spaced development, intact forested areas, and open wetland areas throughout the riparian corridor.

The condition of the riparian corridor indicators (Table 3-7) was assessed based on a combination of information derived from the Regional Land Cover Classification Scheme from NOAA Office for Coastal Management Coastal Change Analysis Program (C-CAP) for the land cover classifications within the subbasins of the Curley Creek watershed, and riparian condition information qualitatively collected on October 9, 2015 during a limited field reconnaissance.

The land cover classification process differentiated cover into classes and determined percent of the riparian corridor for each class. Developed areas of the riparian zone included the areas of low to high intensity development, pasture/hay, and developed open space categories. These categories are indicative of clearings, managed grass, and residential development. Forested areas included areas classified as deciduous, coniferous, and mixed forests. Total area of wetlands included palustrine wetlands categorized as being forested, scrub-shrub, or emergent. Aquatic bed wetland was differentiated as this category is ecologically distinct, occurring along the shoreline of Long Lake.

Using these data, the riparian corridor condition was qualitatively categorized as good, fair, or poor based generally on the following indicators of riparian condition (Segura Sossa and Booth, 2003):

- Prevalence of multi-aged stands of trees
- Prevalence of conifers
- LWD recruitment potential
- Degree of shading of channel
- Degree of vegetation and soil disturbance on immediately adjacent lands

These factors were assessed where possible during the limited field reconnaissance, and using aerial photo interpretation for areas not field assessed. Other factors considered within the riparian analysis included prevalence of native tree and shrub species, prevalence of invasive plant species, and presence or connections with large wetland areas.

Land Cover within Riparian Corridors

The riparian corridors of the Curley Creek Watershed were defined as the area located within 200 feet from each stream bank along streams designated "fish" and "Shorelines of the State" in the DNR forest practice code as well as a 200 foot wide corridor along the Long Lake and Yukon Harbor shorelines. Type N (no fish) waters are not included in the riparian corridor analysis. However, it should be noted that Type N waters do provide important riparian functions in the watershed such as shade, root reinforcement, and contributions of nutrients, organic matter, and large wood. Type N channels were omitted from the analysis primarily due to relatively poor mapping accuracy in the existing GIS data. This delineation of the riparian corridor is intended to encompass the functional riparian zone that influences stream characteristics such as shade, temperature, input of organic matter, and supply of large woody material into the stream. Additional detail regarding the condition and functions of the riparian corridor is presented in Section 3.1.5. Table 3-10 shows land use designations within each of the riparian corridors. The riparian corridors are primarily characterized by limited rural development with 89% of all the land within the 200-foot shoreline buffer designated as rural residential (1 dwelling unit per 5 acres) or rural protection (1 dwelling unit per 10 acres). The

Long Lake and Salmonberry Creek subbasins additionally have public facilities[2] within the riparian corridor.

The riparian corridors of the Curley Creek Watershed encompass 969 acres of land located within 200 feet from each stream bank along streams designated "fish" and "shorelines of the State" in the DNR forest practice code as well as a 200 foot wide corridor along the Long Lake and Yukon Harbor shorelines. The five riparian corridor analysis areas shown in Figure 3-8 include Curley Creek and its tributaries, the Long Lake tributaries (including Upper Curley Creek), Salmonberry Creek (including Cool Creek and other tributaries), the Long Lake shoreline, and the Yukon Harbor Shoreline. Table 3-8 shows the distribution of land cover classifications within each riparian corridor.

The riparian corridor along Curley Creek and Tributaries is about three times larger than the corridor along the Long Lake Tributaries subbasin but the distribution of land cover classifications is similar. The Curley Creek and Tributaries riparian corridor has the most acres classified as forest (218 acres upland forest and 35.3 acres of forested wetland) and second highest percentage (80%) of forest within the riparian corridor for the subbasins in the watershed. Agricultural uses characterize the next highest percent of the riparian corridor (8%) with about 27 acres classified as pasture/hay land – the only agricultural type found in the riparian corridors. Approximately 5% (15 acres) of the land in the stream corridor is developed, similar to that in the riparian corridor of the Long Lake Tributaries.

The **Long Lake Tributaries riparian corridor** has the highest percentage of land cover (89%) classified as forest (upland forest and forested wetlands combined) of any of the subbasins. Approximately 7% (7 acres) of the land in the riparian corridor is developed, mostly with low intensity development.

The **Salmonberry Creek riparian corridor** has the highest percentage (47%) and number of acres (163 acres) of wetlands, the majority of which is forested wetland. Another 29% of the area is classified as upland forest. Development accounts for about 16% of the land cover in the Salmonberry Creek riparian corridor, although the majority is developed open space. Grassland occupies 5% and scrub/shrub 2% of the riparian corridor land cover.

Riparian Corridor Condition

The riparian corridor throughout the watershed is characterized by a diverse mixture of native tree, shrub and understory species, typically deciduous trees such as big-leaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*), and black cottonwood (*Populus balsamifera*), with an often dense understory of sword fern (*Polystichum munitum*), Oregon-grape (*Mahonia nervosa*), red elderberry (*Sambucus racemosa*), and Indian plum (*Oemleria cerasiformis*) in the drier areas and species such as salmonberry (*Rubus spectabalis*) and red-osier dogwood (*Cornus sericea*) in the lower, wetter areas along the stream channel. English ivy and Himalayan blackberry were the two invasive species most frequently noted in the riparian corridor, particularly in the understory near rural residential areas.

Coniferous trees such as western hemlock (*Tsuga heterophylla*), Douglas fir (*Pseudotsuga menziesii*), western red cedar (*Thuja plicata*) and Sitka spruce (*Picea sitchensis*) also occur sporadically in the riparian zone, most notably in the less disturbed areas along the main channel downstream of the lake and in the headwater areas of Salmonberry and Cool Creek. Most large conifers were logged out early in the last century and are slow to regenerate naturally. Canopy height data, derived as the difference between first return and bare earth DEMs using 2000 Lidar (Appendix E), indicates that

---

[2] These public facilities appear to be parks but may include some other facilities.

even within the forested areas of the riparian corridor, forest communities are relatively immature with trees more than 100 feet in height occupying only 1 to 2.4% of the corridor (Table 3-9).

Tree height is indicative of both the structure of the forest, as well as hydrologic maturity. Large woody debris recruitment potential is low throughout the riparian corridor, based on the absence of large, particularly conifer, trees. However, the corridor is mostly vegetated, which is protective of water quality functions to a greater degree than areas with higher concentration of development in the corridor.

The riparian corridor along Long Lake is largely developed with single family homes, scattered patches of trees and native vegetation and expanses of lawn. Ninety-one percent of the trees in the riparian corridor along the lake are less than 50 feet in height.

Similarly, the riparian corridor along Yukon Harbor is developed, particularly north of the estuary, with scattered areas of overhanging vegetation. Large trees including big-leaf maple (*Acer macrophyllum*) and Douglas fir (*Pseudotsuga menziesii*) are present but 93% of the trees in the riparian corridor along the shoreline are less than 50 feet in height.

Table 3-7. Indicators for Riparian Condition and Function.

ECOSYSTEM COMPONENT: SMALL CHANNELS		
KEA	**INDICATOR(S)**	**INDICATOR DESCRIPTION**
Riparian Corridor condition and function	Percent forested cover	Acres of upland forests and forested wetlands within the riparian corridor
	Forest maturity	Tree height within the riparian corridor as corollary for tree age and stature and potential to provide large wood to stream channel
Supporting Information		
Tree height data derived from 2000 LiDAR DEM (Top surface – Bare Earth)	Qualitative field observations of diameter and species diversity	
Data Gaps: quantitative field survey of riparian corridor		

Extent and Risk of Disturbance

Table 3-10 shows land use designations within each of the riparian corridors. The riparian corridors are primarily characterized by rural residential development land use designations. Rural residential (1 dwelling unit per 5 acres) or rural protection (1 dwelling unit per 10 acres) designations characterize 89% of the land within the 200-foot riparian corridor in the Curley Creek watershed. The Salmonberry Creek subbasin has 7% of its riparian corridor designated for more intensive land uses (i.e. public facilities and urban medium/high density residential).

The County's critical areas ordinance and fish and wildlife habitat conservation area buffers (Kitsap County Code, 19.300.315) are intended to limit encroachment into riparian corridors through 15-foot building setbacks and limits on allowed uses within the regulatory buffer on Shorelines of the State and Type S/Type 1 streams. Regulatory buffers vary between 50 and 100 feet along saltwater shorelines and lakes depending on the shoreline designation; Type S/Type 1 streams, including segments of Curley Creek are afforded a 200 foot buffer (Kitsap County Code, 19.300.315). However, WDFW change analysis data between 2006 and 2013 (Appendix C) indicates that although disturbance (i.e. tree removal and conversion to non-forested vegetation) within the riparian corridor is occurring at a slower rate than within the overall watershed, disturbance is still occurring (Table 3-11), potentially compromising the functions of the riparian corridor for the Curley Creek watershed. This suggests a need for more detailed review of effectiveness of existing Critical Area Ordinance regulations. Riparian zone disturbance ranged from 0.1 to 0.2% of the riparian corridor over the 2006-2013 period along Curley Creek and Salmonberry Creek to 2.3% along the tributaries to Long Lake. It should be noted that this data encompasses a period of national and regional economic slowing, which has since recovered. Data for the 2013-2016 period was not yet available at the time this report was produced, but should reflect any effect of the rejuvenated economy and more recent increased development pressure within the watershed.

The Long Lake riparian corridor along the shoreline experienced the highest percent change, at 2.3% over the 2006-2013 period, likely related to the extensive residential development along the lakeshore. The riparian corridor along the Yukon Harbor shoreline experienced a higher rate of change in disturbed area (0.6%) than along the stream channels in the watershed, likely due to the higher concentration of residential development along the shoreline, but much less than along Long Lake.

Table 3-8. Land Cover Classification within Riparian Corridors of the Curley Creek Watershed (NOAA Regional Land Cover Classification Scheme, 2011 Imagery).

Land Cover Classification [i]	Curley Creek and Tributaries		Long Lake Tributaries		Salmonberry Creek		Long Lake Shoreline		Yukon Harbor Shoreline	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Medium Intensity Developed	0.0	0%	0.7	1%	1.3	0%	4.2	4%	2.2	3%
Low Intensity Developed	9.8	3%	5.6	5%	13.8	4%	30.2	25%	19.3	23%
Developed Open Space	5.3	2%	0.9	1%	39.3	11%	5.1	4%	6.9	8%
Subtotal – Developed Land	**15.1**	**5%**	**7.2**	**7%**	**54.4**	**16%**	**39.5**	**33%**	28.4	34%
Pasture/Hay	26.5	8%	0.7	1%	1.1	0%	3.6	3%	5.6	7%
Subtotal – Agricultural Land	**26.5**	**8%**	**0.7**	**1%**	**1.1**	**0%[iii]**	**3.6**	**3%**	**5.6**	7%
Grassland	4.4	1%	0.7	1%	18.9	5%	6.2	5%	7.8	9%
Subtotal – Grassland	**4.4**	**1%**	**0.7**	**1%**	**18.9**	**5%**	**6.2**	**5%**	**7.8**	**9%**
Deciduous Forest	95.4	30%	22.0	21%	55.6	16%	20.7	17%	10.9	13%
Evergreen Forest	23.8	8%	17.6	17%	9.1	3%	11.8	10%	5.3	6%
Mixed Forest	98.9	31%	36.7	35%	36.5	11%	4.7	4%	4.7	6%
Subtotal – Forest Land	**218.1**	**69%**	**76.3**	**73%**	**101.2**	**29%**	**37.2**	**31%**	20.9	25%
Scrub/Shrub	8.2	3%	2.0	2%	5.8	2%	9.8	8%	8.0	9%
Subtotal – Scrub/Shrub Land	**8.2**	**3%**	**2.0**	**2%**	**5.8**	**2%**	**9.8**	**8%**	8.0	9%
Palustrine Forested Wetland	35.3	11%	16.7	16%	95.1	28%	6.0	5%	0.0	0%
Palustrine Scrub/Shrub Wetland	3.8	1%	0.4	0%	28.0	8%	2.7	2%	0.0	0%
Palustrine Emergent Wetland	4.0	1%	0	0%	39.6	11%	1.1	1%	0.0	0%
Palustrine Aquatic Bed [ii]	0	0%	0	0%	0	0%	6.2	5%	0.0	0%
Subtotal – Wetlands	**43.1**	**14%**	**17.1**	**16%**	**162.7**	**47%[iii]**	**16.0**	**13%**	0.0	0%
Unconsolidated Shore	0.0	0%	0.0	0%	0.0	0%	1.6	1%	13.8	16%
Open Water	0.0	0%	0.0	0%	0.7	<1%	5.6	5%	0.0	0%
Subtotal - Barren Land and Water	**0.0**	**0%**	**0.0**	**0%**	**0.7**	**<1%**	**7.2**	6%	13.8	16%
Total	**315.4**	**100%**	**104.0**	**100%**	**344.8**	**100%**	**119.5**	**100%**	84.5	100%

Notes:

i) The following NOAA Regional Land Cover Classification Scheme categories were not identified in the Curley Creek Watershed: Unclassified, Estuarine Forested Wetland, Estuarine Scrub/Shrub Wetland, Estuarine Emergent Wetland, Bare Land, Estuarine Aquatic Bed, Tundra, Snow/Ice.

ii) Palustrine Aquatic Bed is included in the sub-total for wetlands because it includes areas where vegetation cover is greater than 80% (typically waterward of the shoreline of a body of water such as a lake) and thus more similar to this land cover than open water for the purposes of this study.

iii) Landcover data classify several agricultural areas in Salmonberry Creek valley as wetlands, thus under-reporting the acreage of agricultural land use.

Table 3-9. Tree canopy heights in riparian corridors derived from 2000 LiDAR.

	% of Area in Riparian Corridor				
Tree Canopy Height (feet)	**Curley_Creek**	**Long_Lake Tribs**	**Salmonberry Creek**	**Long_Lake**	**Yukon_Harbor**
Unforested (<10)	44%	52%	60%	66%	70%
10 - 50	35%	27%	27%	25%	23%
50 - 100	19%	19%	12%	8%	7%
100 - 150	2.4%	1.8%	0.9%	1.5%	0.4%
>150	0.1%	0.0%	0.0%	0.0%	0.0%
Total	100%	100%	100%	100%	100%

Table 3-10: Land Use Designations by Subbasin Riparian Corridor (Based on Comp Plan Designations)

LAND COVER CLASSIFICATION	CURLEY CREEK AND TRIBUTARIES		LONG LAKE SHORELINE		SALMONBERRY CREEK		LONG LAKE TRIBUTARIES		YUKON HARBOR SHORELINE	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Rural Residential	-	0%	25	21%	26	7%	20	19%	41	48%
Rural Protection	315	100%	75	63%	259	75%	83	81%	21	25%
Urban Low-Density Residential	-	0%	-	0%	40	12%	-	0%	-	0%
Urban Medium/High-Density Residential	-	0%	-	0%	2	1%	-	0%	-	0%
Limited Area of More Intense Rural Development-I	-	0%	-	0%	-	0%	-	0%	23	27%
Public Facility	-	0%	5	4%	19	6%	-	0%	-	0%
Lake	-	0%	14	12%	-	0%	-	0%	-	0%
Total	**316**	**100%**	**118**	**100%**	**345**	**100%**	**103**	**100%**	**86**	**100%**
Note: All acres are rounded to the nearest whole acre.										

Table 3-11. WDFW Change Analysis Data for the Riparian Corridors of the Curley Creek Watershed by Subbasin.

		DISTURBED AREA PER RIPARIAN CORRIDOR BY SUBBASIN (ACRES)											
		Curley Creek		Salmonberry Creek		Long Lake Shoreline		Long Lake Tributaries		Yukon Harbor Shoreline		Watershed (Total)	
		Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
	Total Area	315		345		104		119		85		968	
Time Period	2006-2009	0.23	0.1%	0.0	0.0%	0.47	0.5%	0.24	0.2%	0.07	0.1%	1.01	0.1%
	2009-2011	0.0	0.0%	0.3	0.1%	0.84	0.8%	2.22	1.9%	0.06	0.1%	3.42	0.4%
	2011-2013	0.06	0.0%	0.26	0.1%	0.57	0.5%	0.26	0.2%	0.49	0.6%	1.64	0.2%
	2006-2013	**0.29**	**0.1%**	**0.55**	**0.2%**	**1.88**	**1.8%**	**2.72**	**2.3%**	**0.62**	**0.7%**	**6.06**	**0.6%**

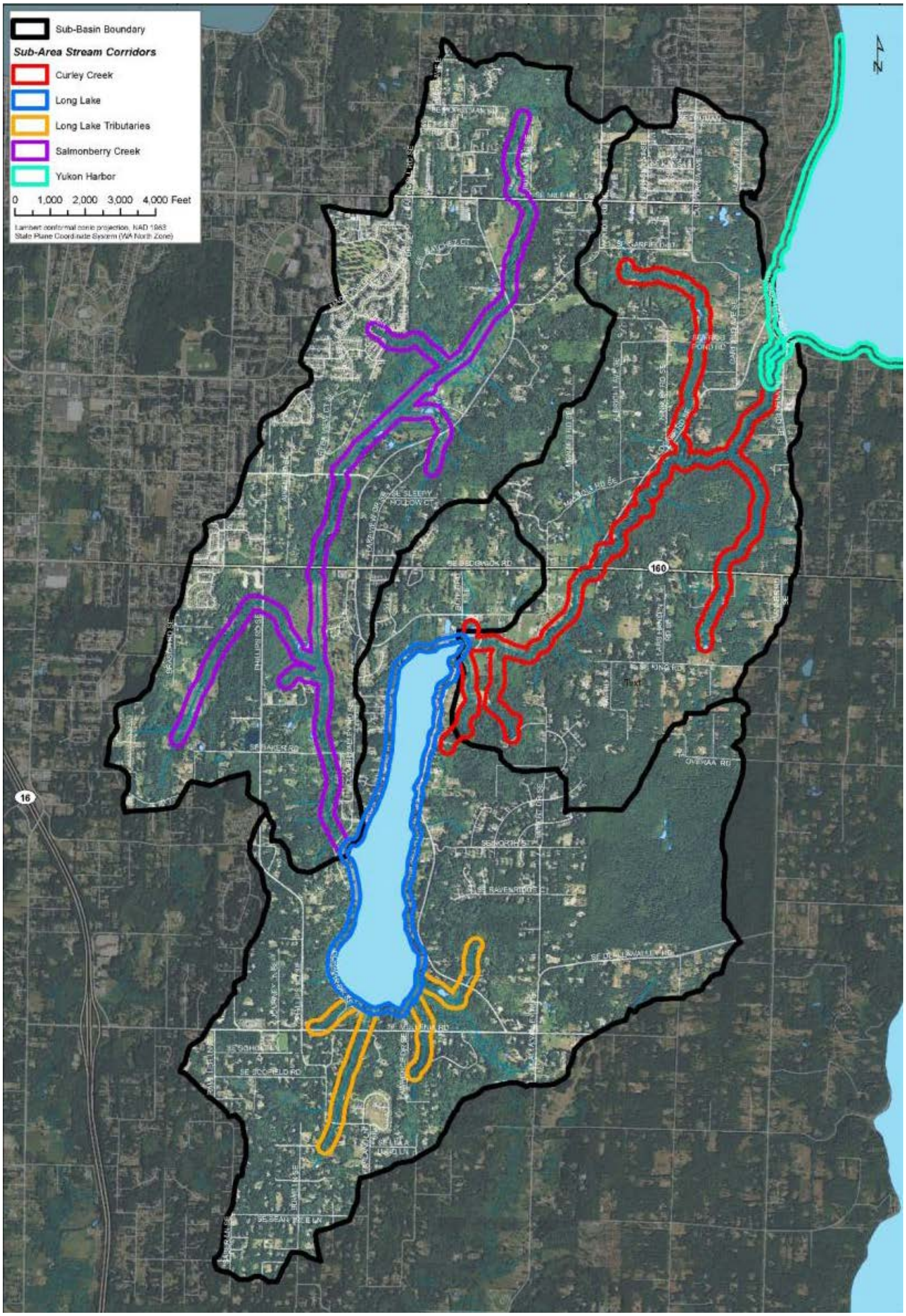

Figure 3-8. Aerial image (2013) of the Curley Creek Watershed with subbasin areas and riparian corridors used as overlays in land cover analysis.

3.1.6 KEA Stream Structure

Key Parameters and Watershed Pressures

The physical structure of stream channels in the Curley Creek watershed is sensitive to changes in both watershed- and reach-scale processes. Dynamic fluvial processes such as wood recruitment, channel migration, channel-floodplain connectivity, and habitat formation by beaver, collectively influence the diversity and distribution of aquatic habitat types in the watershed. In relatively undeveloped watersheds with few human impacts, natural variability produces a shifting habitat mosaic in which individual habitat units may change year-to-year but the overall patterns and distribution of habitat types remain stable over time (Ward et al, 2002). Land use activities that alter these processes, however, can shift the relative abundance, diversity, and distribution of habitat types with adverse impacts to local salmonid populations.

Widespread timber harvest from riparian forests (past harvest left little, if any, riparian buffer) and intentional wood removal to clear channels has greatly diminished the abundance of wood in stream channels. While some active wood recruitment has occurred in parts of the Curley Creek watershed with recovering riparian forests, much of the wood is either: (1) hardwood species such as alder that decay rapidly, (2) insufficiently small to function as stable key pieces, or (3) intentionally removed from the channel by people following recruitment. Current wood abundance in Puget Lowland rivers is estimated to be one or two orders of magnitude less than the conditions that prevailed prior to the period of European settlement beginning in the mid-1800s (Collins et al., 2002).

Low abundance of large wood and lack of physical complexity are key habitat limiting factors for salmon and steelhead in the Curley Creek Watershed (Haring, 2000). Physical complexity is critical to the maintenance of diverse fish habitat and river food webs (Power 1992, Power et al. 1995, Carpenter et al. 1996, Power and Dietrich 2002). Natural processes that create physical complexity in temperate forest river valleys of the Pacific Northwest are controlled by the formation of stable wood jams that increase the number and depth of pools (Montgomery et al., 1995), form islands by inducing sediment deposition (Abbe and Montgomery, 1996), increase potential for floodplain inundation (Abbe and Montgomery, 1996; Collins et al., 2002; Brummer et. al., 2006), and create an anastomosing channel pattern with perennial secondary channels (Abbe and Montgomery, 2003; Montgomery and Abbe, 2006).

In addition, the historic and ongoing removal of beaver has simplified stream channel habitat characteristics. Beavers historically occupied a much greater area in Puget Sound watersheds, including Curley Creek, and were an important component of the landscape in which salmon evolved. Beaver dams provide important hydrologic and geomorphic functions affecting stream structure and the quantity and diversity of aquatic habitats (Pollock et al., 2003). Localized increases in water surface elevation upstream of beaver dams increase floodplain connectivity and elevate the water table in adjacent riparian areas. Historic trapping of beaver and widespread reduction in beaver dams changed channel structure in ways that adversely affect productivity of salmonid populations. Beaver create dams that impound water to form deep pools and ponds which are important habitats for juvenile salmon that rear in freshwater systems such as coho (Pollock et al., 2004).

A key process influencing stream structure and floodplain connectivity in the Curley Creek Watershed has been channelization (primarily ditching) of the stream through low gradient valleys. Areas of channel straightening and ditches are mapped in the Lidar DEM included as Appendix F.

Indicators

Recommended indicators for assessment and monitoring of stream structure are listed in Table 3-12. The indicator for large wood in the channel is a quantitative inventory of wood pieces derived from field assessment of stream channels and normalized as the number of pieces per unit channel length. Reference information compiled from surveys in unmanaged forest areas of the Pacific Northwest provide target wood loading values for comparison to existing reach conditions (Fox and Bolton, 2007). No quantitative data are available to assess existing conditions in the Curley Creek Watershed. However, reconnaissance level assessment verified a very low abundance of wood and lack of channel complexity throughout the watershed.

No quantitative data are available for evaluation of channel structure. A generalized evaluation of indicators was developed from limited field reconnaissance in select parts of the watershed. We know that wood loading is impaired throughout the watershed due to past clearing of riparian forest and intentional wood removal. Habitat composition and pool frequency were rated as "Fair", considering a known correlation of pool frequency and depth to wood loading. Channel sinuosity is impaired in both Curley Creek and Salmonberry Creek where streams have been channelized by ditching over the historic period. Bank armor has not been inventoried but is generally rated "Fair" given some areas of known riprap have been identified but not to the degree seen in more impacted watersheds.

Table 3-12. Indicators for stream structure.

COMPONENT: SMALL CHANNELS		
KEA	**INDICATOR(S)**	**INDICATOR DESCRIPTION**
Stream Structure	Large Wood	Inventory of large wood normalized as # pieces/channel length
	Habitat Composition	Percent pool, riffle, run
	Pool Frequency and Depth	Spacing between pools (# pools/channel width), mean and max residual pool depth
	Beaver Pond Frequency	Number of beaver ponds per length of channel (#/mi)
	Sinuosity	Channel length / Valley Length
	Length of bank armor	Length of bank armor
Supporting Information		
Qualitative information in Limiting Factors Analysis (Haring, 2000)		
Field reconnaissance of select areas (Appendix B)		
Data Gaps		
Stream surveys needed to monitor channel structure, including wood loading		

Data Gaps

No quantitative data are available to characterize stream structure in the Curley Creek Watershed. Stream surveys should be completed to establish baseline metrics for indicators in Table 3-12.

3.1.7 KEA Habitat Connectivity

The Habitat Connectivity KEA is characterized by length of potential small channel habitat available to salmonids. This assessment reviewed existing data and information to identify fish passage conditions in small stream channels in the Curley Creek Watershed. This information is used to identify stream channels that are partially or completely blocked to fish passage (juvenile and adult). Barriers to fish passage, in the form of road culverts, dams, dikes, and other obstructions, reduce the distribution and habitat available to salmonids. In particular, the inability of fish to access upstream spawning and rearing areas results in decreased production. Migration barriers also limit the ability of juvenile salmonids to move into summer and winter habitats. The dispersal and movement of juvenile salmonids during freshwater rearing can be in response to avoidance of high flow, dewatering of sections of stream, or to avoid high water temperatures (Kahler and Quinn, 1998).

WDFW maintains a statewide online database of fish passage barriers caused by road-based stream crossing structures, dams, dikes, and other structures obstructing fish movements. The database, which includes data compiled from WDFW and non-WDFW fish passage barrier inventory efforts, is used to identify, locate, and prioritize correction of human-made fish passage barriers in Washington State. WDFW also uses the data to track where inventory efforts have occurred. A map of all fish passage barriers in the WDFW inventory (including partial barriers) is shown for the Curley Creek Watershed in Figure 3-9. WDFW culvert assessment reports are attached as Appendix G.

The fish barrier database describes the type of barrier (e.g., road stream crossing, private road, water impoundment structure, etc.) and includes an assessment of passability through the structure (WDFW 2009). Nearly all fish passage barriers in the Curley Creek Watershed are associated with road stream crossing culverts. Passability was based on size of the culvert, length of the culvert, water velocity through the culvert, slope within the culvert, water depth, and water surface vertical drop at the downstream end of the culvert. The site survey is based on a one-time visit to a stream crossing and analysis of conditions at the time of the survey. Assessment results in the database do not distinguish between juvenile and adult passage and are intended to represent general categories of passability. Assessment methodologies are based on the ability of a 15.2 cm (6 inch) trout to migrate through the structure. Each structure is assessed for percent passability for four categories: 1) 0% - complete barrier, 2) 33% partial passage, 3) 67% less severe partial passage or 4) 100% passage, a non-barrier to fish migration.

The habitat connectivity KEA was assessed by calculating the length of potential fish bearing waters (WDNR Type F water type) blocked or partially blocked to the movement of salmonids. The KEA indicator for connectivity is the percent of fish bearing stream length fully accessible to the movement of salmonids.

Most of the culverts in the Curley Creek Watershed were located on non-fish bearing streams according to the WDNR stream type database. However, many of these streams may be potential fish bearing streams. The Wild Fish Conservancy conducted a water type field survey in nearby Blackjack Creek and reported numerous discrepancies between the WDNR stream type maps and field observations (WFC 2014). Therefore, total stream length with potential fish use based on the WDNR water type code is likely a low estimate.

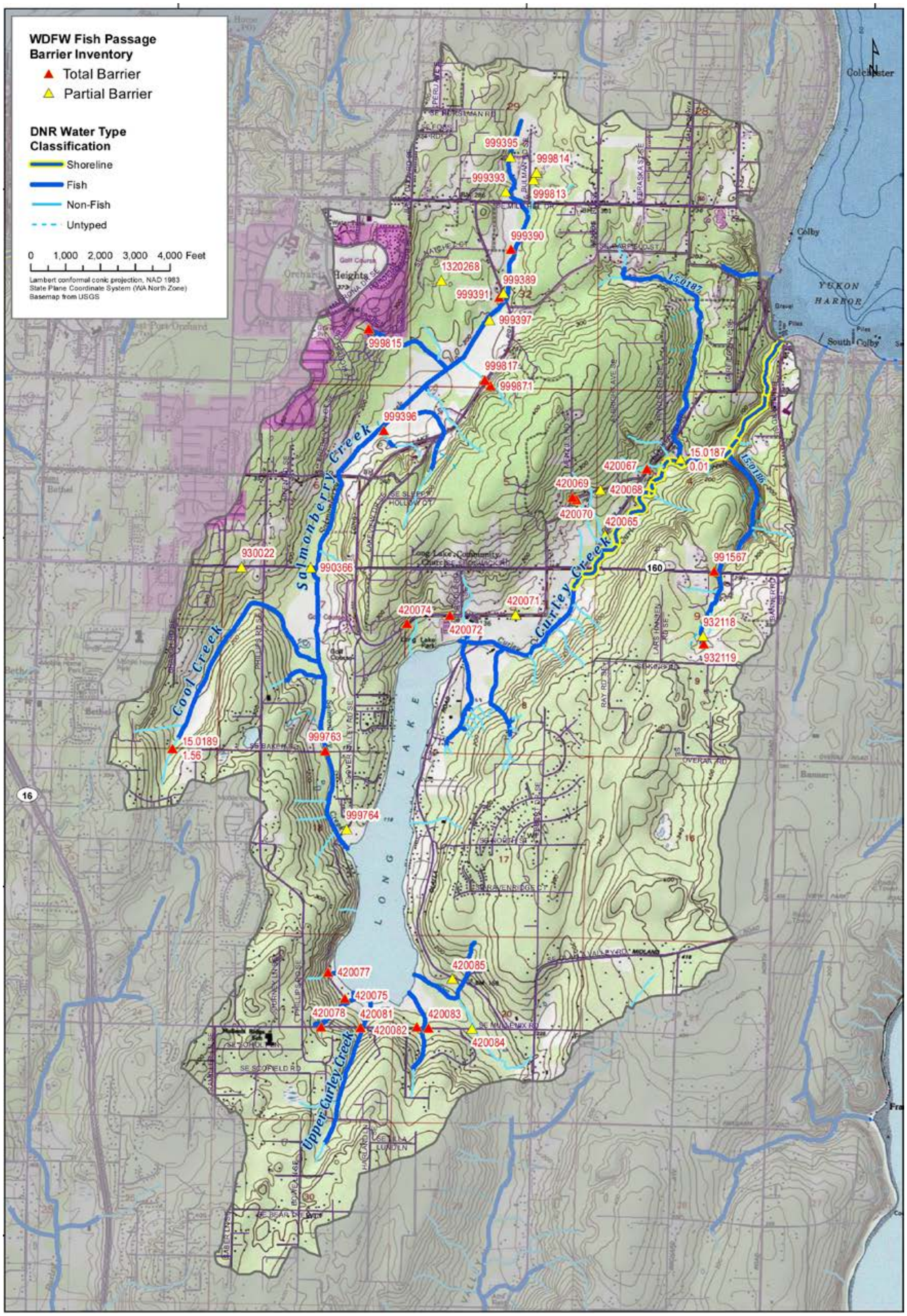

Figure 3-9. WDFW fish passage inventory for the Curley Creek Watershed.

Subbasin: Curley Creek

A total of 11 structures were identified as partial or complete fish passage barriers impacting habitat connectivity in the Curley Creek subbasin (Table 3-13). Seven of the structures in the Curley Creek subbasin were located on non-fish bearing streams according to the WDNR stream type database (Figure 3-9).

Table 3-13. Summary of WDFW fish passage inventory for the Curley Creek subbasin.

Indicator	Results
Number of features in WDFW Database	11 culverts and 2 dam structures
Number of features complete barrier (0% passability)	5 culverts and 1 earthen dam in the headwaters of Banner Creek (15.0186)
Number of features partial barrier (33% passability)	4 culverts
Number of features less severe partial barrier (67% passability)	1 concrete weir at base of fish ladder on Tributary 15.0187
Number of features unknown passability	2 culverts (Banner Creek)
Total Type F stream length (km) in subbasin	11.69 km
Percent Type F stream length with complete barrier	6.4%
Percent Type F stream length with partial (33% or 67%) barrier	20.3%
KEA Indicator: percent of Type F stream length fully accessible to salmonids	73.3%

Fish migration barriers are more significant in tributaries to Curley Creek. The Curley Creek subbasin assessment includes 6.12 km of Curley Creek proper from estuary to Long Lake. The amount of stream length with barriers in tributaries to Curley Creek is much higher (56% - most of tributary 15.0187 and 0.75 km of Banner Creek).

Unnamed tributary 15.0187 is fish bearing for most of its length. However, a partial barrier concrete dam structure on this tributary and associated fish ladder just upstream from Curley Creek impairs fish passage to the entire tributary length.

Banner Creek (15.0186) is classified fish bearing through most of its length and has three structures classified as complete or partial barriers to fish passage. The most significant is the lower most complete barrier on SE Sedgwick Road. The culvert was classified a complete barrier based on the 0.74 meter drop on the downstream end. A photo taken during the survey on September 14, 2011 shows water flowing through the culvert during the survey. The dam structure in the headwaters of the tributary is an earthen dam impounding a wetland/pond area. Two culverts were identified in Banner Creek upstream of the SE Sedgwick road crossing that were not assessed for fish passage because the survey crew could not complete the full survey.

Subbasin: Long Lake Tributaries

A total of 9 structures were identified as partial or complete fish passage barriers impacting habitat connectivity in the Long Lake subbasin (Table 3-14). Two of the structures in the Long Lake subbasin were located on non-fish bearing streams according to the WDNR stream type database (Figure 3-9). Two culverts were at the upstream extent of the fish bearing streams. Two culverts appear to be mapped to the same stream and were counted as one barrier for this analysis.

Table 3-14. Summary of WDFW fish passage inventory for the Long Lake subbasin (tributaries entering lake, excluding Salmonberry Creek).

Indicator	Results
Number of features in WDFW Database	8 culverts
Number of features complete barrier (0% passability)	6 culverts
Number of features partial barrier (33% passability)	2 culverts
Number of features less severe partial barrier (67% passability)	0 culverts
Number of features unknown passability	0
Total Type F stream length (km) in subbasin	3.53 km
Percent Type F stream length with complete barrier	51.4%
Percent Type F stream length with partial (33% or 67%) barrier	10.6%
KEA Indicator: percent of Type F stream length fully accessible to salmonids	38.0%

Three streams entering Long Lake had complete barriers blocking salmonid access to a large portion of the stream length. One complete barrier was located just upstream of Long Lake.

Subbasin: Salmonberry Creek

A total of 19 structures were identified as partial or complete fish passage barriers impacting habitat connectivity in the Salmonberry Creek subbasin (Table 3-15). Five structures in the Salmonberry subbasin were located on non-fish bearing streams according to the WDNR stream type database (Figure 3-9). The stream crossing at Clover Valley Road SE is located just upstream of the inlet to Long Lake and is listed as a partial barrier (33% passability) based on velocity through the culvert. The field survey measured a velocity of 1.9 m/sec in the culvert. This velocity would restrict upstream movement of juvenile salmonids into Salmonberry Creek to avoid warm temperatures in Long Lake during the summer.

The next crossing upstream at SE Baker Road is listed as a complete barrier to fish passage based on slope in the culvert (slope greater than 1%). The barrier inventory reported a slope of 2.16% through the culvert. During a field visit in October 2015 we observed the culvert outlet was backwatered such that the culvert slope was not creating a barrier at that time (Appendix A) but we were unable to inspect the downstream channel segment on private property.

The stream crossing at Sedgwick Road on Salmonberry Creek is perched creating a partial barrier due to the water surface drop. Field observations from Steve Todd (Suquamish Fisheries Department) in late spring 2017 noted a second culvert under Sedgwick Road to the east of the known barrier. Initial reconnaissance revealed a drop that would likely qualify as a barrier. It is not clear if this is a side channel of Salmonberry Creek or a tributary stream entering the valley from the adjacent hillslope. Additional surveys are needed to determine barrier status of this culvert.

Table 3-15. Summary of WDFW fish passage inventory for the Salmonberry Creek subbasin.

Indicator	Results
Number of features in WDFW Database	16 culverts, 2 dam structures, and 1 non-culvert blocking feature
Number of features complete barrier (0% passability)	5 culverts, 1 dam structure and 1 non-culvert feature
Number of features partial barrier (33% passability)	5 culverts and 1 dam structure
Number of features less severe partial barrier (67% passability)	6 culverts
Number of features unknown passability	0
Total Type F stream length (km) in subbasin	11.63 km
Percent Type F stream length with complete barrier	91% (55% if Baker Rd reclassified)
Percent Type F stream length with partial (33% or 67%) barrier	>99%
KEA Indicator: percent of Type F stream length fully accessible to salmonids	<1%

The two dam structures in Salmonberry Creek were a small concrete dam and a plank and boulder structure, both associated with ponds. The non-culvert feature was an undefined structure blocking a side channel in the floodplain of Salmonberry Creek.

Not included in the fish passage barrier inventory was the impact of past agriculture practices and loss of beaver and beaver pond wetland habitat in the Salmonberry Creek floodplain on lateral connectivity to floodplain habitats. Two migration barriers were identified on unnamed side channels to Salmonberry Creek. Past ditching and straightening of the creek in some sections has disconnected the creek from the historic floodplain.

Indicators

Component: Small Channels (Subbasin: Curley Creek and tributaries downstream of Long Lake)		
KEA	**Indicator(s)**	**Indicator Description**
Habitat Connectivity	% historic stream miles available by species (Chinook, coho, chum, steelhead, and cutthroat)	PSP Indicator/March 2016; What is the extent of human-made adult fish passage barriers in Tiers 1 and 2 waters?
Supporting Information		
Unknown	Length (km) assumed historic stream km used by species	Stream km by species
WDNR	Length (km) of fish bearing (Type F) streams	Stream km for Type F streams in watershed
WDFW Fish Passage Inventory Database	Number and locations of fish passage barriers	Count of partial and complete barriers to fish passage by subbasin and stream
Data Gaps: comprehensive assessment of fish bearing or potential fish bearing streams, ideally classified by salmonid species.		

Indicator Bins for Habitat Connectivity

Indicator bins are based on percent of Type F (fish bearing) streams by subbasin.

		Condition			
KEA/Subbasin	**Indicator**	**Poor**	**Fair**	**Good**	**Very Good**
Habitat Connectivity/Curley Creek	Percent of Type F stream length fully accessible to salmonids	<50%	>= 50% and <76%	>= 75% and <90%	>= 90%
Habitat Connectivity/Long Lake Streams	Percent of Type F stream length fully accessible to salmonids	<50%	>= 50% and <76%	>= 75% and <90%	>= 90%
Habitat Connectivity/Salmonberry	Percent of Type F stream length fully accessible to salmonids	<50%	>= 50% and <76%	>= 75% and <90%	>= 90%

Data Gaps

The biggest data gap is the lack of a comprehensive field survey of stream potential to support salmonids (i.e., stream typing). The WDNR stream type classification in the Curley Creek watershed appears to be a map-based analysis of stream size and gradient, possibly supplemented with a few field observations. The findings from field surveys in nearby Blackjack Creek (WFC, 2014) suggest the length of Type F waters would increase substantially from a field survey.

The WDFW passage barrier database appears relatively comprehensive for the Curley Watershed compared with many other area watersheds. There were several barriers identified on non-fish bearing streams. Updated surveys should be completed for Baker Road and Clover Valley Road in lower Salmonberry Creek to verify barrier status. Additional barriers will likely be identified as part of comprehensive water typing assessment recommended for the watershed. A comprehensive water typing assessment would include smaller, unmapped streams not likely included in the WDFW passage barrier database.

3.1.8 Condition Ratings for Stream Channels

Condition ratings evaluating current status of KEA indicators based on available information are synthesized below in Table 3-16. Effects of land use change and development are generally to a level at which impacts are beginning to alter flow regime and sediment dynamics. Limited field reconnaissance and review of aerial imagery suggest that past clearing of riparian forest, channelization, beaver removal, and intentional wood removal have degraded stream structure and resulted in loss of channel complexity needed for creation and maintenance of aquatic habitats.

Table 3-16. Condition ratings assigned to indicators for stream channel KEAs. Fields noted with * indicate condition rating based on professional judgement where data are not available to quantify the indicator.

Key Ecological Attribute	Indicator	Subbasin	Condition		
			Poor	Fair	Good
Ecosystem Component: Small Channels					
Hydrologic Regime	7-day Low Flow	Curley Creek		*	
		Long Lake Tributaries			
		Salmonberry Creek			
	Annual Maximum Flow	Curley Creek		*	
		Long Lake Tributaries			
		Salmonberry Creek			
	T_{qmean}	Curley Creek		*	
		Long Lake Tributaries			
		Salmonberry Creek			
	% Impervious Surface	Curley Creek			
		Long Lake Tributaries			
		Salmonberry Creek			
	% Forest Cover	Curley Creek			
		Long Lake Tributaries			
		Salmonberry Creek			
Sediment Dynamics	Substrate Composition	Curley Creek		*	
		Long Lake Tributaries		*	
		Salmonberry Creek		*	
	Armor Ratio	Curley Creek		*	
		Long Lake Tributaries		*	
		Salmonberry Creek		*	
	Channel Stability	Curley Creek	*		
		Long Lake Tributaries	*		
		Salmonberry Creek	*		
Water Quality	Water Temperature: 7DADM	Curley Creek			
		Long Lake Tributaries			
		Salmonberry Creek			

Key Ecological Attribute	**Indicator**	**Subbasin**	**Condition**		
			Poor	**Fair**	**Good**
	Nutrient enrichment (N, P)	Curley Creek			
		Long Lake Tributaries			
		Salmonberry Creek			
	Fecal Coliform Bacteria	Curley Creek			
		Long Lake Tributaries			
		Salmonberry Creek			
Wetland Condition and Functions	Wetland conditions and functions (HGM class; landscape context; vegetation richness; wildlife habitat)	Curley Creek			*
		Long Lake Tributaries		*	
		Salmonberry Creek		*	
Riparian Zone Condition (within 200 feet either side fish-bearing streams)	Percent forested cover (upland forests and forested wetlands)	Curley Creek			
		Long Lake Tributaries			
		Salmonberry Creek			
	Forest maturity (derived from tree height data)	Curley Creek			
		Long Lake Tributaries			
		Salmonberry Creek			
Stream Structure	# Wood Pieces in Bankfull Channel/100 m	Curley Creek	*		
		Long Lake Tributaries	*		
		Salmonberry Creek	*		
	Habitat Composition (pool/riffle/run)	Curley Creek		*	
		Long Lake Tributaries		*	
		Salmonberry Creek		*	
	Pool frequency (per channel width)	Curley Creek		*	
		Long Lake Tributaries		*	
		Salmonberry Creek		*	
	Sinuosity	Curley Creek		*	
		Long Lake Tributaries			*
		Salmonberry Creek	*		
	Bank Armor Limiting Channel Migration	Curley Creek		*	
		Long Lake Tributaries		*	
		Salmonberry Creek		*	
Habitat Connectivity	% Historic stream miles available to salmonids	Curley Creek			
		Long Lake Tributaries			
		Salmonberry Creek			

3.2 Ecosystem Component: Long Lake

3.2.1 KEA Riparian/Shoreline Condition

The **Long Lake Shoreline** is the most highly developed of the riparian areas in the watershed, with about one third of the riparian corridor developed. Whereas the Salmonberry Creek developed land is primarily developed open space, the development in this subbasin is primarily low-intensity development (25% and 23% of total land cover, respectively).

Only 36% of the riparian corridor along the Long Lake shoreline is forested (upland forest and forested wetlands). Of the 16 acres of wetlands in the Long Lake Shoreline riparian zone, 6.2 acres is classified as aquatic bed vegetation waterward of the shore.

The Long Lake Shoreline subbasin has public facilities designations and 21% of the land within the riparian corridor designated to support rural residential uses.

3.2.2 KEA Water Quality

Long Lake is a narrow water body nearly two miles in length and averaging 1,200 feet in width. The lake captures runoff from nearly two thirds of the watershed and acts as a sink for sediment and nutrients transported from tributary streams. Sedimentation and eutrophication have been issues affecting the lake for several decades. The lake is listed as a Category 5 (polluted water requiring a TMDL) water body for phosphorus under Section 303(d) of the Clean Water Act.

Past management actions to address water quality concerns have included dredging (limited to small area of the lake), drawdown, and application of alum. The community and Kitsap County are working to establish a lake management district in 2017 to fund future management actions in the lake, such as additional alum treatments.

3.2.3 KEA Predator Community

Non-native predator impacts in streams and lakes can be a significant impact on freshwater production of salmonids, especially species that have a long freshwater juvenile residency like coho salmon. Bonar et al. (2005) reported results of surveys of predation impacts of non-native and native fishes on coho salmon in three lowland lakes in western Washington (Long Lake, Lake Symington in the Big Beef Creek Watershed, and Wildcat Lake in the Chico Creek watershed).

Species Composition and Abundance

Bonar et al. (2005) report ten predator species in Long Lake from field surveys during March 1998 to March 1999 and April 1999 to March 2000. Non-native species observed were: 1) Brown bullhead catfish, 2) Black crappie, 3) Bluegill, 4) Golden shiner, 5) Largemouth Bass 6) Pumpkinseed, and 7) Yellow perch.

Bonar et al. (2005) reported largemouth bass had the highest impact on coho, representing 98% of the predation in the three lakes. Long Lake had the largest population of largemouth bass of the three lakes surveyed, and the estimated highest relative impact on coho production. Total smolt potential from the Curley Creek watershed was estimated based on habitat area and ranged from 3,478 coho to 8,404 coho. The number of coho smolt equivalents consumed by largemouth bass (includes adjusted predation of fry and presmolts) ranged from 1,082 coho to 4,632 coho. Based on these results, largemouth bass are likely a substantial impact on coho smolt production from the Curley Creek watershed and are an impediment to improving coho production from the watershed.

The impact on other salmonids is not known. Fish reported as "Bass" were also captured in minnow traps in Salmonberry Creek upstream of Salmonberry Road (Mid Sound Salmon Enhancement Group 2015). These bass may represent an additional predation threat on coho residing in Salmonberry Creek.

Indicators

Recommended indicators are the species composition and abundance of non-native predators.

The Bonar et al. study was nearly two decades ago and, although the species composition may be unchanged, the abundance of non-native species, in particular largemouth bass, should be reassessed. In addition, the minnow trap data from Salmonberry Creek (Mid Sound Salmon Enhancement Group 2015) suggest bass are more widespread than just Long Lake. Antidotal fishing reports for Long Lake suggest largemouth bass are abundant (e.g., http://www.northwestfishingreports.com/Reports/Details/38246).

Recommended is a new field survey of predator composition and abundance in Long Lake and Salmonberry Creek, coupled with an analysis of stomach contents and species predator-prey bioenergetics. These results combined with coho smolt abundance estimates from the Suquamish Tribe outmigrant trap in Curley Creek would be an important assessment of predator effects on coho salmon in the watershed.

If results from a resurvey are consistent with findings from the Bonar et al. study then recommended is a management action to reduce abundance of the primary non-native predators in Long Lake. This action could be a bounty combined with a derby on largemouth bass from Long Lake or an agency lead predator removal program.

3.2.4 Condition Ratings

Long Lake is highly affected by development along the shoreline and in the contributing watershed. Condition ratings of KEA indicators are summarized below in
Table 3-17.

Table 3-17. Condition ratings assigned to indicators for Long Lake KEAs.

KEA	Indicator	Poor	Fair	Good
Riparian/Shoreline Condition	Extent bank modifications			
	Species composition and extent of invasive species		*	
	% Shoreline with overhanging vegetation		*	
Water Quality	Water Temperature: 7DADM		*	
	Nutrient enrichment (N, P)			
	Fecal Coliform Bacteria			
Predator Community	Number of non-native predator species			
	Abundance of non-native predators species			

3.3 Ecosystem Component: Curley Creek Estuary

3.3.1 KEA Estuary Habitat Connectivity

The Curley Creek Estuary is the transitional zone located between marine waters of Yukon Harbor and freshwater habitats in Curley Creek. All salmonid species present in the Curley Creek Watershed utilize the estuary during part of their life cycle. Connectivity through the estuary requires passage beneath the bridge crossing at Southworth Drive. The roadway crossing the estuary is built upon fill materials that constrict the opening. The bridge was replaced in 2012 with a longer structure than the previous bridge built in 1929 and increased the opening beneath the bridge from 35 feet to 95 feet. The crossing is not currently a barrier to fish passage.

3.3.2 KEA Estuary Riparian Vegetation

The riparian corridor along the Curley Creek estuary is characterized by intertidal mud and sandflats that transition to a gravel-dominated shoreline and sporadically forested bluffs. While the southern shoreline zone is fringed with large big-leaf maple (*Acer macrophyllum*), Douglas fir (*Pseudotsuga menziesii*), and native shrubs that overhang the bluff, the northern shoreline at the mouth of the estuary is devoid of mature vegetation. Early seral stage trees and shrubs dominate, providing little/no shade or organic material input to the estuary. The banks of the estuary upstream of the mouth, on the land owned by the Great Peninsula Conservancy, are in better condition, supporting a diverse mixture of native trees, shrubs, and intertidal marsh species including a small patch of native Lyngby's sedge (*Carex lyngbyei*), Douglas aster (*Aster douglasii*), and salt hen. (*Atriplex patula*)

3.3.3 Condition Ratings

The Curley Creek Estuary is generally in "Good" condition relative to other ecosystem components. Condition ratings are summarized below in Table 3-18.

Table 3-18. Condition ratings for indicators identified for the Estuary KEAs.

KEA	Indicator	Poor	Fair	Good
4.3.1 Estuary Habitat Connectivity	Tidally influenced area accessible to fishes			
4.3.2 Estuary Riparian Vegetation	Percent forested cover (upland forests and forested wetlands)			
	Species composition and extent of functioning riparian			*
	Extent bank modifications			

3.4 Ecosystem Component: Bluff-Backed Beaches

3.4.1 KEA Drift Cell Sediment Dynamics

There are two distinct drift cells along the Yukon Harbor shoreline that converge at the Curley Creek Estuary (Figure 3-10). Residential development has occurred along the shoreline resulting in extensive armoring to protect private property from erosion (Figure 3-11). Shoreline armoring disrupts natural rates of beach erosion, sediment delivery to beaches, as well as cross-shore and long-shore sediment transport. Armoring reduces the resilience of nearshore areas to the potential impacts of climate change and sea level rise. Armoring can also directly impact forage fish (sandlance and surf smelt) spawning habitats by burial of upper intertidal areas and by modification of grain size (Dethier et al., 2016). The proposed indicator to track impacts of shoreline development on sediment dynamics is the percentage of modified shoreline. Data in the Washington DNR (WDNR) ShoreZone Inventory collected in the mid-1990s show most of Yukon Harbor is modified along more than 80% of its length (Figure 3-10).

3.4.2 KEA Marine Riparian Vegetation

Trees and shrubs fringing the shoreline and on bluffs within the 200-foot zone along the Yukon Harbor shoreline help to naturally stabilize the bluffs and provide a source of large woody material and other organic material to the marine shoreline zone. Development encompasses the largest portion (34%) of the marine riparian zone, with forested vegetation comprising 25% (all upland forests, mostly on the bluffs) and unconsolidated shoreline/bare ground 16% (Table 3-8). Dominant species of marine riparian vegetation include Douglas fir (*Pseudotsuga menziesii*), big-leaf maple (*Acer macrophyllum*), madrone (*Arbutus menziesii*), and red alder (*Alnus rubra*) trees, as well as scattered western red cedar (*Thuja plicata*) and Sitka spruce (*Picea sitchensis*) trees.

Figure 3-10. Drift cells and percentage of shore modification. Source: Washington State Department of Natural Resources (2000) ShoreZone Inventory.

Figure 3-11. Photo of residential development and shoreline armoring in Yukon Harbor nearshore along drift cell to the northwest of the Curley Creek Estuary.

3.4.3 KEA Submerged Aquatic Vegetation

Submerged aquatic vegetation provide important habitat for crabs, scallops, fish, and other wildlife. The extent of eelgrass (*Zostera marina*) beds in Yukon Harbor is used as an indicator to monitor status of this KEA. The WDNR ShoreZone inventory (based on data from the 1990s) does not show any eelgrass beds in Yukon Harbor, nor fringe of eelgrass near the Curley Creek Estuary. The shoreline to the east of the Curley Creek Estuary and beginning approximately 0.5 miles north of the Estuary are mapped as having a patchy fringe of eelgrass (Figure 3-13). This shoreline was sampled by WDNR (Suquamish funded) in 2016-2017. Results are forthcoming.

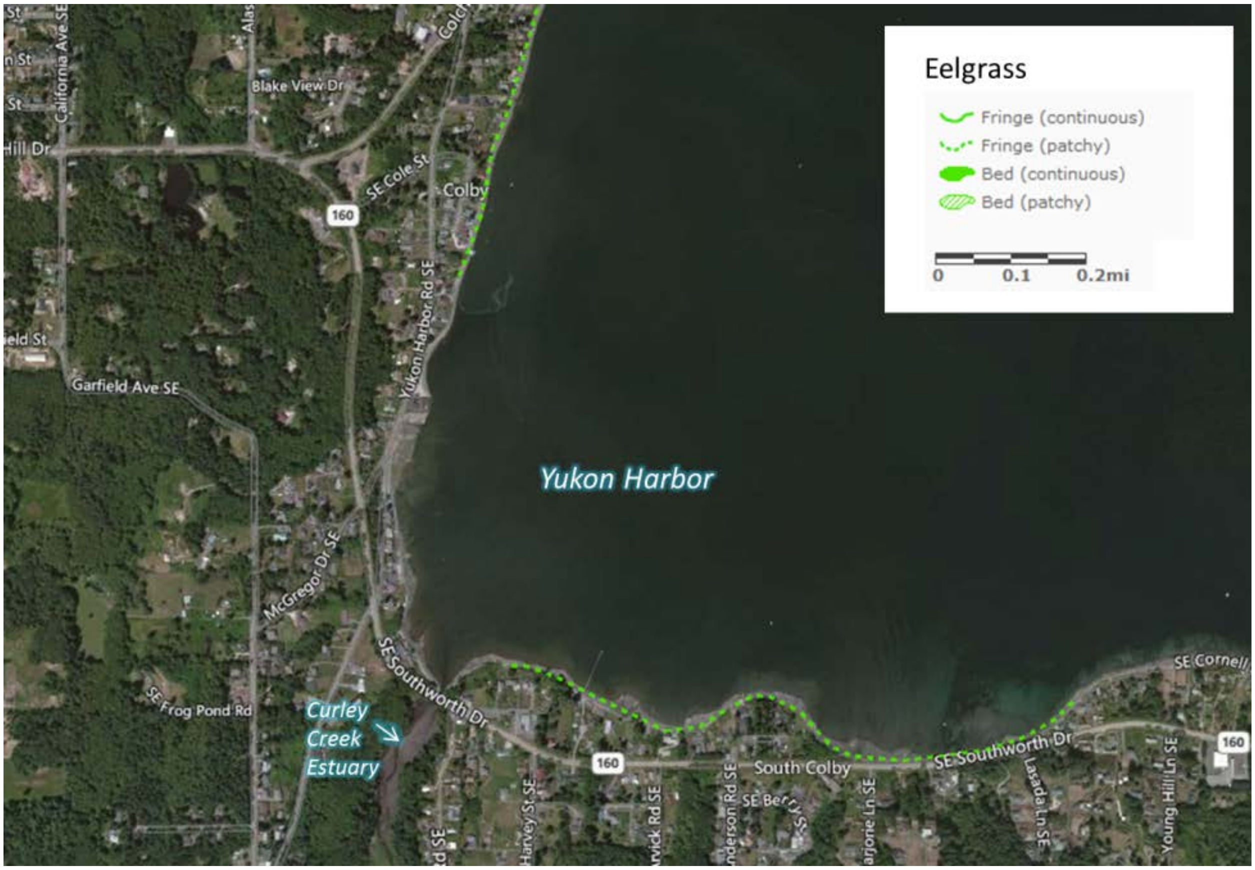

Figure 3-12. Eelgrass abundance in the Yukon Harbor nearshore. Source: Washington State Department of Natural Resources (2000) ShoreZone Inventory.

3.4.4 KEA Water Quality

Marine waters in Yukon harbor are listed as a Category 5 water body for Dissolved Oxygen under Section 303(d) of the Clean Water Act. Yukon Harbor is listed as a Category 2 water body (Area of Concern) for bacteria. Past efforts have worked to identify sources of bacterial pollution from failing on-site sewage systems in the watershed (Drew and Banigan, 2006).

3.4.5 KEA Forage Fish Spawning

Forage fish including sand lance, surf smelt, and Pacific herring are major prey species for Pacific salmon, and important as a food source for predatory fish, birds, and mammals in Puget Sound. Sand lance and surf smelt spawn in sand and gravel of the upper intertidal zone. Both species prefer shaded beaches with overhanging vegetation. Pacific herring use sub-tidal areas of the nearshore to lay eggs on marine vegetation such as eelgrass (Penttila, 2007).

Forage fish populations are sensitive to shoreline modifications and spawning status can be used to assess the health and productivity of the nearshore area. The recommended indicator for this KEA is the presence or absence of spawning. Data from WDFW surveys show small areas of sand lance and surf smelt spawning at the north end of Yukon Harbor near Manchester (Figure 3-14). There is no documented spawning in the nearshore areas close to the Curley Creek Estuary. Recent surveys by WDFW/Suquamish Tribe along Yukon Harbor beaches did not identify forage fish eggs (sand lance and surf smelt) during the October 2015 – June 2017 period; however, most of these surveys were not conducted during winter months when forage fish spawning may be more likely to occur in this area. The Forage Fish Spawning KEA was rated as "Poor".

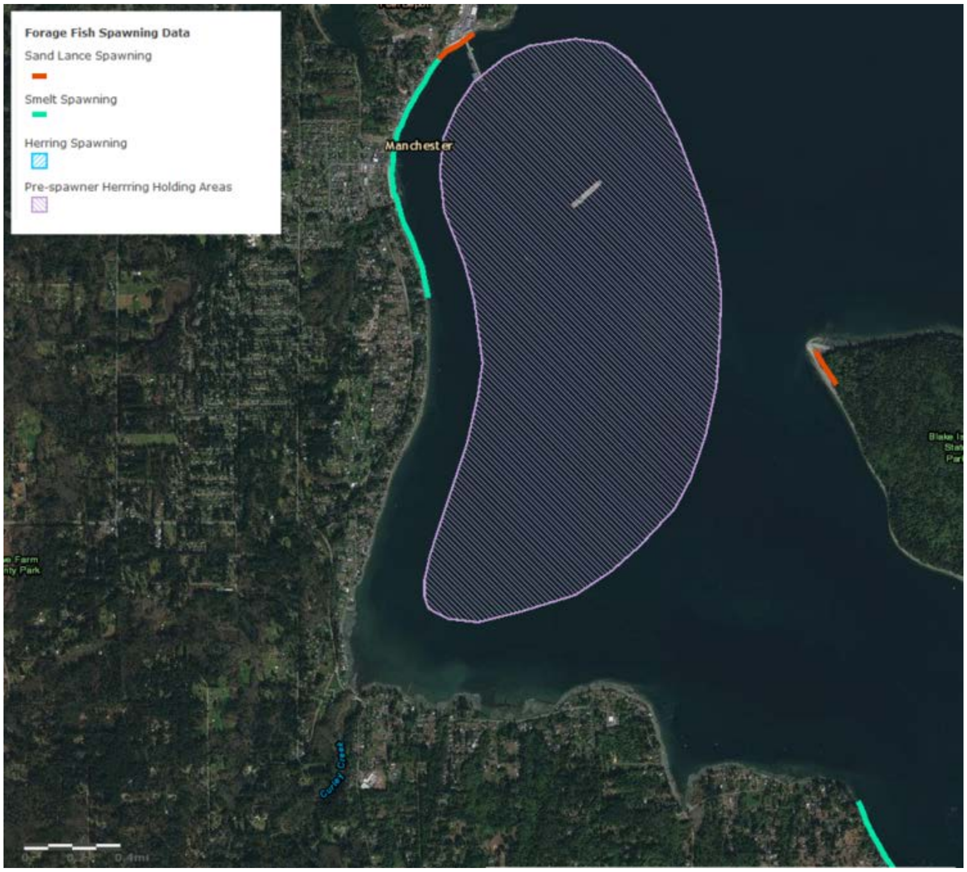

Figure 3-13. Forage fish spawning data in Yukon Harbor from WDFW.

3.4.6 *Condition Ratings*

Nearshore areas along Yukon Harbor have been heavily impacted by residential development. Condition ratings of KEA indicators are summarized below in Table 3-19.

Table 3-19. Condition ratings for indicators identified for Yukon Harbor KEAs.

KEA	Indicator	Poor	Fair	Good
Drift Cell Sediment Dynamics	% Shoreline Hardened			
Marine Riparian Vegetation	Species composition and extent of functioning riparian	*		
Submerged Aquatic Vegetation	Eelgrass spatial extent and patchiness	*		
Water Quality	Fecal Coliform Bacteria			
Forage Fish Spawning	Presence/Absence of Spawning			

4. ECOSYSTEM COMPONENT: SALMONID DISTRIBUTION AND POPULATION STATUS

This section summarizes existing information describing the life history characteristics, abundance, and distribution of the salmonid populations known to utilize habitat areas in the Curley Creek watershed. This information is used to infer status of the Salmonids Ecosystem Component in the Open Standards assessment.

Salmonid species and races known to occur in the Curley Creek watershed and addressed in this assessment are summer and fall chum (*Oncorhynchus keta*), coho (*Oncorhynchus kisutch*), fall Chinook (*Oncorhynchus tshawytscha*), steelhead trout (*Oncorhynchus mykiss*) and cutthroat trout (*Oncorhynchus clarki clarki*). Pink salmon (*Oncorhychus gorbuscha*) have also been observed, thought to be strays from other larger stream systems (J. Oleyar, pers. comm.).

Coho and chum are harvested in tribal treaty and non-treaty sport and commercial fisheries in marine waters. Harvest of Curley Creek coho and chum during “mixed-stock” fisheries, meaning fishing which harvests a mix of populations including Curley Creek populations. Total exploitation rates (fraction of fish harvested of the total run that would return to the river) are not known for Curley Creek chum and coho. There is a possibility that mixed stock fisheries targeting more abundant and productive populations may result in exploitation rates too high for weaker populations. Weaker populations are those, because of low quality habitat, have a low intrinsic productivity. One goal of this watershed plan is to identify habitat strategies to protect and improve habitat quality for chum and coho salmon, which will ensure Tribal fishers can continue to conduct their treaty right fisheries on more abundant populations in mixed stock fisheries.

The potential extent of fish habitat in the watershed is described as part of the WDNR forest practices water typing. However, Wild Fish Conservancy water type field assessments in nearby watersheds have found significant discrepancies between the WDNR water type maps and observed fish distribution from field surveys (Wild Fish Conservancy 2014). They reported from field assessments of 40 streams (205 km of streams) on the Kitsap Peninsula, of the 143 km of streams identified in the WDNR stream maps, 31 km of stream channels did not exist and found an additional 64 km of stream channels not on the official WDNR water type maps. These findings are not surprising given the extent of small, low gradient channels across the Kitsap Peninsula. We conclude that the WDNR stream typing maps are a conservative representation of fish habitat in the Curley Creek watershed.

Nevertheless, the available information provides some context of the extent of fish habitat in the watershed (Table 4-1). Type F streams (fish bearing) are “Streams and waterbodies that are known to be used by fish, or meet the physical criteria to be potentially used by fish. Fish streams may or may not have flowing water all year; they may be perennial or seasonal”. Across the three subbasins about half (23.4 km) of the mapped stream channels (43.23 km) are classified Type F. Based on field observations by the Wild Fish Conservancy for similar streams in Kitsap County we would conclude that is an underestimate of the true extent of fish bearing waters or potential fish bearing waters in the Curley Creek watershed. Specifically, it is likely adult coho would occupy smaller tributaries for spawning and juvenile coho would redistribute to small seasonal streams in the watershed during winter floods.

Known and potential (areas upstream of barriers) fish distributions are mapped for each species. These maps were reviewed by Suquamish Tribe Fisheries biologists and modifications noted based on their knowledge of the watershed. Species extent are classified by spawning and rearing, rearing and migration, and migration in the WDFW Salmonscape database. Mapped species extent are shown and discussed in detail in subsequent sections for each species.

Adult coho and chum salmon abundance indicators are based on index reach spawning surveys conducted annually in Curley, Salmonberry, and Cool creeks. Other information regarding these species' spatial distribution, juvenile abundance, and population productivity in Curley Creek is limited or non-existent. Much of the subsequent assessment and reporting of indicators by species is based on secondary information (suitability indicators such as stream size, confinement, gradient, water temperature, and location in the watershed) to infer population status.

Salmon and Steelhead Habitat Inventory and Assessment Project (SSHIAP) classifications of stream gradient and confinement characteristics in Curley Creek provide one set of indicators of habitat suitability for salmon and steelhead. However, the SSHIAP database covers just 63%, 52%, and 71% of the Curley Creek, Long Lake, and Salmonberry subbasin WDNR mapped stream channels, respectively. The Curley Creek subbasin stream reaches are a mix of low and moderate gradient channels across a range of confinement classifications (Table 4-2). Tributaries flowing into Long Lake tend to be steeper and more confined. A majority of the stream reaches in the Salmonberry Creek subbasin are less than 1% gradient and 49% of the reaches are unconfined.

Table 4-1. Curley Creek Drainage Network. Values in parenthesis are percentage of total stream network within the subbasin (sources: WDNR stream type, 2016, WDFW Salmonscape, 2016, and updates from the Suquamish Tribe Fisheries Department).

Stream Variables (km)	Curley Creek and Tributaries	Tributaries flowing into Long Lake	Salmonberry Creek and Tributaries	Curley Creek Watershed Total
Total stream network	18.56	6.63	18.04	43.23
WDNR Type F Streams	8.26 (44%)	3.5 (53%)	11.6 (64%)	23.4 (54%)
WDNR Type N Streams	9.14 (49%)	3.1 (47%)	5.7 (32%)	17.9 (41%)
Unknown	1.16 (6%)	0 (0%)	0.7 (4%)	1.9 (4%)

Table 4-2. Curley Creek Stream Gradient and Confinement Characteristics. Values in parenthesis are percentage of total stream network assessed for confinement and gradient in the subbasin (source: SSHIAP database, 2016).

Subbasin	Gradient <1%	Gradient 1% to2%	Gradient 2% to 4%	Gradient 4% to 8%	Gradient >8%
Curley Creek and Tributaries – total stream length 11.61 km					
Unconfined	1.35 (12%)	0.48 (4%)	0.77 (7%)	0.00 (0%)	0.00 (0%)
Moderately Confined	1.55 (13%)	1.05 (9%)	0.00 (0%)	0.00 (0%)	0.00 (0%)
Confined	1.13 (10%)	1.88 (16%)	0.67 (6%)	1.89 (16%)	0.84 (7%)
Tributaries flowing into Long Lake – total stream length 3.47 km					
Unconfined	0.23 (7%)	1.46 (42%)	0.27 (8%)	0.00 (0%)	0.00 (0%)
Moderately Confined	0.00 (0%)	0.00 (0%)	0.00 (0%)	0.00 (0%)	0.00 (0%)
Confined	0.00 (0%)	0.00 (0%)	0.00 (0%)	0.21 (6%)	1.30 (37%)
Salmonberry Creek and Tributaries – total stream length 12.85 km					
Unconfined	6.34 (49%)	2.18 (17%)	0.00 (0%)	0.00 (0%)	0.00 (0%)
Moderately Confined	1.63 (13%)	0.38 (3%)	0.00 (0%)	0.00 (0%)	0.00 (0%)
Confined	0.35 (3%)	0.00 (0%)	0.00 (0%)	1.40 (11%)	0.56 (4%)

4.1 Coho Salmon

Coho salmon are most often associated with small streams and rivers and use a wide variety of habitat during their freshwater residence (Sandercock 1991). Coho are assumed to be widely distributed in the Curley Creek Watershed, and likely occupy most Type F streams in the watershed (Figure 4-1).

Based on spawning ground surveys for the last several decades, adult coho salmon appear to be the most abundant salmonid in the Salmonberry subbasin (Table 4-3 and Table 4-4). Coho use in the Curley Creek subbasin is mostly as a migratory pathway to spawning and rearing habitat in Salmonberry Creek. Coho presence and seasonal use in Long Lake and tributaries to Long Lake is not known.

Coho abundance in the watershed was likely much greater in pre-settlement times when floodplain habitat in the Salmonberry and upper Curley Creek subbasins was more abundant and well connected with mainstem habitats. Presumably, an abundance of beaver in the watershed would have created extremely productive pond and wetland rearing conditions for coho within Salmonberry Creek and in Curley Creek downstream of Long Lake to Sedgewick Road. In addition, Long Lake and adjacent low gradient and wetland habitats would have provided abundant over-winter rearing habitat for juvenile coho.

4.1.1 Coho Life History

Puget Sound coho have a three year life cycle. Generally, juvenile coho spend one year in freshwater before migrating to sea in the spring. Recent studies indicate a more complex suite of life history patterns for coho, including the use of estuarine habitat or direct seaward migration by 0 age coho. Koski (2009) reviewed several studies to better understand the role that these "nomadic" coho play in population resiliency, and suggests that estuarine habitats may have a significant role in the recovery of depressed coho populations. Miller and Sadro (2003) reported spring movement of 0 age coho to downstream estuarine habitats for a coastal Oregon stream, where most fry resided through the summer and returned upstream to freshwater to overwinter. Roni, Bennett et al. (2012) reported juvenile coho leaving a Strait of Juan de Fuca stream in the fall of their first year. They reported that over 50% of the juveniles from a given brood year were fall migrants (migrated to sea between early October and end of December).

Puget Sound coho typically spend one year at sea before returning to spawn in the fall and early winter. Curley Creek coho river entry timing is from early/mid-October to early December. Spawning occurs from November to January, with peak spawning from late-November to mid-December (Suquamish and WDFW unpublished spawning ground survey data).

Juvenile coho may remain close to their natal site throughout their freshwater residence or they may move in the spring or fall to find suitable summer or overwinter habitat. Fry dispersal to downstream areas is a common pattern seen across the range of the species (Sandercock 1991). Fall movement of fingerlings is in response to fall freshets and cooler temperatures to seek more suitable overwinter habitat, particularly floodplain channels, wetlands, and ponds. Armstrong and Schindler (2013) summarized studies of movements of juvenile coho across a range of habitats to maximize foraging opportunities and bioenergetics in Southwest Alaskan streams.

These life history patterns and other reported patterns of movement in freshwater (Lestelle et al. 1993) highlight the importance of diverse high quality habitat for coho salmon throughout the Curley Creek watershed.

Throughout their freshwater residence coho are strongly associated with slow water and areas with high channel complexity and physical cover (in-channel wood, vegetated banks, and side channels). Sandercock (1991) summarized a variety of studies that showed the effects of low and high flow on coho survival.

Summer low flow is found to be a significant limiting factor for coho smolt production in Puget Sound streams (Zillges 1977). Low flow affects the quantity of habitat in the stream, and is also correlated with increased water temperature and potentially greater competition and predation with other salmonids. High winter flows can displace juvenile coho and disrupt habitats essential to coho survival. High quality overwinter habitats include streams with ponds adjacent to the channel, slow moving side channels, backwater pools, and beaver ponds. Long Lake also may be an important overwinter habitat as evidenced by WDFW observations from Lake Symington on Big Beef Creek (Baranski 1989) and Suquamish Tribe smolt trap observations (2011-2017) on Wildcat Creek/Chico Creek system downstream of Wildcat Lake (J. Oleyar, pers. comm.).

Numerous studies have documented predation effects of black basses (*Micropterus* spp.) in streams and lakes in the Pacific Northwest (for example, see Tabor et al. 2007). The predicted high predation levels on juvenile coho in Long Lake reported by Bonar et al. (2005) is likely another significant factor affecting freshwater production from Curley Creek.

4.1.2 Coho Abundance

The abundance of adult coho in the Curley Creek watershed is based on a coho index survey reach in Salmonberry Creek (RM 1.6 to 2.1 – approximately Sedgwick Road to S.E. Salmonberry Road) surveyed by WDFW. The Suquamish Tribe conducts surveys for summer chum in Curley Creek (mouth to RM 1.9 – approximately Sedgwick Road) and also reports counts of live and dead coho observed during the surveys. The Tribe also conducts surveys in a reach of Cool Creek (tributary to Salmonberry Creek) to supplement coho abundance information for the watershed.

Survey data reported are based on the WDFW spawning ground survey database provided to the Suquamish Tribe and additional data collected by the Tribe in Cool Creek from 2011 to 2016.

Although these are imperfect measures of abundance and inter-annual trends in abundance, the surveys are useful indicators of patterns of annual abundance and origin (i.e., wild or hatchery) in the watershed. Survey date of peak live count is also reported as an approximation of adult timing in the watershed. Mark status (adipose fin clip or coded wire tag [CWT])) to indicate natural or hatchery origin has been collected from dead fish consistently since 1998 in the Curley Creek index reach.

Time of surveys differ for the three survey reaches. The Curley Creek reach targets summer chum spawning with surveys conducted from early October to mid-November. The Salmonberry index reach and Cool Creek survey reach targets coho salmon and surveys are conducted from late October to early January.

Annual peak live counts from the Curley Creek survey reach likely includes coho migrating to the Salmonberry subbasin. Cumulative counts of dead coho in this reach provide a minimum estimate of coho spawning in Curley Creek and mark sampling a measure of origin of these fish. WDFW generates a watershed wide estimate of coho adult abundance based on the Salmonberry Creek index reach using season live and dead counts and an expansion formula. The Cool Creek survey by the Suquamish Tribe provides an index of coho use and origin in this important tributary to Salmonberry Creek.

For the Curley Creek reach, peak live counts of coho from 1995 to 2016 ranged from 4 to 1,279 fish (Table 4-3). Timing of peak live count ranged from late October to early November. From 1998 to 2016, 700 dead coho were sampled for marks. The proportion with an adipose fin clip or CWT ranged from 0% to 80% (average 35%). By far the largest sample was in 2004 when 433 dead coho were sampled and 69% were marked hatchery origin. In 2004 the tribe recovered 23 CWTs from coho in the reach, all from net pen releases in Puget Sound.

For the Salmonberry Creek index reach, the peak live count of coho from 1995 to 2015 ranged from 20 to 290 fish (Table 4-4). Season cumulative dead counts ranged from 8 to 409 fish. Timing of peak live count tended to be two to three weeks later compared to the Curley Creek survey reach, ranging from early November to early December. However, there were several years when peak live count was the same in the two reaches. Mark proportion (adipose fin clip or CWT) data are reported for 2002 to present. During this period 1,467 coho were sampled for marks. Marked fish ranged from 0% to 53% of the fish sampled (average 11%). Inter-annual variation in peak live counts tended to be similar for the two survey reaches, the exception being 2004 when adult coho from the net pens flooded into the Curley Creek survey reach.

For the Cool Creek survey reach, the peak live count of coho from 2002 to 2015 ranged from 0 to 107 coho (Table 4-4). Season cumulative dead counts ranged from 5 to 263 fish. Timing of peak live count tended to be similar or slightly later to timing in the Salmonberry survey reach, ranging from mid-November to mid-December. From 2002 to 2015 1,226 coho were sampled for marks. Mark proportion (adipose fin clip or CWT) ranged from 0% to 48% of the coho sampled (average 9%). The highest mark proportions were 2004 and 2005.

The Washington Department of Fish and Wildlife (WDFW) released coho that were produced from Minter Creek Hatchery into many Puget Sound streams, including Curley Creek (Table 4-6; source: WDFW fish stocking database, 2016). The database reports coho salmon smolts were released in 1971 and 1973. Reported coho salmon releases from 1977 to 1998 were fry released in March, April or May. These were fry at approximately 1 gram in size released in the spring that would have migrated to sea the following spring. The location of release was not reported. Contribution of these releases to adult return was likely low compared to larger and older coho released in the 1960s and 1970s.

Reported CWT recoveries from mark sampling is spotty (Regional Mark Information System query, June 2017). No CWT recoveries are reported from the Salmonberry survey reach. Reported CWT recoveries by year and hatchery origin from Curley Creek and Cool Creek are as follows:

Curley Creek:

- 2003, 1 coho, origin: Elliot Bay Tribal Net Pens
- 2004, 22 coho, origin: Manchester Fuel Depot Net Pens; 1 coho, origin: Peale Passage Net Pens (South Sound)
- 2005, 1 coho, origin: Peale Passage Net Pens (South Sound)
- 2013, 1 coho, origin: Elliot Bay Tribal Net Pens
- 2014, 1 coho, origin: Agate Passage Net Pens

Cool Creek:

- 2003, 1 coho, origin: Agate Passage Net Pens
- 2005, 1 coho, origin: Minter Creek Hatchery
- 2009, 1 coho, origin: Elliot Bay Tribal Net Pens
- 2014, 1 coho, origin: Agate Passage Net Pens

Hatchery origin coho observed in the Curley Creek index reach in recent years are originating from hatchery releases outside of the basin and are of concern. The large number of coho recovered in Curley Creek in 2004 was from a one-time release of coho from net pens at the Navy Manchester Fuel Depot. The percentage coho of known hatchery origin (marked) has been lower in recent years in the three survey reaches, but still exceeds the 5% management criteria suggested by the HSRG to prevent the loss of local adaptation in the population and maintain population fitness.

Table 4-3. Adult Coho Salmon Season Peak Live Counts and Season Cumulative Dead Count in Curley Creek, RM 0 to 1.9; mouth to approximately Sedgwick Road (sources: Suquamish Tribe and WDFW, unpublished data).

Run Year	Peak Live Count	Date Peak Live Count	Season Cumulative Dead Count	Dead Count Sampled	Percent Dead Adipose Fin Clip or CWT Marked
1995	10	11/15/1995	1		
1996	4	10/15/1996	1		
1997	8	11/18/1997	7		
1998	40	10/30/1998	6	3	67%
1999	15	11/3/1999	4	3	33%
2000	240	10/31/2000	22	21	71%
2001	224	11/9/2001	14	14	29%
2002	175	11/11/2002	9	9	22%
2003	93	11/3/2003	23	23	39%
2004	1,279	11/19/2004	439	433	69%
2005	329	11/17/2005	89	82	80%
2006	426	10/31/2006	13	11	18%
2007	224	11/7/2007	16	16	13%
2008	273	10/28/2008	11	11	0%
2009	211	11/3/2009	4	4	25%
2010	39	10/19/2010	1	1	0%
2011	561	11/3/2011	15	15	53%
2012	280	10/24/2012	4	4	25%
2013	890	10/31/2013	24	24	38%
2014	216	11/3/2014	21	21	19%
2015	47	11/6/2015	5	5	20%
2016	Not Available				

Table 4-4. Adult Coho Salmon Season Peak Live Count, Season Cumulative Dead Count and Percent Marked in Salmonberry Creek Index Reach RM 1.6 to 2.1; approximately Sedgwick Road to S.E. Salmonberry Road (sources: Suquamish Tribe and WDFW , unpublished data).

Run Year	Peak Live Count	Date Peak Live Count	Season Cumulative Dead Count *	Dead Count Sampled	Percent Dead Adipose Fin Clip Marked or CWT
1995	103	11/14/1995	76	0	NA
1996	88	12/3/1996	73	0	NA
1997	90	11/6/1997	206	0	NA
1998	45	11/19/1998	15	0	NA
1999	50	11/17/1999	29	0	NA
2000	95	12/4/2000	82	0	NA
2001	166	11/18/2001	196	0	NA
2002	115	11/22/2002	76	76	17%
2003	184	11/24/2003	144	144	4%
2004	221	11/19/2004	409	409	11%
2005	155	11/15/2005	135	95	53%
2006	147	11/9/2006	70	51	6%
2007	54	11/19/2007	20	15	13%
2008	163	11/10/2008	102	93	1%
2009	72	11/13/2009	55	45	4%
2010	24	11/4/2010	8	6	0%
2011	155	11/28/2011	88	83	12%
2012	107	11/27/2012	44	29	17%
2013	290	11/15/2013	313	282	13%
2014	123	11/7/2014	149	130	9%
2015	20	11/23/2017	17	9	0%
2016	Not Available				

Table 4-5. Adult Coho Salmon Season Peak Live Count, Season Cumulative Dead Count and Percent Marked in Cool Creek Survey Reach; mouth of Cool Creek (RM 0) to 0.8 (well upstream of Philips Rd) (source: Suquamish Tribe, unpublished data).

Run Year	Peak Live Count	Date Peak Live Count	Season Cumulative Dead Count	Dead Count Sampled	Percent Dead Adipose Fin Clip or CWT Marked
2002	23	11/15/2002	9	4	0%
2003	107	11/29/2003	73	73	22%
2004	88	12/4/2004	168	153	26%
2005	97	11/7/2005	186	185	48%
2006	39	11/13/2006	48	48	4%
2007	38	11/19/2007	16	14	0%
2008	9	11/21/2008	64	61	0%
2009	35	11/23/2009	47	46	7%
2010	24	12/1/2010	8	6	0%
2011	84	12/1/2011	96	92	7%
2012	95	11/28/2012	102	101	6%
2013	88	12/3/2013	263	261	3%
2014	84	11/24/2014	179	179	3%
2015	0		5	3	0%
2016	Not Available				

Table 4-6. Release of Hatchery Produced Coho Salmon into Curley Creek (source: WDFW fish stocking database, 2016).

Release Year	Number Released	Size at Release (g)	Stage at Release	Month Released
1971	12,033	21.6	Smolt	April
	130,152	0.4	Fry	April
1972	No Release			
1973	12,000	17.4	Smolt	March
1974	No Release			
1975	195,800	0.6	Fry	April
1976	No Release			
1977	116,480	0.3	Fry	March
1978	53,400	1.7	Fry	March
1979	68,475	0.8	Fry	May
1980	56,200	0.8	Fry	April
1981	60,480	0.9	Fry	April
1982	49,260	0.6	Fry	April
1983	123,900	2.1	Fry	February & June
1984	195,500	1.0	Fry	April
1985	57,700	1.0	Fry	April
1986	105,400	1.1	Fry	April
1987	25,900	0.8	Fry	April
1988	37,300	1.2	Fry	March
1989	148,400	1.3	Fry	March
1990	64,600	0.7	Fry	April
1991	27,900	0.8	Fry	May
1992	100,900	0.7	Fry	March - April
1993	115,200	0.4	Fry	March
1994	35,400	0.5	Fry	March
1995	35,100	1.2	Fry	May
1996	23,307	1.0	Fry	March
1997	22,648	0.8	Fry	March
1998	19,800	1.1	Fry	March

4.1.3 Coho Distribution

Historic coho distribution was likely throughout the watershed, including tributaries to Long Lake, Curley Creek, and multiple low gradient floodplain tributaries to Salmonberry Creek. Steeper stream gradients would have limited coho distribution in some of the upper portions of tributaries. See Figure 4-1 for mapped presumed potential and known distribution of coho salmon and identified barriers to migration. The following sections are summaries of adult and juvenile coho salmon distribution based on conversations and unpublished data provided by the Suquamish Tribe and other sources.

Curley Creek (Mouth to Long Lake)

The moderate stream gradient and pool-riffle combination of Curley Creek includes suitable spawning and rearing habitat for coho salmon.

Channel confinement in lower Curley Creek suggests that fall and winter freshets might displace some juvenile coho downstream. However, the moderating influence of Long Lake on peak flows may lessen effects of flow on juvenile displacement. Curley Creek is considered an important area supporting the entire freshwater lifecycle.

Temperature during the summer is likely a factor affecting coho productivity and abundance in Curley Creek. Water temperature monitoring by the Suquamish Tribe found Curley Creek exceeded the Washington State Water Quality standard 7-day average daily maximum (7DADM) of 16C from June 15-September 15 for 'Core Summer Habitat' designated streams under WAC 173-201A-600 in all years of monitoring and over 90% of the days (Suquamish Tribe, unpublished data). Water temperatures in Curley Creek are affected by warming in Long Lake and moderated through lower Curley Creek by inflows and higher quality riparian shading.

Tributary streams to Curley Creek are not monitored for temperature. These streams are likely cooler during the summer months relative to Curley Creek and may provide thermal refuge for juvenile coho during the summer.

Long Lake Tributary Streams and Long Lake

Streams flowing into Long Lake, other than Salmonberry Creek, are small and are not surveyed for adult coho. It is likely these streams are impacted by residential development. Upper Curley Creek on the south end of the lake may still provide higher quality spawning habitat for coho in the lower portion of the creek, downstream of the barrier on Mullenix Rd. The creek is steep through the middle section which may limit adult coho movement into the less steep upper portion of the creek.

Two unnamed creeks enter the south end of Long Lake through a low gradient marshy area that has the potential to be high quality juvenile habitat. Sections of these creeks are moderately steep possibly limiting coho extent. Portions of these streams may provide suitable spawning habitat for coho. The lower sections likely provide high quality over-winter habitat for juvenile coho.

Shallow, vegetated shoreline margins of Long Lake would have historically provided important habitat for newly emerged coho fry moving into the lake from tributary spawning areas. The amount of shoreline armoring evident from aerial photos suggests that much of this shallow, littoral habitat has been lost in the lake. Bonar et al (2005) noted coho were not captured in Long Lake during the summer and early fall, likely related to higher water temperature and predation from non-native largemouth bass. They reported most coho observed were migrating smolts or newly emerged fry in the spring. Long Lake is shallow and summer water temperatures are likely too warm through the entire water column to support coho. The small creeks flowing into Long Lake would have historically provided summer thermal refuge to juvenile coho during periods when temperatures were not suitable to juvenile coho in the lake. These tributaries may still provide cool water refuge for coho, provided juveniles can access the streams and water temperatures are cool. Cooler, groundwater seeps into Long Lake may also provide additional thermal refuge for coho during the summer.

Long Lake would have historically, and may still, provide good over-winter habitat for juvenile coho. It is likely that juvenile coho disperse to Long Lake in the fall and early winter. Shoreline bank modifications, overwater structures (e.g., docks), and loss of shoreline vegetation has likely reduced the habitat potential of Long Lake for over-wintering coho.

Salmonberry Creek Subbasin

Historically, Salmonberry Creek would have provided excellent summer and winter rearing habitat for juvenile coho. Coho fry would have moved into the low gradient and unconfined portions of the creek from tributaries and mainstem portions of the watershed with suitable spawning habitat. Salmonberry Creek is still the more suitable coho rearing habitat in the Curley Creek watershed. However, as reported elsewhere in this report, portions of Salmonberry Creek have been impacted by historic conversion of wetlands to agriculture, and removal of beaver and wetland/pond habitats. For example, the WDFW spawning ground survey reach in Salmonberry Creek is immediately upstream of a degraded section of Salmonberry Creek just upstream of the confluence with Cool Creek. This section of the creek was ditched, and associated wetlands cleared and drained for agriculture and eventually a golf course was developed (that is no longer in operation). Just downstream of this section is likely the highest quality wetland habitat in Salmonberry Creek associated with the confluence with Cool Creek.

Adult survey counts from Cool Creek indicate this is an important tributary for coho spawning and likely rearing. Coho counts from the Cool Creek survey reach are comparable to coho counts from the Salmonberry Creek survey reach.

4.1.4 KEA Assessment – Coho Salmon

The KEA assessment includes six broad indicators recommended for coho (Table 4-7). Data gaps are significant when evaluating coho status across the entire watershed. However, survey data from Curley Creek, Salmonberry Creek, and Cool Creek provide a good indicator of coho abundance and distribution across the watershed and the level of hatchery influence on the population. The planned smolt trap in lower Curley Creek will provide an important indicator of juvenile freshwater coho abundance and freshwater productivity for the watershed.

Abundance data is the primary quantitative data available for evaluation of coho salmon condition. Live and dead counts from the Salmonberry Creek index reach suggest a variable population, but the data series does not suggest a declining trend in abundance. The higher peak live counts observed in Salmonberry Creek index reach plus the high counts in Cool Creek suggests coho abundance is moderate to high in Salmonberry Creek. The average peak live count from 2000 to 2015 for the half mile Salmonberry index reach was 131 coho, or 260 coho per mile. Coho abundance was rated as "Fair" for the watershed. The Curley Creek watershed has several features (low gradient channels, flooded wetlands, Long Lake, and enough moderate gradient stream channels for spawning) that suggest historically the Curley Creek watershed produced many more coho than currently observed.

The contribution of hatchery fish to natural spawning based on mark recoveries in Salmonberry and Curley creeks exceeds the criteria of less than 5% contribution recommended by the Hatchery Scientific Review Group for an independent population (HSRG 2014). CWT recoveries suggest hatchery fish are originating from hatchery net pen programs in Central Puget Sound (Agate Pass and Elliot Bay) and South Puget Sound

(Peale Passage). Hatchery influence was rated as "Poor" for the watershed based on the high proportion of marked fish observed in the Salmonberry index reach. The high proportion of marked fish in some years in Cool Creek indicates hatchery coho are moving high into the watershed presumably in search of suitable spawning habitat.

An evaluation of other indicators for freshwater production (smolt abundance and spawner to smolt productivity) and spatial diversity is not possible with the limited data. The Suquamish Tribe is developing a smolt trap monitoring project in lower Curley Creek that will provide an indicator of smolt abundance and spawner to smolt productivity.

Table 4-7. KEA Assessment Summary for Coho Salmon.

Component: Salmonids		
KEA	**Indicator(s)**	**Indicator Description**
Coho Salmon	Adult Abundance	Annual estimates of coho spawning abundance in watershed
	Smolt Abundance	Annual estimates of coho smolt abundance from watershed
	Adult to Adult Productivity	Population brood year spawner to spawner ratio
	Adult to Smolt Productivity	Population brood year spawner to smolt outmigrant ratio
	Spatial Diversity	Adult survey reaches in Curley Creek, Salmonberry Creek and Cool Creek to monitor coho use of lower and upper portions of watershed; consider supplemental surveys in other sections of Salmonberry Creek and key tributaries to determine coho presence in other portions of the watershed.
	Hatchery influence	Monitor percent adipose fin clipped in natural spawning in survey reaches. Sample all dead fish for CWTs, make annual estimates of proportion hatchery origin spawners (pHOS) by survey reach and across watershed.

Supporting Information	
Peak live adult counts and season cumulative dead counts	Live and season cumulative carcass counts from annual spawning ground survey conducted by Suquamish Tribe and WDFW survey index reaches
Percent marked (adipose fin clipped or CWT) in natural spawning	Season dead coho mark sampling and number with intact adipose fin and no coded wire tag

Data Gaps	
Live Counts	Survey timing Curley Creek survey reach targeting summer chum salmon spawning and may not extend late enough to cover complete coho spawning period
Mark Sampling	Salmonberry index survey reach does not include CWT recoveries from dead coho, mark sampling indicates high proportion of marked coho in survey reach, lack of CWT data does not allow a means to assess hatchery programs contributing to natural spawning in Salmonberry Creek.
Total Coho Escapement	The Salmonberry Creek index count is expanded to estimate total natural spawning in watershed based on a historic abundance estimate. Survey methodology and expansion method should be reviewed and updated to better estimate to total abundance (possible intensive and extensive survey reaches, redd counts, and evaluation of fish life to expand live counts).

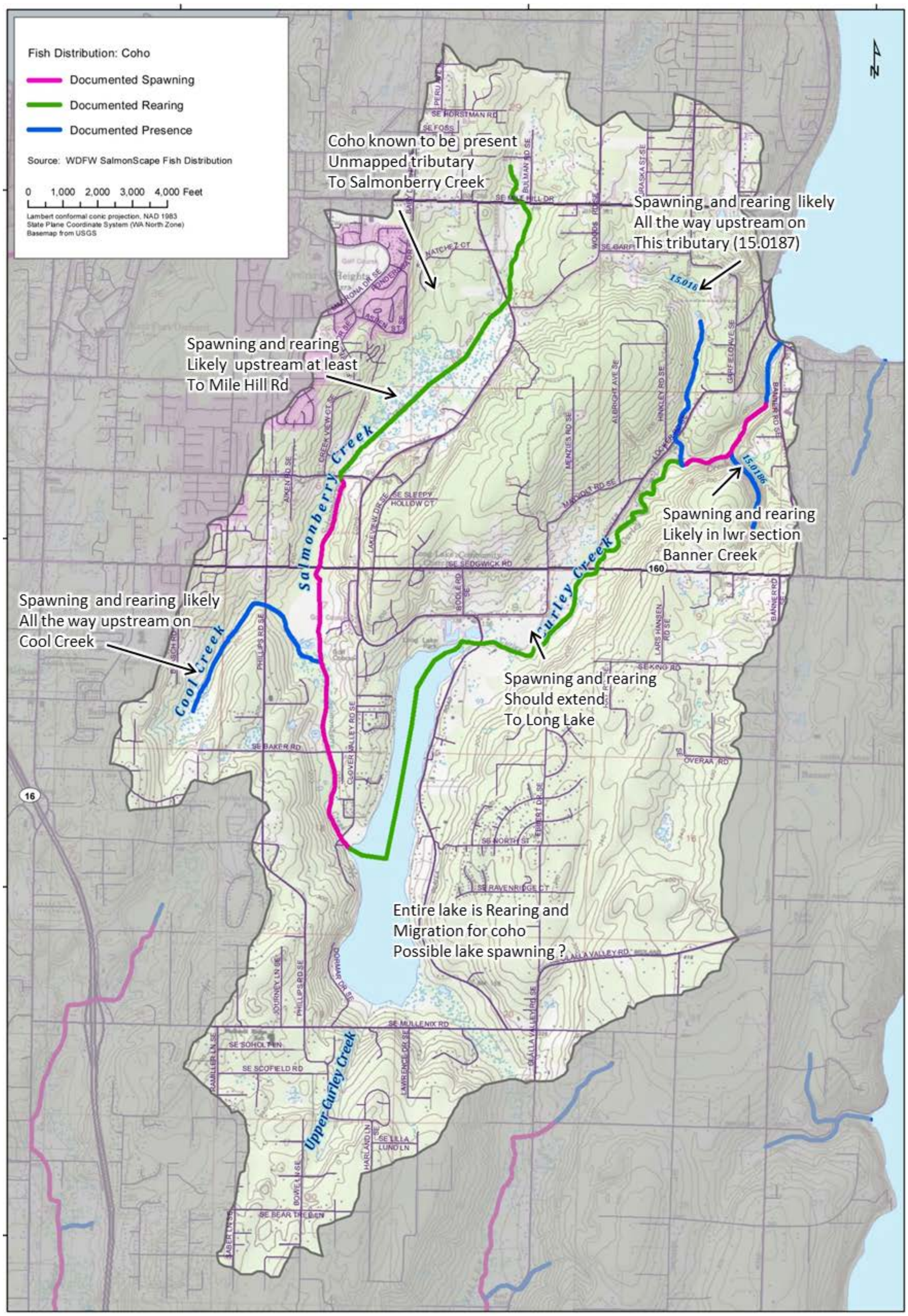

Figure 4-1. SalmonScape fish distribution for coho salmon (source: WDFW 2006) with annotated notes from Suquamish Tribe Fisheries.

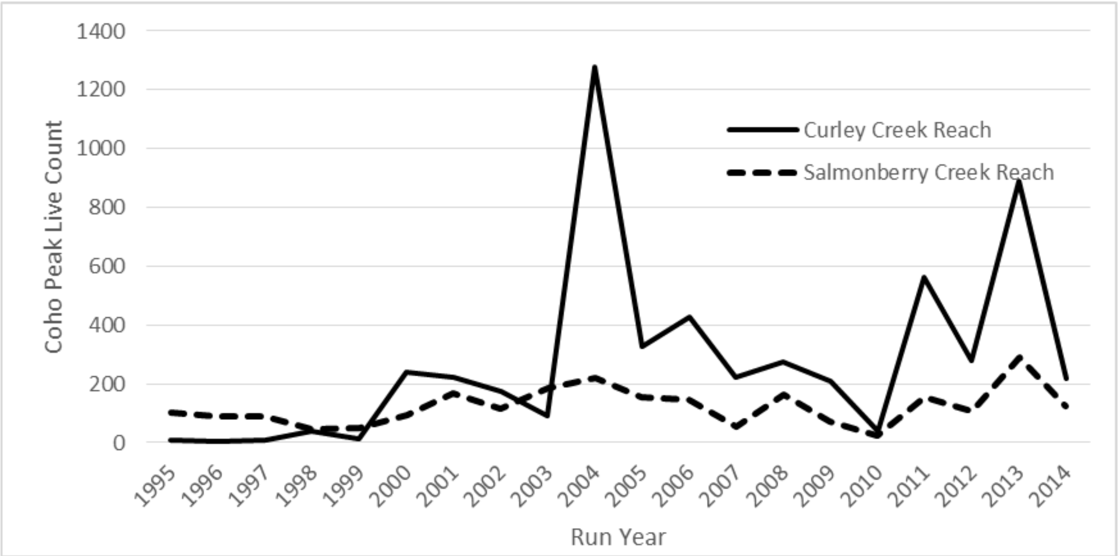

Figure 4-2. Peak Coho Live Counts in Curley Creek and Salmonberry Creek Survey Reaches (sources: WDFW and Suquamish Tribe, 2016).

4.2 Chum Salmon

Chum salmon are the most abundant salmon species in the Curley Creek watershed. Chum salmon in Curley Creek include a summer run and less abundant late fall run. The summer run population in Curley Creek is part of a summer chum group that includes Blackjack Creek and is not included with the Hood Canal ESU listed under ESA.

Chum salmon are not as widely distributed in Curley Creek as coho (Figure 4-3). They occupy the mainstem of Curley Creek, lower portions of the larger tributaries, and the lower portions of Salmonberry Creek and Cool Creek.

The Suquamish Tribe has an index survey reach in Curley Creek from which they make an estimate of total summer chum abundance in Curley Creek.

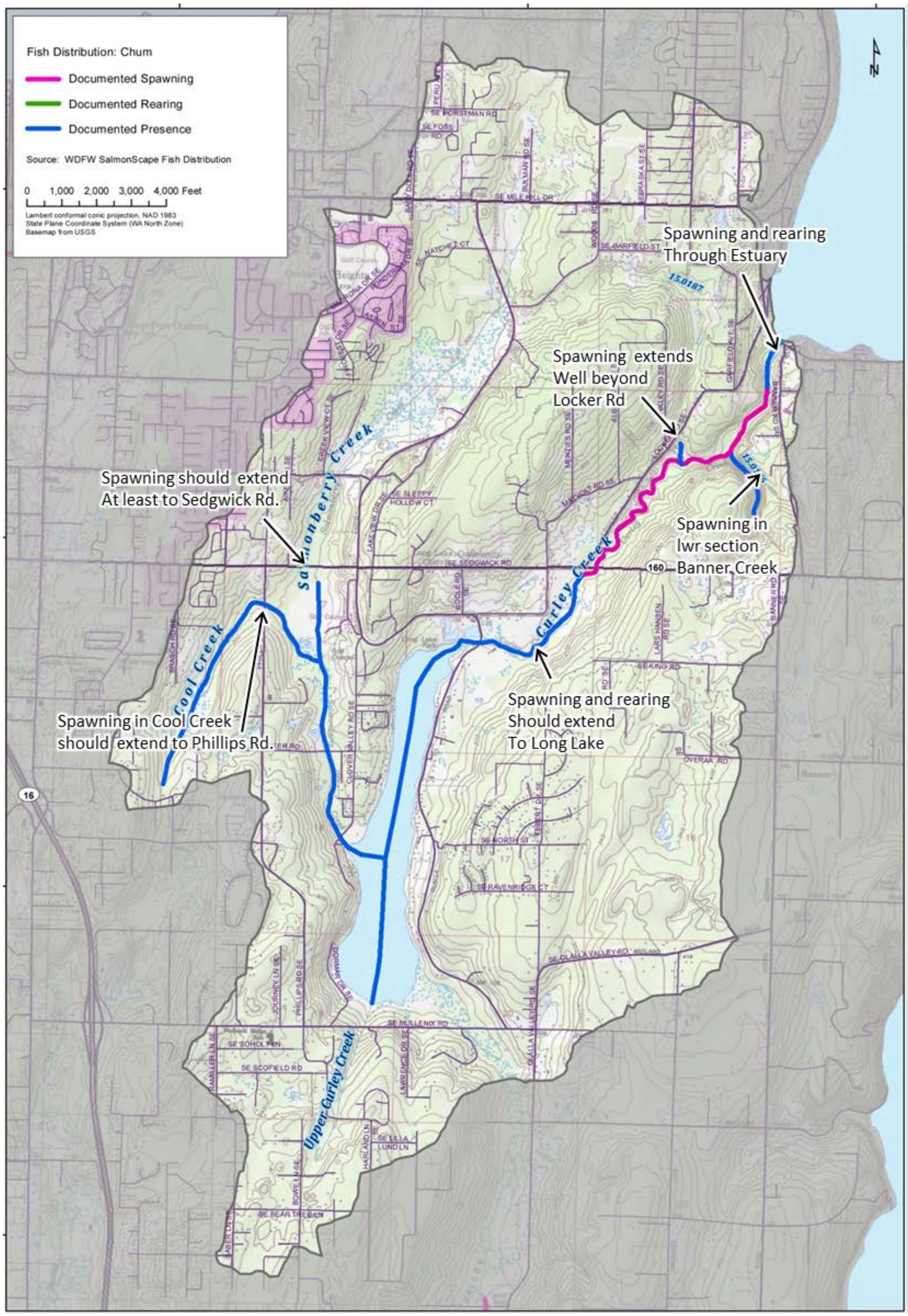

Figure 4-3. SalmonScape fish distribution for chum salmon (source: WDFW 2006) with annotated notes from Suquamish Tribe Fisheries. Potential for chum presence in Salmonberry Creek to Mile Hill Road (pers. comm. Zack Holt, City of Port Orchard).

4.2.1 Chum Life History

Chum salmon have a very short freshwater residency, typically migrating to sea soon after emergence. Their ocean residence can range from two to four years for a total age at return from three to five years. Within Puget Sound there are three races of chum salmon: summer, fall, and winter, based on their river entry and spawn timing. Fall chum are the most numerous and widespread race of chum in Puget Sound. Summer chum occur in several Hood Canal streams, a few streams along the eastern portion of the Strait of Juan de Fuca, and in Blackjack, Curley, and Ollala creeks along the east side of the Kitsap Peninsula (Kassler and Shaklee 2003). Winter chum are most common in the Nisqually River.

The Curley Creek spawning ground survey is timed to coincide with summer chum spawning from first week of October (year week 40) to mid-November (year week 47) (Figure 4-4). Peak live counts in the Curley Creek index reach range from late October to early November (weeks 44 & 45) (Table 4-8). The sporadic observations of chum spawning in Salmonberry Creek tend to be in November (Table 4-9). However, the Salmonberry survey reach is targeting coho spawning and the first survey is the last week of October or first week of November.

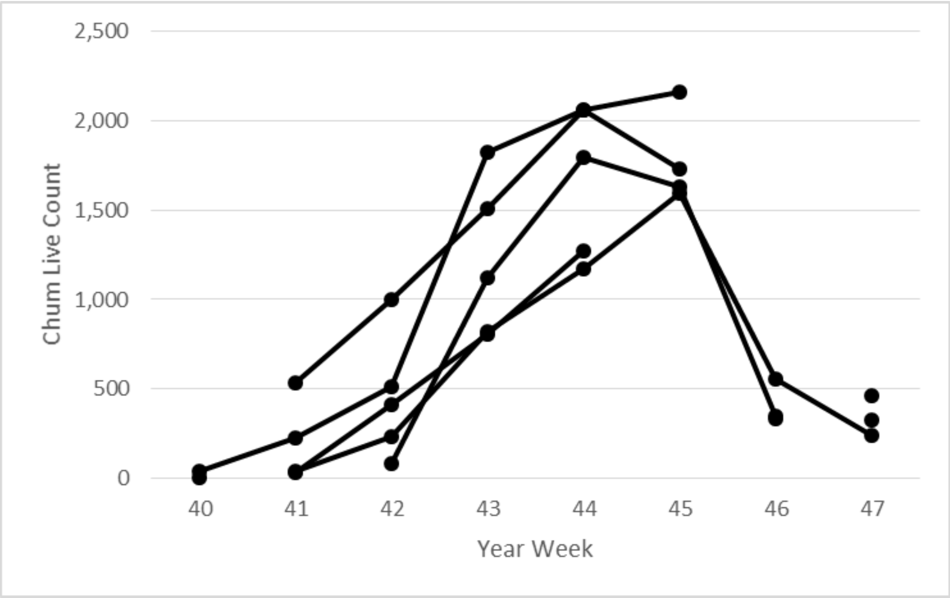

Figure 4-4. Live Chum Counts Curley Creek 2007 to 2011.

Little is known about timing of chum fry emergence in Curley Creek. Data from other watersheds in Puget Sound suggest that most chum salmon fry move quickly out of the system after emergence (Simenstad 2000). Once chum fry leave Curley Creek, it is assumed that they follow patterns observed for other chum populations and inhabit shallow nearshore areas and non-natal estuaries until they reach a larger size at which time they tend to move into deeper offshore waters (Salo 1991, Simenstad 2000).

Historically, summer chum salmon distribution in the watershed may have been limited by beaver dams. The timing of summer chum adult migration in September prior to onset of the fall rains would have made migration upstream of beaver dam complexes particularly difficult, since chum are less willing to migrate past migration barriers compared to other salmonids (Salo 1991).

Degraded habitat conditions that affect chum salmon productivity and abundance in the Curley Creek watershed include degraded and reduced quantity of riffle and glide spawning habitat (substrate size, mobility, and quantity of fine sediment) impacting egg incubation survival and capacity. The modified channel and loss of floodplain habitat in Curley Creek between Sedgwick Road and Long Lake likely has impacted chum salmon in Curley Creek.

4.2.2 Chum Abundance

The abundance of adult chum in the Curley Creek watershed is based on Suquamish Tribe spawning survey index reach in Curley Creek (mouth to RM 1.9 – approximately Sedgwick Road). Curley Creek supports one of the largest summer chum populations in West Puget Sound (Table 4-8). Average escapement of chum salmon to Curley Creek from 1980 to 2016 is 2,808 fish (Suquamish Tribe and WDFW unpublished data provided by J. Oleyar, July 20, 2017).

For the Curley Creek index reach the peak live count of chum from 1980 to 2015 ranged from 42 to 2,636 fish, and season cumulative dead counts from 28 to 7,589 fish (Table 4-8). Adult survey length varied across the years, so live and dead counts per mile were calculated to track trends in chum salmon abundance. Timing of peak live count ranged from late October to early November.

Chum salmon abundance has increased by 2 to 3 fold during the survey period (Figure 4-5). This trend matches that reported for Blackjack Creek by WDFW and South Puget Sound chum salmon in general.

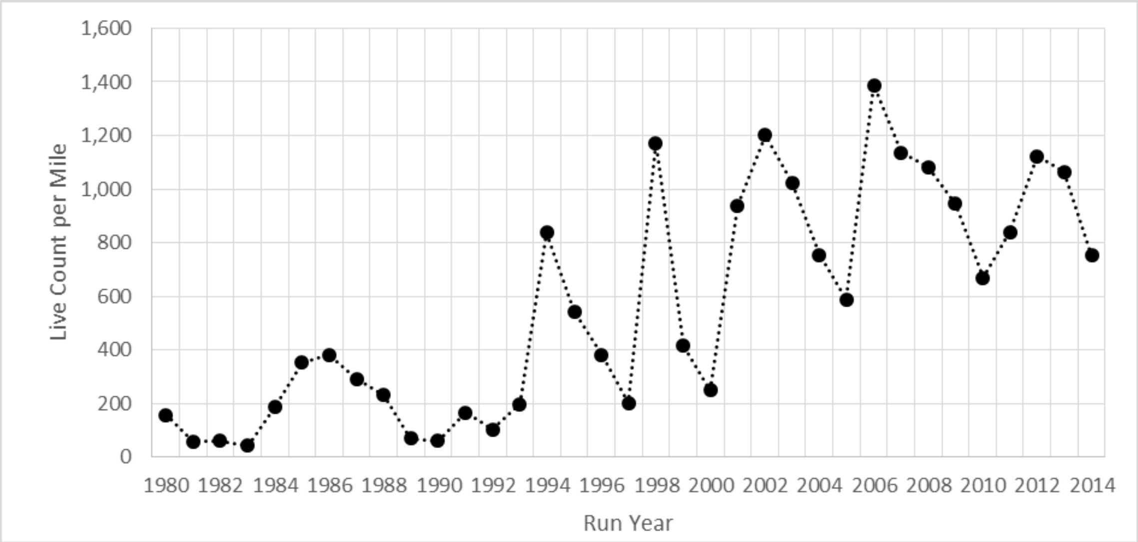

Figure 4-5. Live Summer Chum per mile in Curley Creek.

For the Salmonberry Creek survey reach, the peak live count of chum salmon from 1980 to 2014 ranged from 0 to 10 fish (Table 4-9). Season cumulative dead counts ranged from 0 to 4 fish. Timing of peak live count was inconsistent, with peak counts in some years from late October and early November, and in other years, peak live chum counts were in December.

Few chum salmon are observed in the Cool Creek survey reach. No chum were observed in Cool Creek prior to 2011 (Suquamish Tribe unpublished data provided by J. Oleyar, July 20, 2017.

Table 4-8. Adult Summer Chum Salmon Season Peak Live Counts, Peak Live Count per Survey Mile, and estimated total adult Abundance in Curley Creek. Live counts are for Index Reach, typically RM 0 to 1.9; mouth to approximately Sedgwick Road (sources: Suquamish Tribe and WDFW, unpublished data).

Run Year	Peak Live Count	Date Peak Live Count	Peak Live Count per Mile
1980	109	10/29/1980	156
1981	86	10/26/1981	57
1982	42	10/25/1982	60
1983	63	10/26/1983	42
1984	130	10/29/1984	186
1985	257	10/30/1985	353
1986	495	11/6/1986	381
1987	380	11/3/1987	292
1988	300	10/31/1988	231
1989	89	11/6/1989	68
1990	79	12/6/1990	61
1991	216	10/31/1991	166
1992	133	10/26/1992	102
1993	256	11/15/1993	197
1994	1,089	11/3/1994	838
1995	326	11/2/1995	543
1996	495	11/5/1996	381
1997	261	10/27/1997	201
1998	2,225	10/30/1998	1,171
1999	787	11/3/1999	414
2000	473	10/31/2000	249
2001	1,781	11/1/2001	937
2002	2,283	11/11/2002	1,202
2003	1,945	10/27/2003	1,024
2004	1,432	10/26/2004	754
2005	1,115	11/7/2005	587
2006	2,636	10/23/2006	1,387
2007	2,158	11/7/2007	1,136
2008	2,058	10/28/2008	1,083
2009	1,796	10/28/2009	945
2010	1,270	10/28/2010	668
2011	1,594	11/3/2011	839
2012	2,132	10/24/2012	1,122
2013	2,022	11/6/2013	1,064
2014	1,429	10/27/2014	752
2015	1,084	10/24/2015	570
2016	Not Available		

Table 4-9. Adult Chum Salmon Season Peak Live Counts in Salmonberry Creek Index Reach RM 1.6 to 2.1; approximately Sedgwick Road to S.E. Salmonberry Road (sources: Suquamish Tribe and WDFW, unpublished data).

Run Year	Peak Live Count	Date Peak Live Count
1995	10	12/20/1995
1996	0	
1997	0	
1998	3	12/18/1998
1999	0	
2000	0	
2001	2	10/31/2001
2002	0	
2003	1	10/31/2003
2004	0	
2005	0	
2006	0	
2007	7	12/7/2007
2008	0	
2009	0	
2010	1	11/4/2010
2011	0	
2012	0	
2013	0	
2014	0	
2015	Not Available	
2016	Not Available	

4.2.3 *Chum Distribution*

The following is a summary of adult chum salmon distribution based on conversations and unpublished data provided by the Suquamish Tribe and other sources. See Figure 4-3 for mapped extent of chum salmon and barriers to migration.

Chum adults are strong swimmers, but they are not considered capable leapers (Salo 1991), and their distribution typically stops or is impeded at the first significant barrier. Natural barriers limiting distribution include steep cascades and falls in tributary streams, and probably beaver dams and major log jams in some instances. Man-made barriers are noted in the WDFW Fish Passage Barrier Inventory and mapped in Figure 3-9.

Curley Creek (Mouth to Long Lake)

Curley Creek from the mouth to Long Lake is the primary spawning area for chum salmon spawning in the watershed. Chum also likely use lower portions of the tributaries entering Curley Creek.

Long Lake Tributary Streams and Long Lake

No information is available regarding chum salmon use of tributaries to Long Lake. Chum may use the lower sections of lower gradient tributaries at the south end of Long Lake, but several tributaries may be too steep to be used by spawning chum salmon. Chum may spawn along lakeshore beaches with upwelling groundwater as reported in other East Kitsap Lakes (e.g., Kitsap and Wildcat Lakes in the Chico Creek watershed)(J. Oleyar, Suquamish Tribe, pers. comm.).

Salmonberry Creek Subbasin

Few chum salmon are observed during adult surveys in Salmonberry Creek and Cool Creek. However, as previously described, spawning ground surveys in Salmonberry Creek and Cool Creek are targeting coho and do not begin until early November after peak spawning of summer chum.

4.2.4 *KEA Assessment – Chum Salmon*

The KEA assessment includes three indicators recommended for chum salmon (Table 4-10). The spatial diversity data gap is not significant when evaluating chum status across the entire watershed. The increasing and stable trend in chum salmon adult abundance in the Curley Creek spawning index reach suggests a stable population. However, the population is likely less than historical abundance because of alterations to nearshore marine habitats and possible degradation of spawning habitat in Curley Creek upstream of Sedgewick Road.

Table 4-10. KEA Assessment Summary for Coho Salmon.

Component: Salmonids		
KEA	**Indicator(s)**	**Indicator Description**
Chum Salmon	Adult Abundance	Annual estimates of chum spawning abundance in watershed
	Adult to Adult Productivity	Population brood year spawner to spawner ratio
	Spatial Diversity	Index survey reaches in Curley Creek and Salmonberry Creek to indicate chum salmon use of lower and upper portions of watershed; supplemental surveys in key tributaries to determine chum presences in other portions of the basin
Supporting Information		
Peak live adult counts and season cumulative dead counts	Live and season cumulative dead counts from annual spawning ground survey conducted by Suquamish Tribe and WDFW survey index reaches	
Data Gaps		
Chum salmon distribution in tributaries other than Curley, Salmonberry and Cool creeks	This is a minor data gap as the Curley Creek index reach covers the primary spawning area used by Curley Creek summer chum. However, supplemental surveys in other portions of the watershed during peak summer chum spawning would help describe spatial diversity.	

4.3 Steelhead Trout

In May 2007 the Puget Sound steelhead Distinct Population Segment (DPS) was listed as a threatened species under the Endangered Species Act (ESA). Curley Creek is included in the National Oceanic and Atmospheric Administration's (NOAA) critical habitat designation for the Puget Sound Steelhead DPS (U.S. Office of the Federal Register, 2013). The Puget Sound Steelhead Technical Review Team's (PSSTRT) draft analysis of historic population structure for the Puget Sound DPS does not identify streams in the East Kitsap winter steelhead populations as independent populations (Puget Sound Steelhead Technical Recovery Team 2013); rather, the PSSTRT considers Curley Creek steelhead as one of many small inter-dependent populations that make up a larger distinct independent population (DIP) for the area.

Little is known about current and historic steelhead use of the Curley Creek watershed. Current use and potential for improving productivity and abundance of Curley Creek steelhead should be investigated more closely, particularly given the 2007 ESA listing and the need to develop regional and watershed recovery plans for Puget Sound. Figure 4-6 shows presumed steelhead extent with annotations by Suquamish Tribe Fisheries staff indicating additional areas to include in the steelhead extent.

Kitsap County completed a habitat evaluation study for Kitsap County streams entering West Puget Sound (Nash 2017). The assessment summarized results of an intrinsic potential (IP) analysis of stream channels. It appears the intrinsic potential analysis reported in Nash is the same conducted by the Northwest Indian Fisheries Commission (NWIFC) and reported by Waldo et al. (2013). The IP analysis classified stream channels into low, moderate and high potential for steelhead use based on gradient and bankfull width. High potential channels are low gradient (0 to 0.25%), small (0 to 3 m) channels, and moderate gradient (0.25 to 4%), moderately wide channels (3 to 20 m). Low potential channels are high gradient (greater than 4%) channels of all widths and low gradient, wide channels (greater than 20 m). Extremely low potential areas are lakes. Nash reported IP for 44.42 km of stream channels of which:

- 6.6 km were rated extremely low (Long Lake),
- 14.97 km as low,
- 13.68 km as moderate, and
- 9.17 km as high.

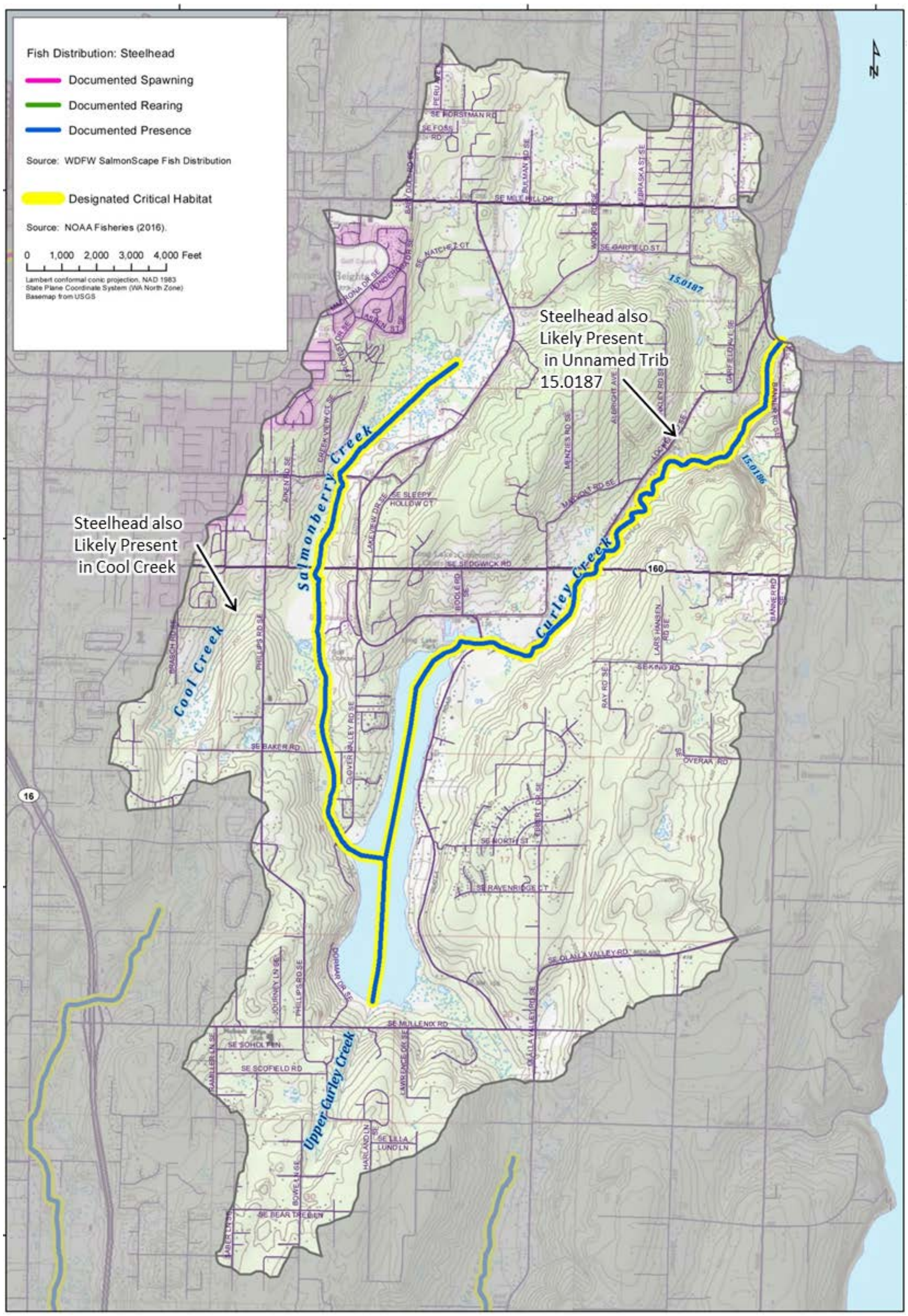

Figure 4-6. SalmonScape fish distribution for steelhead (source: WDFW 2006) and National Oceanic and Atmospheric Administration's (NOAA) critical habitat designation for the Curley Creek portion of the Puget Sound Steelhead DPS.

4.3.1 Steelhead Life history

Puget Sound steelhead exhibit one of the most complex suites of life history strategies among the anadromous Pacific salmonid species. Puget Sound steelhead usually spend 1 to 3 years in freshwater, with the greatest proportion typically spending two years (Busby et al. 1996). Consequently, steelhead rely heavily on freshwater habitats and are present in streams year round. It is likely that juvenile steelhead interact with other salmonids in the watershed, including feeding on chum salmon fry when abundant.

As in other Puget Sound streams, winter run steelhead likely return as adults to Curley Creek from December to April. In most Puget Sound streams spawning occurs from January to mid-June. Prior to spawning, maturing adults hold in pools or in side channels to avoid high winter flows. Steelhead may move high into the watershed to spawn in small, moderate gradient stream channels.

Movement patterns of juvenile steelhead in Curley Creek likely follow observations from other streams. Fry emergence can be protracted depending on spawn timing; fry from fish spawning in January or February would emerge in March to April, whereas steelhead spawning mid-May would emerge sometime in late June to early July depending on temperatures during egg incubation. Steelhead and rainbow trout require about 85 d at 4°C and 26 d at 12°C to reach 50% hatch (Bjornn and Reiser 1991). Steelhead fry emerging early would encounter more favorable flows for dispersal in the watershed, whereas late fry would be emerging as flows are approaching summer lows in Curley Creek. Newly emerged fry occupy shallow riffles and stream margins until large enough to move into deeper water in late summer. Steelhead juveniles seem to occupy nearly all habitat types in the main channel. Fry prefer the interstitial space in the substrate to hide. Juvenile steelhead do not tend to use off-channel ponds. Larger, older steelhead in smaller tributaries of Curley Creek likely move out to overwinter in the mainstem Curley Creek. Steelhead from Curley Creek may migrate as 1 year old and 2 year old smolts.

4.3.2 Steelhead Abundance

Steelhead are in decline throughout Puget Sound. Recent abundance of Puget Sound steelhead has been estimated at only 1% to 4% of historical levels, with abundance estimates for the period 1980 to 2004 of 22,000 fish, compared to historical (1895) abundance of 485,000 to 930,000 fish (Gayeski et al. 2011). Hard et al. (2007) estimated a lower peak historical abundance between 327,592–545,987 fish using slightly different methods.

Since the 1980s, there has been a significant decline in abundance across all Puget Sound streams (Hard et al 2007). The Puget Sound Partnership, Puget Sound Tribes, and WDFW are coordinating a research effort to investigate marine survival as a common factor affecting Puget Sound populations.

There are no recent quantitative estimates of winter steelhead in the Curley Creek watershed, but their abundance is assumed to be chronically low at least in recent decades, consistent with observations of steelhead in other Central and South Sound watersheds (Hard et al. 2013). Occasional spawning ground surveys in Curley Creek have recorded a few steelhead (Table 4-11).

There are no recorded observations of steelhead in Salmonberry Creek. However, adult surveys are not conducted in the spring during spawning.

A hatchery release of just over 5,000 smolt-sized steelhead is reported in 1977 and just over 10,000 smolt-sized steelhead in 1978 and 1979. There are no other records of steelhead hatchery plants in the watershed. However, the Suquamish Tribe reports the Washington Department of Game planted steelhead in Curley Creek for several decades to support a sport fishery in the watershed (P. Dorn, Suquamish Tribe pers. Comm.). Rainbow trout have been planted in Long Lake for many years to support a recreational fishery. The most recent reported release was 100 rainbow trout in 2010. Prior to 2010, rainbow trout were released in 2001 (5,004 trout), and approximately 200 trout annually from 1993 to 1999.

Table 4-11. Adult Steelhead Live Counts and Redd Counts in Curley Creek (sources: Suquamish Tribe and WDFW, unpublished data).

Run Year	Live Count	Redd Count	Date
1984	2		1/11/1984
1988	7		1/19/1988
1989	1		1/9/1989
1999	1	10	4/16/1999
2000	2	5	3/21/2000
2001	1		4/20/2001
2002	1		1/16/2002
2003		2	4/2/2003

4.3.3 Steelhead Distribution

Steelhead distribution in the watershed is not well known; they might occupy more tributary streams than shown in Figure 4-6, based on gradient and stream size (i.e., see results of the IP analysis).

Spawning surveys for steelhead are not regularly conducted in Curley Creek. Since 2016, the Suquamish Tribe has operated an outmigrant fish trap in the spring on Curley Creek just downstream of Sedgwick Rd. In 2016 the trap captured one juvenile *O. mykiss* (presumably a steelhead smolt) even though the trap was installed late in the season and operated for just one week. Genetic analysis by WDFW confirmed this was a native *O. mykiss*.

4.3.4 KEA Assessment – Steelhead Trout

The KEA assessment includes recommended indicators for steelhead (Table 4-12). Data gaps are significant when evaluating steelhead status across the entire watershed.

The lack of quantitative information for steelhead did not allow an assessment of steelhead status for these indicators. The outmigrant trap in lower Curley Creek will provide an important additional indicator of steelhead presence, abundance, and productivity.

Table 4-12. KEA Assessment Summary for Steelhead Trout.

<table>
<tr><th colspan="3">Component: Salmonids</th></tr>
<tr><th>KEA</th><th>Indicator(s)</th><th>Indicator Description</th></tr>
<tr><td rowspan="5">Steelhead Trout</td><td>Adult Abundance</td><td>Annual estimates of steelhead spawning abundance in watershed</td></tr>
<tr><td>Smolt Abundance</td><td>Annual estimates of steelhead smolt abundance from watershed</td></tr>
<tr><td>Adult to Adult Productivity</td><td>Population brood year spawner to spawner ratio</td></tr>
<tr><td>Adult to Smolt Productivity</td><td>Population brood year spawner to smolt outmigrant ratio</td></tr>
<tr><td>Spatial Diversity</td><td>Index survey reaches Curley Creek and Salmonberry Creek to indicate steelhead use of lower and upper portions of watershed; supplemental surveys in key tributaries to determine steelhead presence in other portions of the basin</td></tr>
<tr><th colspan="3">Supporting Information</th></tr>
<tr><td>Occasional spawning ground surveys</td><td colspan="2">Occasional spring spawning ground survey in Curley Creek</td></tr>
<tr><th colspan="3">Data Gaps - Significant</th></tr>
<tr><td>Spawning ground surveys</td><td colspan="2">Spring spawning ground surveys conducted occasionally</td></tr>
<tr><td>Total Steelhead Escapement</td><td colspan="2">Surveys are not adequate to estimate total natural spawning in watershed. Survey methodology will need to be reviewed to estimate to total abundance (intensive and extensive survey reaches, redd counts, and evaluation of fish life to expand live counts.</td></tr>
</table>

4.4 Chinook Salmon

The Puget Sound Technical Recovery Team (TRT) did not identify any independent Chinook populations originating from East Kitsap streams, including Curley Creek. The National Oceanic and Atmospheric Administration's (NOAA) critical habitat designation for Puget Sound Chinook included the Curley Creek estuary and Yukon Harbor nearshore habitats (Figure 4-7).

The Suquamish Tribe observes Chinook adults in most years in the lower survey reach in Curley Creek (J. Oleyar, Suquamish Tribe pers. comm.). These Chinook are likely adult strays from nearby hatchery programs such as Gorst Creek near Bremerton.

Juvenile Chinook salmon from nearby watersheds with Chinook populations (including Gorst, Grovers, Nisqually, Puyallup, and Green/Duwamish) would likely use the Curley Creek estuary and adjacent nearshore habitats for feeding.

Chinook salmon were planted into Curley Creek in the early 1960s. Based on the size of these fish it appears they were large yearling Chinook. In 1976 approximately 10,000 smaller subyearling Chinook were released into Curley Creek in the spring.

4.5 Cutthroat Trout

Little is known of the abundance and distribution of cutthroat trout in the Curley Creek watershed, although it is assumed that cutthroat occupy many parts of the watershed, including many tributaries and connected wetland/pond habitats. Cutthroat are observed each year during adult chum spawning surveys in lower Curley, and large cutthroat are seen in Cool Creek as well (J. Oleyar, Suquamish Tribe pers. comm.).

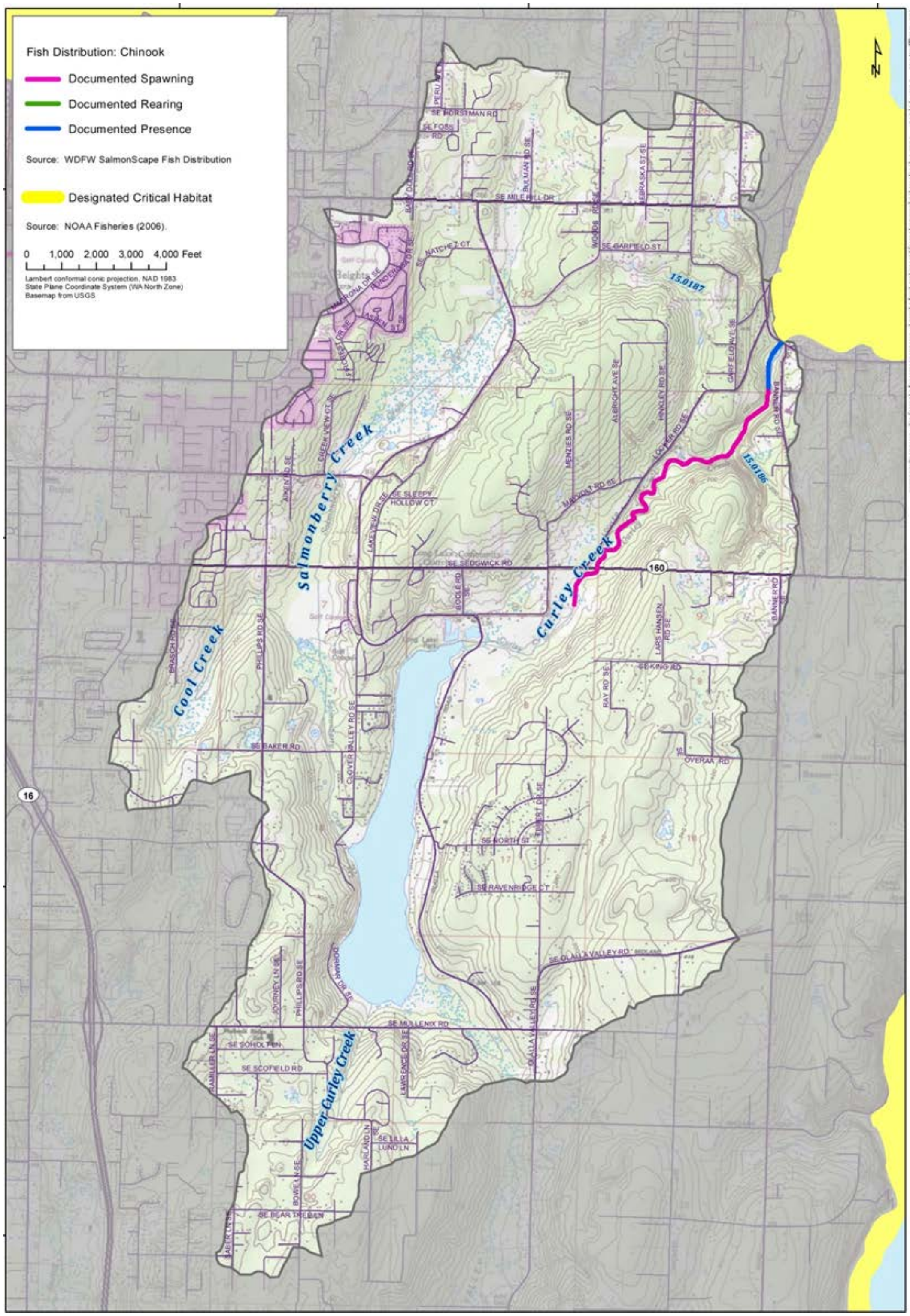

Figure 4-7. National Oceanic and Atmospheric Administration's (NOAA) critical habitat designation for the Puget Sound Chinook.

5. PROTECTION AND RESTORATION STRATEGIES

5.1 Dedicate Stream Corridor for Habitat Protection

Problem: Portions of the watershed are at risk of conversion of forest and agricultural lands to residential and associated transportation development. Riparian corridors, headwater tributaries, and wetlands in these areas are particularly vulnerable to these land use conversions.

Approach: Coordinate with landowners to establish conservation easements in critical areas of the stream corridor, and/or pursue land acquisition for conservation purposes to protect forested areas, wetlands, and the riparian corridor from potential disturbance.

This strategy is intended to contribute to objectives that support hydrologic (peak and base flows) and sediment regimes, floodplain complexity and connectivity, riparian, in-channel wood recruitment and abundance, water temperature, and nutrient cycling (food chain).

Expected benefits to Key Ecological Attributes (KEAs) are:

- Protecting riparian functions
  - Stream shading
  - Sources of wood recruitment
  - Root reinforcement of streambanks
- Reducing impacts to hydrologic regime
  - Minimizing conversion of forestland to impervious surface
  - Maintaining floodplain connectivity which moderates streamflow by attenuating peak flow in winter and contributing to base flow in summer
- Reducing impacts to sediment dynamics
  - Preventing incision in headwater reaches will protect downstream channel segments from excessive sedimentation.
- Protection of water quality
  - Forest canopy shade moderates water temperature
  - Nutrient enrichment and food chain support
- Protection of stream channel structure
  - Channel complexity
  - Pool frequency
  - Sinuosity

Expected benefits to salmonids are:

- Improved egg to fry survival from reduced exposure to bed scour and substrate composition more suitable to spawning and egg survival (substrate size and reduced fine sediment).
- Improved fry survival from improved stream margin habitat complexity and increased side channel complexity.
- Improved juvenile coho and steelhead summer and overwinter survival (sediment loading, streamflow, habitat structural complexity, water temperature, and food chain).

- Improved adult habitat utilization from increased availability and quality of adult holding habitats (hydrologic and sediment regime and in-stream habitats).

Existing Protection: Areas of the riparian corridor currently protected include:

- Regulatory buffers defined in Critical Areas Ordinance and Shoreline Master Program
- Curley Creek estuary acquisitions completed by GPC
- Conservation easements with private landowners along Salmonberry Creek upstream of Salmonberry Road

5.2 Protect and Enhance Instream Flows

Problem: Low flow conditions, particularly during summer, can stress fish populations due to reductions in habitat area and connectivity, food availability, and water quality. Surface water and some groundwater withdrawals potentially reduce flows in the channel and can limit habitat availability during critical low flow periods. Development pressures that increase impervious area can limit opportunities for groundwater recharge. Loss of mature riparian forest, reductions in large wood recruitment, and declines in beaver populations all contribute to a "flashier" hydrologic regime with higher peak flows and lower base flows. Salmonberry Creek has been closed year-round since 1948 (see WAC 173-515-040) and Curley Creek is closed seasonally (June 15 to October 15) to further consumptive water uses. In addition, instream flows have been established (see WAC 173-515-030) for Curley Creek.

Approach: This strategy involves efforts to work with Kitsap County, Washington Department of Ecology, and others to ensure that neither land use changes nor future appropriations (including permit exempt appropriations) adversely impact instream flows in the Curley Creek watershed. This may include more detailed (i.e., downscaled) studies, building on recent groundwater/surface water modeling work by USGS on the Kitsap Peninsula, to assess groundwater/surface water interactions affecting low flows in the Curley Creek Watershed. Further actions include enforcement of stormwater management regulations in developing areas and restoration and protection of forest cover and wetland functions to maintain hydrologic maturity. Other strategies discussed in this section provide complimentary functions related to instream flows. For example, efforts to protect land areas in the stream corridor (Section 5.1) and actions that restore floodplain connectivity through incised or channelized reaches of the watershed (Section 5.3) are important to moderate the flow regime by increasing the proportion of flood runoff that is routed through and seasonally stored in floodplain areas as opposed to running off directly via the channel network.

Expected benefits to Key Ecological Attributes (KEAs) are:

- Reducing impacts to hydrologic regime
  - Protects against future increases in consumptive water uses
  - Moderates streamflow by attenuating peak flow in winter and contributing to base flow in summer
- Improved water quality
  - Increased hyporheic exchange and cool water refugia

Expected benefits to salmonids are:

- Improved juvenile coho and steelhead survival during summer from increased habitat availability and thermal refugia.

5.3 Floodplain and Channel Migration Zone Reconnection

Problem: Impacts to the stream corridor that limit channel migration and floodplain connectivity include bank protection/stabilization measures, channelization to straighten the channel alignment, removal of beaver and beaver pond/wetland complexes, and channel incision.

Approach: This strategy removes constraints to lateral connectivity that would allow lateral channel migration and restore habitat forming processes. Lateral constraints evident in the Curley Creek Watershed include fill, bank hardening, and stream crossing structures. Channel migration is also impaired by riparian impacts, historic wood removal, and historic and continued removal of beaver and beaver pond habitats. Channel incision disconnects secondary channel features and floodplain areas previously hydrologically connected to the channel.

This strategy is intended to achieve objectives for promoting lateral channel migration, side channel and off-channel habitat formation, and increased capacity for flood flows to support priorities for reforming side channels, reconnecting floodplain habitats, increasing in-channel complexity, and promoting increased food chain support with improved riparian corridor condition. This strategy may also involve the recovery of beaver and the habitats that beaver form, and/or the use of beaver dam analogs. Secondary benefits are from increased lateral extent of hyporheic zone, which may increase base flows and provide thermal refugia.

Expected benefits to KEAs are:

- Reduced impacts to hydrologic regime
  - Increased flood conveyance
  - Increased surface water storage
- Reduced impacts to sediment dynamics
  - Fine sediment deposited overbank in floodplain
- Improved water quality
  - Increased hyporheic exchange and cool water refugia
- Improved wetland condition and function
- Increased channel complexity
  - Increased wood loading
  - Increased pool frequency
  - Increased sinuosity

Expected benefits to salmonids are:

- Improved egg to fry survival from reduced exposure to bed scour (flood flows) and substrate composition more suitable to spawning and egg survival (floodplain storage of fine sediment)
- Improved chum fry survival from improved stream margin habitat complexity and increased side channel complexity.
- Improved juvenile coho and steelhead survival during summer from increased habitat complexity, pools, side channels, and thermal refugia.
- Improved juvenile coho survival during winter from increased in-channel complexity, and floodplain habitat complexity and quantity.
- Improved juvenile steelhead survival during winter from increased in-channel habitat complexity and flood flow refuge.

5.4 Riparian Restoration and Management

Problem: Clearing of forest vegetation within the riparian corridor has degraded riparian function.

Approach: This strategy is intended to address impacts from past and on-going land use in the riparian corridor. Riparian restoration is expected to increase streambank and floodplain structural complexity, provide shade to moderate water temperatures, provide increased food chain support, and increase wood loading. Riparian restoration is an important long-term strategy to restore habitat forming processes in the watershed, and is expected to be a key strategy associated with nearly all actions identified in the watershed.

Expected benefits to KEAs are:

- Restoring riparian functions
  - Stream shading
  - Sources of wood recruitment
  - Root reinforcement of streambanks
- Reducing impacts to hydrologic regime
  - Wood supply critical to maintaining floodplain connectivity which moderates streamflow by attenuating peak flow in winter and contributing to base flow in summer
- Reducing impacts to sediment dynamics
  - Wood supply is driver of hydraulic variability that leads to sorting of sediment
  - Wood inputs are critical to partitioning of shear stress and preventing imbalance between sediment supply and transport capacity (a cause of channel incision)
  - Preventing incision in headwater reaches will protect downstream channel segments from excessive sedimentation.
- Improving water quality
  - Shade moderates water temperature
  - Nutrient enrichment and food chain support
- Restoring stream channel structure
  - Channel complexity
  - Pool frequency
  - Sinuosity

Expected benefits to salmonids are:

- Improved egg to fry survival from reduced exposure to bed scour and substrate composition more suitable to spawning and egg survival (substrate size and reduced fine sediment).
- Improved chum fry survival from improved stream margin habitat complexity and increased side channel complexity.
- Improved juvenile coho and steelhead survival during summer from increased habitat complexity and pools.
- Improved juvenile coho survival during winter from increased in-channel complexity, and floodplain habitat complexity and quantity.
- Improved juvenile steelhead survival during winter from increased in-channel habitat complexity and flood flow refuge.
- Improved adult habitat utilization from increased availability and quality of adult holding habitats.

5.5 Channel Restoration

Problem: Past land uses have cleared valley bottom areas for agriculture, removed beaver and the habitats they form, and channelized streams into linear ditches to increase drainage and maximize usable pasture area. Effects include: reduction in channel sinuosity and length, steepening of channel gradient, increased sediment transport capacity, reduced channel complexity, and loss of connectivity with side channels and off-channel habitats.

Approach: The goal of this approach should be to restore a channel pattern compatible to the geomorphic setting and that is self-maintaining. This implies the channel will have capacity to migrate and adjust to changing inputs of flow, sediment, and wood. Side-channel creation is also included as an element of this approach where side channels or connectivity with off-channel features have been lost by channelization.

Expected benefits to KEAs:

- Reduced impacts to hydrologic regime
  - Increase frequency and duration of floodplain connectivity and attenuate peak flows
- Reduced impacts to sediment dynamics
  - Sediment sorting with increased hydraulic variability
  - Overbank deposition
  - Prevention of, or treatment for, channel incision
- Improvements to stream channel structure
  - Increased pool frequency
  - Increased sinuosity
  - Increased side channel connectivity

Expected benefits to salmonids are:

- Improved egg to fry survival from reduced exposure to bed scour and substrate composition more suitable to spawning and egg survival (substrate size and reduced fine sediment).
- Improved chum fry survival from improved stream margin habitat complexity and increased side channel complexity.
- Improved juvenile coho and steelhead survival during summer from increased habitat complexity and pools.
- Improved juvenile coho survival during winter from increased in-channel complexity, and floodplain habitat complexity and quantity.
- Improved juvenile steelhead survival during winter from increased in-channel habitat complexity and flood flow refuge.
- Improved adult habitat utilization from increased availability and quality of adult holding habitats.

5.6 Wood Placement

Problem: Past impacts have cleared forest areas from the stream corridor and intentionally removed wood from the channel. Many areas have reforested riparian corridors; however, the wood that is now available for recruitment is usually insufficient in size to function as stable key pieces.

Approach: Wood placement is important to prevent further channel incision and improve habitat conditions in channel segments lacking in wood due to riparian impacts that limit natural recruitment and intentional wood removal. Wood placement will be important to enhance habitat conditions during the time required for restoration of natural processes (e.g., channel migration, growth of riparian forests, and wood recruitment). This strategy is intended to achieve objectives promoting processes of scour and deposition to form complex arrangements of channel features including pools and bar areas, and increase sediment storage capacity by trapping material within depositional features in the alluvial channel and floodplain. Meeting these objectives is expected to support priorities for increasing in-channel complexity, reforming side channels, and restoring or reconnecting floodplain habitats.

This strategy is intended to address impacts from past and on-going land use in the riparian corridor.

Expected benefits to KEAs:

- Reduced impacts to hydrologic regime
  - Hydraulic roughness from instream wood can increase frequency and duration of floodplain connectivity and attenuate peak flows
- Reduced impacts to sediment dynamics
  - Sediment sorting
  - Prevention of, or treatment for channel incision
- Improvements to stream channel structure
  - Increased pool frequency
  - Increased sinuosity
  - Increased side channel connectivity

Expected benefits to salmonids are:

- Improved egg to fry survival from reduced exposure to bed scour and substrate composition more suitable to spawning and egg survival (substrate size and reduced fine sediment).
- Improved chum fry survival from improved stream margin habitat complexity and increased side channel complexity.
- Improved juvenile coho and steelhead survival during summer from increased habitat complexity and pools.
- Improved juvenile coho survival during winter from increased in-channel complexity, and floodplain habitat complexity and quantity.
- Improved juvenile steelhead survival during winter from increased in-channel habitat complexity and flood flow refuge.
- Improved adult habitat utilization from increased availability and quality of adult holding habitats.

5.7 Restore Fish Passage

Problem: Fish passage is blocked or partially blocked at several road crossings and other artificial structures.

Approach: This strategy is primarily intended to address migration barriers to juvenile and adult salmonids. Restoring longitudinal connectivity will also benefit downstream habitats by restoring sediment processes, downstream wood transport and loading, nutrient cycling, and in a few places, downstream hydrology. Meeting these objectives is expected to support priorities for fish passage, reversing channel incision, improving wood loading, and promoting increased food chain support.

Expected benefits to KEAs:

- Increased longitudinal habitat connectivity
- Increased delivery of marine-derived nutrients (via salmon carcasses)

Expected benefits to salmonids:

- Increased adult access to spawning habitat.
- Increased access by juvenile coho and steelhead to moderate and high quality habitats.
- Reduced impact of partial barriers on behavior of migrating adults.

6. RECOMMENDED ACTIONS BY SUBREACH

Maps labeling the location of recommended actions are attached to this report as Appendix H. A framework for prioritizing these actions is provided as Appendix I.

6.1 Curley Creek

Curley Creek originates at the Long Lake outlet and flows over a distance of approximately 3 miles to the estuary. There are two main tributaries designated as fish-bearing streams in WDNR's water type assessment. Banner Creek (labeled 15.0186 in WDFW stream catalog) drains the area to the south, between Curley Creek and Banner Forest Heritage Park and meets Curley Creek at right bank approximately 0.7 mile upstream of the estuary. A second, unnamed tributary stream (labeled 15.0187 in the WDFW stream catalog) drains a subbasin area to the north of Curley Creek and meets Curley Creek at left bank at just over 1 mile above the estuary.

The Kitsap Conservation District (KCD) has conducted past restoration projects by providing technical assistance to landowners for projects aimed at restoring habitat in the Curley Creek Watershed. Carin Anderson, Program Manager with KCD, provided the following list of completed actions coordinated through KCD in the Curley Creek subbasin:

- In the mid-1990s, Eric Bauer (property owner located just downstream of Long Lake Rd near outlet of Long Lake) installed approximately 2,553 feet of stream exclusion fencing and implemented about a half-acre of planting. A small fish rearing pond was also installed and funded by US Fish and Wildlife.
- Merlin Livesay installed exclusion fencing along 950 feet of Curley Creek and planted 2,000 native trees and shrubs on 1.6 acres of riparian area. This project was funded by the Conservation Reserve Enhancement Program in 2006.
- In 2014, a Backyard Habitat Grant funded the repair of a fish ladder on Karen Williamson's property, located along the lower reach of Curley Creek. The ladder is located on unnamed tributary (15.0187), at the junction with Curley Creek. Replacing the weirs improved fish passage to approximately 2 miles of stream habitat, and it is the first time in recent years that chum have been documented in the upper reaches of the tributary. Approximately 100 native trees and shrubs were planted along Curley Creek as part of this project.

Great Peninsula Conservancy (GPC) acquired 20 acres of land surrounding the Curley Creek Estuary in 2004, protecting most of the shoreline. After evaluating multiple parcels in the surrounding area, GPC recently received funding to acquire additional property(ies) upstream of the Curley Creek Estuary for conservation purposes (GPC 2017).

Recommended actions identified in the Curley Creek subbasin, including the two main tributaries draining to Curley Creek, are summarized below.

(1) Curley Creek Estuary and Nearshore

Recommended actions:

- Dedicate Stream Corridor (Estuary/Marine Riparian) for Habitat Protection
- Riparian Restoration and Management
- Prevent further armoring of shoreline

- Identify opportunities to remove shoreline armor or replace with soft shoreline armor
- Identify opportunities to relocate houses or other structures a greater distance from the shoreline to avoid future armor, or to allow for removal of existing armor.
- Enforce compliance with existing SMP.
- Encourage shoreline landowners to protect and restore native shoreline vegetation and maintain LWD and wrack on beaches.

Nearly the entire estuary shoreline upstream of the bridge crossing at Southworth Drive is protected through acquisitions completed by GPC in 2004. There remains a small area of unprotected shoreline in the northeast corner of the estuary; however, this area is unlikely to be developed in the near future given the slope of the embankment. Non-native vegetation, most notably English ivy and Himalayan blackberry, should be managed in the riparian zone to minimize displacement of native shrubs and herbaceous vegetation.

The nearshore area of Yukon Harbor is extensively developed and the shoreline is highly modified. Actions to prevent further shoreline armoring and remove existing armor are needed to allow for natural shoreline adjustments to sea level rise anticipated in Puget Sound.

(2) Curley Creek Estuary to Sedgwick Road

Recommended actions:

- Dedicate Stream Corridor for Habitat Protection
- Riparian Restoration and Management
- Wood Placement

The stream corridor upstream of the Curley Creek Estuary is relatively confined by steep hillslopes forming a ravine. The corridor is recovering from past timber harvest and is currently well forested. A few limited exceptions include areas where residential properties have cleared trees along short segments of the stream corridor. The primary strategy recommended in this segment is protecting the stream corridor from land use impacts by establishing conservation easements along the channel and riparian corridor. There are also opportunities in some locations to restore native riparian vegetation where it has been removed or disturbed. In addition to protecting and restoring riparian processes, wood placement is recommended to increase channel complexity and provide a greater diversity of habitat types. Field reconnaissance of this segment shows a relatively low abundance of large wood in the channel despite the adjacent forest cover (Figure 6-1). Much of the wood recruited to the channel is deciduous species such as alder and maple that decay rapidly and are often too small to function as stable key pieces. Further, intentional wood removal from the channel by adjacent property owners limits wood abundance through parts of this segment. Given this segment has stretches with recovering riparian forest conditions that may yield good potential for wood-recruitment as the forest matures, wood placement actions should be focused on segments where riparian impacts are greatest and natural wood recruitment is unlikely to occur in the foreseeable future.

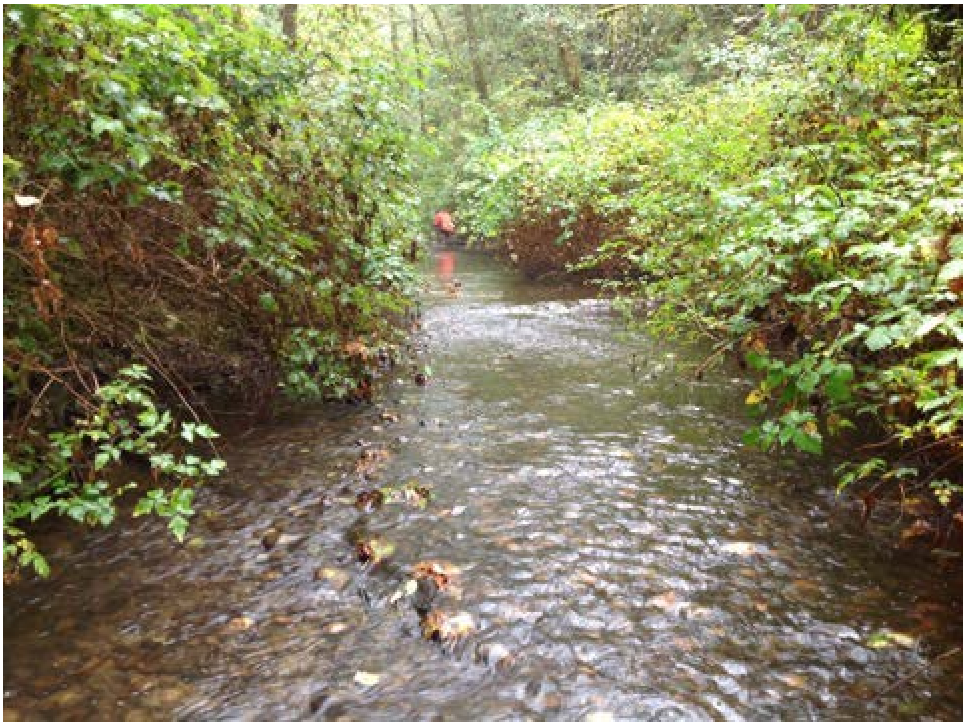

Figure 6-1. Photo of Curley Creek in ravine near junction of Mayvolt Road and Locker Road. The relatively low amount of large wood in the channel results in lack of channel complexity and low diversity of habitat types. Wood placement and protection of wood recruited to the channel will result in more frequent and deeper pool habitats, improved cover, and greater abundance of side channel habitat.

(3) Curley Creek Upstream of Sedgwick Road to Long Lake

Recommended actions:

- Dedicate Stream Corridor for Habitat Protection
- Channel Restoration
- Beaver Restoration and Management
- Wood Placement
- Riparian Restoration and Management

The valley bottom widens and stream gradient flattens upstream of Sedgwick Road to the outlet of Long Lake. The valley bottom was cleared for agriculture and the stream was channelized to drain adjacent wetland areas. Beaver have also been removed from this section (Figure 6-2). The stream corridor is reasonably well forested (although dominated by deciduous trees) along the initial 1000 ft reach upstream of Sedgwick Road for approximately 1,000 feet. At the upstream end of this segment the landowner immediately downstream of Long Lake Road installed stream exclusion fencing, planted riparian vegetation over approximately 0.5 acre, and created a small rearing pond in the early-mid 1990s. The approximately 3,000 foot long segment between these two areas has a narrow riparian corridor developing along the channel in places; however, much of the stream corridor remains cleared and the legacy of channelization limits connectivity with the floodplain and channel migration zone (Figure 6-3). Further, degraded riparian conditions limit wood recruitment and the channel remains simplified, lacking in wood-forced pools or side channel habitats.

The recommended actions include first establishing a protected stream corridor by dedicating land for conservation. Within the established corridor, active channel modification should be considered to relocate the stream out of the artificial ditch to create a more complex channel pattern that is connected with existing depressional areas (floodplain wetlands) to provide connectivity with off-channel habitat. Riparian vegetation should be planted to provide forest cover along the stream and around floodplain wetlands. Wood placements in this restored stream corridor will be important to maintain channel complexity over future decades until the riparian forest can mature to a point where natural rates of wood recruitment can be restored. Beaver should be allowed to establish and persist and help form aquatic habitats within this reach. Beaver recovery and/or use of beaver dam analogs may be an integral component of habitat restoration efforts in this reach.

Beaver management actions should also address hydrologic impairments resulting from beaver activity within the constrained channel segment crossing Long Lake Road. The current road crossing design has a single span bridge with road fill constricting the floodplain on both sides of the channel. As such, beaver dams constructed in the confined segment back water up into Long Lake and substantially reduce flows in the downstream channel segment of Curley Creek. A wider bridge and/or increased number of openings should be considered to provide an overflow for water that backs up behind beaver dams in the segment confined by road fill.

Figure 6-2. Map showing historical (1951) and recent (2015) imagery of Curley Creek between Sedgwick Road and Long Lake. The stream was channelized and disconnected from the floodplain and channel migration zone.

Figure 6-3. 2006 photo of Curley Creek between Sedgwick Road and Long Lake (view upstream). Photo: Washington Department of Ecology Coastal Atlas.

(4) Banner Creek (15.0186) to Sedgwick Road

Recommended actions:

- Dedicate Stream Corridor for Habitat Protection
- Wood Placement

The stream corridor along this tributary to Curley Creek is a well forested ravine and should be protected by dedicating land for conservation. Field assessment of this tributary is recommended to assess wood loading, as the relatively steep channel gradient (5%) makes this stream sensitive to channel incision with increases in runoff from the contributing watershed. Absent sufficient wood loading, channel incision will undercut steep hillslopes of the ravine disrupting sediment dynamics and resulting in excessive sedimentation in the lower gradient areas of Curley Creek near the tributary confluence. Wood placements should include pieces that span the channel to form step-pool morphology that will provide habitat, dissipate stream energy, and prevent channel incision.

(5) Banner Creek (15.0186) Crossing at Sedgwick Road

Recommended actions:

- Fish Passage Restoration
- Wood Placement

The stream passes through a 2.5 foot diameter culvert over a length of 175 feet crossing Sedgwick Road (SR 160) identified as a fish passage barrier in the WDFW culvert assessment (Figure 6-4). The culvert has a slope of 5% and a water surface drop of 2.5 feet. The recommended action is to replace the existing crossing with a bridge (preferred) or larger culvert that meets 'stream simulation' design and conforms to WDFW water crossing guidelines for fish passage and allows the channel to make adjustments over time. Note: Sedgwick Rd. (SR160) is a State-owned road and therefore any culvert replacements must comply with the culvert injunction.

The perched outlet could indicate the effects of past incision in the reach. The undersized culvert acts as a grade control and this rigidity causes problems in a stream that may adjust vertically over time; an abrupt drop will develop at the outlet as the downstream channel degrades. A drop can also form when an undersized culvert prevents adequate passage of upstream sediment and wood, and from high velocities through the pipe. The potential consequences for renewed incision with further progression of a headcut through the upstream channel segment should be considered. In addition to culvert replacement, the channel may also need to have wood placed in both the downstream and upstream segments to re-establish channel complexity, promote sediment storage, and prevent additional accelerated incision.

Figure 6-4. Culvert in Banner Creek (15.0186) at Sedgwick Road (photo from WDFW).

(6) Banner Creek (15.0186) Upstream of Sedgwick Road

Recommended action:

- Dedicate Stream Corridor for Habitat Protection

The channel segment upstream of Sedgwick Road is less steep than the ravine segment downstream and is connected with several small tributaries forming the headwaters of this creek. The stream corridor should be protected from land use impacts by dedicating land for habitat protection.

(7) Unnamed Stream 15.0187 to Locker Road

Recommended actions:

- Dedicate Stream Corridor for Habitat Protection
- Fish Passage Restoration
- Channel Restoration
- Wood Placement
- Riparian Restoration and Management

An earthen dam impounds the tributary channel at the confluence with Curley Creek. A four foot wide concrete weir-pool fishway provides fish passage from Curley Creek into the tributary (Figure 6-5). The weirs were replaced in 2014 with funding from KCD. In the year following the repair adult chum were observed in the upper reaches of this tributary for the first time in likely many years or decades. The remaining problem with the fishway is that the concrete weir acts as a hydraulic control at the junction with Curley Creek. The WDFW fishway assessment report notes the concrete weir has an excessive outfall drop of approximately 18 inches and an undersized low flow notch (Figure 6-5). Given this, WDFW classifies the fishway as a partial passage barrier with an estimated passability of 67%.

In the near term, recommended actions in this area include a simple replacement of the concrete control with additional weirs or log assemblage that reduce the water surface drop to enhance fish passage. Recommendations for longer term actions at this site include removal of the dam and restoration of floodplain and channel migration zone connectivity at the tributary confluence. Such actions will require dedicating a stream corridor and creating a new channel through or around the existing upstream impoundment. Riparian vegetation should be planted to provide forest cover along the stream and wood placements in this restored stream corridor will be important to maintain channel complexity over future decades until the riparian forest can mature to a point where natural rates of wood recruitment can be restored.

Figure 6-5. Photos of the fishway in Unnamed Tributary 15.0187.

(8) Unnamed Stream 15.0187 in Ravine Upstream of Locker Road

Recommended action:

- Dedicate Stream Corridor for Habitat Protection

The stream flows through a relatively confined ravine upstream of Locker Road at a gradient of approximately 3%. The stream corridor is forested and should be protected from land use impacts by dedicating land for habitat protection. Field assessment of this tributary is recommended to assess wood loading. Absent sufficient wood loading, channel incision will undercut steep hillslopes of the ravine disrupting sediment dynamics and resulting in excessive sedimentation in the lower gradient areas of Curley Creek near the tributary confluence. Wood placements should include pieces that span the channel to form step-pool morphology that will provide habitat, dissipate the stream energy, and prevent channel incision.

(9) Unnamed Stream 15.0187 near Frog Pond Road

Recommended actions:

- Dedicate Stream Corridor for Habitat Protection
- Riparian Restoration and Management

Approximately 0.5 mile upstream of Locker Road, the tributary valley widens slightly and gradient decreases from approximately 3% in the ravine to about 1% in the segment upstream. Frog Pond Road previously dammed the creek channel creating an impoundment used to raise frogs in the 1940s (Yukon Harbor Historical Society). Field assessment was not completed in this tributary but review of GIS data and imagery suggests this impoundment has been removed. Additional ponds have been created in the floodplain upstream of Frog Pond Road and the riparian corridor is relatively narrow in this segment.

Recommended actions include field assessment of channel conditions, dedication of land for habitat protection in a stream corridor encompassing the channel and off-channel wetlands, placement of wood, and riparian restoration to maintain channel complexity until the riparian corridor reaches maturity to sustain wood recruitment processes.

(10) Headwaters of Unnamed Stream 15.0187

Recommended action:

- Dedicate Stream Corridor for Habitat Protection

The upper segment of this tributary flows from west to east and steepens in gradient compared to the downstream reach. Drainage from a developing residential area off of Mile Hill Road contributes runoff to the stream. The stream corridor is generally well forested and should be protected by dedicating land for habitat protection. Wood placement is recommended to provide channel stability and prevent incision associated with land use impacts to peak flows.

6.2 Salmonberry Creek

Salmonberry Creek and tributaries, including Cool Creek, provide important salmonid habitats in the Curley Creek watershed. Land use impacts in this subbasin are primarily driven by agricultural land uses that cleared much of the stream corridor, removed beaver, and channelized the stream in an effort to increase drainage of the valley bottom for agricultural purposes. More recent pressures affecting the subbasin involve conversion of land for residential development. More intensive development has occurred, and is projected to continue within the Urban Growth Area that extends into the tributary areas draining from the west side of the subbasin.

The Kitsap Conservation District has coordinated with landowners in implementing best management practices and restoration actions in the Salmonberry Creek subbasin, including the following: [3].

- In 1982, Stan Jones installed a wildlife rearing pond with US Farm Service assistance.
- Butch Ashby installed almost a mile of stream and wetland exclusion fencing along Cool Creek and planted a 25 foot riparian wide buffer with primarily Red Osier dogwood in the mid 1990s with the help of US Fish and Wildlife grants. A pond and fish ladder were installed on a tributary to improve fish habitat.
- In the mid-1990s, the department of Agriculture and Irrigation helped fund excavation of a 3 acre pond complex connected to Salmonberry Creek, to enhance salmon habitat. The Department of Fish and Wildlife funded approximately 1,000 feet of hedge row plantings and approximately .25 mile stream exclusion fencing.
- The Armstrong's, located on Salmonberry Creek, just south of the Childers property, planted approximately 0.33 acre along 660 feet of a tributary.
- In 2014, a Backyard Habitat grant helped fund planting of 400 cedar, spruce and hemlock trees, along 1,220 feet (1.7 acres) of stream, on two tributaries to Salmonberry Creek.
- In 2015, the Backyard Habitat grant funded the removal of two fish barriers in the upper Salmonberry Creek watershed, on the Childers property. An 18 inch culvert was removed and replaced with a 5 foot culvert. At the second crossing, a failing culvert and road bed fill was removed, and a stream ford installed. These projects improved salmonid access to approximately 1 mile of stream in the upper watershed. 220 native trees and shrubs were planted.

In addition, a wetland mitigation project was implemented in the Salmonberry Creek floodplain between 2003 and 2005. The project excavated nearly 4 acres of ponds, created upland planting mounds totaling 1 acre in area, and hydric mounds on 1.5 acres. The Mid Sound Fisheries Enhancement Group (2015) produced a wetland mitigation report documenting vegetation, hydrology, and wildlife at the site and concluded that the initial goal to improve habitat conditions for coho salmon has been met and complemented by recent beaver activity that has increased water surface elevations in the project area.

The WSU Noxious Weed Board has monitored and treated noxious weeds in the Curley Creek Watershed. One patch of knotweed, located on Salmonberry Creek, was found and treated.

Recommended actions for protection and restoration, by sub-reach, are summarized below.

(11) Salmonberry Creek Outlet at Long Lake

Recommended actions:

- Dedicate Stream Corridor for Habitat Protection
- Riparian Restoration and Management
- Floodplain and Channel Migration Zone Restoration
- Wood Placement

---

[3] Completed action summaries provided by Carin Anderson (KCD).

The Salmonberry Creek mouth where it flows into Long Lake is an important transition zone for both adult salmon migrating upstream and juvenile salmon either outmigrating or seeking rearing habitat near the lakeshore. The existing outlet channel crosses three residential properties downstream of Clover Valley Road and has minimal riparian cover along the approximately 500 foot long segment upstream of the lake (Figure 6-6).

Restoration actions recommended in this area include removing constraints to lateral channel migration and planting in the riparian corridor. Actions are constrained by the current land use. Replanting the riparian corridor could be feasible through coordination with existing landowners. Smaller wood placements may be possible without adverse impacts to private property. Full restoration of natural processes in this segment would include larger wood placements that exert geomorphic responses and reconnect the floodplain and channel migration zone. Such actions may not be compatible with existing land use but should be considered a long term objective requiring potential easements or acquisition should the properties be offered for sale at a future date.

Figure 6-6. Mouth of Salmonberry Creek where it flows into Long Lake (2007 photo from Department of Ecology Shoreline Atlas).

(12) Salmonberry Creek Crossing at Clover Valley Road SE

Recommended action:

- Fish Passage Restoration

Salmonberry Creek passes through an 8.5 foot diameter pipe arch culvert that is undersized given that bankfull width for this segment of Salmonberry Creek is approximately 15 feet. WDFW's Level A culvert assessment identified the crossing as a partial barrier (33% passability) due to high velocity. WDFW measured velocity exceeding 6 ft/sec during the May 2008 survey. The recommended action is to replace the existing crossing with a bridge or larger culvert that conforms to WDFW water crossing guidelines for fish passage.

(13) Salmonberry Creek from Clover Valley Road to Baker Road

Recommended actions:

- Dedicate Stream Corridor for Habitat Protection
- Wood placement
- Riparian Restoration and Management

The stream corridor between Clover Valley Road and Baker Road is recovering from past clearing and is relatively well forested in some locations. Protecting riparian functions in areas with functioning riparian cover and restoring riparian conditions in impacted areas throughout this segment is important for the long term recovery of ecological habitats. Wood placement is recommended to create channel complexity in the near term while the riparian forest matures to a point that can provide wood recruitment.

(14) Salmonberry Creek Crossing at SE Baker Road

Recommended action:

- Fish Passage Restoration

Salmonberry Creek flows through a 6 foot diameter round culvert at a slope of 2.2% (Figure 6-7). Channel slope in the upstream and downstream channel segments is less than 0.5%. WDFW's Level A culvert assessment lists the crossing as a fish passage barrier given that the culvert slope exceeds 1%. During field reconnaissance in 2015 with Suquamish Tribe Fisheries staff, the crossing at Baker Road was observed to be backwatered such that slope of the culvert was not creating a fish passage barrier at that time. The cause of the backwater effect was not determined but may have been associated with beaver activity in the downstream channel segment. The recommendation is to replace the existing culvert with a bridge or larger culvert that meets design criteria in the WDFW water crossing guidelines.

Figure 6-7. Existing culvert in Salmonberry Creek at SE Baker Road (photo from WDFW).

(15) Salmonberry Creek from Baker Road to Cool Creek confluence

Recommended action:

- Dedicate Stream Corridor for Habitat Protection

The channel segment upstream of Baker Road flows through a relatively narrow valley bottom that is forested along the channel margin. The riparian corridor could be expanded through additional planting; however, the overall condition in this reach is better than other segments that completely lack forest cover. The valley widens approximately 1,000 feet upstream of Baker Road to the confluence with Cool Creek and contains a relatively large shrub-scrub wetland complex that includes beaver activity. The stream corridor in this segment should be protected by conservation easements or other means.

(16) Salmonberry Creek from Cool Creek confluence to Sedgwick Road

Recommended actions:

- Dedicate Stream Corridor for Habitat Protection
- Channel Modification
- Wood Placement
- Riparian Restoration and Management

Salmonberry Creek has been channelized downstream of Sedgwick Road into a straightened alignment along the eastern side of a broad valley approximately 1,000 feet in width (Figure 6-8). The ditch occupied by Salmonberry Creek is approximately 10 to 15 feet wide and has steep banks, approximately 4 feet high (Figure 6-9). The valley bottom was cleared for agricultural use in the early settlement period and drained by artificial ditches. A golf course was created in the former agricultural fields during the early 1960s. The golf course closed operations in the early 2000s and the current owner has renovated the property to create botanical gardens. The disconnected floodplain area extending west from the ditch channel to the valley margin is flat and overgrown with reed canarygrass (Figure 6-10). Cool Creek enters into the valley from the west and flows through a ditched channel that drains into Salmonberry Creek.

Restoration actions along this reach should aim to re-meander the stream channel out of the straightened alignment, replant riparian vegetation, and place large wood structures (logjams and/or beaver dam analogs) in the channel and valley bottom to restore channel complexity. Off-channel ponds and wetlands should be hydrologically connected to the stream. Beavers should be allowed to establish and persist in this and other reaches of the Salmonberry valley. The confluence area with Cool Creek may need to be re-constructed to enable future channel adjustments. The forested riparian corridor between the former golf course (current nursery) property and Sedgwick Road should be protected with conservation easements or other means.

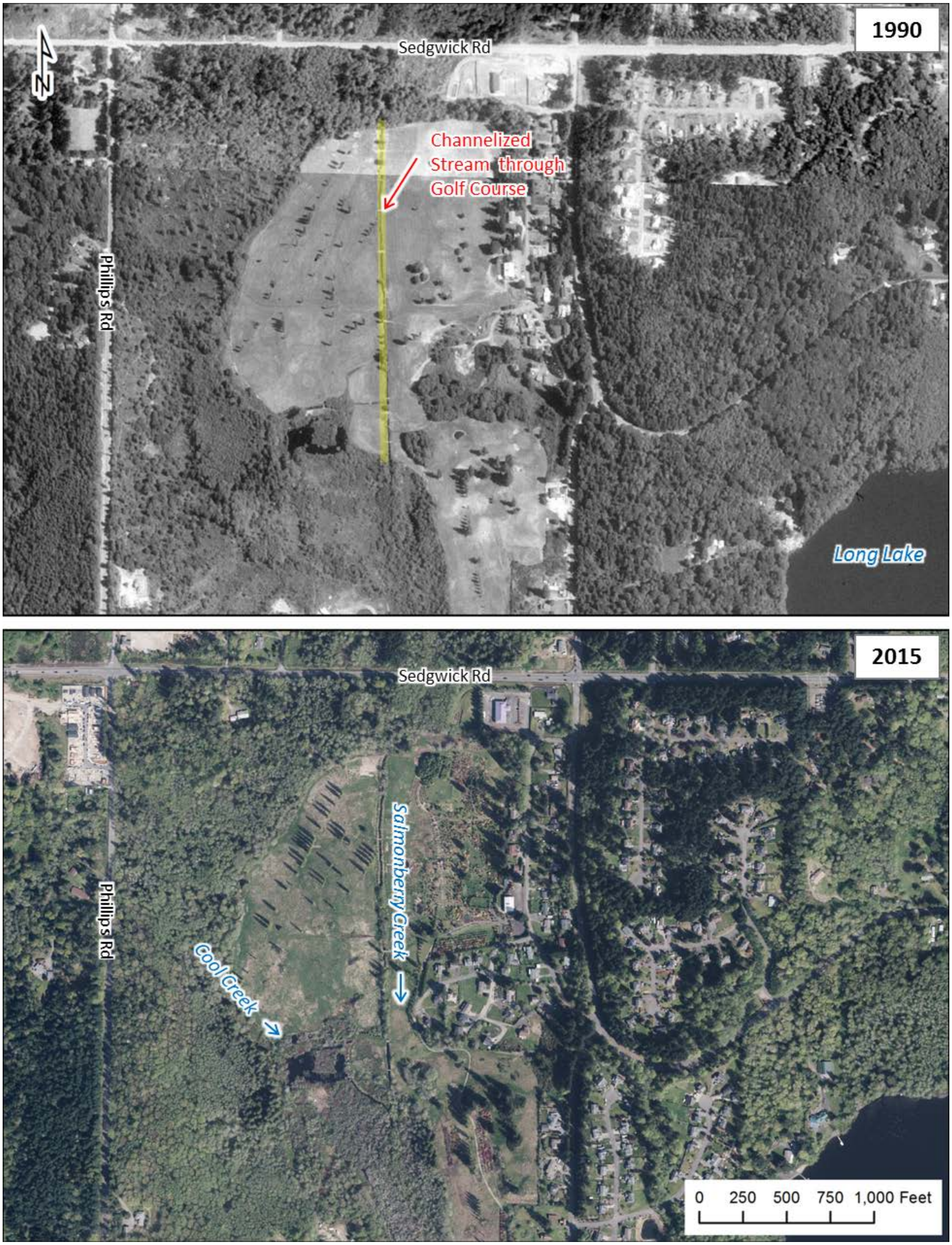

Figure 6-8. Air photos from 1990 and 2015 of Salmonberry Creek in the channelized segment crossing the former golf course property downstream of Sedgwick Road.

Figure 6-9. Channelized segment of Salmonberry Creek downstream of Sedgwick Road.

Figure 6-10. Disconnected floodplain area adjacent to ditch shown in photo above.

(17) Salmonberry Creek Crossing at SE Sedgwick Road

Recommended action:

- Fish Passage Restoration

The stream crossing at Sedgwick Road passes flow through a 7.5 foot diameter arched culvert at a slope of 0.2%. The WDFW Level A culvert assessment report identifies the culvert as a partial fish passage barrier (passability 33%) due to a water surface drop of 1.5 feet on the downstream side of the crossing (Figure 6-11). This drop was likely caused by channel incision in the downstream channel segment that resulted from historic channel straightening and wood removal and led to progression of a headcut that worked upstream to the road crossing. The pipe is undersized for the channel width and should be replaced by a bridge (preferred) or larger culvert that meets ‘stream simulation’ design and conforms to WDFW water crossing guidelines that would allow the channel to adjust over time. Note: Sedgwick Rd. (SR160) is a State-owned road and therefore any culvert replacements must comply with the culvert injunction. In addition to culvert replacement, the channel may also need to have wood placed in the downstream segment to re-establish channel complexity, promote sediment storage, and prevent additional accelerated incision. An additional channel crossing occurs a short distance east of Salmonberry Creek along Sedgwick Rd, and is also a fish passage barrier (not included in the WDFW inventory). The origin of this channel is uncertain and should be investigated further.

Figure 6-11. Culvert in Salmonberry Creek at Sedgwick Road (photo from Steve Todd).

(18) Salmonberry Creek between Sedgwick Road and Salmonberry Road

Recommended action:

- Dedicate Stream Corridor for Habitat Protection

The valley narrows through this segment relative to the broad valley bottoms in upstream and downstream channel segments. The stream corridor is well forested and should be protected from potential riparian impacts through conservation easements or other means, where possible. Riparian and channel conditions should be inspected to verify status and evaluate need for additional actions. If natural wood recruitment is unlikely given riparian conditions, wood placement is recommended to create channel complexity in the near term while the riparian forest matures to a point when it can provide wood recruitment.

(19) Salmonberry Creek from Salmonberry Road to Constructed Side Channel Ponds

Recommended actions:

- Dedicate Stream Corridor for Habitat Protection
- Channel Restoration
- Wood Placement
- Riparian Restoration and Management

The segment upstream of Salmonberry Road was previously cleared of riparian vegetation and channelized in a ditch crossing agricultural fields (Figure 6-12). Restoration actions completed in 2004 established conservation easements and created a complex of side channel ponds. There is an approximately 1,000 foot segment of the stream corridor between Salmonberry Road and the constructed side channel ponds that has not been treated and remains impaired by past impacts.

(20) Salmonberry Creek from Constructed Side Channel Ponds to Long Lake Road

Recommended actions:

- Dedicate Stream Corridor for Habitat Protection
- Channel Restoration
- Wood Placement
- Riparian Restoration and Management

Upstream of the constructed side channel/off-channel ponds, Salmonberry Creek remains confined in a ditch that was channelized when the land was cleared for agricultural land use. Restoration actions in this segment should aim to restore channel complexity, floodplain connectivity, and riparian conditions.

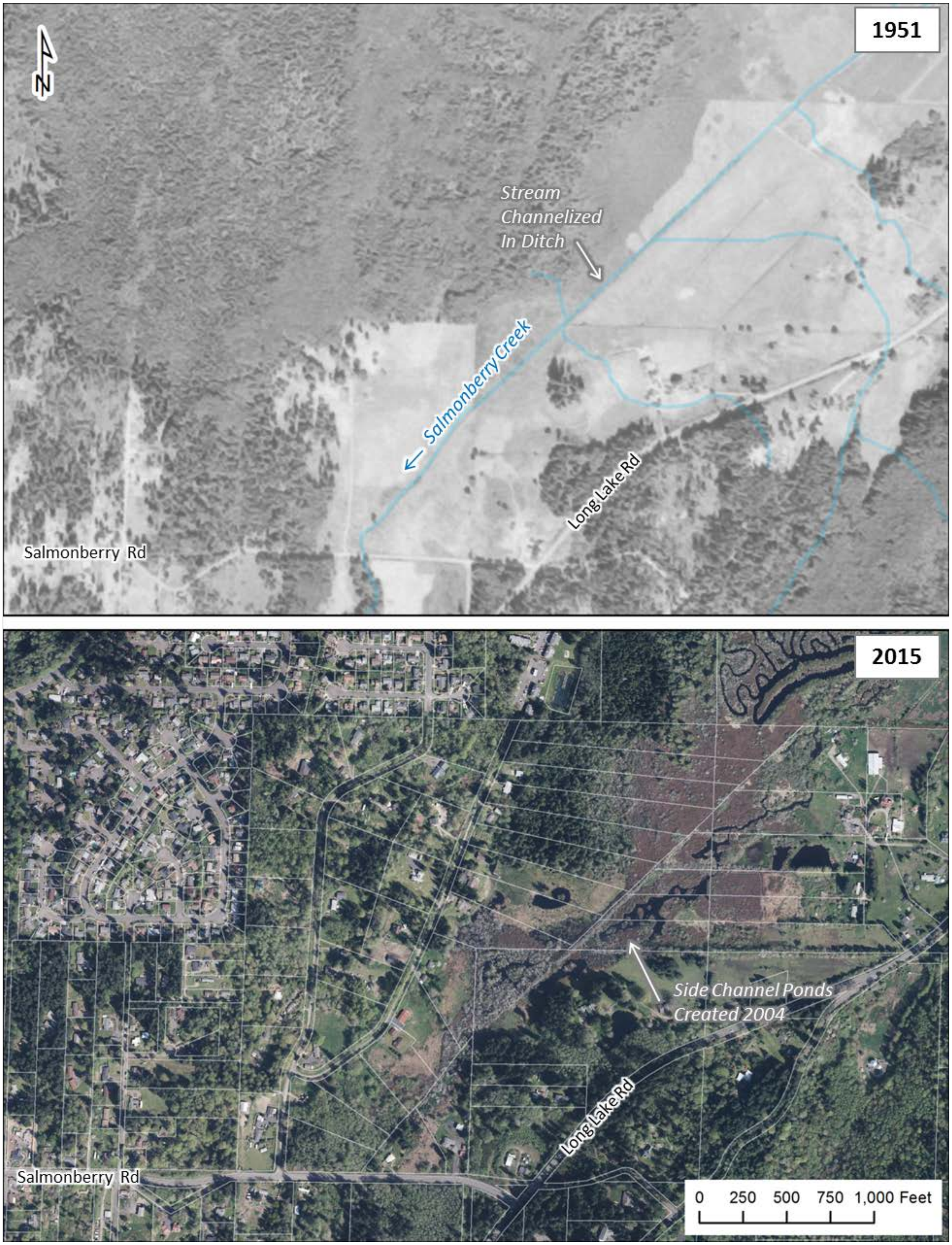

Figure 6-12. Historic (1951) and recent (2015) aerial imagery of Salmonberry Creek upstream of Salmonberry Road.

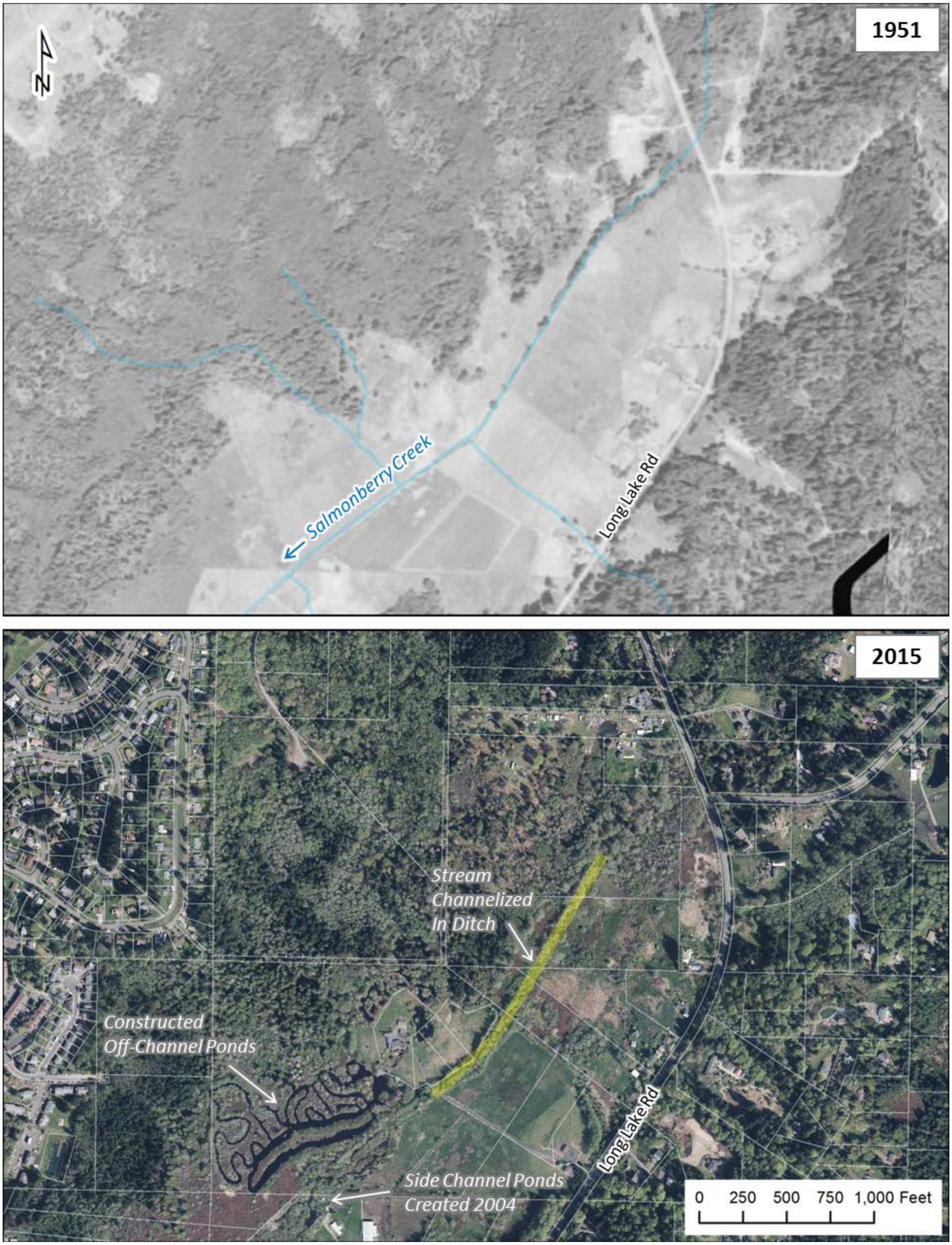

Figure 6-13. Historic (1951) and recent (2015) aerial imagery of Salmonberry Creek downstream of Long Lake Road.

(21) Salmonberry Creek Crossing at Private Road Downstream of Long Lake Road

Recommended action:

- Fish Passage Restoration

Salmonberry Creek crosses a private road through a 2 foot diameter culvert at a slope of 11%. The WDFW assessment report from 2008 noted that the culvert was beginning to wash out and that a 1 foot diameter PVC overflow pipe was added to avert the problem but had been unsuccessful. The culvert is listed as a fish passage barrier due to the slope. The recommended action is to replace the existing crossing with a bridge or larger culvert that conforms to WDFW water crossing guidelines for fish passage.

(22) Salmonberry Creek Crossing at Long Lake Road

Recommended action:

- Fish Passage Restoration

Salmonberry Creek at Long Lake Road flows through a 3 foot diameter culvert. The WDFW report lists a slope of -0.4% (inverse slope), and identifies the culvert as a partial fish passage barrier (passability 67%) due to velocity (greater than 6 ft/second). The recommended action is to replace the existing crossing with a bridge or larger culvert that conforms to WDFW water crossing guidelines for fish passage.

(23) Salmonberry Creek at Howe Farm County Park

Recommended actions:

- Fish Passage Restoration
- Wood Placement
- Riparian Restoration and Management

Kitsap County purchased the farm located between Long Lake Road and Mile Hill Road in 1996 to establish a preserved farmland park. There is an approximately 1,000 foot long segment of the stream near the middle of the property that has a very narrow riparian corridor (Figure 6-14). Willow plantings were established along the stream in the 1990s and conifers in more recent years but there are opportunities to expand and enhance the riparian vegetation as well as install wood structures throughout the stream corridor at Howe Farm. Field reconnaissance in spring 2017 observed evidence of beaver in the reach upstream of the fish barrier culvert crossing, including open water areas (Steve Todd, Suquamish Tribe Fisheries Department).

A trail crosses Salmonberry Creek through a 4 foot diameter steel culvert over a length of 12 feet at a slope of 8%. WDFW's culvert assessment identified the culvert as a barrier due to slope. The WDFW assessment also noted that the culvert is collapsing because the invert is rusted out and folded under.

Figure 6-14. Map of Howe Farm County Park. (Source: Kitsap County Parks).

(24) Cool Creek Alluvial Fan Downstream of Phillips Road

Recommended actions:

- Dedicate Stream Corridor for Habitat Protection
- Channel Restoration
- Wood Placement
- Riparian Restoration and Management

Cool Creek passes through a forested riparian area downstream of Phillips Road and then decreases in gradient as it emerges into the broad valley of Salmonberry Creek. Deposition of sediment in this transitional area has built up a small alluvial fan over time. The upper segment of this fan is forested and should be protected, particularly where the stream corridor intersects the Port Orchard UGA. There is little wood in this segment and field reconnaissance by Suquamish Tribe noted some incision with steep banks in part of this reach. Wood placement is recommended to restore channel elevation through aggradation, reconnection of the floodplain, and increasing channel complexity. As the channel flattens onto the Salmonberry Creek valley, it is channelized into a ditch that routes flow to a constructed pond and into Salmonberry Creek. Re-routing Cool Creek out of this ditch and restoring a forested stream corridor in this reach should be completed in tandem with restoration in the former golf course (current nursery) reach just upstream of the confluence. As part of restoration in this reach, beaver should be allowed to establish and persist, helping to form and maintain salmonid habitat in the reach.

(25) Cool Creek upstream of Phillips Road

Recommended actions:

- Dedicate Stream Corridor for Habitat Protection
- Wood Placement

The stream corridor extending approximately 2,500 feet upstream of Phillips Road has a relatively well established riparian corridor that should be protected. The Port Orchard UGA encompasses the stream corridor in this reach (Figure 6-15). Wood placement is recommended in some locations to increase channel complexity and stabilize the channel from potential alterations in flow regime due to past and ongoing residential development in contributing tributaries draining areas of the UGA.

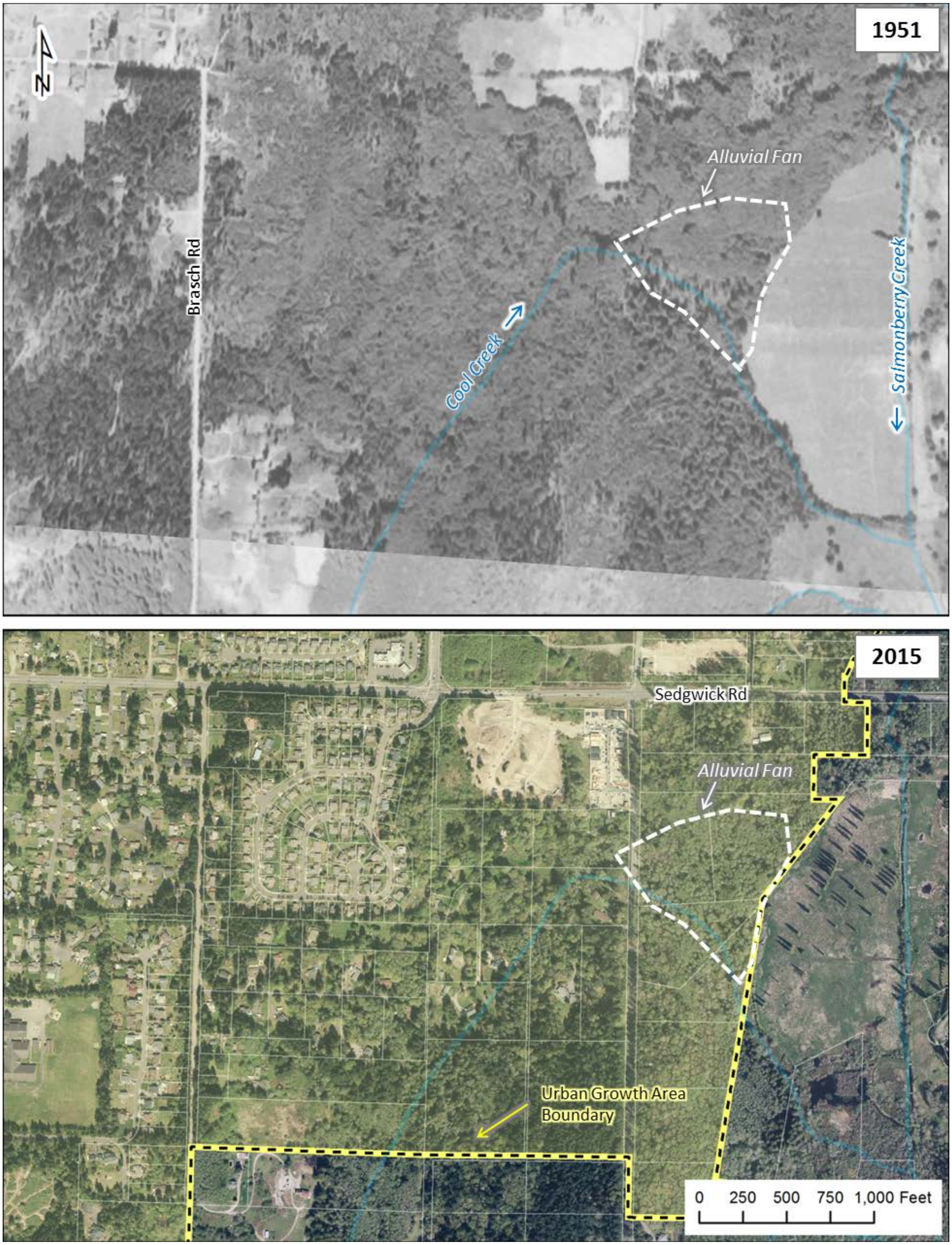

Figure 6-15. Historic (1951) and recent (2015) aerial imagery of Cool Creek and the Salmonberry Creek confluence.

(26) Cool Creek Downstream of Baker Road (Ashby Farm)

Recommended actions:

- Dedicate Stream Corridor for Habitat Protection
- Channel Restoration
- Wood Placement
- Riparian Restoration and Management

There is an approximately 1,000 foot long segment of Cool Creek that is channelized through agricultural lands. The landowner previously planted a 25-foot riparian buffer (primarily Red Osier dogwood) along the stream and installed fencing to exclude cattle. There are opportunities to enhance habitat with restoration of a wider, more complex stream corridor including wood placement, additional planting, and creation of a more sinuous channel connected with side channel/off channel features.

Figure 6-16. Photo of the Cool Creek floodplain at Ashby Farm (view upstream). Cool Creek is channelized within a narrow corridor at the right side of the image.

(27) Tributary Channels Draining Urban Growth Area

Recommended actions:

- Dedicate Stream Corridor for Habitat Protection
- Wood Placement
- Riparian Restoration and Management

Several small tributaries drain upland hillslope areas, including portions draining from the UGA, and discharge into Cool Creek and Salmonberry Creek. Most of the tributary channels have not been mapped or surveyed for fish presence. Field reconnaissance by Suquamish Tribe Fisheries staff noted a left bank tributary that joins Cool Creek only a few hundred feet upstream of Phillips Road is not included on the WDNR water type map. This tributary has physical characteristics that would support salmonids; however, the channel appears more incised as it nears an area that is currently undergoing residential development. At least two additional tributaries that are also not shown on water type maps join this left bank tributary to Cool Creek (Figure 6-17). These tributaries may provide habitat for coho, cutthroat, and steelhead, and they are important source areas for runoff and sediment that are sensitive to channel incision given the steep gradient and proximity to residential developments.

Recommended actions include detailed mapping of the tributary channels to identify their locations and geomorphic characteristics. Defining a riparian corridor around these channels is important for establishing protection from future disturbance and supporting the maturity of existing riparian vegetation. Wood placement in these tributaries will be important for maintaining hydraulic resistance and preventing further channel incision that would result in excessive sedimentation to downstream reaches.

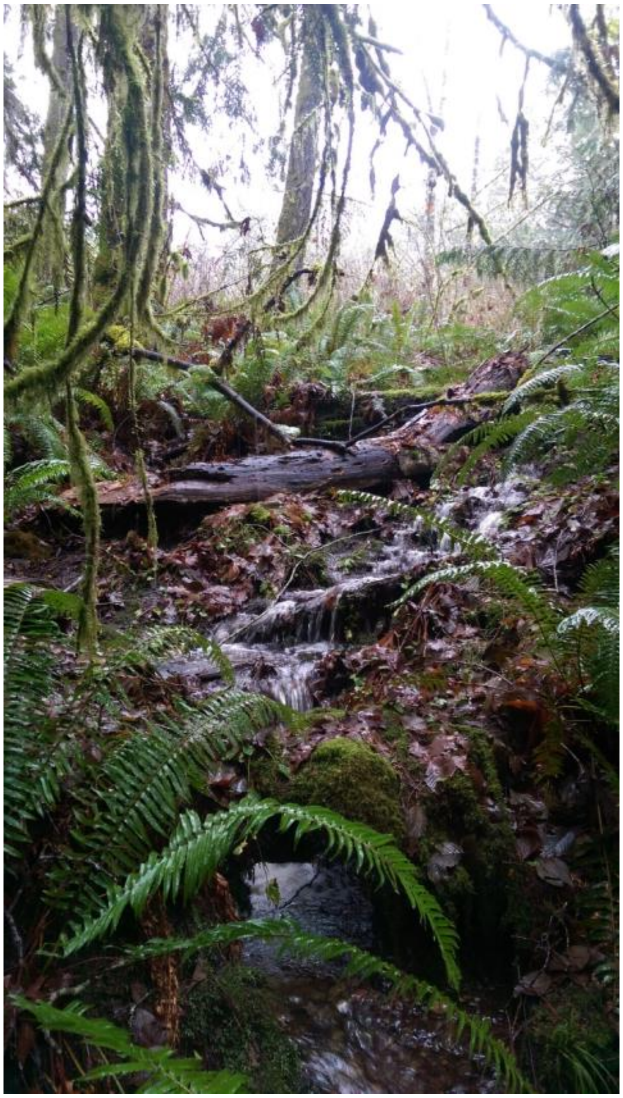

Figure 6-17. Small tributary to Cool Creek that conveys runoff from development in the Port Orchard UGA (Photo by Steve Todd, Suquamish Tribe).

6.3 Long Lake and Tributaries

(28) Long Lake Shoreline

Recommended actions:

- Dedicate Stream Corridor (Riparian) for Habitat Protection
- Riparian restoration
- Management of fertilizer/pesticide use along shoreline
- Manage predation of coho by largemouth bass population

The lake shoreline is heavily developed with residential land use and the shoreline is modified extensively. Opportunities to protect remaining areas of undeveloped shoreline should be pursued via conservation easement, acquisition, or other means. Revegetation of impacted shoreline areas will help improve habitat conditions. Ongoing water quality concerns such as phosphorus pollution and excessive growth of aquatic plants have been treated in past efforts through alum treatments, lake drawdown, and limited dredging. These treatments are expensive and can have their own negative ecological consequences. A long term management plan should be developed that also considers strategies to control the input of nutrients and pesticides into the lake from the surrounding land areas, as well as protecting and restoring native riparian vegetation along the shoreline.

Recommended is a new field survey of predator composition and abundance in Long Lake and Salmonberry Creek, coupled with an analysis of stomach contents and species predator-prey bioenergetics. These results, combined with coho smolt abundance estimates from the Suquamish Tribe outmigrant trap in Curley Creek, would be an important assessment of predator effects on coho salmon in the watershed. If results from a resurvey are consistent with findings from the Bonar et al. (2005) study then recommended is a management action to reduce abundance of the primary non-native predators in Long Lake. This action could be a bounty fishery combined with a derby on largemouth bass from Long Lake, or an agency- led predator removal program.

(29) Upper Curley Creek

Recommended actions:

- Dedicate Stream Corridor for Habitat Protection
- Fish Passage Restoration
- Wood Placement
- Riparian Restoration and Management

The lower gradient channel segment between Long Lake and Mullenix Road is channelized and incised. Wood placement is needed to restore channel complexity and reconnect floodplain habitats. Riparian restoration is needed where vegetation has been removed, including a recently harvested area that likely should have been more effectively protected from logging.

The stream crossing at Mullenix Road is a complete fish passage barrier due to the water surface drop (Figure 6-18). The culvert should be replaced with a bridge span or larger culvert that meets WDFW fish passage criteria. Culvert replacement design needs to consider potential implications of channel incision such that removal of the grade control (existing culvert) does not worsen channel conditions upstream.

Incorporation of large wood placement into the creek is recommended to prevent further incision and restore channel complexity.

Figure 6-18. Culvert in Upper Curley Creek at Mullenix Road (Photo by Steve Todd, Suquamish Tribe).

(30) Additional Tributaries draining to Long Lake

Recommended actions:

- Dedicate Stream Corridor for Habitat Protection
- Fish Passage Restoration

Little information was discovered to characterize other tributary channels draining to Long Lake. Areas with functioning riparian conditions should be protected. Fish passage barriers in tributaries crossing Mullenix Road should be replaced with bridge spans or larger culverts meeting WDFW fish passage criteria. Culvert replacement in the smaller tributaries should be coordinated with replacement of the culvert at Upper Curley Creek to reduce costs and minimize traffic impacts to local residents. Further evaluation of riparian and channel conditions is needed to determine potential additional actions.

(31) Wetland Complex at SE corner of Long Lake

Recommended actions:

- Dedicate Stream Corridor (Riparian) for Habitat Protection
- Restore Fish Passage

Little information was found to characterize the large wetland complex at the southeast corner of Long Lake. Protection of the existing wetland condition and functions is recommended as is further assessment to evaluate existing conditions. Further actions regarding wetland restoration should be considered following evaluation.

7. DATA GAPS AND RECOMMENDATIONS

This assessment aimed to identify protection and restoration strategies and specific actions to maintain and/or improve salmonid habitat conditions and ecological resilience in the Curley Creek watershed. Assessment of watershed impairments was based primarily on review of previous studies and by GIS analysis of existing information. Further refinement and expansion of this study is warranted to include more detailed investigation and to address data gaps identified in the assessment.

Additional work needed to refine the assessment of salmonid habitat and watershed impairment includes:

- Water typing assessment with field surveys to refine stream mapping and correct misclassifications of fish-bearing streams (see WFC, 2014). Accurate water type maps are necessary to ensure adequate protection of existing habitat in areas of future development.
- Establish a continuous stream gaging station to monitor flows in Salmonberry Creek and potentially Cool Creek, and track hydrologic response to ongoing development of the Port Orchard UGA.
- Quantitative analysis of potential changes in hydrologic regime under future climate change scenarios.
- Stream inventories with field data to develop a quantitative characterization of channel units (pool, riffle, side channel, etc), substrate, wood loading, and riparian conditions.
- Longitudinal profile and cross-sectional surveys at targeted locations to monitor geomorphic channel changes and patterns of deposition and erosion.
- Water temperature observations in tributaries entering Long Lake that may provide cool water refugia for juvenile coho and steelhead entering the lake prior to the summer.
- Live count surveys for coho; the timing of past live counts in the Curley Creek survey reach target summer chum salmon spawning and may not extend late enough to cover complete coho spawning period.
- Mark sampling of adult coho in Salmonberry Creek is needed to improve understanding of the influence of hatchery origin strays on the population
- Total coho escapement. The Salmonberry Creek index count is expanded to estimate total natural spawning in watershed based on a historic abundance estimate. Survey methodology and expansion method should be reviewed and updated to better estimate to total abundance (possible intensive and extensive survey reaches, redd counts, and evaluation of fish life to expand live counts).
- Chum salmon distribution in tributaries other than Curley, Salmonberry and Cool creeks. This is a minor data gap as the Curley Creek index reach covers the primary spawning area used by Curley Creek summer chum. However, supplemental surveys in other portions of the watershed during peak summer chum spawning would help describe spatial diversity.
- Investigation of the current use, and potential for improving productivity and abundance of steelhead in the watershed.

- Total Steelhead Escapement. Surveys are not adequate to estimate total natural spawning in watershed. Survey methodology will need to be reviewed to estimate to total abundance (intensive and extensive survey reaches, redd counts, and evaluation of fish life to expand live counts.
- Field survey of predator composition and abundance in Long Lake and Salmonberry Creek, coupled with an analysis of stomach contents and species predator-prey bioenergetics.
- If results from a resurvey are consistent with findings from the Bonar et al. (2005) study then a management action is recommended to reduce abundance of the primary non-native predators in Long Lake. This action could be a bounty fishery combined with a derby on largemouth bass from Long Lake, or an agency lead predator removal program.
- Evaluate the effectiveness of existing regulatory protection and Critical Areas Ordinance implementation by tracking land use changes in future iterations of the High Resolution Change Detection assessment by WDFW (Pierce, 2011).

8. REFERENCES

Abbe, T.B., Montgomery, D.R., 1996. Large woody debris jams, channel hydraulics and habitat formation in large rivers. Regulated Rivers, 12(2-3), 201-221.

Abbe, T.B., Montgomery, D.R., 2003. Patterns and processes of wood debris accumulation in the Queets river basin, Washington. Geomorphology, 51, 81-107.

Armstrong, J.B. and Schindler, D.E., 2013. Going with the flow: spatial distributions of juvenile coho salmon track an annually shifting mosaic of water temperature. Ecosystems, 16(8), pp.1429-1441.

Baird, K., Stromberg, J., Maddock, T., III, 2005. Linking Riparian Dynamics and Groundwater: An Ecohydrologic Approach to Modeling Groundwater and Riparian Vegetation. Environmental management, 36(4), 551-564.

Baranski, C., 1989. Coho smolt production in ten Puget Sound streams. Washington Department of Fish and Wildlife.

Bjornn, T., Reiser, D., 1991. Habitat requirements of salmonids in streams. American Fisheries Society Special Publication, 19, 83-138.

Bonar S. A., B. D. Bolding, M. Divens, and W. Meyer. 2005. Effects of introduced fishes on wild juvenile coho salmon in three shallow Pacific Northwest lakes. Transactions of the American Fisheries Society, 134, 641-652.

Booth, D.B., Hartley, D., Jackson, R., 2002. Forest Cover, Impervious Surface Area, and the Mitigation of Stormwater Impacts. Journal of the American Water Resources Association, 38(3), 835-845.

Brummer, C.J., Abbe, T.B., Sampson, J.R., Montgomery, D.R., 2006. Influence of vertical channel change associated with wood accumulations on delineating channel migration zones, Washington, USA. Geomorphology, 80, 295-309.

Busby, P.J., Wainwright, T.C., Bryant, G.J., Lierheimer, L.J., Waples, R.S., Waknitz, F.W. and Lagomarsino, I.V., 1996. Status review of steelhead from Washington, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC, 27.

Carpenter, S., Frost, T., Persson, L., Power, M., Soto, D., 1996. Freshwater ecosystems: linkages of complexity and processes. SCOPE-SCIENTIFIC COMMITTEE ON PROBLEMS OF THE ENVIRONMENT INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS, 55, 299-325.

Collins, B.D., Montgomery, D.R., Haas, A.D., 2002. Historical changes in the distribution and functions of large wood in Puget Lowland rivers. Canadian Journal of Fisheries and Aquatic Sciences, 59(1), 66-76.

Cummins, J.E., 1976. Low Flow Characteristics of Streams on the Kitsap Peninsula and Selected Adjacent Islands, Washington. U.S. Geological Survey Open File Report 76-704.

Décamps, H., Naiman, R.J., McClain, M.E., 2009. Riparian Zones. Reference Module in Earth Systems and Environmental Sciences, from Encyclopedia of Inland Waters.

Dethier, M.N., Raymond, W.W., McBride, A.N., Toft, J.D., Cordell, J.R., Ogston, A.S., Heerhartz, S.M., Berry, H.D., 2016. Multiscale impacts of armoring on Salish Sea shorelines: evidence for cumulative and threshold effects. Estuarine, Coastal and Shelf Science, 175, 106-117.

Drew, M., Banigan, L., 2006. Yukon Harbor Watershed Restoration Project, Kitsap County Health District, Environmental Health Division, Water Quality Program.

Elsner, M.M., Cuo, L., Voisin, N., Deems, J.S., Hamlet, A.F., Vano, J.A., Mickelson, K.E., Lee, S.-Y., Lettenmaier, D.P., 2010. Implications of 21st century climate change for the hydrology of Washington State. Climatic Change, 102(1-2), 225-260.

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

Gayeski, N., McMillan, B., Trotter, P., 2011. Historical abundance of Puget Sound steelhead, Oncorhynchus mykiss, estimated from catch record data. Canadian Journal of Fisheries and Aquatic Sciences, 68(3), 498-510.

Great Peninsula Conservancy, 2017. Curley Creek Acquisition Feasibility: Assessment Report. RCO Project Number 14-1632.

Hard, J.J., Myers, J., Ford, M., Kope, R., Pess, G., 2007. Status Review of Puget Sound Steelhead ('Oncorhynchus mykiss').

Haring, D., 2000. Salmonid Habitat Limiting Factors, Water Resource Area 15 (East). Washington Conservation Commission.

Kassler, T., Shaklee, J., 2003. An analysis of the genetic characteristics and interrelationships of summer chum in Hood Canal and Strait of Juan de Fuca and of chum in Curley Creek (Puget Sound) using allozyme data. Washington Department of Fish and Wildlife, Summer Chum Salmon Conservation Initiative Supplemental Report 4.

Kitsap County, 2016. Kitsap County Comprehensive Plan 2016-2036.

Kitsap Public Health District, 2012. 2012 Water Quality Monitoring Report.

Konrad, C.P., Booth, D.B., 2002. Hydrologic trends associated with urban development for selected streams in the Puget Sound Basin, Western Washington. US Geological Survey Water Resources Investigations Report 02-4040.

Koski, K., 2009. The fate of coho salmon nomads: the story of an estuarine-rearing strategy promoting resilience. Ecology & Society, 14(1).

Lestelle, L., Blair, G., Chitwood, S., 1993. Approaches to supplementing coho salmon in the Queets River, Washington, Proceedings of the coho workshop. British Columbia Department of Fisheries and Oceans, Vancouver, BC, pp. 104-119.

Lytle, D.A., Poff, N.L., 2004. Adaptation to natural flow regimes. Trends in Ecology & Evolution, 19(2), 94-100.

Mid Sound Salmon Enhancement Group, 2015. Salmonberry Wetland Mitigation Report.

Miller, B.A., Sadro, S., 2003. Residence time and seasonal movements of juvenile coho salmon in the ecotone and lower estuary of Winchester Creek, South Slough, Oregon. Transactions of the American Fisheries Society, 132(3), 546-559.

Montgomery, D.R., Buffington, J.M., Smith, R.D., Schmidt, K.M., Pess, G., 1995. Pool Spacing in Forest Channels. Water Resources Research, 31(4), 1097-1105.

Montgomery, D.R., Abbe, T.B., 2006. Influence of logjam-formed hard points on the formation of valley-bottom landforms in an old-growth forest valley, Queets River, Washington, USA. Quaternary Research, 65(1), 147-155.

Naiman, R., Bilby, R.E., 2001. River ecology and management: lessons from the Pacific coastal ecoregion. Springer.

Nash, D.W., 2017. East Kitsap Steelhead Habitat Evaluation Project. Prepared for West Sound Watersheds Council.

OFM, 2012. 2012 GMA Population Projections. Last accessed 7/25/2016.

Penttila, D., 2007. Marine Forage Fishes in Puget Sound. Prepared in support of the Puget Sound Nearshore Partnership. Washington Department of Fish and Wildlife, Technical Report 2007-03.

Pierce, Ken. WDFW. 2011. Final Report on High Resolution Change Detection Project

Poff, N.L., Allan, J.D., Bain, M.B., Karr, J.R., Prestegaard, K.L., Richter, B.D., Sparks, R.E., Stromberg, J.C., 1997. The natural flow regime. BioScience, 47(11), 769-784.

Pollock, M. M., Heim, M., and Werner, D., 2003. Hydrologic and geomorphic effects of beaver dams and their influence on fishes. In American Fisheries Society Symposium (Vol. 37, pp. 213-233).

Pollock, M. M., Pess, G. R., Beechie, T. J., and Montgomery, D. R. 2004. The importance of beaver ponds to coho salmon production in the Stillaguamish River basin, Washington, USA. North American Journal of Fisheries Management, 24(3), 749-760.

Power, M.E., 1992. Habitat Heterogeneity and The Functional Significance of Fish in River Food Webs. Ecology, 73(5), 1675-1688.

Power, M.E., Sun, A., Parker, G., Dietrich, W.E., Wootton, J.T., 1995. Hydraulic food-chain models. BioScience, 159-167.

Power, M.E., Dietrich, W.E., 2002. Food webs in river networks. Ecological Research, 17(4), 451-471.

Roni, P., Bennett, T., Holland, R., Pess, G., Hanson, K., Moses, R., McHenry, M., Ehinger, W., Walter, J., 2012. Factors affecting migration timing, growth, and survival of juvenile Coho Salmon in two coastal Washington watersheds. Transactions of the American Fisheries Society, 141(4), 890-906.

Salo, E.O., 1991. Life history of chum salmon (Oncorhynchus keta).

Sandercock, F.K., 1991. Life history of coho salmon (Oncorhynchus kisutch). Pacific salmon life histories, pp.395-445.

Segura Sossa, C., Booth, D.B., 2003. Comparing and evaluating rapid assessment techniques of stream channel conditions for assessing the quality of aquatic habitat at the watershed scale, Georgia Basin/Puget Sound Research Conference, Vancouver, BC.

Simenstad, C., 2000. Estuarine landscape impacts on Hood Canal and Strait of Juan de Fuca summer chum salmon and recommended actions. Appendix Report, 3, A3.

Tabor, R. A., B. A. Footen, K. L. Fresh, M. Celedonia, F. Mejia, D. L. Low, and L. Park. 2007. Smallmouth bass and largemouth bass predation on juvenile Chinook salmon and other salmonids in the Lake Washington basin. North American Journal of Fisheries Management. 27:1174 – 1188.

U.S. Office of the Federal Register, 2013. Endangered and Threatened Species; Designation of Critical Habitat for Lower Columbia River Coho Salmon and Puget Sound Steelhead; Proposed Rule. Federal Register 78:9(14 January, 2013):2725-2796.

Waldo, T., C. Clark, and B. Jones. 2013. Applying the NOAA-Fisheries threshold intrinsic potential model from NHD Plus (100K) to NHD high resolution (24K or higher resolution): Puget Sound steelhead trout (Onchorynchus mykiss). Report to Puget Sound Partnership. Northwest Indian Fisheries Commission, Salmon and Steelhead Inventory Assessment Program.

Waples, R.S., Pess, G.R., Beechie, T., 2008. Evolutionary history of Pacific salmon in dynamic environments. Evolutionary Applications, 1(2), 189-206.

Ward, J., Tockner, K., Arscott, D., Claret, C., 2002. Riverine landscape diversity. Freshwater Biology, 47(4), 517-539.

Warner, M.D., Mass, C.F., Salathé Jr, E.P., 2015. Changes in winter atmospheric rivers along the North American west coast in CMIP5 climate models. Journal of Hydrometeorology, 16(1), 118-128.

Washington Department of Ecology, 2012a. Water Quality Assessment and 303(d) List.

Washington Department of Ecology, 2012b. Water Quality Standards for Surface Waters of the State of Washington, Chapter 173-201A WAC. Publication # 06-10-091.

Wild Fish Conservancy 2014. West Sound Watersheds Watertype Assessment Project - Phase II.

Zillges, G., 1977. Methodology for determining Puget Sound coho escapement goals, escapement estimates, 1977 pre-season run size prediction and in-season run assessment. State of Washington, Department of Fisheries.