Clackamette Cove
Water Quality and Habitat Improvement Feasibility Study

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Contents

Acronyms and Abbreviations

Best Management Practice	BMP
Cascade Environmental Group	Cascade
City of Oregon City	City
Clackamette Cove	Cove
Clackamette Cove Feasibility Study Area	Study Area
Clackamas River Basin Council	CRBC
Clackamas River Water Providers	CRWP
Endangered Species Act	ESA
Federal Emergency Management Agency	FEMA
Global Positioning System	GPS
Greater Oregon City Watershed Council	GOCWC
Harmful Algal Blooms	HABs
Low-Impact Development	LID
Low-Impact Development Approach	LIDA
Municipal Separate Storm Sewer System	MS4
National Marine Fisheries Service	NMFS
National Pollutant Discharge Elimination System	NPDES
Natural Resources Damages Assessment	NRDA
Natural Resources Overlay District	NROD
National Vertical Geodetic Datum	NVGD
North American Vertical Datum of 1988	NAVD88
Ordinary High Water	OHW
Oregon Department of Environmental Quality	DEQ
Oregon Department of Fish and Wildlife	ODFW
Oregon Health Authority	OHA
Oregon Watershed Enhancement Board	OWEB
Polycyclic aromatic hydrocarbons	PAHs
Prospective Purchaser Agreement	PPA
US Geological Survey	USGS
Water Quality and Habitat Improvement Feasibility Study	Feasibility Study

Introduction

The City of Oregon City (City) is designing a plan, the "Cove Development Plan", to implement a phased, mixed-use development adjacent to Clackamette Cove (Cove), an embayment connected to the Clackamas River. In the late summer and early fall of 2015 there was a harmful algal bloom (HAB) in the Cove, which prompted the Oregon Health Authority (OHA) to issue a health advisory warning against water contact activities in the Cove because toxins produced by HABs are potentially harmful to people.

Prompted by the implementation of the Cove Development Plan, the City is evaluating the Cove's interrelated natural resources issues with a focus on water quality, algal blooms, and fish and wildlife habitat. As part of this effort, the City retained Cascade Environmental Group, LLC. (Cascade) to conduct a Water Quality and Habitat Improvement Feasibility Study (Feasibility Study). The goals of the Feasibility Study are to: 1) to characterize the Cove's current natural and built environment in the context of historical and current land uses and future recreational, residential, and commercial uses of the area; and 2) identify comprehensive and integrated restoration and mitigation approaches to prevent or mitigate future HABs, improve water quality, and enhance fish and wildlife habitat.

Clackamette Cove's Regional Setting

The Cove's expanse of open water and its immediate surrounding area were created by past gravel mining and other industrial operations. With its location adjacent to the City's Clackamette Park and near the confluence of the Clackamas and Willamette Rivers, the Cove provides regionally important fish and wildlife habitat and recreational amenities. A network of trails, parks, and natural areas connects the Cove to the surrounding landscape and natural areas (Figure 1). A popular pedestrian/bicycle trail generally parallels the east side of the Cove and connects Main Street to Washington Street, approximately one mile to the north. This trail links the City to the Clackamas River, provides a connection to the City of Gladstone, and provides access to a regional network of trails, parks, and natural areas.

The Clackamas River provides important fish habitat and water resources. The river, which has some of the healthiest native fish populations in the Willamette Basin, provides critical habitat for salmon and steelhead, which are listed under the federal Endangered Species Act (ESA). The Willamette-Clackamas river confluence area is recognized by the State of Oregon and federal agencies as important habitat for salmon, steelhead, and other native fish populations, including Pacific lamprey. Maintaining water quality in the Clackamas River is also important; the river supplies high-quality drinking water to nearly 400,000 people in the Portland Metropolitan region, including supplying drinking water to the City[1].

The Cove is located within an area encompassing lower Willamette River tributaries that collectively are part of a regional planning effort focused on improving water quality and native fish populations. The Clackamas River Basin Council (CRBC) is collaborating with the Greater Oregon City Watershed Council (GOCWC), the Oregon Watershed Enhancement Board (OWEB), the Oregon Departments of Fish and

[1] **Clackamas River Water Providers (CRWP). 2016.** The Clackamas River Watershed. CRWP, the City of Oregon City, OR. http://www.clackamasproviders.org/images/stories/Watershed_Poster_Final.pdf

Wildlife (ODFW) and Environmental Quality (DEQ), Clackamas County, Metro, and other partners to develop a comprehensive strategy and funding framework for pursuing habitat restoration and water quality improvements throughout the Clackamas River Basin and the surrounding metropolitan area. Within the City, this strategic planning area encompasses the Cove, Abernethy Creek, and the Willamette River from its confluence with the Clackamas River up to Willamette Falls.

The Clackamette Cove Development Plan

With their scenic location and proximity to transportation, shopping, and recreational amenities, the undeveloped parcels adjacent to the Cove are attractive for mixed-use development. After many years of planning, the City is partnering with a private developer to embark on a plan to design and implement an ambitious multi-phased development, the Cove Development Plan, on these parcels. The purpose of the Cove Development Plan is to "create an exciting new master-planned mixed-use waterfront village that will connect developed areas with open spaces through a network of multi-modal pathways, trails, and a waterfront esplanade"[2]. The proposed development is located adjacent to the Cove on challenging sites within the City's Urban Renewal District and will be constructed in phases over time.

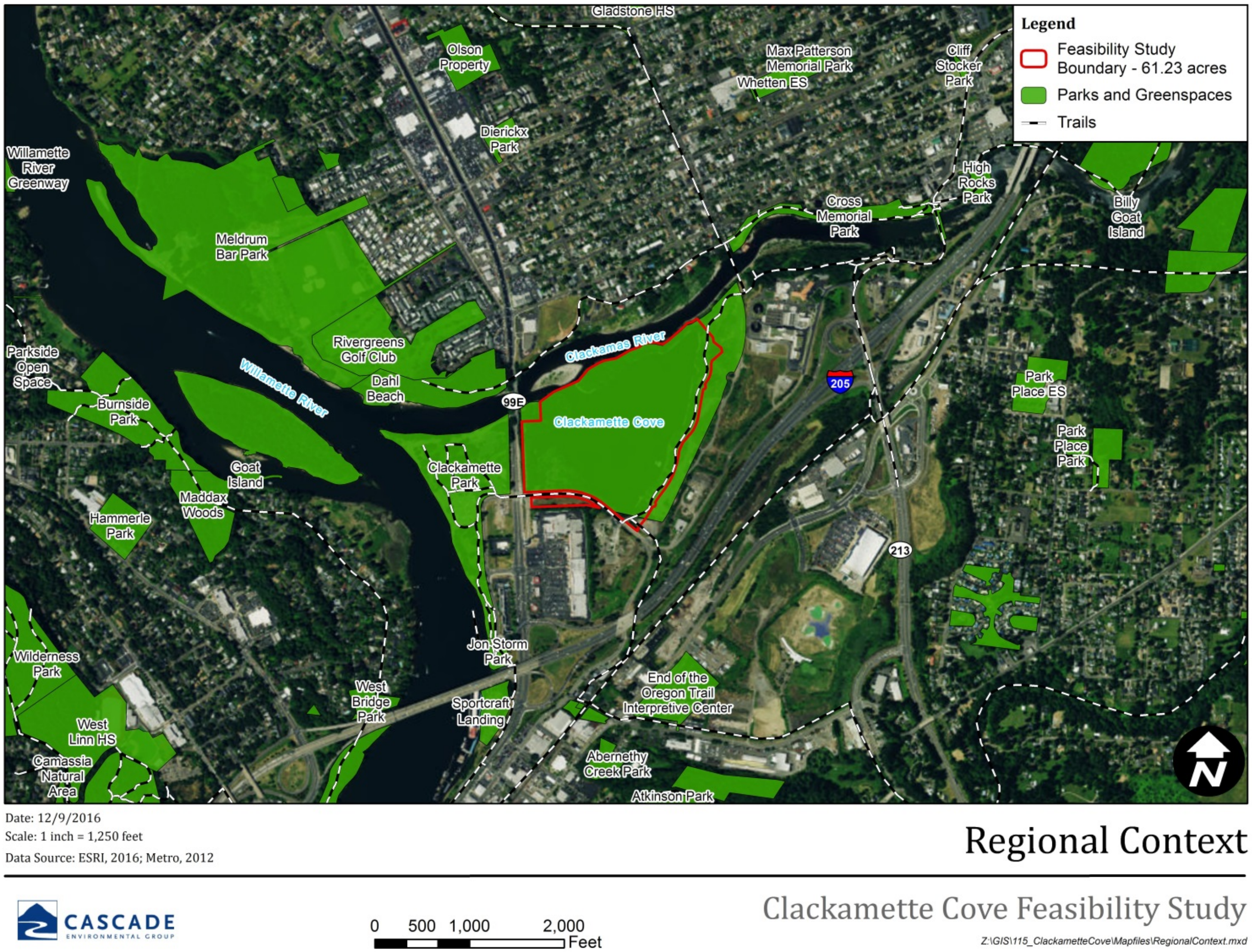
Located next to the former Rossman Landfill and within an area of past industrial land uses, the Cove Development Plan area currently is assessed at a negative value, meaning it is estimated that it would take more money than the parcels are worth to develop them. Recognizing the "substantial cost of correcting the defects in the project site and the substantial cost of building the streets, utilities, and public amenities to create a financially viable project," the Oregon City Urban Renewal Commission has agreed to reimburse the developer for a portion of the development costs after the completion of the project elements.

Since portions of the Cove Development Project are within the Federal Emergency Management Agency's (FEMA) 100-year base flood elevation, all fill material for construction will be sourced from within the 100-year floodplain. Proposed grading activities will not occur below the ordinary high water (OHW) line of the Cove [18 feet (NAVD88)][3] and no fill will be placed within the floodway. Sourcing all fill material from within the floodplain will result in balanced cut and fill within the City's Flood Management Overlay District to ensure that the Cove Development Project does not reduce flood storage capacity.

[2] **Grand Cove, LLC. 2015.** The Cove, Oregon City, Oregon: An Application for Amended Concept Development Plan. Grand Cove, LLC, Denver, CO. http://www.orcity.org/sites/default/files/fileattachments/planning/project/6059/exhibit_a_revised_narrative_1.pdf

[3] **Pacific Habitat Services, Inc. 2015.** Natural Resources Overlay District Report: Garden Apartments Project. Pacific Habitat Services, Inc. Wilsonville, OR. http://www.orcity.org/planning/project/cp-15-0001-dp-15-0001-nr-15-0005-us-15-0006

Figure 1. Clackamette Cove's location at the confluence of the Willamette and Clackamas rivers. An interconnected network of parks, natural areas, and trails connects the Cove to the surrounding landscape and metropolitan region.



The Cove Development Plan's Phase 1 development site is located along the north end of Main Street behind the Oregon City Shopping Center and across Main Street from the Cove (Figure 2). Construction of Phase 1 began in the summer of 2016 with a mass grading effort to prepare the site for development. This work will be followed by construction of a multi-family mixed-use complex (Garden Apartments), stormwater treatment and conveyance facilities, and other infrastructure[4].

Ultimate constructed grades for all buildings in the area require finished floor elevations at approximately 53 feet or greater in order to be above the 100-year base flood elevation. An area in the north-east portion of the site (the North Park site) is being excavated to provide fill and balance floodplain storage for the Garden Apartment project and to bring portions of the North Park site to its final design grade for development of park areas and an amphitheater (Figure 2).

The Phase 2 development site, which has not gained the City's final approval, will include multi-story residential, commercial, and restaurant spaces along the Cove's eastern edge (Figure 2) and will feature views of the Cove. The project will require balancing fill and floodplain storage capacity, and includes infrastructure improvements such as parking areas and stormwater treatment facilities. This phase will also provide additional public access to the Cove. Some grading will take place along the bank of the Cove, but the exact locations and fill removal quantities have not yet been determined. The trail adjacent to the eastern bank of the Cove will remain.

The Feasibility Study Area

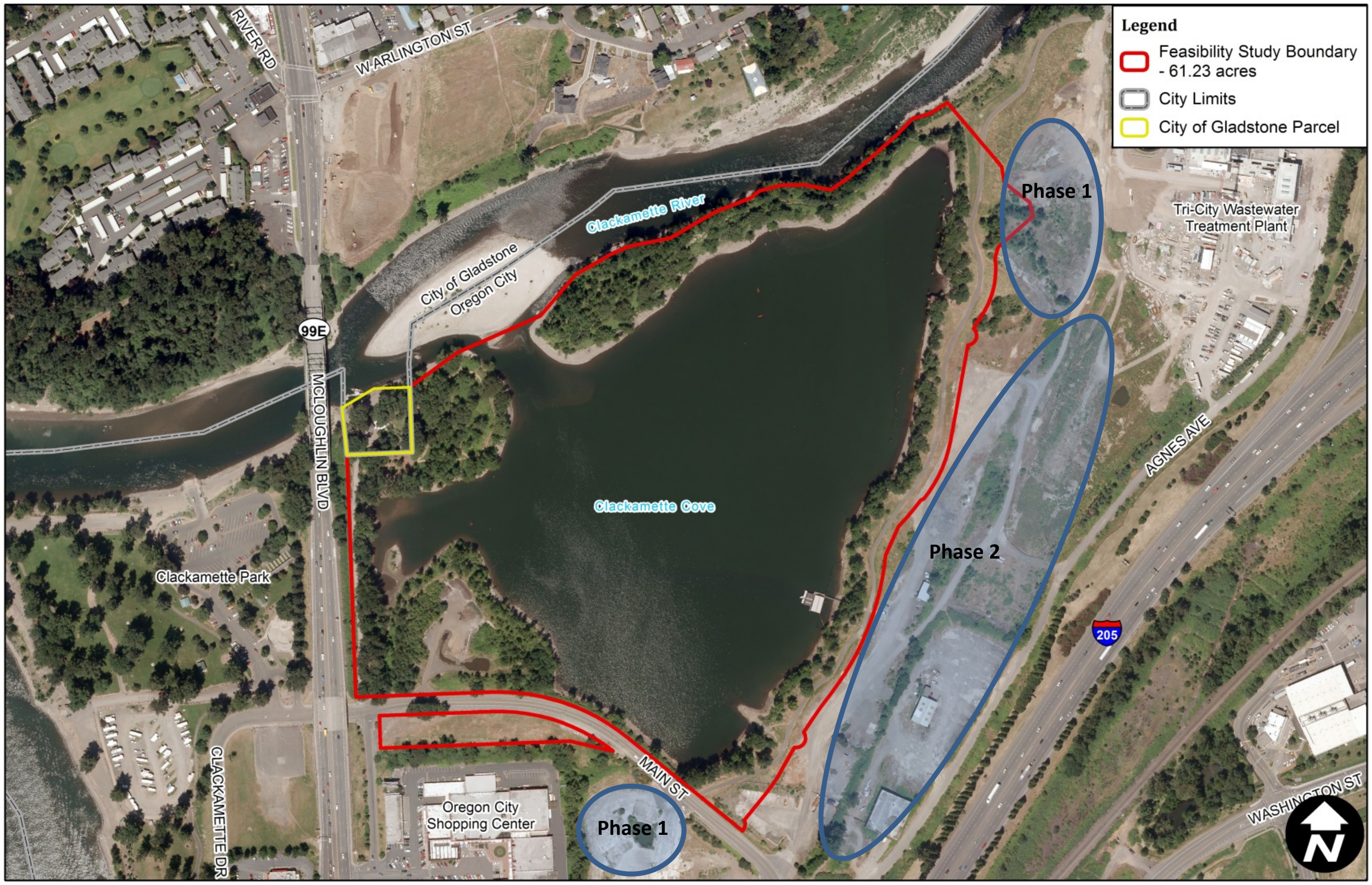
The Clackamette Cove Feasibility Study Area (Study Area) boundary encompasses 61.23 acres, including the open water areas, associated floodplain, and the shoreline of the adjacent Clackamas River (Figure 2). The entire Study Area is below FEMA's 100-year base flood elevation (approximately 48 feet NAVD88[5]). The Cove's open water and a large portion of the banks that transition into the terraced floodplain are below the OHW elevation. The OHW elevation is an approximate boundary between aquatic resources and the transition into riparian and upland areas. Areas below OHW are regulated by local, state, and federal agencies as aquatic and wetland resources.

The Study Area is bounded in the north by the Clackamas River and the City of Gladstone; the eastern boundary encompasses the transition between the Cove's steep banks and the gently sloping area adjacent to the proposed Cove Development Plan's Phase 2 building footprint. The Tri-City Waste Water Treatment Plant borders the northeastern portion of the Study Area; the southern border is adjacent to Main Street and the nearby Oregon City Shopping Center is south of the area. The Study Area's western boundary follows McLaughlin Blvd (Highway 99E) and includes one small parcel south of Main Street, adjacent to the Phase 1 development site (Figure 2). A City of Gladstone parcel that includes an inoperative pumping station lies adjacent to the Study Area's northwest corner.

[4] **The City of Oregon City. 2016.** Press Release: Ground Breaking Event – The Grand Cove Project. The City of Oregon City, OR. https://www.orcity.org/citycommission/ground-breaking-event-grand-cove-project

[5] T**he North American Vertical Datum of 1988** (NAVD 88) is the vertical control datum of orthometric height established for vertical control surveying in the United States. Oregon City has a design flood elevation (DFE) that was set based on the 1996 flood inundation level, 50.7 feet (NAVD88).

Figure 2. Clackamette Cove Feasibility Study Area and general locations of Phase 1 and Phase 2 of the Cove Development Plan.



Date: 12/15/2016
Scale: 1 inch = 400 feet
Data Source: Clackamas County, 2016; USGS, 2010

Feasibility Study Area

Clackamette Cove Feasibility Study

CASCADE ENVIRONMENTAL GROUP

0 200 400 800 Feet

Z:\GIS\115_ClackametteCove\Mapfiles\ProjectAreas.mxd

The Feasibility Study generally focuses on characterizing and evaluating environmental features associated with open water and adjacent floodplain areas, with elevations ranging from below OHW to the 100-year base flood elevation. The Feasibility Study evaluates the current and future Cove Development Plan features that directly affect the Cove's aquatic environment, floodplain habitats, and water quality: bank grading and other activities that impact vegetation and habitats adjacent to the open water area, and stormwater conveyance into the Cove from the new development and surrounding areas. The areas within the Cove Development Plan's building footprint are not characterized in detail because the intent of this study is to evaluate the broad environmental impacts of the development and not the development's site-specific features.

The development's current and proposed site-specific features (e.g., building locations, street design details, etc.) are being evaluated by the City in reference to land use designations and appropriate municipal codes. Most of the Study Area is within the City's Natural Resource Overlay District (NROD), which is intended to protect the Clackamas River, riparian vegetation, wetlands and wildlife habitat, and their associated functions[6]. An NROD assessment that characterizes natural resource areas, wetlands, and vegetated corridor width and condition has been completed for Phase 1[7]. The assessment evaluated tree removal and other impacts within the vegetated corridor as well as the development's consistency with the NROD and assessed potential conflicts with the provisions of the Oregon City Municipal Code. The assessment found that the proposed development largely avoids adverse impacts to NROD resources through minimization and avoidance measures that include:

- Avoiding impacting wetlands or areas below OHW;
- Removing invasive, non-native plant species from the development area;
- Balancing cut and fill within the development area;
- Creating stormwater treatment and conveyance systems that will utilize pervious pavement throughout the site, bioswales within the public right-of-way, and rain gardens in the building area; and
- Leaving the majority of the site as open space or parks to assist with the protection of the aquatic and terrestrial habitat.

The NROD assessment found some unavoidable impacts (primarily tree removal) to the vegetated corridor and outlined required mitigation, which focuses on native vegetation plantings and invasive species removal at a two-to-one ratio of mitigation area to disturbance area.

The Clackamas River is evaluated relative to the Study Area in terms of its influence on the Cove (e.g., hydrology, bank erosion, and the large gravel bar at the Cove's mouth). The City's boundary is located approximately in the center of the river channel; the City does not have jurisdiction over the north bank of the Clackamas River, which is part of the City of Gladstone.

[6] **The City of Oregon City. 2016.** Natural Resource Overlay District. Oregon City, OR. http://www.orcity.org/planning/natural-resource-overlay-district-nrod

[7] **Pacific Habitat Services, Inc. 2015.**

Clackamette Cove's Historical Development

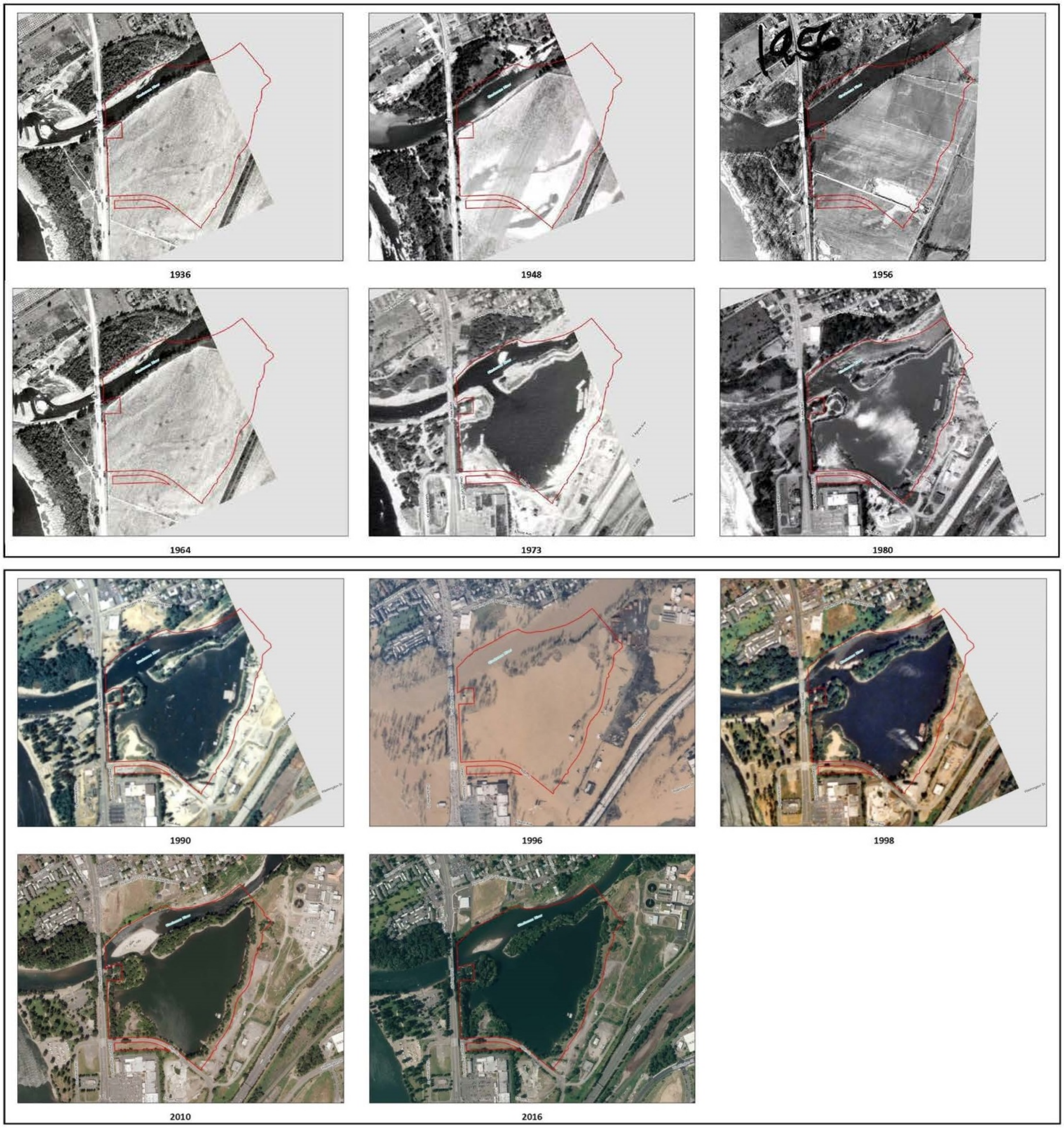
The Cove is part of a dynamic floodplain and river environment that has been modified by land uses, industrial practices, and changes in flood regimes. Historical aerial photography taken between 1936 and 2016 illustrates how the Cove and surrounding river channel and floodplain habitats have changed over time (Figure 3). Sand and gravel mining and other land uses have dramatically altered the landscape of the Willamette-Clackamas river confluence area. The period from the early 1900s through the 1960s was characterized by extensive gravel mining within the river's channels. The 1936 image shows active mining in the Clackamas and Willamette rivers below the Highway 99E Bridge.

The floodplain area that is now occupied by the Cove was used for agricultural production until the mid-1950s when Pit Rock Products began mining sand and gravel and producing concrete and asphalt[8] at the Cove. In the 1960s a channel was dredged to create a connection between the Cove and the Clackamas River; after its creation, sand and gravel were barged to the Cove for processing and mining at the site ended. The area immediately east of the Study Area was used as a shallow, unlined landfill (Rossman Landfill) from 1960 to 1969. In 1971, the operator, Klineline Sand & Gravel, extended the sand and gravel processing operation from the Cove to this previous landfill property. The entire operation was purchased by Western Pacific Construction Materials in 1972. The property owners declared bankruptcy in late 1986, and a company called Lonestar, Inc. reportedly continued site operations in the area into the early 1990s. These operations ended in 2008 and all associated buildings were then demolished.

Frequent floods would historically inundate the floodplain surrounding the confluence of the Willamette and Clackamas Rivers, including the area now occupied by the Cove. These periodic floods would deposit sand, gravel, and cobbles (also called bedload), creating a shifting network of channels at the confluence of the two rivers. The construction of large flood control dams on upper Willamette Basin tributaries dramatically reduced flooding and decreased the amount of bedload in the system. The Cove and the surrounding floodplain, however, are still subject to flood inundation. Most large floods in the Willamette and Clackamas river basins are a result of rain-on-snow events in which warm rains rapidly melt snowpack. While the Willamette Basin dams can contain a portion of the floodwaters and reduce the magnitude and frequency of floods and associated of downstream impacts, flooding still occurs. The 1964 flood, which predated most of the Willamette Basin dams, was a large, 100-year event. The 1996 flood, the largest flood since 1964, was the result of a large rain-on-snow event in the Willamette and Clackamas river basins. The 1996 flood, which reached an elevation of 50.7 feet (NAVD88) inundated the Cove and surrounding floodplain terrace, Clackamette Park, and much of the surrounding area (Figure 3).

[8] **Oregon Department of Environmental Quality (DEQ). 2016.** Environmental Cleanup Site Information Database Site Summary Report, Clackamette Cove. DEQ, Portland, OR. http://www.deq.state.or.us/lq/ECSI/ecsidetail.asp?seqnbr=2301#siteinfo

Figure 3. Historical aerial photography, Study Area and adjoining Clackamas river corridor, 1936 – 2016.



Clackamette Cove's Natural and Built Environments

The following sections describe the Study Area's environmental setting. The focus is on summarizing the Study Area's current conditions, including topography, shoreline and bank features, Clackamas River channel dynamics, water level fluctuation, vegetation, water quality and HABs, fish and wildlife populations and habitats, and recreation and human access. In addition to summarizing current conditions, issues that should be addressed are identified for each topic. Subsequent sections of the Feasibility Study will describe strategies and approaches to comprehensively address the identified problems.

Topography, Bathymetry, and Water Level Fluctuations

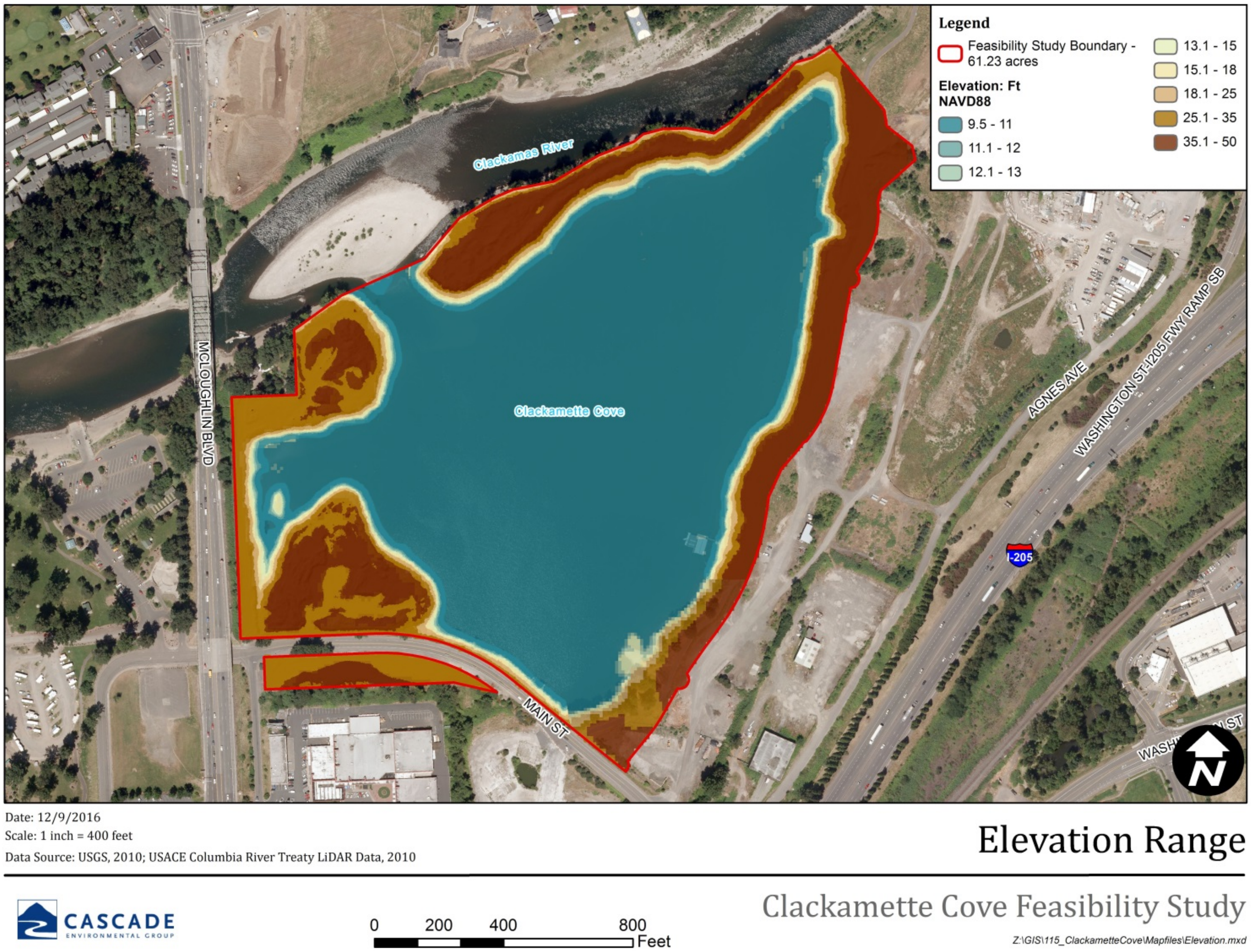
Topography

The Study Area's topography has generally been disturbed by past mining and other activities. Steeply sloped banks created by mining activities separate the open water areas from the floodplain terrace areas (Figure 4). The steep banks lining the Cove transition into a floodplain terrace that is nearly level to gently sloping, with areas of minor topographic relief. Most of the Study Area has been disturbed by past mining and other industrial operations. A geotechnical survey found that much of the floodplain terrace area within Phases 1 and 2 of the Cove Development Plan has been previously filled, with the fill material generally consisting of a mix of silts, sands, gravels, boulders, and debris[9]. Large slabs of concrete and other debris were encountered on the surface and at depth throughout the Study Area.

Photo 1. Clackamette Cove's environment is characterized by steeply sloped banks composed of gravels, cobbles, boulders, and debris from past mining and other industrial land uses.

[9] **Ash Creek Associates, Inc. 2011.** Geotechnical Assessment Clackamette Cove Development Oregon City, Oregon, Ash Creek Associates, Portland, OR. https://www.orcity.org/sites/default/files/fileattachments/planning/project/6059/exhibit_g.2_geotechnical_assessment_0.pdf

Figure 4. Clackamette Cove's topography and elevations. Note the steeply sloped banks that transition into gently sloping floodplain terrace areas.



Bathymetric and Topographic Survey

A bathymetric survey of the subsurface water elevations was conducted in 2005[10] (Figure 5). Cascade supplemented the previous bathymetric data with a topographic survey during the summer low-flow period (August 2016). The survey recorded precise elevations for a number of features, including shoreline water levels, points along the bank, the transition from the bank to below the water line, and the Clackamas River gravel bar near the mouth of the Cove. The waterline elevation at the time of the survey was approximately 10 Feet (NAVD88).

At the water's edge, the Cove's shoreline is characterized by sloped banks that drop steeply into deeper water areas. Elevations at the bottom surface of the Cove are variable but generally there are no dramatic changes in topographic relief. The lowest elevations lie within the western portion of the Cove. Based on water depth measurements taken during the low-flow period, the water depth of the Cove varies in concert with the topography identified in the bathymetric survey, with most recorded depths ranging between 6 and 12 feet; the deepest recorded depth was 18 feet (Figure 5).

Water Level Fluctuations

Water depths, and the corresponding waterline elevations along the banks, vary throughout the year in response to changes in the flow of the Clackamas River. The river's higher flows in the winter and spring correspond to higher water elevations within the Cove. Conversely, the lowest water levels occur during the summer and early Fall when river flows are their lowest.

An understanding of seasonal fluctuations in water levels and how frequently different areas within the Cove are inundated is an important element of assessing habitat potential within the Cove. Inundation frequency is closely tied to vegetation communities and the potential for wetland habitat to occur and persist within the Cove. Information on water level fluctuations can also guide models of habitat use and the prioritization of restoration actions within an environment where water levels fluctuate seasonally.

The analysis of inundation frequencies within the Cove is based on the fact that the Cove is always connected to the Clackamas River, even if that connection is shallow. There is a current 1-dimensional hydraulic model that includes the Study Area, and a nearby streamflow gauge on the Clackamas River has a long record of mean daily discharge data[11].

As part of this Feasibility Study, a model was created to calculate inundation frequencies for a range of elevations that occur within the Cove. The results of this analysis are shown in Table 1 and Figure 6[12]. The results suggest that water surface elevations do not decline below elevation 10 feet (NAVD88) and that 88% of the area occupied by open water is inundated continuously.

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[10] **Minister-Glaeser Surveying, Inc. 2015.** Minister-Glaeser Surveying, Inc, Vancouver, WA.

[11] **U.S. Geological Survey (USGS). 2016**. Clackamas River Near Oregon City, OR, Gauge 14211010. USGS, Washington, DC. https://waterdata.usgs.gov/usa/nwis/uv?14211010

[12] It is important to distinguish between inundation frequencies and flood probabilities. Inundation frequencies are based on data – in this case, Clackamas River discharge data from 2001-2016. Flood reoccurrence estimates, on the other hand, are the probability, expressed as a percentage, of an event of a specific magnitude occurring in any given year. For example, a 100-year flood has a one percent chance of being equaled or exceeded during any given year.

Figure 5. Clackamette Cove's subsurface water elevations. The arrow denotes the maximum depth (18 Feet) measured during low water, August, 2016.

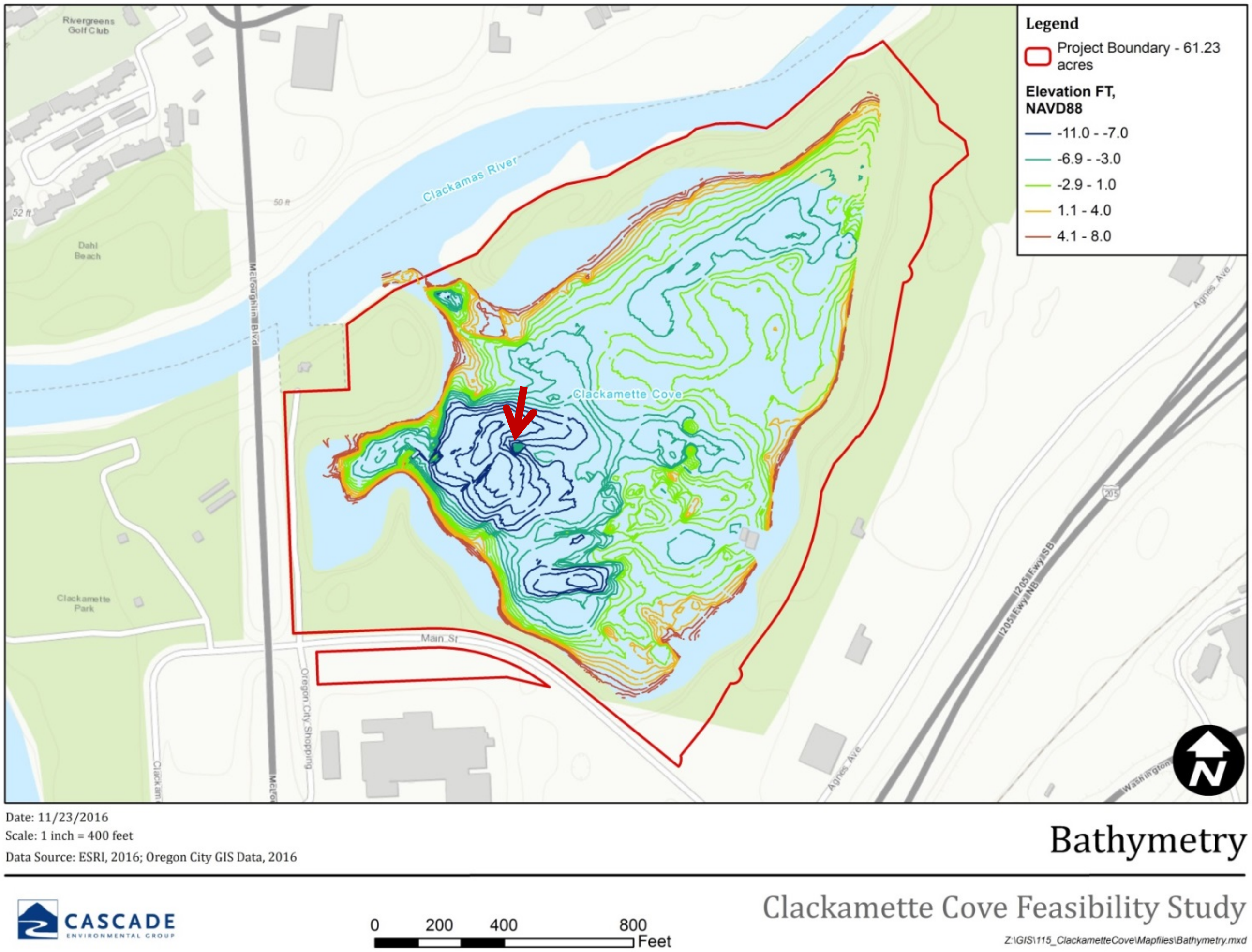


Table 1. Inundation frequencies and total acres inundated within Clackamette Cove based on Clackamas River discharge data from 2001-2016.

Time Inundated	Estimated Water Surface Elev. (ft)	Area Inundated (acres)
99%	10.0	37.1
95%	10.1	37.2
90%	10.2	37.3
75%	10.4	37.4
50%	11.7	38.5
30%	12.9	39.2
10%	15.2	40.1
5%	17.1	40.7
1%	22.2	42.0

Shoreline and Bank Features

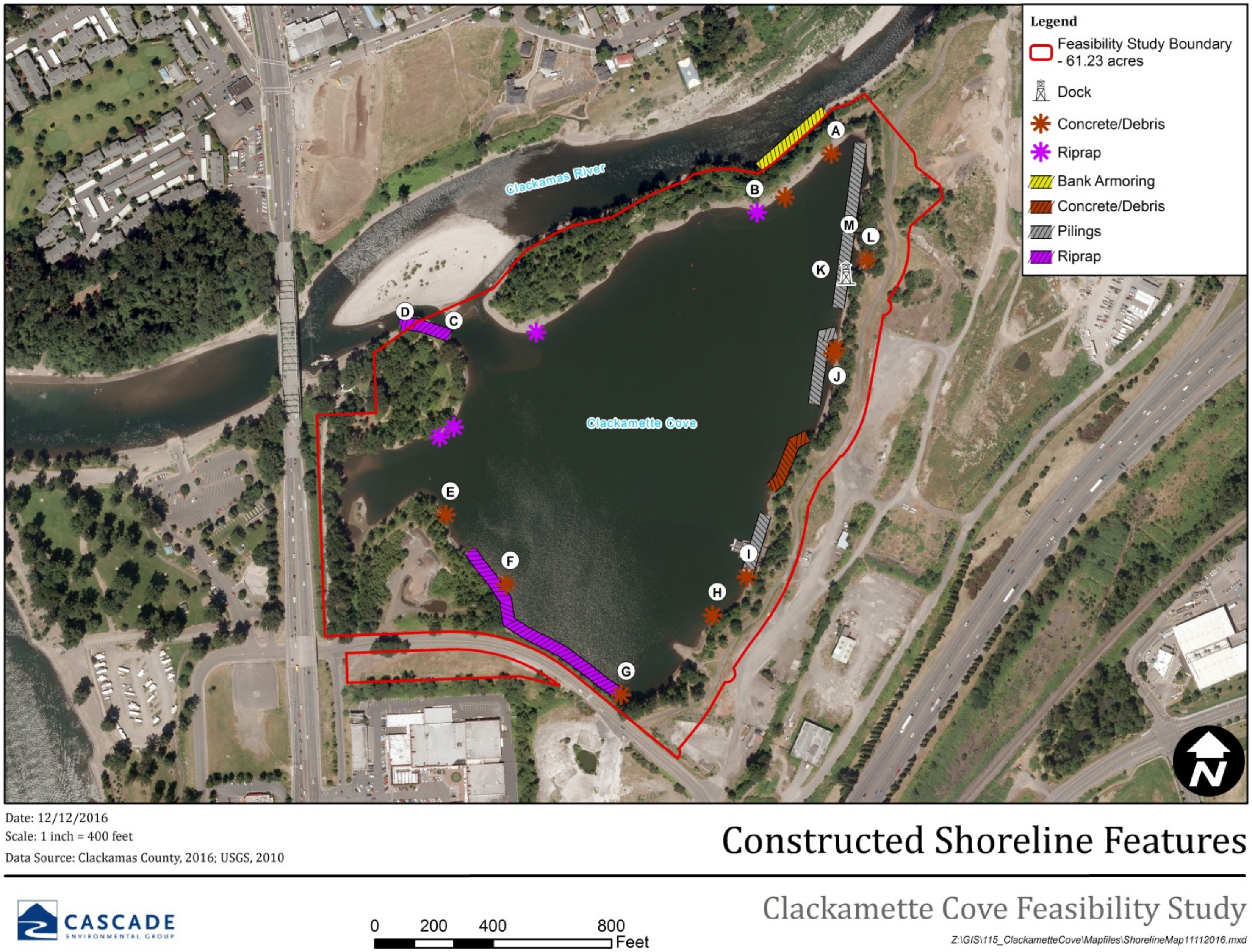
Shoreline and bank features, including industrial debris and other items, were located with a GPS[13] and mapped as part of the topographic survey. Large areas of the shoreline and banks are covered in debris or occupied by remnant structures from past mining and other land uses (Figure 7; Photos 2a – 2m). Debris noted along the shoreline includes concrete, boulders, wire cable, and remnants of docks and other industrial structures. Several old structures, including piers and remnant docks, are located within open water areas or along the banks.

The Clackamas County sheriff's office has a boat facility along the eastern bank of the Cove. The boat facility is not actively used by the sheriff's office and other uses for the facility are being considered as part of the Cove Development Plan; additional facilities or marinas for motorized boats are not being considered as part of the plan. Any additional water access areas will be designed only for the use of non-motorized water craft.

The shoreline along the Clackamas River was not surveyed but debris was noted during field reconnaissance, including extensive areas covered in wire cable, concrete, and boulders. The City has installed vegetation and geotechnical materials along the eastern part of the Clackamas River channel bordering the Feasibility Study Area. This work is intended to armor the river bank and prevent future erosion and the possibility of the river rerouting itself through the Cove.

[13] Global Position System (GPS)

Figure 6. Clackamette Cove shoreline and bank features, including debris and remnant industrial structures, August, 2016. The letters on the map correspond to the photos below.



Photos 2a – 2m. Shoreline bank features, including debris and remnant industrial structures, August, 2016.

Landscape Features

Figure 7 shows the primary landscape features present in the Study Area. The landscape features were characterized based on topography, past land uses, and location relative to the current and proposed developments (Table 2). The open water area of the Cove encompasses 41.31 acres. The other landscape features consist of steeply sloped bank areas transitioning into a gently sloped floodplain terrace. The landscape features, corresponding to the designations in Figure 7, include three areas that function as peninsulas perched above the open water areas (A, North-West Peninsula; B, South-West Peninsula; D, North-East Peninsula); an expanse on the east side of the Cove adjacent to the planned Phase 2 development (C); and an isolated parcel between Main Street and the Oregon City Shopping Center (E).

Figure 7. Clackamette Cove's primary landscape features. Table 2 describes the landscape features.

Table 2. Clackamette Cove's primary landscape features based on topographyand location relative to the current and proposed developments. Landscape feature locations are shown on Figure 7.

Landscape Feature	Size (acres)	Description	Notes
A	2.68	The North-West Peninsula is adjacent to the mouth of the Cove. It is bordered by the Cove on the south and the Clackamas River on the north, and the City of Gladstone property and 99E to the west. The banks on both the Cove and Clackamas River sides rise steeply to the upper terrace of the peninsula where there is relatively gentle topography.	The area is bordered on the west by City of Gladstone property with an inoperative water pumping station. The City of Gladstone considers this to be surplus property and is seeking a buyer. Access to the property is by a gravel road from Main Street that parallels Highway 99E.
B	4.56	The South-West Peninsula was historically mined and then filled with a variety of materials. The peninsula is bordered on the east by Highway 99E, on the south by Main Street, and on the north by a small, shallow open-water embayment within the Cove.	Geotechnical test pits in the area found logs, boulders, cables, chain, concrete, asphalt, and random garbage in a sandy-silt matrix.
C	7.23	The eastern and southeastern portion of the Study Area, which borders the open water of the Cove to the west and Main Street to the southeast and sits adjacent to, the Phase 2 development. Steeply sloped banks transition into the relatively gentle topography of the floodplain terrace.	Geotechnical test pits in the area found variable materials: Sandy- silt topsoil, asphalt debris, dry silt, and gravel/cobbles with trace organics. This area includes a pedestrian/bicycle trail that generally parallels the east side of the Cove.
D	4.12	The North-East Peninsula is adjacent to the mouth of the Cove. The peninsula is bordered by the Cove on the south and the Clackamas River on the north, and to the northeast by the North Park site. The banks on both the Cove and Clackamas River sides rise steeply to the upper terrace of the peninsula where there is relatively gentle topography.	The City has installed vegetation, boulders, and geotechnical materials along the Clackamas River bordering the eastern portion of the peninsula to prevent further erosion.
E	1.33	An isolated parcel between Main Street to the north and the Oregon City Shopping Center to the south.	
Clackamas River	13.14	The Clackamas River corridor, bordered on the south by the mouth of the Cove and peninsulas A and D.	
Clackamette Cove	41.31	The open water area of the Cove at approximately its average annual high water level.	

Clackamas River Channel Dynamics

Historically, the channel morphology at the confluence of the Clackamas and Willamette Rivers was largely influenced by the sediment transport regime of the Clackamas River. Cobble, gravel, and sand delivery from the Clackamas River created a large depositional area and braided channel morphology where the higher-gradient Clackamas River transitioned to the lower-gradient and tidally-influenced Willamette River (Photos 3a and 3b). The disparities in the gradients of these two large river systems resulted in the formation of an alluvial fan at the mouth of the Clackamas River as coarse bed material emanating from the higher-energy Clackamas River deposited in the lower-energy confluence environment.

Photo 3a and 3b: The photo on the left shows the area surrounding the Clackamas and Willamette river confluence in the 1920's and pre-dates significant mining activity at the mouth of the Clackamas River. The photo on the right shows how mining activity in the lower Clackamas River's channel reduced bed load transport and changed channel dynamics at the confluence of the Willamette and Clackamas rivers.

Coarse bedload deposition at the mouth of the Clackamas River had a significant influence on the bed elevations and morphology of the Willamette River for thousands of feet upstream and downstream of the confluence. Goat Island is a remnant of this feature and many maps still refer to this portion of the Willamette River as the Clackamas Rapids. The bed of the Willamette River, adjacent to the Clackamas River, was 10-20 feet higher in elevation than the present day elevation. The reach at that time was most likely not influenced by tidal processes, and prior to the 1930's navigation past this portion of the Willamette River would have been difficult.

Over the past century, changes to both the Clackamas and Willamette River watersheds (i.e., dam construction, modified hydrology, levee construction, and bank revetments), along with local impacts associated with gravel mining and dredging of the Willamette to improve navigation, have resulted in major changes at the confluence. Regional-scale changes to the form and function of the Willamette and Clackamas Rivers have reduced channel complexity and narrowed and deepened the channels of these mainstem river systems, often driven by the desire to improve navigation, provide flood control, and encourage development of floodplain and terrace areas.

Dam construction in the Clackamas River basin has severely reduced the sediment supply to the lower river. Much of the remaining sediment currently delivered to the lower river is supplied from tributaries downstream of the large dams and from bank erosion along the mainstem. The reduced sediment supply has contributed to significant changes in the lower portion of the Clackamas River. The channel area from the confluence with the Willamette River to the Highway 99E Bridge functions basically as a backwater of the Willamette River during most flow conditions; during periods of high flows, the Willamette can backwater above the Highway 99E Bridge and into the Cove.

Reduced bedload in the Clackamas and Willamette rivers has contributed to channel downcutting, which has resulted in lower channel elevations than were historically present. As a result of the lower channel elevations, the Willamette and Clackamas rivers near the Cove are subject to daily changes in water surface elevations from tidal processes. During high flow periods, when the water surface elevations of the Willamette and Clackamas Rivers are higher, tidal flows can influence the Cove. During the low flow periods of the summer and early fall, a gravel bar and associated deposition at the mouth of the Cove creates a consistent 10-foot (NAVD88) water surface elevation within the Cove. Tidal flows during the low water period end approximately at the Highway 99E Bridge and do not extend into the Cove. However, observers have noted that there have been periods in the past when the Cove's summer water surface elevation was lower and tidal flows were able to access the Cove[14].

Gravel Bar Creation

The Cove's opening to the Clackamas River is approximately 100 feet wide and is located several hundred feet upstream of the Highway 99E Bridge. Past mining activities have created bottom surface elevations within the Cove that are significantly lower than the channel bed elevations within the adjacent Clackamas River. Much of the coarse bedload being delivered to the lower Clackamas River is deposited upstream of the Highway 99E Bridge at the mouth of the Cove. During low-flow conditions, in the summer, the Cove is almost disconnected from the Clackamas River by the gravel bar that has formed adjacent to the Cove's mouth. This gravel bar extends several hundred feet upstream and downstream of the mouth and is currently several hundred feet across. While most of the river's flow is along its northern bank, there is evidence of some bank erosion caused by flows at the mouth of the Cove.

A number of factors appear to be contributing to a favorable depositional environment and the creation of the gravel bar at the mouth of the Cove, including: 1) The portion of the Clackamas River opposite the Cove mouth is relatively wide compared to upstream reaches and appears to be going through a depositional bar development phase similar to what previously occurred in this area historically; 2) the presence of the Cove's mouth creates favorable hydraulic conditions for deposition as flow diverges, slows down, and enters the Cove under high-flow conditions; 3) at certain times, the Willamette River backwaters into the area, creating slow flows and gravel deposition; and 4) the Highway 99E Bridge structures are too narrow to accommodate normal channel dynamics; during high water events, the bridge constricts the flow of the Clackamas River, creating a depositional environment.

[14] **Jerry Herrmann. 2016.** Jerry Herrmann, Earth Crusaders-River of Life Center, Gladstone, OR. Personal Communication.

Oregon City currently has the required federal and state permits to implement a dredging plan to remove 9,000 cubic yards of cobble, gravel, and sand from the gravel bar. The stated purpose of the dredging is to provide year-round access into the Cove for watercraft for public safety. The proposed dredging plan consists of excavating a 775-foot-long by 75-foot-wide by 5-foot-deep channel from inside the north end of the Cove, out the mouth, and downstream toward the Highway 99E Bridge. The proposed excavation will cut the channel to approximately elevation zero (NVGD[15]) with side slopes varying between 3H:1V and 2H:1V.

Based on the geomorphic evaluation of the Clackamas River, it is not anticipated that the navigational benefits achieved by the dredging would persist for long. Keeping the navigational channel continuously open would require frequent maintenance. The configuration of the proposed channel, with up to 2H:1V side slopes and a bend at the downstream margin of the gravel bar, would likely exacerbate deposition within the newly constructed channel unless it is combined with a more aggressive periodic bar skimming (removal of the top layer of gravel in the bar). Bar skimming would provide benefits by reducing the local source of sediment that could mobilize and fill the channel, while also creating additional storage on the existing gravel bar where the depositional environment is favorable.

The conclusion that the dredged channel would not be sustainable for the long-term is based on the following observations of geomorphic conditions at the gravel bar:

- The size of the material on the bar ranges from 8” (203mm) rounded cobbles down to sand, with a D50 that was estimated to be approximately 3” (76mm). To evaluate how readily the material on the bar mobilizes, given its size, shear stress values were developed along a cross-section that cuts through the mid-point of the bar using the 2-D model developed by West Consultants for the Clackamette Park Boat Ramp. The results, shown in Table 3, suggest that much of the larger bedload delivered to the gravel bar site during high flow events will deposit there.
- Portions of the gravel bar have aggraded to the point where permanent vegetation (primarily willow) is establishing, which appears to match up with the elevation of vegetation along adjacent streambanks (Photo 4). This indicates that the height of the bar has not increased significantly for at least several years, and may not significantly increase over time.
- It appears, based on aerial photos, that the width of the bar has stayed relatively consistent since at least 2007. The height and width of the bar will likely put erosive pressure on the north bank of the Clackamas River, where the highest velocities occur. Whether the north bank erodes in response and the bar continues to widen will be a function of the resistance of the north bank materials to erosion and the bar material’s resistance to mobilization. The potential for erosion on the north bank of the Clackamas River should be evaluated.

It is important to note that dredging would lower the channel connecting the mouth of the Cove to the Clackamas River. Lowering the elevation of the Cove’s mouth would lower water levels in the Cove during the summer low-flow periods from its current elevation of 10 feet (NAVD88). Over time the dredged channel would fill with gravel and sediment, which would create variability in the Cove’s summer water elevations until the time at which the water level equilibrates to the river channel’s

[15] National Vertical Geodetic Datum

depositional environment. This variability in the Cove's water surface elevations would create problematic conditions for wetland plant establishment.

Table 3. Shear stress and particle mobility conditions along a cross-section of the Clackamas River that intersects the mouth of the Cove. The results are presented from the right bank to the left bank for a range of modeling scenarios (three different combinations of Clackamas and Willamette river flood reoccurrence intervals).

Bank Side	25-yr Clackamas 5-yr Willamette		25-yr Clackamas 25-yr Willamette		2-yr Clackamas 25-yr Willamette	
	Shear Stress (lbs-sq. ft.)	Particle Mobilized (in mm))	Shear Stress (lbs-sq. ft.)	Particle Mobilized (in mm))	Shear Stress (lbs-sq. ft.)	Particle Mobilized (in mm)
Right Bank	0.808	39.9	0.356	17.6	0.106	5.2
	0.936	46.2	0.414	20.4	0.120	5.9
↓	1.099	54.2	0.488	24.1	0.138	6.8
	1.196	59.0	0.531	26.2	0.150	7.4
	1.295	63.9	0.577	28.5	0.164	8.1
	1.338	66.0	0.598	29.5	0.171	8.4
	1.352	66.7	0.600	29.6	0.173	8.6
	1.307	64.5	0.578	28.5	0.168	8.3
	1.217	60.1	0.531	26.2	0.157	7.7
	1.083	53.4	0.465	22.9	0.140	6.9
Left Bank	0.829	40.9	0.347	17.1	0.108	5.3
	0.470	23.2	0.186	9.2	0.060	3.0

Photo 4. View looking upstream from the west end of the Clackamette Cove's mouth towards the bar formation. Note the growth of vegetation at the top of the bar.

Vegetation

Cascade characterized and mapped the Study Area's vegetation communities (Figure 8). The vegetation communities are described in Table 4. Appendix A contains the photos corresponding to the Photo Points shown.

Vegetation composition and density in the Study Area varies dramatically based on elevation. Scattered plants, largely non-native weedy species, occupy the Cove's banks and shoreline. With the exception of these weedy species, the lower banks are largely unvegetated. The substrate on the banks is dominated by cobbles, gravel, and, in some places, boulders. This very coarse substrate, with little fine material or organic soil, creates very difficult conditions for plant survival. While the bank areas are periodically inundated as water levels vary throughout the course of the year, the coarse bank materials do not hold water moisture and thus provide a very harsh environment for plant establishment. In addition, the steeply sloped banks do not provide conditions that promote the establishment of wetland or other vegetation. Gentle, varied slopes (5H:1V or flatter) are necessary to allow for the establishment of wetland plant species and promote plant diversity[16].

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[16] Norman, D. K., P. J. Wampler, A. H. Throop, E. F. Schnitzer, and J. M. Roloff. 1997. Best Management Practices for Reclaiming Surface Mines in Washington and Oregon. Oregon Department of Geology and Mineral Industries, Salem, OR; and Washington State Department of Natural Resources, Olympia, WA. http://file.dnr.wa.gov/publications/ger_ofr96-2_best_management_practices.pdf

Above the OHW line, less frequent inundation and the presence of organic soils allows for the establishment of trees and other riparian vegetation on the banks and the floodplain terrace. For the most part, the riparian area is dominated by relatively large (18- to 24-inch diameter) black cottonwood (*Populus balsamifera*), Douglas-fir (*Pseudotsuga menziesii*) , and other native trees, with an understory consisting largely of Himalayan blackberry (*Rubus armeniacus*), English ivy (*Hedera helix*), and other weedy species. The width of the riparian corridor along the Cove varies, from a narrow strip along the eastern side to relatively wide expanses of vegetation on the three peninsulas (Figure 8).

Figure 8. Clackamette Cove's vegetation communities. The vegetation communities are described in Table 4. Appendix A contains the photos corresponding to the photo points.

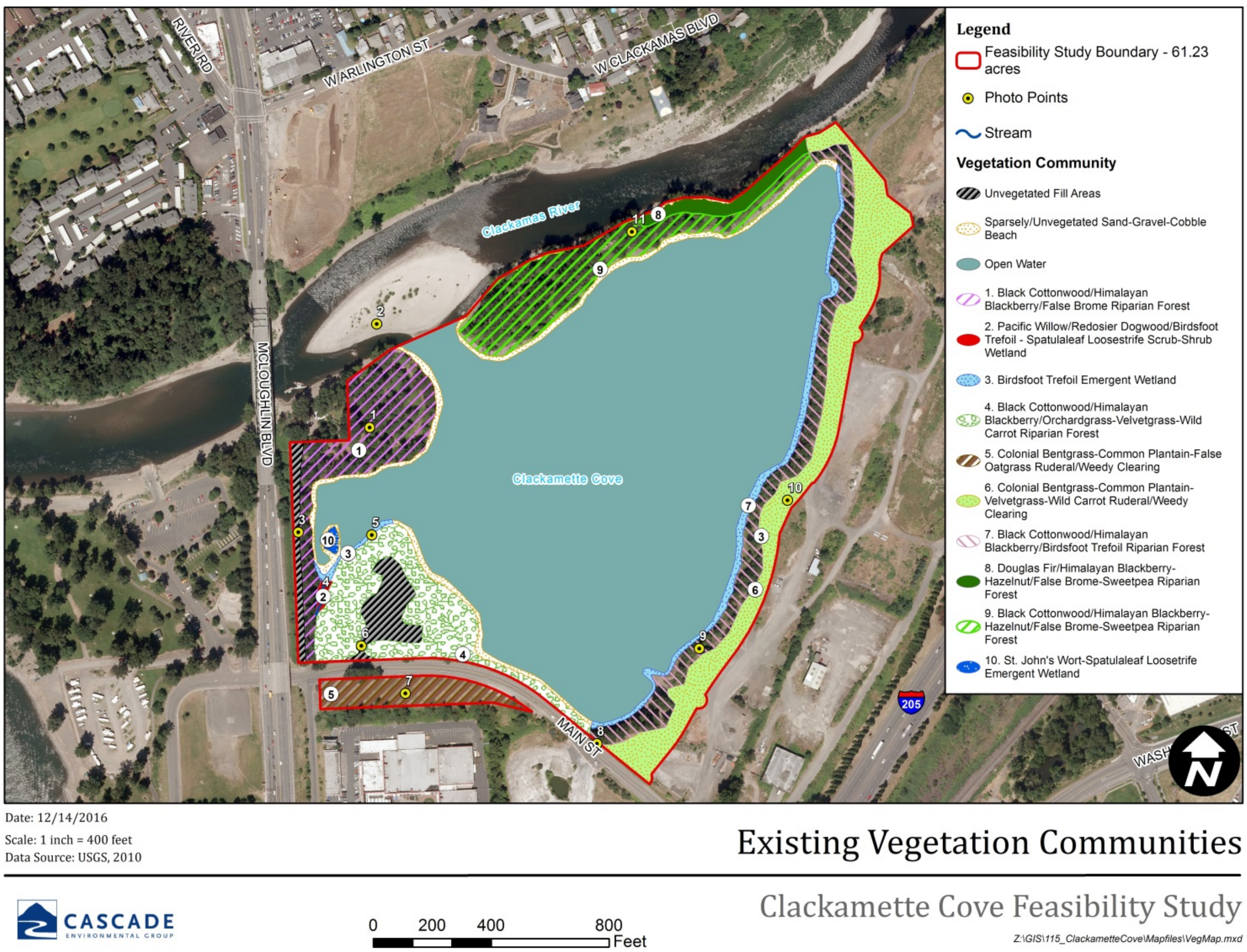


Table 4. Description of Clackamette Cove's vegetation communities corresponding to Figure 8. Non-native vegetation/weed species are designated in bold type. Appendix A contains the photos for each vegetation community corresponding to the photo points.

Figure #	Plant Community	Description
1	Black Cottonwood/Himalayan Blackberry/False Brome Riparian Forest	This riparian upland forest community occupies the North-West Peninsula and the bank and terrace on the western edge of the Cove. The overstory is largely native, dominated by black cottonwood interspersed with a few Oregon ash (*Fraxinus latifolia*) and **domestic cherry** (*Prunus avium*) trees. A few young conifers (Douglas fir and western redcedar [*Thuja plicata*]) are emerging in the understory. The understory of this community is predominantly invasive, composed largely of dense **Himalayan blackberry** thickets with a scattering of other shrubs including invasive **Japanese knotweed** (*Fallopia japonica*) and **English holly** (*Ilex aquifolium*), as well as native snowberry (*Symphoricarpos albus*), hawthorn (*Crataegus douglasii*), and oceanspray (*Holodiscus discolor*). The sparse herb layer is composed of mixed grasses and weedy forb species; the invasive species **false brome** (*Brachypodium sylvaticum*) and **field bindweed** (*Convolvulus arvense*) are most prominent in the herb layer.
2	Pacific Willow/ Redosier Dogwood/ Birdsfoot Trefoil-Spatulaleaf Loostrife Scrub-Shrub Wetland	This community occupies a small area along an intermittent stream that drains into the southwestern corner of the Cove. It is a largely native wetland community featuring an overstory of Pacific willow (*Salix lasiandra*) and redosier dogwood (*Cornus sericea*) studded with Oregon ash trees. The herbaceous layer includes weedy forb species common to shoreline areas subject to fluvial disturbance, such as **birdsfoot trefoil** (*Lotus corniculatus*) and **spatulaleaf loosestrife** (*Lythrum portula*), as well as native self-heal (*Prunella vulgaris*).
3	Birdsfoot Trefoil Emergent Wetland	This herbaceous wetland community forms a narrow, linear fringe along much of the eastern shoreline of the Cove and along a segment in the southwestern portion of the area. It is dominated by **birdsfoot trefoil** interspersed occasionally with self-heal and other weedy forbs such as **spatulaleaf loosestrife** and **teasel** (*Dipsacus fullonum*). A few scattered redosier dogwood and **Japanese knotweed** shrubs are also present.
4	Black Cottonwood/ Himalayan Blackberry/ Orchardgrass-Velvetgrass-Wild Carrot Riparian Forest	This upland forest community surrounds the concrete lot within the South-East Peninsula and forms a narrow fringe between the southern shoreline of the Cove and Main Street. The community shares similarities with Community #1, featuring an overstory dominated by native black cottonwood and an invasive understory dominated by **Himalayan blackberry**. However, this community includes occasional bigleaf maple (*Acer macrophyllum*) trees and **black locust** (*Robinia pseudoacacia*) groves within the overstory, and a more developed (though equally weedy) herbaceous layer that includes **orchardgrass** (*Dactylis glomerata*), **velvetgrass** (*Hoclus lanatus*), **wild carrot** (*Daucus carota*), **tansy ragwort** (*Senecio jacobea*), and **teasel**.

Figure #	Plant Community	Description
5	Colonial Bentgrass-Common Plantain-False Oatgrass Ruderal/Weedy Clearing	This upland community occupies the cleared parcel along the south side of Main Street. It is composed of introduced mixed grasses such as **colonial bentgrass** (*Agrostis capillaris*) and **false oatgrass** (*Arrhenatherum elatius*) and common turf weeds such as **plantain** (*Plantago lanceolata and P. majora*), **wild carrot**, **dandelion** (*Taraxacum officinale*), and **chicory** (*Cichorium intybus*). It is regularly mown.
6	Colonial Bentgrass-Common Plantain-Velvetgrass-Wild Carrot Ruderal/ Weedy Clearing	Similar in composition to Community #5, this upland community occupies the cleared terrace along the eastern bank of the Cove. In addition to the species described above, it also features other weeds such as **tansy ragwort**, **false brome**, and **hairy cat's ear** (*Hypochaeris radicata*).
7	Black Cottonwood/ Himalayan Blackberry/ Birdsfoot Trefoil Riparian Forest	This community, which has a dominant black cottonwood overstory and **Himalayan blackberry** understory, occupies the margin of the cleared terrace and the steep eastern bank of the Cove. This riparian community also features Oregon ash and **black locust** groves in the overstory and **Japanese knotweed** and redosier dogwood in the shrub layer. The herbaceous layer features a mix of weedy forbs including **birdsfoot trefoil**, **field bindweed**, **Canada thistle** (*Cirsium arvense*), **oxeye daisy** (*Leucanthemum vulgare*), and **St. John's wort** (*Hypericum perforatum*), along with self-heal.
8	Black Cottonwood/ Himalayan Blackberry-Hazelnut/ False Brome-Sweetpea Riparian Forest	This riparian upland forest community occupies the majority of the North-East Peninsula. It is similar to Community #1 while featuring a bit more diversity in the understory. Shrub species present include hazelnut, dogwood, **Scotch broom** (*Cytisus scoparius*), and snowberry. The weedy herbaceous layer is co-dominated by **false brome** and **sweet pea** (*Lathyrus latifolius*) along with **white sweetclover** (*Melilotus albus*) and **English ivy,** interspersed with **wild carrot**, **teasel**, self-heal, **common tansy** (*Tanacetum vulgare*), **culinary oregano** (*Origanum vulgare*), and **wild Clematis** (*Clematis vitalba*).
9	Douglas Fir/ Himalayan Blackberry - Hazelnut/ False Brome-Sweetpea Riparian Forest	This community occupies the northeast side of the North-East Peninsula. It is nearly identical to Community #8 with the exception of Douglas fir as the dominant overstory species and the near absence of black cottonwood. It is unclear whether this is truly a separate community or only a minor variation. Due to the small size of the patch, the presence of the single grove of Douglas fir may be enough to outcompete other tree species and maintain the stand.
10	St. John's Wort - Spatulaleaf loosestrife Emergent Wetland	This emergent wetland community covers a small island in the western portion of the Cove. It is largely composed of herbaceous weeds: **St. John's wort**, **spatulaleaf loosestrife**, **birdsfoot trefoil**, and **oxeye daisy**, with a single redosier dogwood shrub and a single black cottonwood sapling.

Water Quality

This section describes the Cove's water quality conditions, with an emphasis on water quality factors that can affect fish populations and/or contribute to HABs: water temperatures, stormwater, and groundwater contamination.

Water Temperatures

Water temperatures are a critical factor in maintaining and restoring healthy fish populations. DEQ employs the 7-day moving average of maximum daily temperatures as a method to summarize and gauge the impact of water temperatures on aquatic organisms. Because maximum water temperatures are averaged over a moving seven-day window, this method of summarizing the data accounts for longer periods of high water temperatures when fish and other aquatic organisms are the most stressed by sustained high water temperatures.

DEQ has established the following water temperature standards for salmon and trout (i.e., salmonids):

- For a waterbody identified as having salmon and trout rearing, the 7-day moving average of maximum daily temperatures may not exceed 64.4 degrees Fahrenheit (18.0 degrees Celsius), and
- For a waterbody identified as a trout or salmon migration corridor, the 7-day moving average of maximum daily temperatures may not exceed 68.0 degrees Fahrenheit (20.0 degrees Celsius).

Water temperatures are influenced by solar radiation, shade, ambient air temperatures, groundwater inflows, the volume of the waterbody, and flow. Water temperatures in the Cove vary throughout the year, with the highest temperatures corresponding to the summer through early fall period when solar radiation and air temperatures are at annual highs and water flows are low.

Comprehensive water temperature data are not available for the Cove[17]. Water temperature data from the U.S. Geological Survey (USGS) gauge on the lower Clackamas River near the City was used to characterize the Cove's water temperature patterns. Because the Cove's temperatures and water levels are largely influenced by the Clackamas River, the nearby USGS gauge provides an approximation of the Cove's water temperature patterns. Figure 9 shows the river's 7-day moving average of maximum daily temperatures and daily mean discharge, during the years 2010 – 2016. In most years, water temperatures in the lower Clackamas River exceed DEQ's salmonid migration standard from mid-July through early September, a period that corresponds to low flows in the Clackamas River. In 2015, the state of Oregon, including the Clackamas River basin, suffered a severe drought. The dry conditions resulted in extremely low flows in the Clackamas River. By June, the river was already flowing at levels typically seen in August, with correspondingly high water temperatures.

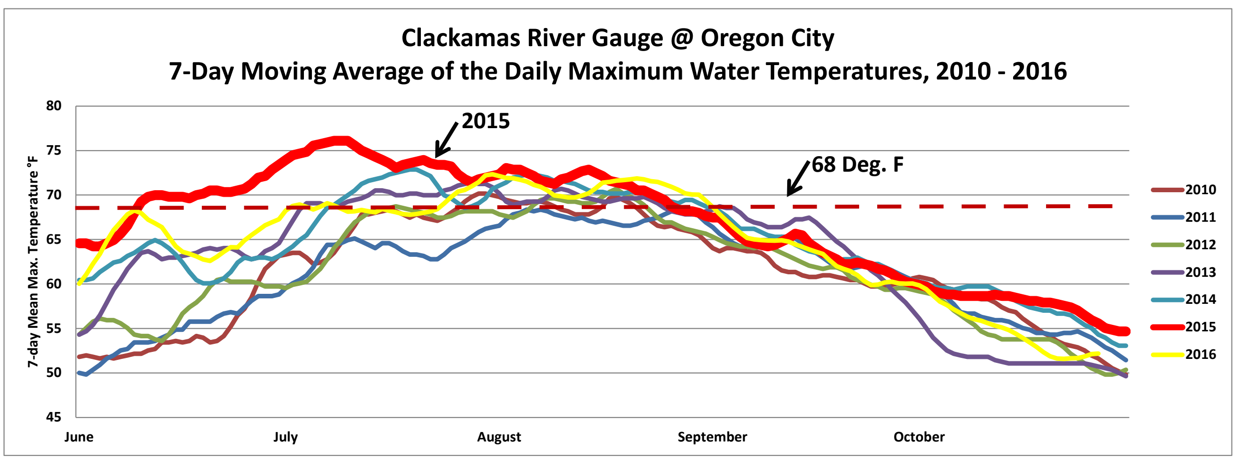
Water temperatures in the Cove are largely determined by interactions with the Clackamas River. During the summer and early fall, when water temperatures are high, there is little connection between the

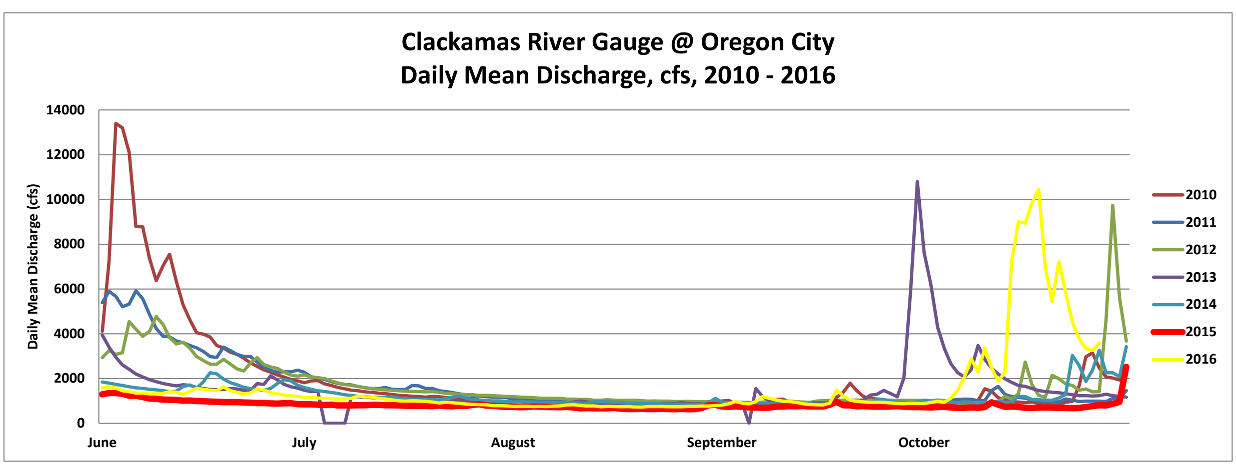
[17] In August, 2016, Cascade placed water temperature/water level data loggers at three locations within the Cove. One set of data loggers was lost/stolen; the other 2 data loggers remain. The data from the loggers, however, has not been collected and analyzed because the loggers are currently under excessively deep water and will be inaccessible until water levels drop. The loggers continue to collect data and Cascade will provide the City with an analysis of the water temperatures and water levels in July, 2017.

flow of the Clackamas River and the Cove. As result, the water in the Cove is stagnant with no perceptible flow. The stagnant water condition, combined with minimal cool water inputs from the Clackamas River, creates ideal conditions for rising water temperatures. Groundwater inputs into the Cove may provide a source of cool water, but further study is necessary to characterize to what extent groundwater influences the Cove's water temperatures. Water temperature stratification can occur in lakes and other water bodies similar to the Cove, resulting in warmer water at the surface and cooler water at the bottom. Thermal stratification has been observed in the 160-foot-deep Ross Island Lagoon, another remnant gravel mine in the lower Willamette River with stagnant water conditions that is similar to the Cove. The Cove's relatively shallow depth (approximately 18 feet at the deepest location) probably minimizes any thermal stratification.

Water temperatures are the result of solar radiation inputs heating a given volume of water. As the volume of water increases, so does the amount of thermal input necessary to heat the water body. Shade from trees and other vegetation can reduce water temperatures in streams with moderate volumes of flowing water. The trees along the shore of the Cove have a negligible impact on reducing water temperatures because of the Cove's relatively large volume of deep, stagnant water.

Figure 9. 7-day moving average of the daily maximum water temperatures and daily mean discharge for the Clackamas River gauge at Oregon City, 2010 – 2016. The lowest discharge levels and corresponding highest water temperatures were recorded in 2015.





Stormwater

Stormwater originating in the City is discharged into the Cove at two locations. Figure 10 shows the location of stormwater Outfall 1, which consists of two outlet pipes that convey stormwater from a large mixed use area to the northwest of the Cove and also from the new Phase 1 development. The conveyance pipe at stormwater Outfall 2 drains the Oregon City Shopping Center, south of the Cove (Figure 11). Combined, these two stormwater conveyance systems drain a large area of impervious surfaces (e.g., roofs, parking areas, and roads) which generates a considerable volume of stormwater runoff during periods of precipitation.

DEQ regulates stormwater runoff from the City through Municipal Separate Storm Sewer System (MS4) National Pollutant Discharge Elimination System (NPDES) Permit No. 101348. The City's MS4 NPDES permit was reissued in 2012. This permit covers all discharges of stormwater from the within the City's incorporated area, including the new Clackamette Cove Development. The permit covers 6 activities intended to improve stormwater quality over time: 1) Education, 2) outreach, 3) construction best management practices (BMPs), 4) post construction BMPs, 5) illicit discharge detection and elimination, and 6) improved municipal operations.

The City is required to submit an annual report to DEQ that summarizes accomplishments and implementation of the Stormwater Management Plan . One component of the annual reporting is a summary of stormwater quality monitoring. The water quality for the Cove's two stormwater outfalls is periodically monitored during rainfall events. Stormwater Outfall 1 is monitored at the outfall into the Cove (Figure 10). The monitoring site for stormwater Outfall 2 is near the shopping center (Figure 11).

Roadways, parking lots, and other impervious surfaces, as well as landscape surfaces, can be the source of and can accumulate a mixture of contaminants, including sediment; metals (copper, nickel, zinc, etc.); petroleum-derived compounds from oil, grease, and vehicle exhaust; and other contaminants. During rainfall events, stormwater collects these contaminants and transports them to the Cove. The City monitors stormwater that drains into the Cove's two outfalls during rain events. The monitoring samples are tested for a variety of water quality constituents, including dissolved copper, dissolved lead, dissolved zinc, E. coli bacteria, nitrate-nitrite, ortho phosphate, total dissolved and suspended solids, and other contaminants.

The City's stormwater monitoring results for the Cove's two stormwater outfalls consistently show detections of dissolved copper, zinc, and lead – all stormwater contaminates that have been linked to harmful effects on salmon and steelhead. Recent research by the National Marine Fisheries Service (NMFS) and others has shown that common stormwater contaminants can impair salmon and steelhead health in a variety of ways[18]. For example, petroleum-derived compounds suppress the immune system, rendering fish more vulnerable to pathogens that cause lethal diseases. Certain metals are toxic to the salmon nervous system, thereby disrupting feeding and predator avoidance. Dissolved copper is a particularly pervasive contaminant in stormwater that threatens salmon and steelhead survival. Copper in stormwater can come from a variety sources; one significant source is vehicle exhaust and brake pads. Copper, like many other metals, is toxic to the sensory systems of fish. Dissolved copper specifically

[18]**NMFS. 2016.** How Toxic Runoff Affects Pacific Salmon & Steelhead. NMFS, Pacific Northwest Region, Seattle, WA. http://www.westcoast.fisheries.noaa.gov/publications/habitat/fact_sheets/stormwater_fact_sheet_3.22.2016.pdf

impairs salmon and steelhead's ability to detect odors. The olfactory sense guides these fishes' response to environmental cues and impairment of smell interferes with certain behaviors, including impeding predator detection and avoidance, prey detection, orientation, and homing. Disruption of these behaviors affects salmon and steelhead distribution, feeding, and reproductive success.

A fish habitat assessment evaluated the impact of Phase 1 of the Cove Development Plan, including increased stormwater discharge, on salmon and steelhead species listed as threatened or endangered under the ESA[19]. New stormwater facilities will treat expected pollutants (i.e. oil, polycyclic aromatic hydrocarbons [PAHs], heavy metals, nutrients, and sediments) associated with roof runoff and vehicle use. The new stormwater facilities will include a combination of Low-Impact Development Approach (LIDA) swales and storm filters designed to capture contaminates. The LIDA swales will collect and treat stormwater runoff through vegetation and soil media, while also providing flow attenuation. Portions of the existing 36-inch stormwater pipe will be upsized to a 48-inch pipe during construction of the proposed Main Street roadway improvements to provide additional stormwater capacity for future development. However, the existing outfalls into the Cove will be retained and no new outfalls are proposed.

The stormwater assessment focused on three pollutants of concern that typically occur at elevated concentrations in stormwater effluent, including dissolved copper, dissolved zinc, and PAHs (specifically fluoranthene). Based on the results of a stormwater mixing zone analysis, the assessment concluded that the effects of treated stormwater will be insignificant. This finding was based on the conclusions that 1) there is limited occurrence of ESA-listed salmonids within the Cove during the summer months when water levels and the corresponding contaminate dilution factor are at their lowest; and 2) higher concentrations of dissolved copper will immediately dilute to below water quality criteria levels upon entering the Cove.

While the findings of the assessment are valid for direct and indirect stormwater impacts on juvenile salmon and steelhead, the assessment does not evaluate stormwater impacts on aquatic habitat restoration actions. Because the stormwater discharge locations are within or near potential habitat restoration areas (e.g., created wetlands), NMFS and other agencies will seek much more rigorous stormwater quality criteria, particularly for the key contaminates of concern. Habitat restoration actions would be designed to increase the number of juvenile salmonids rearing within the Cove, and thus there would be an expectation that stormwater inputs over time would not directly or indirectly affect fish or habitat.

[19] **Pacific Habitat Services, Inc. 2015.** Habitat Assessment of the Potential Effects of the Proposed Garden Apartments Project (Phase I of The Cove Development Plan) on Fish Species Listed as Threatened or Endangered under the Federal Endangered Species Act. Pacific Habitat Services, Wilsonville, OR.

Figure 10. Clackamette Cove stormwater outfall 1 and associated conveyance system. Water quality monitoring samples are collected at the outfall. Map courtesy of the City of Oregon City.

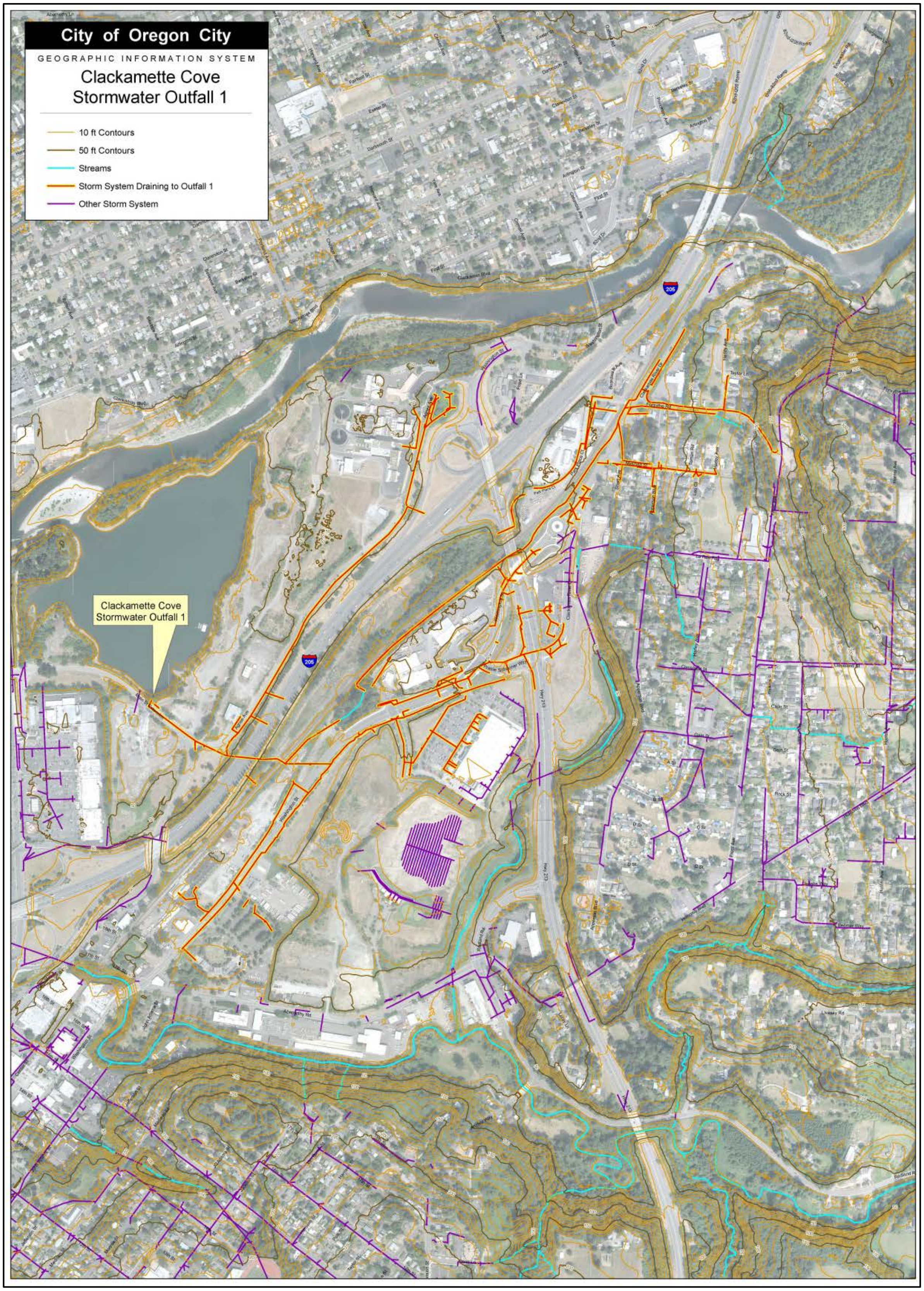


Figure 11. Clackamette Cove stormwater outfall 2 and associated conveyance system. Water quality monitoring samples are collected at a site near the shopping center. Graphic courtesy of the City of Oregon City.

Groundwater Contamination

Several investigations of potential groundwater contamination have been completed for areas within the Study Area[20]. Collectively, these investigations have documented the presence of soil and groundwater contamination that has resulted both from land uses adjacent to the Study Area and groundwater migration from off-site. Contaminants detected include moderate levels of diesel fuel and petroleum, arsenic, and lead in soils around the former asphalt plants. Moderate levels of heavy oil-range petroleum were also found in some shallow sediment samples collected along the Cove's eastern shoreline. Contaminants migrating in shallow groundwater from the old landfill and other areas outside of the Study Area and Phase 1 and Phase 2 development footprints include chlorinated solvents, arsenic, lead, and typical landfill constituents such as iron and manganese. Petroleum hydrocarbons have migrated to the north end of the Study Area from a large gasoline release that occurred at an adjacent property. The contaminants of concern have not been detected in water samples collected from the Cove's shoreline.

Additional detailed soil and groundwater investigations were completed before construction of the Garden Apartment complex (Phase 1 of the Cove Development Plan). Based on the available information, DEQ concluded that contaminant levels in the soils and groundwater at the Phase 1 site are currently not a threat to public health and the environment and that the site requires no further action to address contaminates[21].

While it appears that groundwater contamination is not affecting the Cove's aquatic environment, additional study is necessary to ensure that there are no current or potential future direct or indirect effects on fish or aquatic habitats. Similar to the need for more evaluation of stormwater inputs, state and federal agencies will require additional evaluation of groundwater contamination before implementing habitat restoration actions. This would include evaluating potential contaminates in the Study Area, and the potential for migration of contaminates into any habitat restoration sites.

Harmful Algal Blooms

In 2015 there was an extensive algal bloom in the Cove. Based on a sample of the bloom, the OHA issued a health advisory warning against water contact activities in the Cove because toxins produced by HABs are potentially harmful to people. The health advisory, the first ever for the Cove, was in place from September 28 through November 4, 2015. A similar heath advisory was in effect in 2015 for Ross Island Lagoon.

A recent workshop with attendees from research and regulatory agencies discussed the scientific understanding of HABs, with a focus on the factors contributing to the blooms in Ross Island Lagoon and the Cove[22]. HABs appear to be increasing in extent and intensity in the Pacific Northwest and around the

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[20] **Oregon Department of Environmental Quality (DEQ). 2016.** Environmental Cleanup Site Information Database Site Summary Report - Details for Site ID 2301, Clackamette Cove. DEQ, Portland, OR. http://www.deq.state.or.us/lq/ECSI/ecsidetail.asp?seqnbr=2301

[21] **Oregon Department of Environmental Quality (DEQ). 2014.** Partial No Further Action Determination for Parker Pond Site, Oregon City. DEQ, Northwest Region, Portland, OR.

[22] **Urban Green Spaces Institute, Oregon Lakes Society, and River Restoration Northwest. 2016.** Harmful Algal Bloom Workshop, July 20, 2016, Portland State University.

globe[23]. In addition to the 2015 advisory, health advisories were issued for Ross Island Lagoon in 2014 and 2016 (Table 5). While a health advisory was not issued for the Cove in 2016, notices were posted warning for the public to be aware of potential HAB conditions.

Testing of HABs conducted by DEQ detected some toxins, including microcystin, which is a toxin that primarily affects the liver. People do not absorb microcystin through their skin, which reduces the risk to swimmers. However, ingesting water during swimming can be harmful. The symptoms of microcystin exposure are similar to food poisoning: vomiting, diarrhea, and occasionally fever and chills. The toxins released by the algae can also cause skin rashes. The blooms can contaminate drinking water with taste, odor, or toxic compounds. The toxins produced by HABs can also be very harmful or fatal to dogs, even at low levels.

Table 5. OHA health advisory warnings for the Cove and Ross Island Lagoon, both former gravel mines with open water areas. Information provided by the OHA.

Year	Location	Dominate Genus	Dates	Number of Days
2016	Ross Island, lower Willamette River	Microcystis	August 19 – September 1	14
2015	Ross Island, lower Willamette River	Microcystis, Dolichospermum, and Cylindrospermopsis	July 9 – October 1	84
	Clackamette Cove, lower Clackamas River	Anabaena planctonica	September 28 – November 4	37
2014	Ross Island, lower Willamette River	Microcystis	September 19 – October 2	16

The primary catalyst for HABs in the Willamette River is warm water temperatures and minimal water flow velocities[24]. The 2015 bloom that resulted in the health advisory for the Cove corresponded to extremely low flows in the Clackamas River and correspondingly high water temperatures (Figure 9). Harmful algal species are present in the Clackamas and Willamette rivers, but usually do not create large blooms in the rivers because flowing water inhibits the growth of large colonies. Algal blooms usually occur in lakes. In the Portland metropolitan area, large algal blooms have developed in Lake Oswego and Blue Lake in Gresham. The stagnant water conditions in the Cove and Ross Island Lagoon create conditions much like a lake and provide perfect conditions for the species to multiply into large mats of green scum. The absence of a green sheen on the surface of the water doesn't necessarily mean that the area is free from the algae because they can change their buoyancy in the water column. The colonies tend to rise to the surface to capture sunlight for photosynthesis, and then sink down in the water

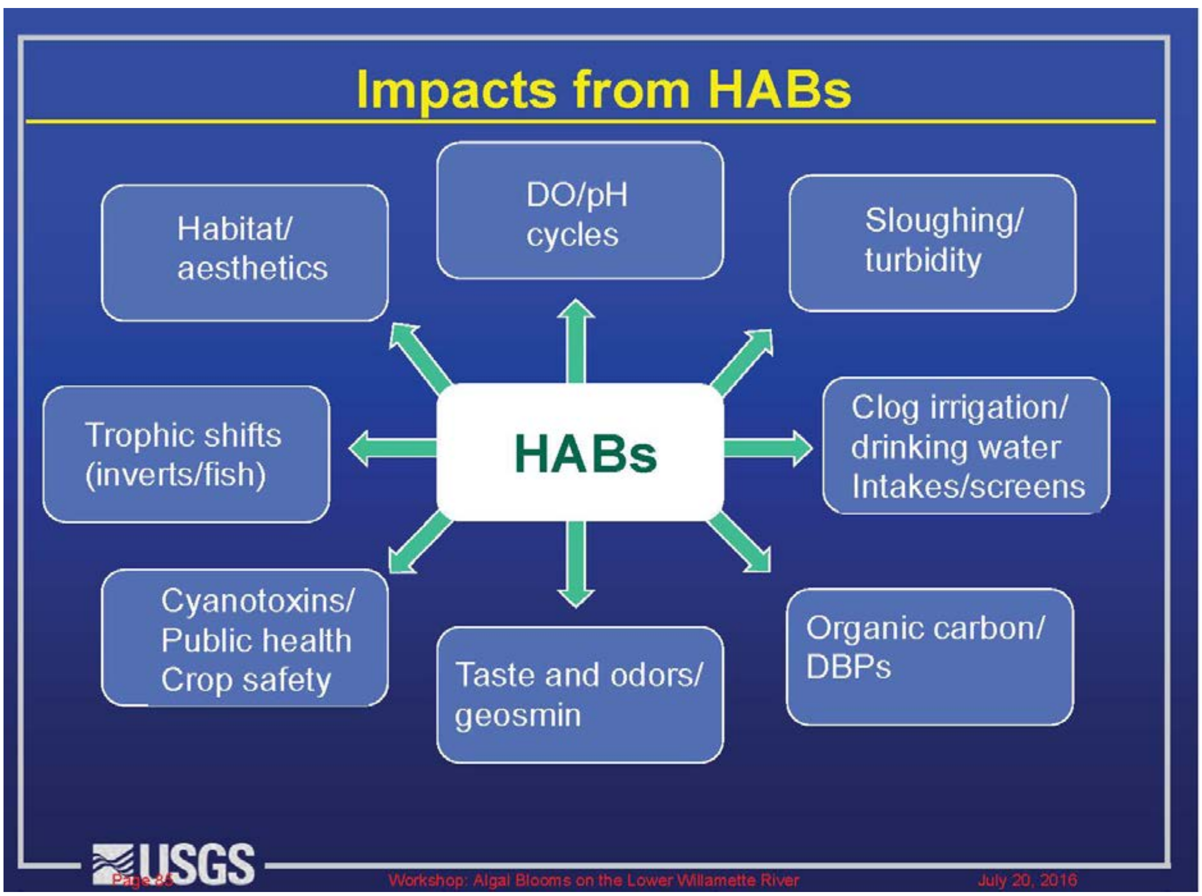
[23] While referred to as algal blooms, the organisms responsible for the blooms are photosynthetic cyanobacteria. This report uses the term harmful algal blooms (HABs) because it is the standard reference in use by the public, research institutions, and government agencies.
[24] **Urban Green Spaces Institute et al., 2016.**

column when they have created sufficient carbohydrates. Sometimes the bloom will be at the surface of the water, and during other times the blooms are deeper and not visible.

Nutrients entering waterways can also contribute to HABs. Phosphorus and nitrogen, which are present in many fertilizers and lawn products, can help algae grow. Phosphorous in particular can promote algal blooms. Some species of algae can metabolize atmospheric nitrogen, which means that nitrogen in the water is usually less of a factor in promoting HABs. However, while nutrients can be a factor in HABs, it appears that the primary drivers of the blooms in the Cove and Ross Island Lagoon are stagnant water followed by high water temperatures.

In addition to the threats to public health, HABs also create ecological problems and visual/aesthetic issues (Figure 12). Algal blooms can affect food web interactions by decreasing the amount of edible phytoplankton and zooplankton that fish and other primary consumers need to survive. When the cells in the bloom begin to die, dissolved oxygen levels can decrease, and pH levels can shift, which can be lethal to other aquatic organisms, including fish. Low dissolved oxygen can be made worse by overcast days and warmer temperatures.

Figure 12. Harmful algal blooms (HABs) affect human health, ecological processes, and aesthetics. (Graphic curtesy of Kurt Carpenter, U.S. Geological Survey, Portland, OR.)



The primary driver of HABs in the Cove appears to be the stagnant water conditions. Extensive algal blooms were not observed there until approximately 2013, which appeared to correspond to the extensive gravel deposition at the mouth of the Cove. It is theorized that the gravel deposition at the Cove's mouth restricted tidal flushing during the summer months and thus contributed to the algal blooms. Research has demonstrated that stagnant water contributes to the formation of extensive blooms. There is also evidence that minimal flow velocities (approximately 0.05 meters per second) are sufficient to disrupt the formation of blooms[25].

An analysis of Clackamas River water residence time within the Cove was conducted to better understand existing conditions within the Cove and provide a basis for recommending enhancement actions that could improve circulation and water exchange (Appendix B). Under summer low-flow conditions (642 cfs), and assuming a direct connection to Clackamas River with flows into the Cove of 7.2 cfs, the water residence time is one day – that is the entire water volume in the Cove would be replaced over a 24-hour period. While this analysis does not characterize flow velocities, it does provide strong evidence that flushing of water out of the Cove occurs on a frequent basis. The analysis assumes that water entering the Cove would be well-mixed and circulate throughout the Cove. That assumption would need to be evaluated through a more detailed hydraulic and engineering analysis. Creating appropriate flow velocities would likely require specific actions within the Cove to make full circulation a possibility. The source and location of inflow would also need to be evaluated. Preliminarily, the best approach to increasing summer inflow into the Cove from the Clackamas River would be to create a second opening (an engineered channel) to the Clackamas at a point within the North-East peninsula.

To evaluate the feasibility of this approach, a detailed engineering and hydraulic study would need to address the following topics:

- Irrespective of residence time, what are the likely circulation patterns within the Cove under a range of inflow rates? This could be addressed by running scenarios with a 2-dimensional model that has already been developed for the area. The model would need to be evaluated to determine if additional site information should be collected and if the resolution of the model is adequate to address the questions.

- If an opening is created, what would be the configuration and size to ensure the following: 1) an adequate amount of summertime flow enters the Cove; 2) that erosion of the opening does not occur during high flow conditions on the Clackamas; and 3) the opening does not accumulate sediment to the point where summertime flows no longer enter the Cove.

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[25] **Dreher T. 2016.** River-associated cyanobacterial blooms: Why's and what's for Oregon. Presentation to the: Harmful Algal Bloom Workshop, July 20, 2016, Portland State University. Theo Dreher Professor of Microbiology, Oregon State University, Corvallis, OR.

Sediments

Sediment sampling and chemical analysis was completed for the Cove in 2006[26]. The purpose was to assess if sediments within the Cove contain chemicals above background levels and at concentrations that may pose an unacceptable risk to human health or the environment.

Five surface sediment samples were collected from the Cove on April 12, 2006. The sediment samples were analyzed for total petroleum hydrocarbons, PAHs, metals, total organic carbon, and grain size. Chemical results from the samples, as well as 8 additional samples collected in 1998 (13 total), were compared to conservative screening levels to assess the potential risk to human health and the environment.

All concentrations of all tested chemicals were below screening levels for human health except arsenic in one of the 13 samples. The concentration of arsenic in that sample was 8.6 mg/kg, only slightly above the background concentration of 7.9 mg/kg. For risk assessment purposes, the estimated exposure point concentration of arsenic in sediment (based on the data collected) is 4.2 mg/kg, below the background concentration. Human health risks from the Cove's sediments appear to be acceptable, and recreational use of the Cove should not be restricted based on potential human exposure to sediments.

Concentrations of PAHs and/or metals were detected above ecological screening levels in 4 of the samples. Except for one sample, the detected concentrations exceeded the screening levels by less than 50 percent. In one sample, individual PAHs were detected at concentrations between 2 to 4 times the screening levels. The sediment ecological screening levels are generally very conservative, so these concentrations may not indicate unacceptable ecological risk[27].

Development of the Cove Development Area is subject to a Prospective Purchaser Agreement (PPA) between the City and DEQ. Under the restrictions of the PPA, developers of the property adjacent to the Cove would not be required to conduct investigation or cleanup of sediments in the Cove. However, the DEQ reserved the right to take action on sediment in the future that could include restricting access to the sediments or water of the Cove.

According to the City's agreement with DEQ, prior to disturbing sediments or allowing use or access to sediments in the Cove, including for the development of restoration sites, the City is required to submit a written report, for DEQ approval, addressing potential uses, exposure pathways, and proposed actions to manage risks, if any[28].

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[26] **Ash Creek Associates. 2006.** Sediment Sampling Report Clackamette Cove, Oregon City, Oregon. Ash Creek Associates, Portland, OR.

[27] **Ash Creek Associates. 2006.**

[28] **Ash Creek Associates. 2006**

Fish Populations and Habitat

Native Fish Species

The Cove provides aquatic habitats that are occupied by a variety of native fish species, including juvenile salmon, steelhead, and Pacific lamprey. While there are no detailed observations of Juvenile salmon, steelhead, and lamprey residing in the Cove, these fish are present all year in the lower Willamette and Clackamas Rivers and are expected to be present in the Cove. Research has shown, for example, that spring Chinook salmon juveniles occupy the lower Willamette River throughout the year, with peak densities occurring in winter and spring[29]. The research also shows that these fish are actively growing during their residence, suggesting that feeding and rearing in these areas are important for their survival.

Salmon, steelhead, and Pacific lamprey populations are declining. The upper Willamette Basin and the lower Columbia River salmon and steelhead populations, which are at historically low numbers, are listed as threatened under the ESA. The ESA-listed fish populations include spring and fall Chinook salmon, coho salmon, and steelhead. The Willamette River Basin has the largest returns of Pacific lamprey of any of the Columbia River tributaries and also supports one of the only remaining traditional tribal harvest locations in the Columbia River Basin, at Willamette Falls. Pacific lamprey populations are also declining throughout the Columbia River Basin. Pacific lamprey is listed as a sensitive species by the federal government and the State of Oregon.

Juvenile salmon and steelhead in the Cove come from adults that spawn in the Clackamas River or tributaries in the upper Willamette Basin. During the period of high flows, the Willamette and Clackamas Rivers' flows interact, which often results in the Willamette River "backwatering" into the lower Clackamas River and the Cove. During these high-flow periods, the Cove is essentially connected to the Willamette River and is accessed by juvenile salmon and steelhead derived from both the upper Willamette Basin and Clackamas River stocks.

Pacific lamprey, like salmon and steelhead, are anadromous – after a period growing in the ocean, adults migrate into rivers where they spawn and the juveniles, after residing for some time in fresh water, return to the ocean and thus repeat the cycle. There are no recorded observations of juvenile Pacific lamprey in the Cove; however, it is expected that they are found there since there are observations of juvenile lamprey in similar lower Willamette River habitats near the Cove – open water areas with slow flows and muddy substrate.[30]

Pacific lamprey adults spawn in gravel areas similar to, and often overlapping, the spawning areas preferred by salmon and steelhead. Pacific lamprey spawning has been noted in a riffle a short distance up the Clackamas River from the mouth of the Cove[31]. The presence of juvenile Pacific lamprey in

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[29] **Friesen, T.A., J. S. Vileb, A. L. Pribylc. 2007.** Outmigration of Juvenile Chinook Salmon in the Lower Willamette River, Oregon. Northwest Science 81(3):173-190. http://www.bioone.org/doi/abs/10.3955/0029-344X-81.3.173

[30] **Schultz, L., M. P. Mayfield, G. T. Sheoships, L. A. Wyss, B. J. Clemens, B. Chasco, and C. B. Schreck. 2014.** The Distribution and Relative Abundance of Spawning and Larval Pacific Lamprey in the Willamette River Basin. Report prepared for the Columbia River Inter-Tribal Fish Commission for Project years 2011 – 2014, Portland, OR.

[31] **Alsbury, T. 2016.** Todd Alsbury, Oregon Department of Fish and Wildlife, Clackamas, OR. Personal communication.

Clackamette Cove probably contributes to adults spawning in the Clackamas River close to the mouth of the Cove. Juvenile lampreys emit bile salts that attract adults to nearby spawning areas.

The native fish species present in the Cove varies through the course of the year. During the late fall through spring period when water levels are the highest and water temperatures are low, juvenile steelhead and salmon and adult trout are present. These fish are probably not present in the Cove between July and mid-October, when water temperatures are the highest. The one exception is Pacific lamprey juveniles, which are a native species that probably resides in the Cove all year.

Non-Native Fish Species

Non-native warm-water fish including small- and largemouth bass, crappie, and walleye are present in the Cove. The Cove is a popular fishing location for these warm-water species[32]. Some of these non-native fish such as largemouth bass are predators that could consume juvenile salmon and steelhead. Research in the lower Willamette River has shown that densities of these predators is generally low, but consistently higher at sites characterized by riprap, mixed rock, and rock outcrops, similar to the Cove[33]. This research concluded that there is very little evidence of warm-water fish predation on juvenile salmonids. For example, by weight, the diets of largemouth bass were dominated by crayfish; while the diets of walleye and smallmouth bass consisted primarily of fish, the identifiable fish in their diets were usually sculpins.

Fish Habitat Quality

The Cove's expanse of relatively deep water (e.g., greater than 3 feet), and simplified shoreline areas characterized by steeply sloped banks, coarse cobbles and other materials, and minimal wetland or other shoreline vegetation, provides very little of the habitats that juvenile salmon and steelhead need to rear and grow during their migration to the ocean. These fish prefer to rear and feed in shallow areas with a diversity of habitat types, including wetland vegetation and large wood. For example, juvenile coho salmon usually are found near shore and prefer gently sloped beach areas with sandy substrates[34]. Juvenile coho avoid areas with the kinds of habitats present in the Cove: steeply sloped banks, coarse substrates, and areas of debris.

The limited quantities of shallow water habitat found in the Cove are also typical of current conditions in the lower Clackamas and Willamette rivers. Historically, the river channels in the area were lined with shallow water areas, extensive expanses of wetland and floodplain vegetation, and accumulations of large wood. Riverside development and wetland filling, gravel and wood removal, and bank hardening, have reduced the amount of shallow water habitats to a small fraction of the historical extent. The Clackamas River in the vicinity of the Cove is listed as critical habitat for ESA-listed salmon and steelhead adult migration and juvenile rearing. As a result of these habitat alterations and the need to recover ESA-listed salmon and steelhead, state and federal fisheries agencies have prioritized the restoration of

[32] **Fishing Notes Web Site. 2016.** http://www.fishingnotes.com/fishing-report/or/Clackamette-Cove
[33] **Friesen et al. 2007.**
[34] **Friesen et al. 2007.**

shallow water habitats at the confluence of the Willamette and Clackamas rivers[35]. Two shallow water habitat restoration projects in the vicinity of the Cove were constructed in 2016. Both of these projects are on north side of the lower Clackamas River in the City of Gladstone's Dahl Beach Park.

In contrast to salmon and steelhead, Pacific lamprey juveniles prefer deeper water habitats with abundant sediments. After hatching, Pacific lamprey spend about 4-7 years rearing in river channel sediments as filter feeding larvae (ammocoetes) prior to metamorphosing and migrating to the ocean[36]. A sediment evaluation of the Cove found bottom materials consisted predominantly of silt with little sand or gravel content; it is likely that Pacific lamprey ammocoetes reside in the portions of the Cove where sediments and organic material has accumulated on the bottom. Because freshwater rearing consists of a relatively high fraction of the life cycle of the Pacific lamprey, this stage is generally viewed as critical for the viability of the species.

Wildlife Populations and Habitat

Wildlife Species

The Cove provides habitat for a variety of wildlife species. Deer, coyotes, mink, otter, and beaver have been observed there[37]. Numerous bird species also occupy the aquatic and riparian areas, including osprey, great blue heron, and cormorants. ODFW has observed amphibian adults and egg masses, including rough-skinned newts, pacific tree frog (egg masses), and red-legged frog (egg masses)[38]. There have been reports of native turtles in the Cove, but their presence has not been confirmed. If native turtles are not present, they could eventually move into the Cove. There is a native painted turtle population in close proximity, within the City of Gladstone's Meldrum Bar Park.

In an evaluation of habitats throughout the Study Area, ODFW noted that while some area currently provide high-quality wildlife habitat, most of the areas around the Cove do not provide good habitat because of their narrow riparian vegetation corridors and lack of diversity of habitat types, including very little wetland area[39].

The North-West Peninsula is the only habitat that is currently rated as 'high' quality by ODFW and it is essentially the only refuge for wildlife disturbed by human presence in the Study Area. In their evaluation, ODFW recommended that this Peninsula be set aside as wildlife habitat, with limits on human access, including decommissioning the existing trail system and providing interpretive signage describing why the refuge area was established.

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[35] **Oregon Watershed Enhancement Board (OWEB). 2016.** Willamette River Anchor Habitat Priorities. OWEB, Salem, OR. https://www.oregon.gov/OWEB/Pages/SIPMaps.aspx
[36] Schultz et al. 2014
[37] **Jerry Herrmann. 2016.** Jerry Herrmann, Earth Crusaders-River of Life Center, Gladstone, OR. Personal Communication.
[38] **Oregon Department of Fish and Wildlife (ODFW). 2010.** Recommendations for Clackamette Cove Development. Memo from Elizabeth Ruther, Habitat Conservation Biologist, to Oregon City. ODFW, Clackamas, OR.
[39] **Oregon Department of Fish and Wildlife (ODFW). 2010.**

Recreation and Human Access

The Study Area is popular for boating, swimming, fishing, hiking, and bird watching. A popular pedestrian/bicycle trail generally parallels the east side of the Cove. There is an extensive network of informal trails and water access points throughout the area. Activities in the Cove include general recreation and access, as well as organized events. Triathlons – events that include running, swimming, and cycling – have been held at the Cove in the past and a triathlon event there is planned for 2017[40]. In the warmer months, recurring HABs inhibit swimming and other recreational activities in the Cove.

The Study Area provides regionally important recreational resources. The trail along the east side of the area links Oregon City to the Clackamas River, provides a connection to the City of Gladstone, and provides access to a regional network of trails, parks, and natural areas. Other than this trail, human access to and use of the floodplain terrace area, banks, and water is not controlled through designated trails or formal access points. The resulting network of informal trails and water access points has led to extensive habitat impacts, including vegetation removal and trampling, erosion, and litter.

The Cove's recurring HABs result in aesthetic and visual concerns and impact recreational activities. At times the entire water surface of the Cove is covered in green mats of algae (Photo 5). The combination of the visual impact and the smell when cells begin to die creates a very unpleasant environment for recreation and other activities. Cascade staff interviewed a number of swimmers and other individuals who regularly recreate in the water at the Cove, all of whom cited the HABs as the primary issue that inhibits their enjoyment of the Cove. Most individuals said that they will not swim in the Cove after July because of health concerns.

In addition to habitat impacts from human access, the Study Area's steep topography and remnant industrial debris create an unsafe setting for recreational activities. The limited shallow areas and banks that drop steeply into deep water create a potential drowning hazard. Oregon statutes require a 3H:1V bank slope to 6 feet below the low-water mark to provide a means of escape in the event that someone were to fall in[41]. Piers and remnant industrial structures on the banks and in the water also create unsafe conditions.

Human access should be controlled and directed in a manner that minimizes impacts to the Study Area's aquatic and riparian environments. This will entail developing and implementing a Recreation and Public Access Plan with details on formal trail locations, shoreline and water access points, and areas where human use should be discouraged to protect habitat values. Recreational facilities in the Study Area should be designed to allow for viewing of habitat areas while minimizing the impact on fish and wildlife and their habitats (Photo 6).

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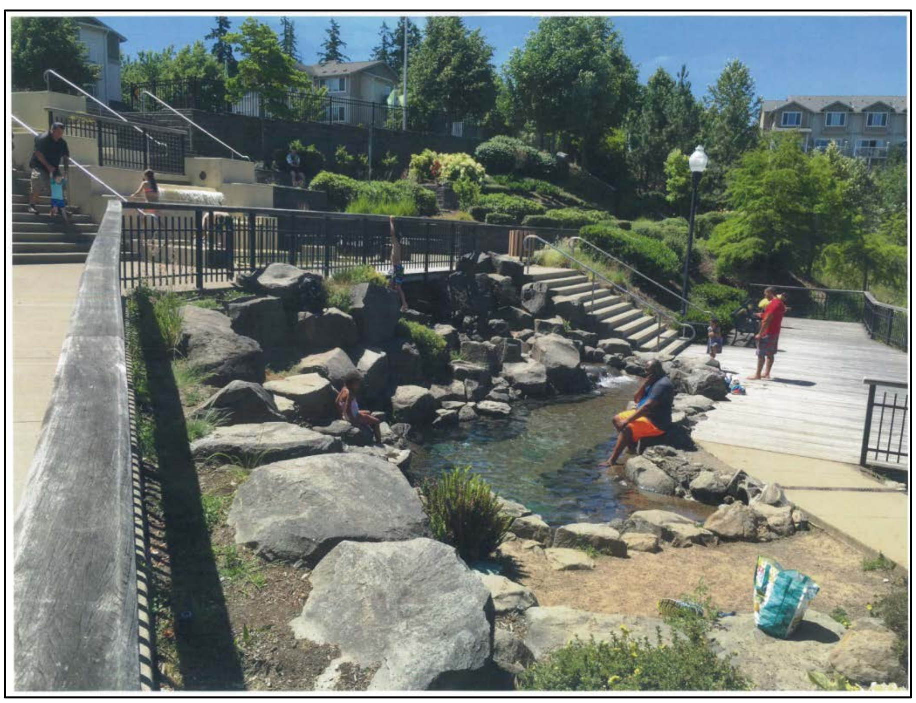
[40] **Clackamas Cove Triathlon. 2016.** http://clackamascovetriathlon.com/

[41] **Norman, D. K., P. J. Wampler, A. H. Throop, E. F. Schnitzer, and J. M. Roloff. 1997.** Best Management Practices for Reclaiming Surface Mines in Washington and Oregon. Oregon Department of Geology and Mineral Industries, Salem, OR; and Washington State Department of Natural Resources, Olympia, WA. http://file.dnr.wa.gov/publications/ger_ofr96-2_best_management_practices.pdf

Photo 5. Algal bloom, Clackamette Cove, September 3, 2016.

Photo 6. An example of a recreational facility designed to direct human access away from shoreline habitat areas. This site was a former gravel mine, and is now a lake, in Beaverton, Oregon.



Integrated Approach to Improving Water Quality, Fish and Wildlife Habitat, and Human Access

The Cove was created through gravel mining and other industrial land uses. These activities have resulted in an altered landscape that does not function as natural floodplain or river habitat. The Cove is essentially an embayment of the Clackamas River, and the connection between the Clackamas River and the Cove varies throughout the year in response to the river's flows. During periods of high flows – November through June in most years – the river and Cove are hydrologically connected. In periods of low flows in the summer and early fall, there is little direct connection between the river and the Cove. During these periods, the Cove functions more like a lake than a flowing embayment of the river, creating stagnant water conditions and high water temperatures that promote HABs.

The altered landscape left from gravel mining and other actions has also created unnatural landforms and a legacy of industrial debris and groundwater and sediment contaminates, all of which do, or have the potential to, affect habitat and fish and wildlife populations. Steep banks and minimal shallow water areas limit the establishment of riparian vegetation, wetlands, and the complex habitats preferred by fish and wildlife. The extensive industrial debris – cables, blocks of concrete and metal pieces – and remnant structures on the banks and in the open water areas further degrade habitat. Groundwater and sediment contaminates, while not currently a threat to human health and the environment, require further evaluation to ensure that they do not impact fish and wildlife restoration actions. The absence of wetland and riparian vegetation and the debris also degrade the Study Area's aesthetic and recreational qualities. Wetlands along the shoreline of the Cove, for example, would add to the area's scenic values (Photo 7).

Photo 7. An example of wetlands along the shoreline of a restored floodplain gravel mine. The formally steep banks were regraded to gentle slopes to provide a variety riparian and wetland habitats.

While conditions in the Study Area present environmental challenges, there is also the opportunity to restore aquatic and floodplain habitats and create a valuable scenic and recreational asset. Through restoration actions, the area can provide habitats that are important to a wide array of fish and wildlife species, including ESA-listed steelhead and salmon and Pacific lamprey (a state and federal species of special concern). Addressing the HABs will address ecological concerns and improve the Study Area's recreational and aesthetic qualities.

The key issues that must be addressed to improve the Study Area's water quality, habitat value, and recreational value are as follows:

- HABs and Connectivity to the Clackamas River
- Unnatural Landforms and Debris
- Stormwater Quality and Other Potential Contaminates
- Simplified Aquatic and Wetland Habitats
- Simplified Riparian and Floodplain Habitats
- Structures below the OHW line
- Recreation and Human Access

Table 6 summarizes the issues and outlines recommended approaches to address the problems.

Table 6. An evaluation of the issues that affect water quality and fish and wildlife habitat in the Cove, and recommended approaches to address the issues.

Issue	Description	Evaluation	Recommended Approach
Harmful Algal Blooms and Connectivity to the Clackamas River	Past mining of the area has created an unnatural embayment of the Clackamas River with a narrow opening to the river. This has resulted in limited flow interaction with the river, particularly during the summer to early fall low-flow periods, which results in warm and stagnant water in the Cove. These conditions, particularly the stagnant water, create an environment that promotes HABs. The OHA closed the Cove to swimming and other water contact activities in 2015 and a general advisory was in effect in 2016. There have been similar HABs in the metropolitan area in in other legacy gravel mine sites, including Ross Island Lagoon within the Willamette River.	• Limited flow velocities within the Cove during the Clackamas River's low flow periods (July – September in most years) are the primary driver of HABs, but water temperatures also contribute to the blooms. Nutrients (primarily phosphorus) are also contributing to the blooms. • The narrow mouth to the Cove limits connectivity to the river, particularly during low flow periods. The mouth is not positioned in a manner that directs flows into the Cove. • A gravel bar that has developed at the mouth the Cove also contributes to restricting connectivity (and limiting boat access), but the narrow mouth and its position in the river channel is the primary factor limiting flow connectivity between the Cove and the river. • Dredging the gravel bar at the mouth of the Cove would improve low water connectivity between the Clackamas River and the Cove. However, dredging would lead to lower summer water levels in the Cove. • The dredged channel would, over time, fill with gravels and bedload, again limiting interaction between the river and the Cove, and gradually raising summer water elevations in response. The resulting variability in the Cove's water elevations would create poor conditions for establishing wetlands and other habitats that are dependent on water depth. • Channel dredging is not sustainable over the long term. Repeated gravel bar dredging would be required to maintain the open channel at the mouth of the Cove. Permits for continued dredging would be difficult to obtain, and will become increasingly so due to concerns about ESA-listed fish. • Flows with velocities as low as 0.05 meters per second can prevent HAB colonies from forming and creating extensive blooms. • Creating a channel that directs flows from the Clackamas River during low flows could provide enough flow velocity during the low-flow periods to disrupt the growth of HABs. • HABs disrupt aquatic recreational use of the Cove during warmer months, and degrade the Cove's aesthetic qualities.	• Conduct an engineering feasibility study focused on creating a stable, engineered channel throughout the North-East Peninsula that would direct flows from the river into the Cove, with an emphasis on improving connectivity. • Explore a range of options, such as designing the engineered channel to provide connectivity to the river only during low-flow periods or through a range of high and low flows. • Evaluate a range of hydraulic and biological conditions created by an engineered channel, through a detailed engineering study, including 2-D hydraulic modeling, to understand flow velocities that would be created within the Cove and their effect on HABs, sustainability of the engineered channel and the North-East Peninsula's banks over time, sediment deposition patterns as a result of the improved connectivity, water temperature changes, and impacts on fish and wildlife. • Pursue other actions that would improve water temperatures and nutrients in the Cove over time, including creating wetland areas and enhancing floodplain vegetation.
Unnatural Landforms and Debris	Past mining and other industrial activities have created unnaturally steep banks above OHW, with coarse substrates (cobbles, boulders, etc.), and areas littered in debris. Large areas of the shoreline and banks are covered in debris or occupied by remnant structures from past mining and other land uses. Debris includes concrete, boulders, wire cable, and remnants of buildings and other industrial structures. Several old structures, including piers and docks, are located within open water areas or along the banks.	• The steep banks (nearly 1:1 slopes in many areas) rise from the bottom of the Cove to the floodplain terraces above. The uniformly steep banks limit habitat diversity and have created poor conditions for the establishment of high-quality habitat, including wetlands and riparian areas. • The coarse substrate and limited fine organic matter, combined with water level fluctuations, also create poor conditions for establishing wetlands and other vegetation communities. • The east side of the Cove presents the best opportunity for contouring the banks to a more natural slope. The North-West and North-East Peninsulas are narrow and subject to erosion from the Clackamas River; any bank grading in these areas would need to be done in a manner that does not create conditions that could lead to the river eroding through the peninsulas. • Bank debris and remnant structures limit habitat complexity. • Debris, remnant industrial structures, and steep banks create public safety hazards. • The Study Area's aesthetic qualities are degraded by bank debris, remnant structures, and lack of high-quality habitat.	• Contouring the banks to a more natural landform would improve revegetation success and provide more diverse fish and wildlife habitat. • The east side of the Cove is where most of the slope grading should be focused. • Bank slopes above OHW of 3H:1V or flatter should be targeted, for both optimal vegetation establishment and public safety. In some areas course substrate would need to be augmented to create soil conditions suitable for plant establishment. • Debris and remnant structures should be removed as part of bank grading and habitat restoration actions.
Stormwater Quality and Other Potential Contaminates	Two primary stormwater conveyance systems that drain into the Cove. These stormwater systems drain the Oregon City Shopping Center and a large area to the south and east of the Cove. Stormwater contains copper and other constituents that can affect ESA-listed salmon and steelhead and water quality in general. Groundwater and sediment samples in the area have tested positive for some contaminates but not at levels that currently affect fish, wildlife, and human health.	• The City is applying appropriate BMPs and other actions designed to limit stormwater quantities and improve water quality. • The stormwater outfalls are within areas that would be targeted for habitat restoration actions, including created wetlands and other habitats. • Given the possible impact of stormwater, groundwater, and sediment contaminates on salmonid behavior and survival, NMFS, ODFW, and other state and federal agencies would expect that as the City improves habitat in the Study Area it would also pursue measures that would, over time, improve stormwater quality and ensure that groundwater and sediment contaminates would not affect habitat restoration areas and fish. • Contaminants migrating in shallow groundwater from the old landfill and other areas outside of the Study Area include chlorinated solvents, arsenic, lead, and other typical landfill constituents such as iron and manganese. • Concentrations of PAHs and metals were detected in some sediment samples above ecological screening levels. • DEQ has evaluated the groundwater and sediment studies for the area and has found that at this time groundwater sediment contaminates do not appear to be affecting the Cove's aquatic environment or human health.	• Implement a long-term and comprehensive approach that encompasses a variety of actions to address stormwater quality and quantity throughout each outfall's drainage area. • Phase stormwater actions in over time, including "retrofitting" the existing stormwater drainage system with Low-Impact Development BMPs. • Evaluate groundwater and sediment contaminates before implementing wetland and aquatic habitat restoration/ mitigation actions. Assess potential direct and indirect impacts on fish and wildlife and their habitats. This would include evaluating contaminates at the restoration/ mitigation site, and the potential for migration of contaminates into the restoration site.

Simplified Aquatic and Wetland Habitats	ESA-listed salmon and steelhead juveniles reside in the Cove during periods of high flow (November – June). The Cove's uniformly steep banks do not provide the kinds the complex, shallow water habitats that juvenile salmonids need to avoid predators and feed. Juvenile Pacific lamprey, a state and federal sensitive species, likely grow and feed in the Cove's sediments.	• Juvenile salmonids prefer to rear and feed in shallow areas with a diversity of habitat types, including wetland vegetation and large wood. Juvenile coho avoid areas with the kinds of habitats present in the Cove: steeply sloped banks, coarse substrates, and areas of debris. • Historically, there were complex shallow water habitats throughout the lower Clackamas and Willamette Rivers. These habitats, which are essential for recovering ESA-listed salmonid populations, have been lost over time. • The Willamette – Clackamas river confluence area, including the Study Area, is recognized by state and federal agencies as a high priority for habitat restoration. • There are large areas of the Cove that are suitable for the creation of shallow water habitats and wetlands. • Any restoration activities within the Cove should take into account the likely presence of juvenile lamprey.	• Create gentle in-water (below OHW line) slopes, 5H:1V or flatter, to allow development of wetland plant species. • Create slope variations to enhance the plant diversity in created wetlands. Add large wood, including rootwads,and other structures in some areas to provide habitat complexity and cover for both fish and wildlife.
Simplified Riparian and Floodplain Habitats	For the most part, the upper banks and floodplain terraces are dominated by relatively large (18- to 24-inch diameter) black cottonwood, Douglas fir, and other native trees, with an understory consisting largely of Himalayan blackberry, English ivy, Japanese knotweed, and other weedy species. The width of the riparian corridor along the Cove varies, from a narrow strip along the eastern side to relatively wide expanses of vegetation on the three peninsulas.	• ODFW notes that while some of the Study Area currently functions as high-quality wildlife habitat, most of the area does not provide good habitat because of the narrow riparian vegetation corridors, prevalence of invasive species, and limited diversity of habitat types. • The North-East Peninsula is the only habitat that is currently rated as high-quality by ODFW and it is essentially the only refuge for wildlife in the area. • There are large native trees throughout the Study Area, but invasive weeds occupy understory areas, which degrades habitat quality. • A variety of wildlife species have been observed in the Study Area, including amphibians: Rough-skinned newts, pacific tree frog (egg masses), and red-legged frog (egg masses). • There have been reports of native turtles in the Study Area, but the observations have not been confirmed. If native turtles are not present, they could eventually move into the Study Area. There is a native painted turtle population in close proximity, within the City of Gladstone's Meldrum Bar Park.	• Retain as many mature native trees as possible and plant native vegetation in areas that will increase the width, total area, and diversity of riparian habitat. • Remove non-native plants and weeds and replant with native vegetation at appropriate elevations. • Establish the North-East Peninsula as wildlife habitat, with limits on human access, including decommissioning the existing trail system. Place downed trees (mimicking natural tree fall) in the aquatic areas for aquatic-dependent species like turtles and amphibians. A variety of branch sizes allows turtles of various sizes to climb out of the water and bask and provides egg attachment sites for amphibians. •
Structures below the OHW line	Currently the sheriff's boathouse is the only structure that is planned to remain in the Study Area. Existing piers and docks are slated for removal. Other existing structures, such as docks and piers, degrade the habitat and aesthetics of the Study Area	• Installation of docks or other structures below OHW would affect aquatic resources, which would require state and federal permits and would trigger mitigation to address the impacts. • Docks and other structures on the surface of the water can provide hiding places for non-native fish species that prey on native fish and should be designed to minimize this function • Mitigation actions to compensate for any unavoidable impacts from construction of the Cove Development Project could entail removing existing industrial structures and/or creating other habitats, including creating complex shallow water habitats. • Removal of existing piers and docks would improve aquatic habitat and aesthetics.	• Limit the number and extent of docks and other in-water structures installed in the Cove to minimize impacts on aquatic habitat. • Integrate the planning for the location and types of in-water structures with planned habitat restoration areas to minimize the impact on restoration goals.
Recreation and Human Access	The Study Area is popular for boating, swimming, fishing, hiking, and bird watching. There is a well-used pedestrian/bicycle trail that generally parallels the east side of the Cove. There is an extensive network of informal trails and water access points throughout the area.	• A network of trails, parks, and natural areas connects the Study Area to the surrounding landscape and natural areas. • The trail along the east side of the Cove links the City to the Clackamas River, provides a connection to the City of Gladstone, and provides access to a regional network of trails, parks, and natural areas. • The extensive network of informal trails and water access points results in extensive habitat impacts, including removal and trampling of vegetation, erosion, and litter. • For the most part, human use of the floodplain terrace area and banks and water access is not controlled through designated trails or formal access points. • The recurring HABs inhibit swimming and other recreational activities and degrade the aesthetics of the Study Area. • In addition to habitat impacts from human access, the Cove's steep topography and industrial debris create an unsafe setting for recreational activities.	• Develop and implement a Recreation and Public Access Plan with details on formal trail locations, water access points, and areas where human use should be discouraged. • Integrate the Recreation and Public Access Plan with habitat restoration plans to ensure that human impacts will not conflict with restoration goals. • Establish the North-East Peninsula as wildlife habitat, with limits on human access, including decommissioning the existing trail system. • Create 3H:1V slope to 6 feet below the low-water mark to provide a means of escape in the event that someone were to fall in. • Remove coarse bank material and create sandy beaches for summer recreational activities as well as good winter fish rearing habitat.

Partnerships and Funding Opportunities

Partnerships

The CRBC is collaborating with the GOCWC, OWEB, ODFW, DEQ, Clackamas County, Metro, and other partners to develop a comprehensive strategy and funding framework for pursuing habitat restoration and water quality improvements throughout the Clackamas River Basin and the surrounding metropolitan area. The CRBC's strategic planning area includes the Cove. Cascade staff are under contract to facilitate the strategic planning effort.

At the October, 2016 CRBC meeting, Cascade staff provided an overview of the Feasibility Study and outlined restoration opportunities in the Cove. At the meeting, Council members stated that the Cove is an important area for improving water quality and fish and wildlife habitat. CRBC Board Members also stated that they are amenable to pursuing a partnership with the City to work collaboratively on securing funding and implementing habitat restoration actions.

There are numerous benefits that the City could derive from a Partnership with the CRBC and participating in the strategic planning process, including potentially securing funding for habitat restoration actions. CRBC's strategic planning effort is funded by OWEB and it is anticipated that OWEB funds will assist with future restoration actions. In addition, participants in the planning process, including Metro and Clackamas County, will provide additional funds intended to match the OWEB funding.

An additional benefit in participating in the strategic planning process is developing partnerships with participating entities. Metro is a participant and is also currently facilitating and providing some funding for the Willamette Falls Legacy project. With a location spanning both the mouth of the Clackamas River and Willamette Falls, the City is positioned at the gateway to some of the most important salmon and steelhead runs in the Pacific Northwest. In addition to the important fishery resources, the Cove and Willamette Falls are also regionally important recreational and economic assets. A partnership with Metro could assist with planning and implementing both habitat and recreational improvements at the Cove.

There are a number of grant opportunities that could assist with funding habitat improvements at the Cove. Grant funding entities include OWEB, the U.S. Environmental Protection Agency, Oregon State Parks and Recreation Department, and NMFS. Collaborating with the Council, Metro, and perhaps other entities in grant proposals will assist with securing grants.

Other Willamette River basin cities have restored former floodplain gravel mine sites from an environmental liability to a natural resource and recreational asset. The City of Eugene's Delta Pond project is model of a comprehensive approach to gravel mine and floodplain restoration accomplished through partnerships and creative funding strategies[42]. The Delta Ponds Restoration Project focused on revitalizing the floodplain and former gravel mine sites through phased restoration of fish and wildlife

[42] **City of Eugene. 2014.** Delta Ponds Restoration Project: From Opportunity to Completion. City of Eugene, OR. http//willametteinitiative.org/tools-resources/delta-ponds-restoration-project-opportunity-completion

habitat, water quality improvements, and better access and interpretive facilities (Photo 8). Water quality improvements included addressing algal blooms through improved flow connectivity with the Willamette River and other actions. The City of Eugene worked collaboratively with an extensive group of partners including federal, state, and local organizations and community groups. Funding for the project was through a variety of sources, including federal appropriations to the U.S. Army Corps of Engineers and grants awards from the U.S. Bureau of Land Management, ODFW, OWEB, Oregon Parks and Recreation Department, and NMFS.

Photo 8a – 8b. Eugene's Delta Ponds are an example of floodplain gravel mines that have been restored through phased actions. The photo on the left shows grading of fine fill material to create riparian benches and wetland areas. The restored area includes trail access and interpretive facilities (photo on the right).

Habitat Mitigation Banking

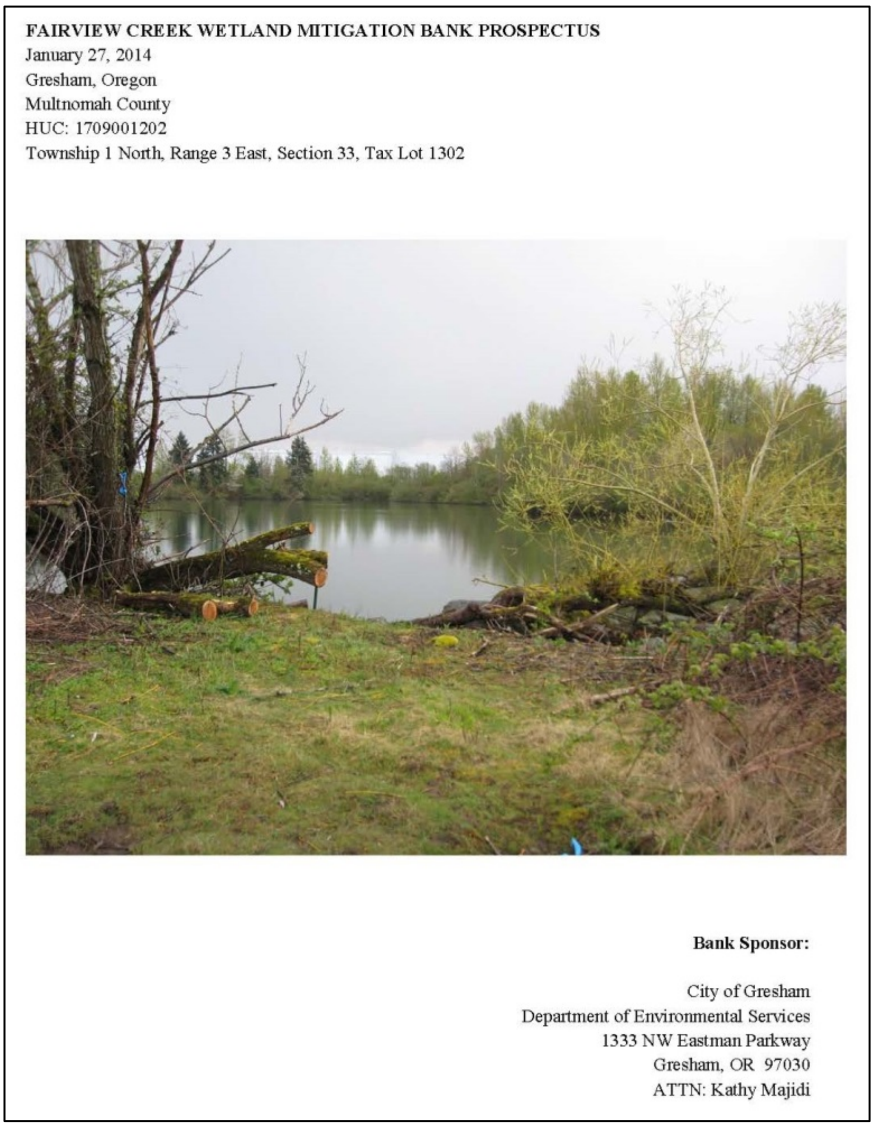
Environmental mitigation, or compensatory mitigation, are terms used primarily by the United States government and the related environmental industry to describe projects or programs intended to offset known impacts to an existing natural resource. The impacts can affect streams, wetlands, endangered species, or other resources.

Formal environmental mitigation is part of a crediting system established by state and federal agencies which involves allocating debits and credits. Debits occur in situations where a natural resource has been destroyed or severely impaired and credits are given in situations where a natural resource has been deemed to be improved or preserved.

In the lower Willamette region, including the Cove, there are three primary mitigation markets in place or in development, including: 1) Wetlands and waters of the U.S.; 2) Natural Resources Damages Assessment (NRDA); and 3) endangered species conservation. Each of these markets offers opportunities to create a mitigation bank in the Cove. A mitigation bank is an area of restored habitat from which private and government entities with environmental damages (debits) can purchase mitigation credits that address their damages within the region ('service area') in which the damages occur.

Wetlands and Waters of the U.S.

Of the mitigation banking options, Wetland and Waters of the U.S. mitigation banking has the longest history as a functioning mitigation market. These banks are designed to address impacts to wetland or aquatic resources authorized under the U.S. Clean Water Act. There are a number of wetland mitigation banks in the Portland metropolitan region. Wetland banks have been developed by private and public entities. The City of Eugene, for example, developed and operates a wetland mitigation bank. The City of Gresham is currently developing a mitigation bank at a former gravel mine site on Fairview Creek in partnership with the Port of Portland, which is anticipating the need for wetland credits due to anticipated infrastructure development impacts in the bank's service area (Figure 13). A private entity operates the Foster Creek Mitigation Bank, which serves development primarily in the Clackamas Basin. Credits for the Foster Creek Mitigation Bank are now being purchased for approximately $250,000 per credit (one credit equals one acre of mitigation). The bank has a limited number of credits remaining and there are no other wetland banks that cover the same service area. The Cove is within this service area.


FAIRVIEW CREEK WETLAND MITIGATION BANK PROSPECTUS
January 27, 2014
Gresham, Oregon
Multnomah County
HUC: 1709001202
Township 1 North, Range 3 East, Section 33, Tax Lot 1302

Bank Sponsor:

City of Gresham
Department of Environmental Services
1333 NW Eastman Parkway
Gresham, OR 97030
ATTN: Kathy Majidi

Figure 13. The Fairview Creek Mitigation Bank Prospectus. The City of Gresham is developing a mitigation bank within former floodplain gravel mine.

Natural Resources Damages Assessment

NRDA is a framework for mitigating for past damages resulting from designated Superfund Sites. The Lower Willamette Superfund site is located in Portland's industrial harbor. In this case, NRDA restoration addresses past damages to fish and wildlife from ship building and other activities that damaged habitat and released contaminates. Most of the NRDA mitigation focus is on restoring habitat for ESA-listed salmon and steelhead, primarily restoring shallow water habitats and associated floodplain vegetation. The parties with NRDA liabilities seeking to purchase NRDA restoration credits must obtain half the credits from sites within the inner Portland harbor; the other half of the credits can be purchased from an outer harbor site, located essentially above the inner harbor area up to Willamette Falls. Based on conversations with NMFS staff, the Cove would likely be included in the outer harbor because it is subject to tidal flows and juvenile fish populations from both the upper Willamette River basin and the Clackamas River occupy the area.

At this time there is one fully-approved NRDA restoration site, Alder Creek, which is operated by Wildlands, a private entity. This site is within the inner harbor and has sold a limited number of credits to the City of Portland. Other restoration sites in the inner and outer harbor are now under development. The 33-acre Rinearson Natural Area in the City of Gladstone's Meldrum Bar Park is being developed as a NRDA restoration site through a partnership between a private entity and the City of Gladstone. The private entity is providing most of the funding to design, permit, and restore the site, and the city is providing the land.

A very limited number of credits have been sold under the Portland Harbor NRDA restoration framework. Credit costs for NRDA restoration sites are variable and will change as the market develops, but the costs per credit are conservatively a multiple of two to three times the cost of a wetland mitigation bank credit on a per acre basis.

Endangered and Sensitive Species Conservation

Conservation banks are a relatively new mitigation framework designed to address impacts to essential habitat for special status species, including federally listed ESA species. There are no conservation banks in Oregon, but several have recently been established in Washington. Based on conversations with NMFS staff, there is a need for conservation banks in the Portland metropolitan area that can address impacts ESA-listed salmon and steelhead habitat in the lower Willamette River and tributary streams. Currently, there is not a market to base credit costs on, but it is anticipated that the credit costs would be similar to NRDA restoration credits because both frameworks are within the same impact area (roughly the lower Willamette River and associated floodplains) and thus competing for habitat mitigation crediting.

Evaluation of Mitigation Banking Opportunities for the Cove

Developing a mitigation bank in the Cove could provide the City with both restored habitat and revenue over time. Developing a bank in the Cove would entail upfront costs to engage state and federal agencies to design, permit, and construct the bank. The primary agencies that regulate banks are the Oregon Division of State Lands, and the federal Corps of Engineers (wetland mitigation) or NMFS and U.S. Fish and Wildlife (NRDA and conservation banking). Once a bank is approved, it is eligible to release 10% of its credits prior to construction. After construction, credits are released over a 5 to 10 year period based on meeting performance criteria. Credit sales would occur over time, and depending on the market demand, the sales could extend beyond 10 years.

The bank could be developed by the City, or through a private entity that would cover all the costs in return for a percentage of credit sales. It would feasible for the City to develop a mitigation bank in partnership with a private entity – for example, the City could receive credits or revenue from the entity in return for the use of City property. The mitigation bank could also potentially be developed and funded by an entity that anticipates a large future mitigation need. For example, a port that is anticipating extensive shallow water habitat impacts from expansion of its facilities could purchase the entire bank to cover their impacts.

Based on initial conversations with state and federal agency staff, the Cove is suitable for wetland, NRDA, and conservation credits. Because of the Cove's strategic position at the Willamette and Clackamas river confluence, mitigation and restoration would address habitat needs for multiple ESA-listed salmon and steelhead populations (i.e., upper Willamette and Clackamas runs) and other sensitive species (e.g., Pacific lamprey). There are mitigation sites that cover multiple mitigation markets, and it may be possible to create a bank that could sell credits for the three credit frameworks. It is important to note that the state and federal agencies that were consulted about mitigation options for the Cove were not committing to the feasibility of mitigation. The first step in exploring mitigation banking options would be to hold a formal "pre-prospectus" meeting with the state and federal agencies. At the meeting, the agencies would provide their perspective on the suitability of the site, credit markets, and outline the formal process for agency approval of the mitigation site. Based on agency feedback, a formal Mitigation Bank Prospectus would be developed for agency review and approval. A Mitigation Bank Prospectus is a brief document (approximately 15 pages) that outlines the entity that will develop and run the mitigation bank (private entity, City, or a partnership), credit type(s), the potential market for the credits and anticipated credit demand, and habitat creation / restoration area boundaries and approach. Approval of the Mitigation Bank Prospectus sets the stage for developing the detailed mitigation bank design and agency oversight and approval process.

Habitat and Water Quality Phasing and Costs

Addressing the Cove's water quality and habitat concerns will require an integrated strategy that phases in improvements over time. An integrated strategy will entail developing an approach that demonstrates to state and federal agencies that that HABs, stormwater quality, groundwater and sediment contaminates, and recreational uses have been evaluated. A comprehensive and feasible plan will need to be in place to address agency concerns before implementing habitat restoration or mitigation banking actions.

Figure 14 shows a conceptual design for the Cove that integrates improved connectivity to the Clackamas River with habitat improvement actions, creating more natural landforms, and developing a mitigation bank area. All of the habitat and water quality improvements would be integrated with carefully designed recreational access and facilities (e.g., viewing platforms), and are designed to work together to improve the Cove's habitat and aesthetic qualities. The areas on the map are conservative; the habitat improvement areas and the mitigation bank size could increase by a considerable amount.

The key variables controlling the size and relative locations of the habitat improvement areas and the mitigation bank are 1) flow and water mixing patterns from a constructed channel to the Clackamas River; 2) the amount of fill required to create shallow water areas and wetlands along the shoreline; and 3) the costs associated with the habitat improvements and the mitigation bank.

Table 7 outlines habitat mitigation, restoration, and water quality improvement phasing, timelines, and concept-level costs.

Figure 14. A conceptual habitat and water quality enhancement design for Clackamette Cove that integrates improved connectivity to the Clackamas River (red arrow) with habitat restoration actions and a habitat mitigation bank.

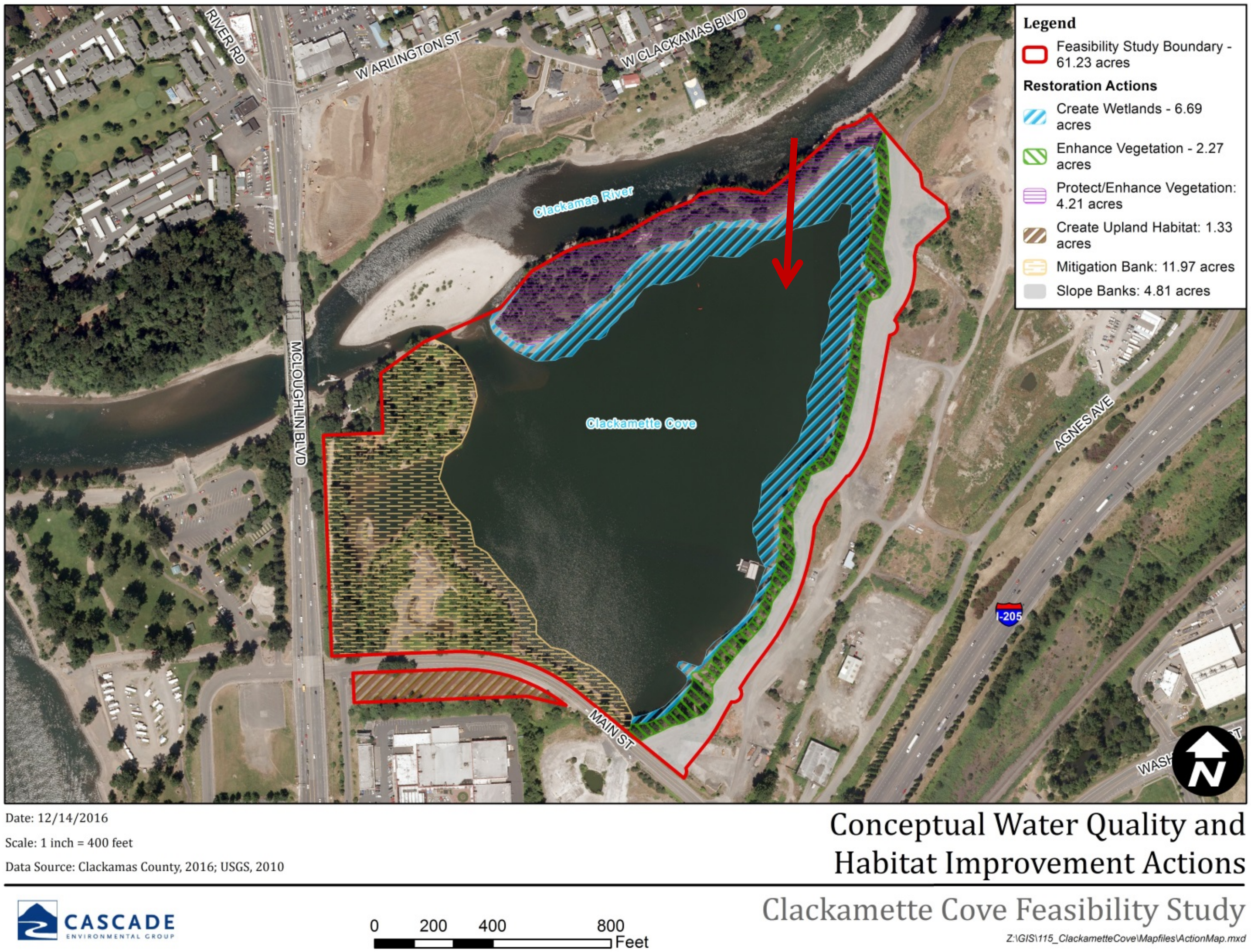


Table 7. An outline of habitat mitigation, restoration, and water quality improvement action phasing, timelines, and concept-level costs. The phase timeline assume the components are completed in parallel during the same timeframe; the components can be completed at different timeframes, but this would extend the phase timeline.

Phase	Phase Timeline	Action Components	Component Timeline	Conceptual Cost
Phase 1: Mitigation Bank – Agency Feedback	1 month	Mitigation bank pre-prospectus meeting with state and federal agencies	1 month	$10,000
Phase 2: Integrated Water Quality and Mitigation Approach	6 months	Mitigation bank prospectus detailing project components for agency review and approval	6 months	$30,000
		Engineering feasibility study for connectivity channel to the Clackamas River	6 months	$40,000
		Partnership engagement with the Clackamas Basin Council, Metro, and other organizations and exploration of other funding options	6 months - Ongoing	N/A
Phase 3: Integrated Plan	2 - 3 years	Mitigation site engineering design, permitting and agency approval	2 years	$250,000
		Recreation/Public access plan and trail/facility design, permitting and agency approval	12 months	$80,000 - $120,000
		Clackamas connectivity channel engineering design, permitting, and agency approval	12 months	$100,000 - 200,000
Phase 4: Construction	1 years	Mitigation site construction and native vegetation planting	5 months	$400,00 - $800,000
		Recreation trail/facility construction	8 months	300,000 – 800,000
		Clackamas connectivity channel construction	4 months	$300,000 - $800,000
Phase 5: Monitoring	5-10 years	Mitigation bank performance monitoring and annual reports for agency review. Note: Credit sales are linked to successfully meeting performance objectives	5 - 10 years	$20,000 – 40,000 (annual)
	Ongoing	Water quality and HAB monitoring	Ongoing	$6,000 (annual)

APPENDIX A

Vegetation Community Photos

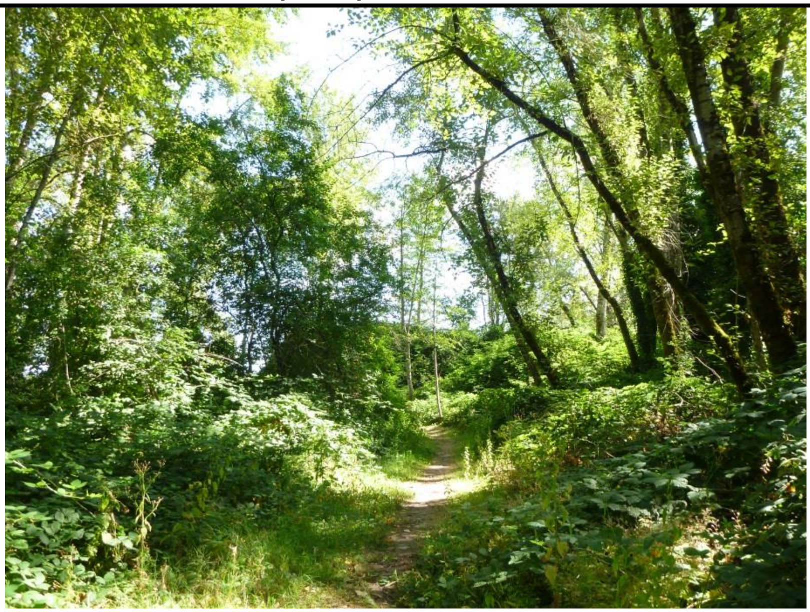


Photo point 1. Photo 1. From the northwestern section of the project site looking 20° at Vegetation Community #1: Black Cottonwood/Himalayan Blackberry/False Brome Riparian Forest.

Photo point 1. Photo 2. From the northwestern section of the project site looking 110° at Vegetation Community #1.

Photo point 1. Photo 3. From the northwestern section of the project site looking 190° at Vegetation Community #1.

Photo point 1. Photo 4. From the northwestern section of the project site looking 285° at Vegetation Community #1.

Photo point 2. Photo 1. From the island at the mouth of the Cove looking 60 ° at sandbar willow, St. John's wort, and pink flower vegetation.

Photo point 2. Photo 2. F From the island at the mouth of the Cove looking 240 ° at sandbar willow, St. John's wort, and Japanese knotweed vegetation.

Photo point 3. Photo 1. From gravel access road along the western site boundary looking 0°.

Photo point 3. Photo 2. From gravel access road along the western site boundary looking 180°.

Photo point 4. Photo 1. From drainage into the Cove looking 165° upstream at vegetation community #2: Pacific Willow/Redosier Dogwood/Birdsfoot Trefoil-Spatulaleaf Loosestrife Scrub-Shrub Wetland.

Photo point 4. Photo 2. From drainage into the Cove looking 200° downstream at vegetation community #2.

Photo point 5. Photo 1. From bank at southwestern section of the site looking 220° at vegetation community #3: Birdsfoot Trefoil Emergent Wetland.

Photo point 6. Photo 1. From the southwestern section of the site looking 30° at gravel lot and vegetation community #4: Black Cottonwood/Himalayan Blackberry/Orchardgrass-Velvetgrass-Wild Carrot Riparian Forest.

Photo point 7. Photo 1. From the parcel south of the Cove looking 95° at vegetation community #5: Colonial Bentgrass-Common Plantain-False Oatgrass Weedy/Ruderal Clearing.

Photo point 8. Photo 1. From Main St. running along the southern site boundary looking 325° at vegetation community #4.

Photo point 9. Photo 1. From the southeastern bank of the cove looking 40° at vegetation community #7: Black Cottonwood/Himalayan Blackberry/Birdsfoot Trefoil Riparian Forest.

Photo point 10. Photo 1. From the Clackamas River Trail along the eastern site boundary looking 170° at vegetation Community #8: Colonial Bentgrass-Common Plantain-Velvetgrass-Wild Carrot Weedy/Ruderal Clearing.

Photo point 10. Photo 2. From the Clackamas River Trail along the eastern site boundary looking 170° at vegetation Community #8:

Photo point 11. Photo 1. From the northern section of the study area looking 65° at vegetation community #8: Douglas fir/Hazelnut-Himalayan blackberry/False Brome-Sweetpea Riparian Forest.

Photo point 11. Photo 2. From the northern section of the study area looking 245° at vegetation community #9: Black Cottonwood/Hazelnut-Himalayan blackberry/False Brome-Sweetpea Riparian Forest

APPENDIX B

Residence Times and Water Quality within Clackamette Cove

TECHNICAL LETTER

To: John Runyon, Cascade Environmental Group

From: John Dvorsky, Waterways Consulting, Inc.

Date: November 22, 2016

Re: Residence Times and Water Quality within Clackamette Cove

Waterways Consulting, Inc (Waterways) has been asked to assist Cascade Environmental Group with an overview of the residence time of water within the Cove, how additional inflow may influence residence times, and the options that may be available to improve circulation in the Cove.

One of the primary concerns amongst stakeholders of existing conditions within the Cove is poor water quality. During the summer, low flow conditions in the Clackamas River, combined with the presence of a single opening to the Cove, results in a lack of flow exchange that has led to toxic algal blooms and health alerts. The lack of flow into the Cove limits circulation and increases the residence time of water, both prerequisites for algal blooms. During the summer months the Cove is essentially a closed system.

To understand existing conditions within the Cove and provide a basis for recommending enhancement actions that could improve circulation and water exchange within the Cove we prepared an analysis of residence times for a range of conditions. The analysis included the following steps:

1. Using the LiDAR and bathymetric data a stage-storage curve was generated for the Cove that correlates a range of water surface elevations to the volume of water in the Cove (Figure 2).
2. The Stage-Storage Curve was then used to develop estimates of the residence time of water at different stages and different inflow conditions (Table 3).

The analysis assumes that water entering the Cove would be well mixed and circulate throughout the Cove. That assumption would need to be evaluated in future phases of the project and would likely require specific actions within the Cove to make full circulation a possibility. The source and location of inflow would also need to be evaluated. Preliminarily, the best approach to increasing summer inflow into the Cove from the Clackamas River would be to create a second opening to the Clackamas at the northeast end of the Cove. To evaluate the feasibility of this approach will require the following questions to be addressed:

1. Irrespective of residence time, what would the circulation patterns within the Cove looks like under a range of inflow rates. This could be addressed by running scenarios with a 2-dimensional model that has already been developed for the area. The model would need to be evaluated to determine if additional site information would need to be collected and if the resolution of the model is adequate to address the questions.
2. If an opening is created, what would be the configuration and size to ensure an adequate amount of summertime flow could enter the Cove, erosion of the opening does not occur during high flow conditions on the Clackamas, and the opening does not accumulate sediment

to the point where summertime flows no longer enter the Cove? These are all design questions that will need to be evaluated during the feasibility and design phases.

Figure 2: Stage-Storage Curve for Clackamette Cove for a range of water surface elevations.

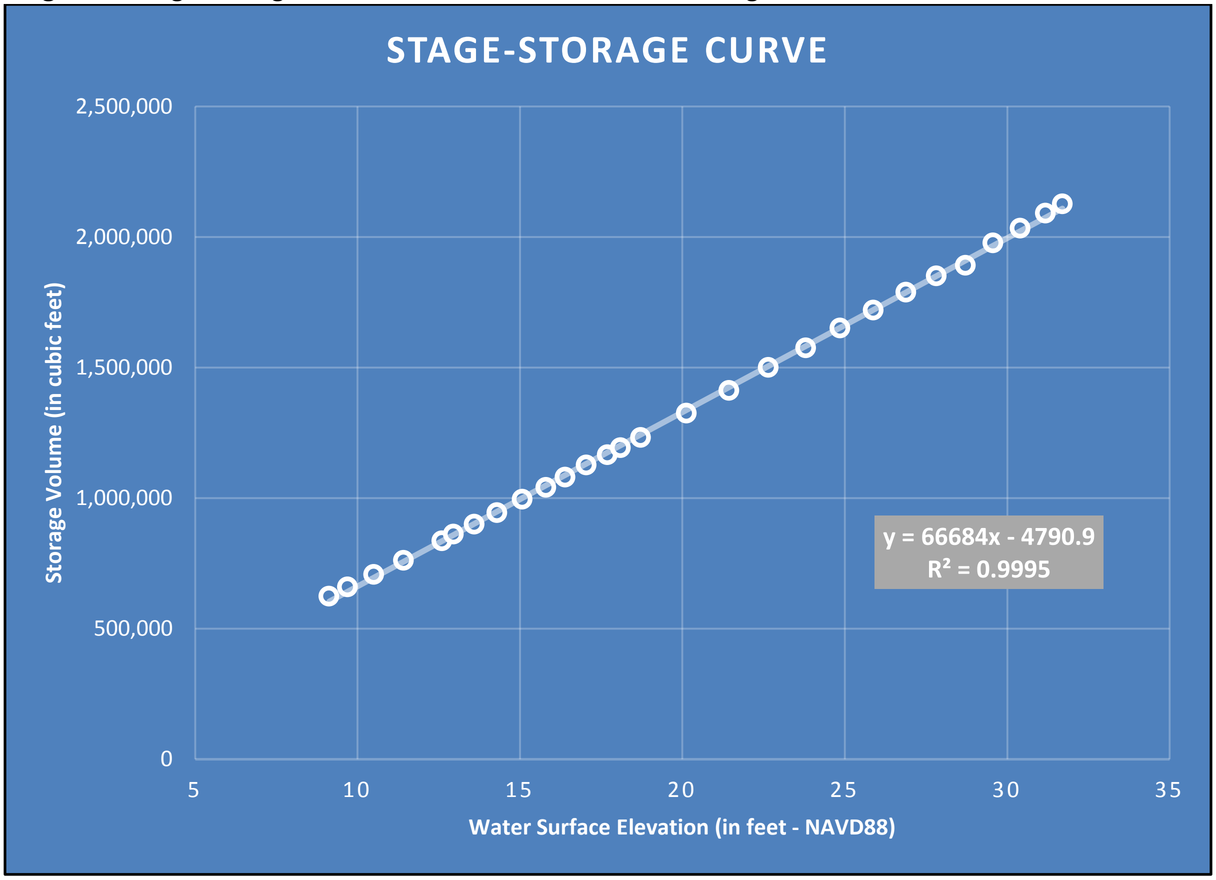


Table 3: Estimated residence time of water in Clackamette Cove under a range of water surface and inflow conditions.

Flow in Clackamas River (cfs)	Estimated WSE in Cove Using HEC-RAS (ft)[1]	Total Storage Volume in Cove (ft^3)	Flow into Cove (cfs)	Residence Time (days)
626	9.1	624,003	7.2	1
			4.8	1.5
			2.4	3
970	9.7	659,380	7.6	1
			5.1	1.5
			2.5	3
1,485	10.5	707,262	8.2	1
			5.5	1.5
			2.7	3
2,000	11.4	762,244	8.8	1
			5.9	1.5
			2.9	3
3,000	12.6	836,982	9.7	1
			6.5	1.5
			3.2	3
4,000	13.6	900,181	10.4	1
			6.9	1.5
			3.5	3
5,000	14.3	944,853	10.9	1
			7.3	1.5
			3.6	3
6,000	15.1	996320.0	11.5	1
			7.7	1.5
			3.8	3
7,000	15.8	1,041,688	12.1	1
			8.0	1.5
			4.0	3
8,000	16.4	1,080,796	12.5	1
			8.3	1.5
			4.2	3

1 - Based on Mean Daily Discharge July-Oct. 2001-2016