Novel Restoration in the Green/Duwamish Watershed: Policy Perspectives and Recommendations

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Abbreviations

Army Corps - U.S. Army Corps of Engineers
Boeing - The Boeing Company
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act
CFW - constructed floating wetland
CWA - Clean Water Act
DFWP - Duwamish Floating Wetlands Project
DNRP - King County Department of Natural Resources and Parks
DNRP/LWRD/RRS - Rural and Regional Services Section of the DNRP's Water and Land Resources Division
DVAP - Duwamish Valley Action Plan
DVP - Duwamish Valley Program
EAA - Early Action Area
Ecology - Washington State Department of Ecology
EHT - Employee Hours Tax
EPA - U.S. Army Corps of Engineers
ESU - Evolutionarily Significant Unit
ISGP - Industrial Stormwater General Permit
LDR - Lower Duwamish River
LDWG - Lower Duwamish Waterway Group
NEPPS - National Environmental Performance Partnership System
NERT - novel ecosystem restoration technique
NMFS - National Marine Fisheries Service
NPDES - National Pollutant Discharge Elimination System
NWIFC - Northwest Indian Fisheries Commission
PAH - polycyclic aromatic hydrocarbon
PCB - polychlorinated biphenyl
PPA - Performance Partnership Agreement
RCW - Revised Code of Washington
RI - Remedial Investigation
SCWG - Source Control Work Group
SMEA - School of Marine and Environmental Affairs
Soundkeeper - Puget Soundkeeper
SRKW - southern resident killer whale
WA DNR - Washington State Department of Natural Resources
WAC - Washington Administrative Code
WDFW - Washington State Department of Fish and Wildlife
WEF - Watershed Ecosystem Forum
WRIA - Water Resource Inventory Area

Glossary

Actor (or **policy actor**)**:** An inclusive term used to refer to all co-managers, stakeholders, individuals, and communities involved in the policy process.

BioBarge: A constructed floating wetland designed for a restoration project case study discussed in this report. Includes a buoyant wooden frame that holds wetland biofilters. The BioBarges were designed to be towable research platforms and provided the external structure for the floating wetlands.

Floating wetland: A general term that describes a buoyant substrate that supports wetland plants growing hydroponically, with roots suspended below the water surface. Floating wetlands have been designed and implemented around the world and can take various forms. In our case study, floating wetlands and constructed floating wetlands (CFWs) both refer to the wetland system designed for this project, which included barge frames (see BioBarge above) and wetland biofilters anchored both within the frames and outside along the longer edges of the frame.

Wetland biofilter (or **biofilter**) **1.0:** A $1m^3$ sixteen-gallon wire gabion containing various biodegradable media including willow brush, wood straw, naturally sourced foam substrate, and native wetland plants.

Wetland biofilter (or **biofilter**) **2.0:** A roughly $0.5m^3$ plastic cage containing biodegradable media in the form of wood straw and native wetland plants, with flotation provided by pumice bricks.

Executive Summary

Seattle's Lower Duwamish River (LDR) and surrounding communities in the Duwamish Valley have been grappling with the legacy of settler colonialism, forcible displacement of Indigenous peoples, heavy industry, and redlining for generations. Today, this legacy manifests itself most visibly in the need for river sediment cleanup, air quality improvements, education and outreach related to hazardous resident seafood species, negative health outcomes, and water quality monitoring. Not only does this industrial legacy impact the human communities of the Duwamish River, but it also has contributed to the decline of Green-Duwamish River ecosystem health and salmon populations.

In 1999 the National Marine Fisheries Service (NMFS) listed Puget Sound Chinook salmon populations as threatened under the Endangered Species Act. A variety of efforts to restore salmon runs have failed, and their population remains a fraction of their historic abundance. Many factors have contributed and continue to contribute to the decline, including overfishing and loss of freshwater and estuarine habitat (NOAA, 2021). The latter is particularly pronounced in the Seattle metropolitan area, today one of the fastest growing regions in the country, where the once-meandering Duwamish River was transformed into a straightened industrial waterway, and its once sprawling estuary unrecognizably urbanized. The maintenance of healthy fish and shellfish populations and ecological function is critical to the long-term cultural, spiritual and economic well-being of the Duwamish, Muckleshoot, Yakama and Suquamish peoples. Ecosystem health is also critical to the human health and well-being of indigenous and non-indigenous communities in the Duwamish Valley.

This policy issue paper provides a wide-ranging look at ecological restoration in the LDR using multiple approaches, beginning with a history of the river and the current status of human and more-than-human communities in the area. Next, the many policy- and decision-making frameworks that currently govern restoration projects in the river are presented. This policy background is followed by a discussion of approaches to restoration in "novel ecosystems" (Higgs, 2017) which includes a look at the current debate over the use of novel ecosystems both as a term and as a framework for restoration, in contrast to the more widely accepted "living shorelines" approach (Boyer et al., 2017). With estuarine habitat critical to juvenile salmon development and survival substantially reduced, we sought to investigate whether a human-constructed "floating wetland" prototype could be beneficial to juvenile salmon.

We examine novel ecosystems further through presenting the Green Futures Lab's Duwamish floating wetlands project (DFWP). The authors of this document participated in the DFWP, providing input into research design, performing field research and data analysis, and completing a technical report for the project (Klein et al., 2021). A summary of the DFWP and interviews with experts in restoration and environmental health are

provided to contextualize the discussion of novel ecosystems and restoration in the South Seattle area.

Working within this policy context and guided by the DFWP case study and related interviews. We provide an evaluative summary of the City of Seattle's Duwamish Valley Action Plan (2018) that provides readers a "case study" of current municipal-level policy targeted toward the LDR and communities in the area. This paper then proposes two policies designed to address environmental issues in the LDR at different levels: The first targets restoration work and water quality in particular, while the second addresses community well-being through a green jobs program. The feasibility of both policies is quantified using a computer-assisted tool.

Guided by these multiple perspectives and analytical approaches to understanding what needs to be done to advance environmental health and well-being in the LDR and surrounding communities, we provide two sets of policy recommendations to guide local policy- and decision-makers in improving ecosystem health and serving both human and more-than-human communities.

1. Introduction

The Green-Duwamish watershed comprises the Green and Duwamish rivers and empties into Puget Sound via Elliott Bay in the south portion of the City of Seattle (**Figure 1**). The terminal reaches of the watershed that flow into Elliott Bay are referred to by public agencies as the Lower Duwamish Waterway. The lower part of the river's original route was changed dramatically by development, channelization, and industrialization leading it to be designated a waterway by the government and primarily seen as a shipping and industrial corridor. However, community activism asserts that the Duwamish is a river due to the historical and cultural significance and ecosystem function it continues to provide. Throughout this report we use "Lower Duwamish River" (LDR) to respect the history of the river and its continued use since time immemorial for purposes other than the heavy industry brought to the region by white settlers. The LDR and the upstream "transition zone" that precedes it are sometimes called "river miles one to ten" by some policymakers and settler academics, and they are an important part of the Salish Sea ecosystem, supporting many human and non-human communities. In this section we will describe the history of the Duwamish/Green river and how it led to contamination, ecosystem degradation and declines in salmon populations. Then we will briefly describe the demographics of South Park and Georgetown, the two neighborhoods that flank the LDR, and how ecosystem degradation impacts their health and well-being.

Figure 1. Map of the Green/Duwamish River. *("Green-Duwamish River," American Rivers)*

The LDR is a highly industrialized, urbanized portion of the Duwamish River. White settlers colonizing the Pacific Northwest forced the original inhabitants of the area, the Duwamish Tribe, out of the lower watershed, ushering in a massive transformation of what is now the LDR and proximate upland areas in South Seattle (**Figure 2**). The intensity and extent of this transformation sets the context for current efforts at ecosystem in and around the LDR, limiting options and constraining efforts to both improve ecosystem function and public health.

Besides being situated in Seattle's industrial hub, the lower reaches of the Green-Duwamish watershed are also critical to salmon population survival and return because this is where juvenile salmon forage, shelter and physiologically transition from freshwater to saltwater conditions (Ostergaard et al., 2014). Returning salmon provide a fishery for the Muckleshoot Tribe as well as for Duwamish Valley residents, who can fish from the shore without the expense of boat ownership.

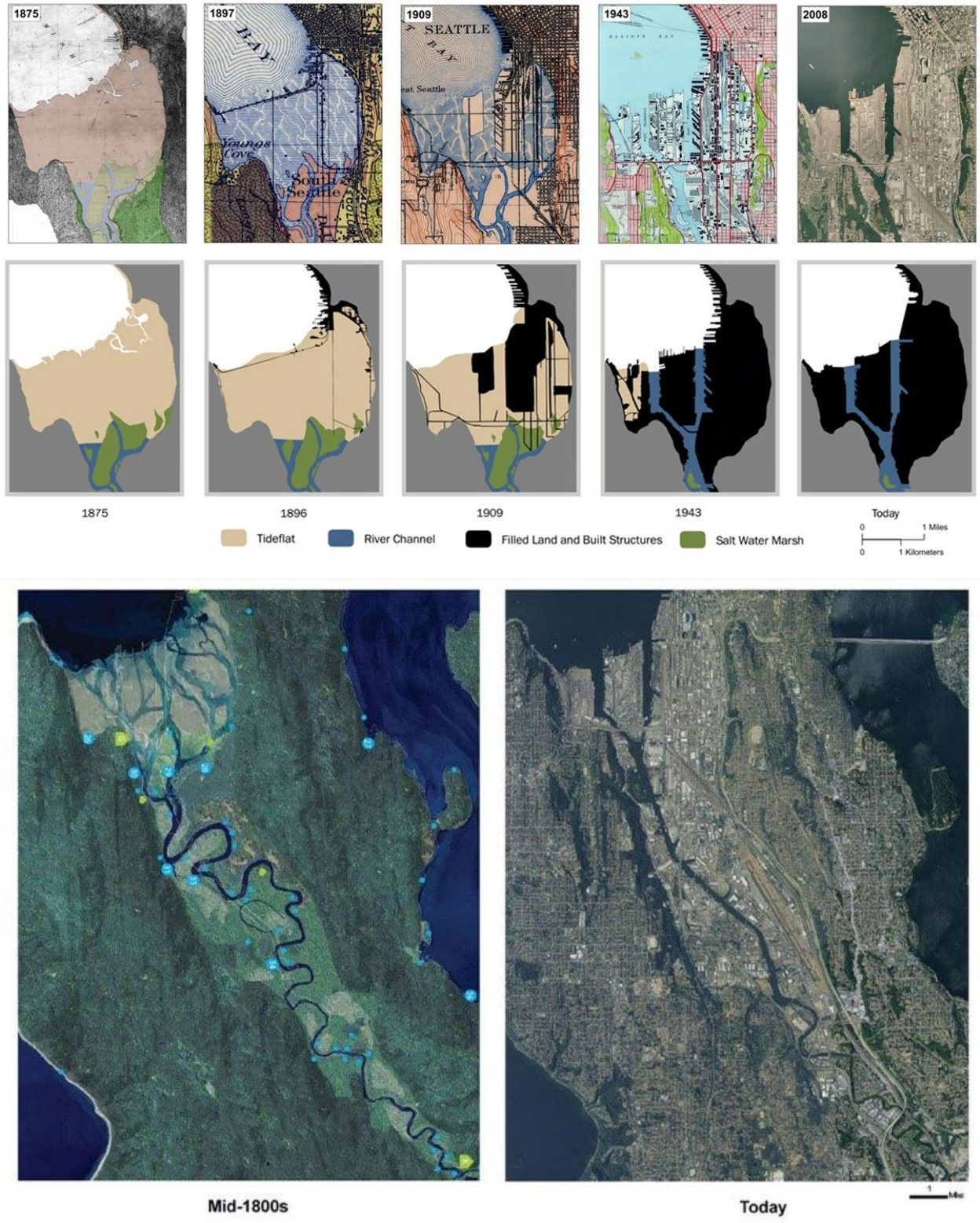

Figure 2. The Duwamish River changes over time. *Top: Time series depicting estuary loss since 1875. Bottom: The meandering Duwamish River in the mid 1850s (left), and the modern rechanneled river (right). (The Waterlines Project, 2015)*

1.1 Duwamish River History

Most of the original marsh, estuarine, and tidal mudflat habitat that made up the Duwamish River estuary has been lost over the past 150 years due to settler-colonial activity that forcibly removed the Duwamish Tribe. The once extensive 3,850 acres of tidal mudflats, marshes, and swamps were reduced to only forty-five acres of mudflats and tidal marshes by 1986 (Army Corps, 2000). The shoreline of the river has also been dramatically altered: 21,000 feet of shoreline has been lost due to straightening of the channel and 53,000 feet has been converted to developed shoreline. Only 19,000 feet of vegetated riparian shoreline remains in the Duwamish estuary (Collins and Sheikh, 2005), and eighty-six percent of the shoreline below the Turning Basin (River Mile 5.3, according to Ostergaard et al., 2014) is armored (Morley, Toft, and Hanson, 2012).

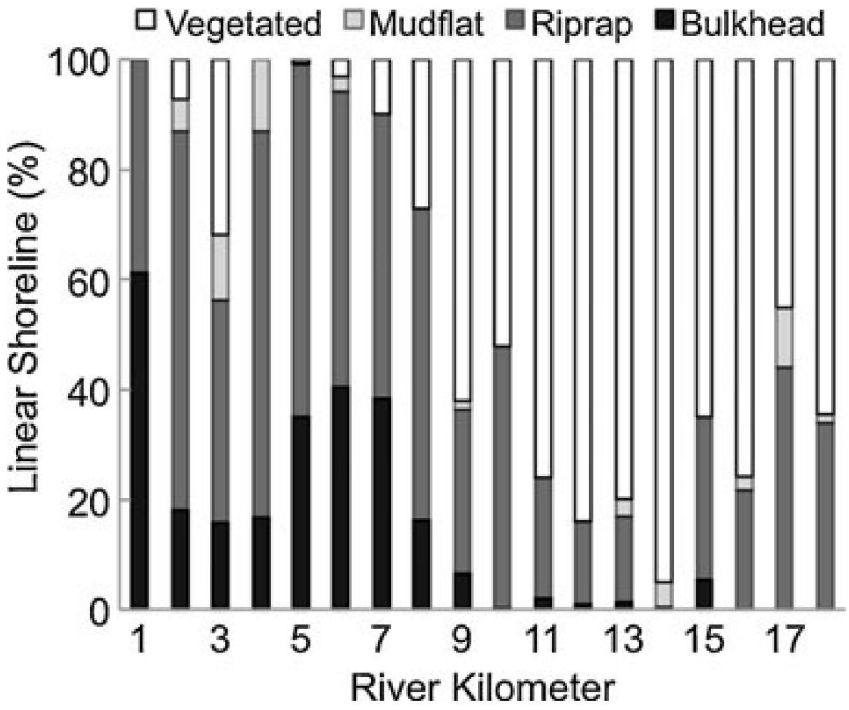

Figure 3. Green/Duwamish River shoreline armoring. *Relative distribution of four major shoreline categories by river kilometer. (Morley, Toft, and Hanson, 2012)*

By the end of the nineteenth century, the removal of the Duwamish people from LDR was nearly complete with the City of Seattle passing ordinances in the 1860s preventing indigenous people from residing within the city limits. Furthermore, settlers burned down Duwamish homes and villages in the 1890s, such as the destruction of t̓uʔəlaltxʷ (Herring's House Village) in 1893. These actions forced many Duwamish people

to abandon their homes and move to the established Muckleshoot and Suquamish reservations (Thrush, 2007) .

Industrialization of the LDR began in the early twentieth century with the dredging of the lower river to straighten and widen it for vessel passage. In the 1900s, the main operations were lumber mills, cement and brick factories, steel mills and marine construction facilities (US EPA, 2014). The first Boeing airplane manufacturing facility was established in 1917; its production and the production of steel and chemical facilities greatly increased during World War II, leading to liquid and solid waste being deposited directly into the river.

Subsequent industries along the Duwamish include cargo storage, metal manufacturing and recycling, airplane, chemical, cement, and wood preservative factories. Contaminants from these industries entered the river through leakage, storm water runoff, groundwater discharge, spills from vessels, and dumping. Decades of heavy industry deposited massive levels of known carcinogens and other toxicants in the LDR's sediments and in upland soils, threatening both public health and the health of the river's ecosystem. Persistent community activism and efforts by public and private actors ultimately brought about the LDR's designation by the U.S. Environmental Protection Agency (EPA) as a Superfund cleanup site in 2001. Superfund sites are locations that need large-scale, long-term response efforts to remediate for hazardous contamination ("Cleanup Activities," US EPA). The Superfund cleanup will be expanded on in Section 2.2.

Since the EPA adopted the final Record of Decision for Superfund early-action areas in the LDR, more than half of the average PCB contamination has been removed from the river and twenty-nine acres of sediment have been clean up (US EPA, 2014; "Our Work - What We've Accomplished," LDWG). Twenty-two habitat restoration projects are underway or have been completed within the Superfund area, with North Wind's Weir Restoration Project near the Seattle/Tukwila border being the most upstream site (LDWG, 2012).

The Boeing Company, however, continues to discharge polychlorinated biphenyls (PCBs) and other toxicants into the river from their industrial sites as of 2018 (Moreno, 2018). Because PCBs continue to persist in the environment despite being banned, this ongoing pollution is the legacy of past use. The City of Seattle sued Monsanto in 2016 for damaging the LDR with PCBs, and that case is still ongoing (Mapes, 2016). PCB bioaccumulation is a driver of a variety of health concerns, not just for humans but also for southern resident killer whales (SKRWs), contributing to their threatened survival (Ross et al., 2000). Other companies with operations near the water, such as Seattle Iron & Metals and Ardagh Glass, have also been alleged to be in violation of regulations meant to prevent continued pollution of the Duwamish's waters (Puget Soundkeeper, 2019; The Skanner News, 2019).

1.2 South Seattle Communities

The Duwamish Valley neighborhoods of Georgetown and South Park are home to 5,600 people (US Census Bureau, 2016). These neighborhoods include many industries and businesses that contribute to Seattle's economy. Many low-income, refugee, and immigrant communities reside in these neighborhoods and contribute greatly to the city. Forty-percent of households in South Park speak a language other than English at home and 33% of residents in South Park are Hispanic or Latinx, and 62.9% are non-white (not Hispanic or Latinx). Georgetown is 13.3% Hispanic or Latinx and 25.2% non-white. These diverse neighborhoods are extremely important to the wellbeing of the Duwamish Valley and the City of Seattle. Georgetown and South Park's median household incomes are also much lower than the Seattle average, at $60,128 and $34,605 compared to the citywide median of $74,458 (City of Seattle, 2018).

Along with this income disparity there are also health and environmental disparities in the Duwamish Valley. This is an environmental justice issue because water, sediment and air pollution are severe in these communities, which are also low-income communities of color. Furthermore, there are documented differential health outcomes for South Park and Georgetown residents compared with other neighborhoods in Seattle. Life expectancy in South Park and Georgetown is 13 years lower than that of a predominantly white, wealthy neighborhood of Laurelhurst in North Seattle (City of Seattle, 2018). Diabetes and diabetes related deaths are higher than average in Georgetown and South Park. Furthermore, the density of fast food restaurants is more than seven times the average in Seattle (City of Seattle, 2018). South Park is considered a food desert, a place where people cannot easily access healthy, affordable foods, which contributes to negative health outcomes (Cheam, 2020). The communities along the LDR have borne a disproportionate amount of health impacts and environmental degradation and pollution in their living spaces from the industrial activities that built Seattle's wealth.

1.3 Endangered Salmon and Steelhead Trout

The Green-Duwamish watershed is home to runs of Chinook, chum, coho and pink salmon, as well as winter steelhead. These species are both commercially and culturally important to the Duwamish and Muckleshoot Tribes and to other fisher communities in the Lower Duwamish River. These runs have declined greatly in the last fifty years due to a combination of habitat loss and contamination (WRIA 9 Steering Committee, 2005). In 1999, the Puget Sound's Evolutionarily Significant Unit (ESU) of Chinook salmon (*Oncorhynchus tshawytscha*) and bull trout (*Salvelinus confluentus*) were listed as threatened under the Endangered Species Act (ESA); this includes the Green-Duwamish summer/fall Chinook and Newaukum Creek summer/fall populations.

Despite the ESA listing and tireless efforts of multiple government and non-governmental organizations, these populations continue to decline, with 2009 being the lowest returning salmon year since 1965, with less than 2,000 Chinook returning to spawn (WRIA 9 Steering Committee, 2005). The shoreline conditions along the Lower Duwamish River are not ideal for salmonid rearing. In order for out-migrating juveniles to transition successfully, they require low-gradient intertidal mudflats lined with tidal marshes, which produce a high-quality diet of invertebrates. Juvenile salmonids feed on a variety of benthic, aquatic, and terrestrial invertebrates (Morley, Toft, and Hanson, 2012; Cordell et al., 2008; Oxborrow et al., 2017). Juvenile salmonids also require habitats with low water velocity to hide from predators and feed as their transition from their freshwater to saltwater form (Ostergaard et al., 2014; Toft and Cordell, 2017).

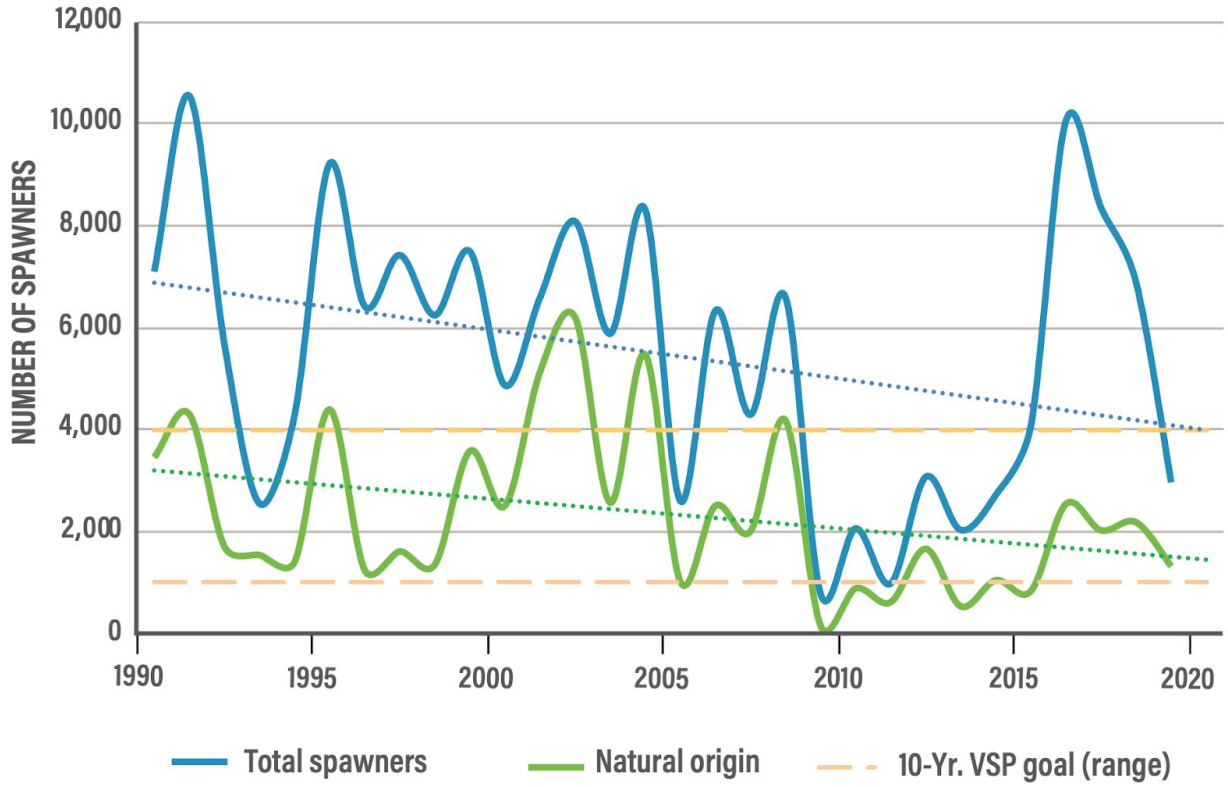

Figure 4. Green River Chinook salmon escapement. *Plot tracking numbers of wild or natural origin spawners and total spawners, with target numbers marked in yellow. The number of natural origin spawners is the primary abundance indicator. (WRIA 9 Steering Committee, 2020)*

The WRIA 9 (Water Resource Inventory Area 9) Salmon Habitat Plan update published in 2020, states its target number of return Chinook spawners is 1,000-4,200 by 2025 and 27,000 by 2055. In the last five years, total Chinook spawners peaked at 10,000 in 2015 and the lowest was around 3,000 in 2020. For natural origin spawners in the last

five years, the lowest was under 1,000 in 2015 and highest was 2,500 in 2016 (**Figure 4**). The Chinook spawners have not yet reached the upper margin of goal number of Chinook spawners. According to the report, Chinook abundance is being constrained by lack of adequate rearing habitat in the lower and middle Green River (Salmon Habitat Plan, 2020). Much more work needs to be done to provide adequate rearing habitat for salmon to reach viable population goals. However, salmon restoration is still vastly underfunded (**Figure 5**).

Figure 5. Washington State salmon recovery budget. *Of the $5 billion needed for salmon recovery by 2020, only $1 billion had been allocated. (Governor's Salmon Recovery Office, 2020)*

Endangered Chinook salmon populations in the Puget Sound have yet to recover, and habitat loss continues to outpace habitat gain (NWIFC, 2020; **Figure 6**). Salmon recovery must focus on correcting the key factors that led to their decline. In the LDW, industrialization and urban growth have resulted in a degraded habitat, and pollution from runoff and climate change impacts complicate recovery, especially for Puget Sound Chinook and steelhead. In 2009, the number of natural origin spawners of Chinook salmon in WRIA 9 was less than 200 fish, the lowest ever recorded (WRIA 9 Steering Committee, 2020). From 2010 to 2019, the number has been below goals set for WRIA 9. Funding is a major factor constraining the habitat restoration needed to increase salmonid populations in the Green/Duwamish River and Puget Sound (WRIA 9 Steering Committee, 2020).

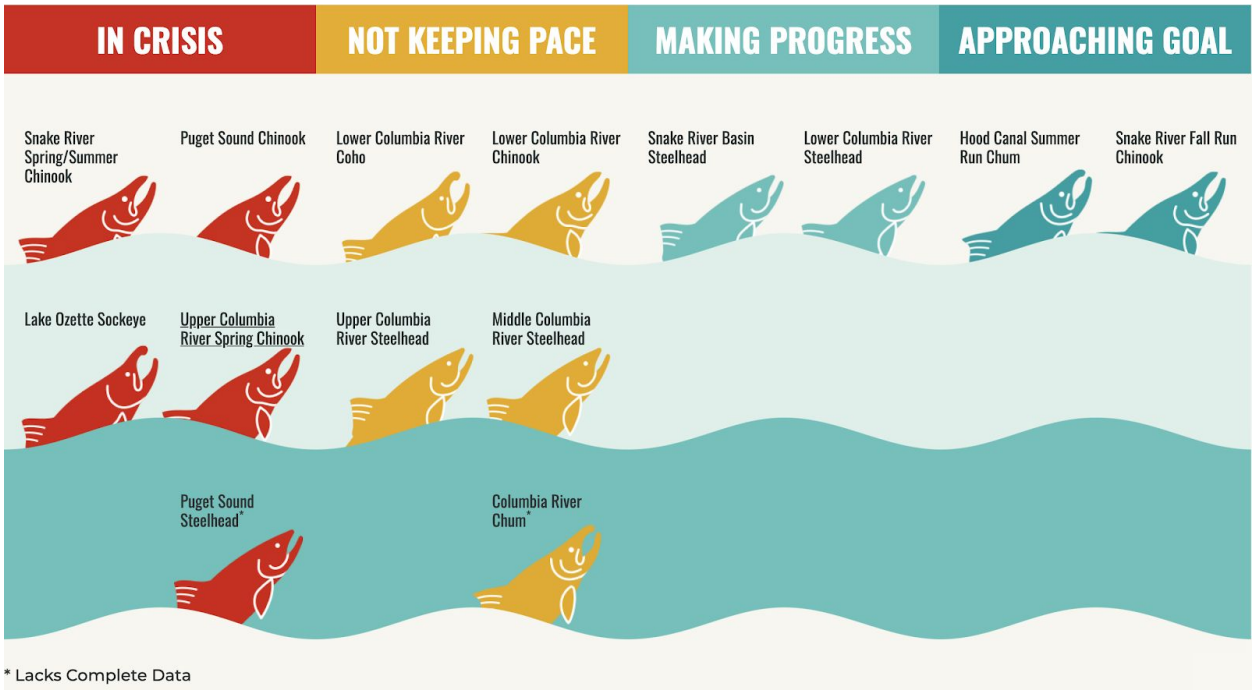

Figure 6. Salmon recovery progress. *Puget Sound Chinook and steelhead populations are considered to be in crisis (red). (Governor's Salmon Recovery Office, 2020)*

2. Policy Background

In this section we survey the wide range of policy actors, decision-making frameworks, and policies that have shaped present day LDR and affected communities past and present of the Duwamish Valley. Our review of policy took place over the course of a year, from the beginning of 2020 to the beginning of 2021, and the comprehensiveness of our coverage should be assessed with that limitation in mind.

This section begins with an overview of the government agencies, both tribal and non-tribal, involved in managing the LDR (**Figure 7**). Next, the Water Resource Inventory Area (WRIA) 9 Watershed Ecosystem Forum, a large partnership organization central to restoration efforts in the Green-Duwamish, is discussed. Public and private actors involved in Superfund cleanup and pollution control are also described, and a discussion of accountability mechanisms is provided. Finally, using this survey of policy as a foundation, we assess the scope and severity of the problems we've identified in the LDR and argue that policy analysis is needed to spur change.

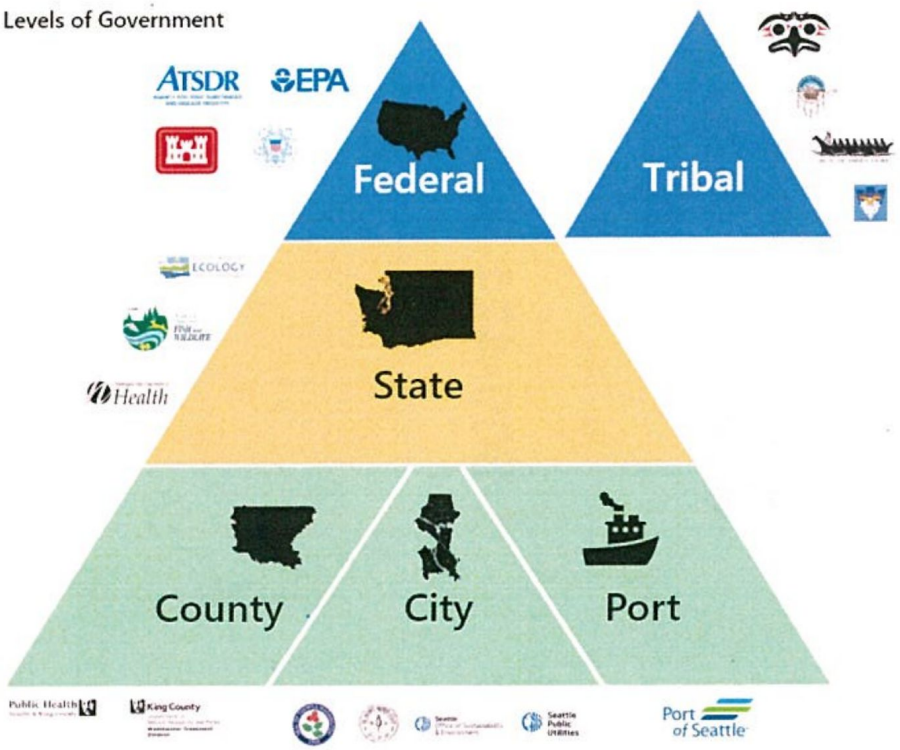

Figure 7. Co-managers of the Lower Duwamish River. *Levels of government involved in co-managing the LDR. (Source: "Who is Who in the Lower Duwamish Waterway," EPA)*

2.1 National, State, and Local Actors

At the national level, the U.S. government and Native nations oversee the LDR. The EPA is the lead agency for cleanup of contaminated sediments in the LDR, and possesses principal implementation authority from a wide range of federal environmental laws. The Army Corps manages the upriver Howard Hanson dam, which controls the flow of the river, and lends technical support to the EPA.

The Army Corps is tasked with permitting regarding all construction activities occurring in U.S. waters, including wetlands. Any work involving the construction of piers, docks, and floats in navigable waters require a Rivers and Harbors Act Section 10 permit from the Army Corps. The Army Corps manages navigation and dredging as well ("Who is Who in the Lower Duwamish Waterway," EPA). Preconstruction design and engineering for a Puget Sound nearshore restoration project has been funded for completion in the 2021 fiscal year (Army Corps, 2021).

The EPA works with three federally recognized Tribes for whom the LDR is part of their usual and accustomed fishing areas: the Muckleshoot, Suquamish, and Yakama Tribes. The EPA also works with the Duwamish Tribe, which lacks federal recognition but has lived in the area since time immemorial. The Snoqualmie Tribe also have interests in the region,

but are not considered partners by the EPA. Native nations and their policies will be discussed more thoroughly in Section 2.2 ("Tribal Policies").

At the state level, Ecology is the lead agency for controlling sources of pollution in the LDR. The Clean Water Act (CWA) allows the EPA to delegate NPDES permitting to qualifying states, and Ecology is authorized to implement the NPDES permit program in Washington. The Washington State legislature in 1991 established the Coastal Protection Fund, enabling the Department of Ecology to issue grants for environmental restoration projects run by local and tribal governments, state and federal agencies, and non-profit organizations that benefit the public.

Also acting at the state level is Governor Jay Inslee's Southern Resident Orca Task Force, formed in 2018. The southern resident killer whale (SRKW) population is near biological extinction, and salmon recovery in Puget Sound is one of the drivers of watershed restoration work because SRKWs prefer to eat Chinook salmon. The task force included nearly fifty members representing state agencies, legislators from all levels of government, tribal leaders, and non-profit organizations, and in 2019 they released their final recommendations.

The task force's recommendations focus on three areas: the need to increase Chinook salmon abundance; reducing vessel noise that may interfere with orcas' hunting; and addressing contaminants in regional waters from nutrient and stormwater runoff to industrial waste (Inslee, 2019). These recommendations led to the passage of five orca recovery bills focused on reducing vessel noise and increasing Chinook hatchery production, and salmon recovery continues to be a priority during the current legislative session (Promoting Salmon Recovery Through Revisions to the State's Comprehensive Planning Framework, 2021).

Locally, King County offers services related to community health, environment, and parks and recreation. Pollution stormwater runoff and salmon recovery in the Green/Duwamish watershed are among its priorities, which it addresses through a variety of initiatives, including its mitigation reserves program and its WaterWorks grant program. Through the WaterWorks grant program, the King County Council awarded $83,780 to the University of Washington's Green Futures lab to fund in part the Duwamish Floating Wetlands Project, which is described in Section 3.4.

A variety of agencies and departments within the City of Seattle directly or indirectly impact businesses and communities along the LDR, including but not limited to Parks and Recreation, Planning and Community Development, Sustainability and Environment, and Public Utilities (SPU). SPU in particular is responsible for managing the city's sewer and drainage systems in order to prevent flooding and protect local waters. Its Green Stormwater Infrastructure Implementation Strategy strives to prevent pollution from stormwater runoff from entering waterways (Seattle Public Utilities, 2020; Seattle Public Utilities, 2015)

The Port of Seattle owns the bed and banks of the LDR, and manages one of the largest container ports on the West Coast. It has an annual budget of $670 million, with $50,000 dedicated to eco-tourism (Port of Seattle, 2018). The Port also manages seventy-eight miles of stormwater pipe and 195 outfalls. Its goal is to rehabilitate seventy-five percent of the stormwater pipe system by 2035. As of 2017, the Port had rehabilitated ten percent of the system (Port of Seattle, 2017).

2.2 Tribal Policies

One of the main tribal initiatives governing salmon habitat recovery in the Green/Duwamish watershed is the Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP). This program is administered under the Northwest Indian Fisheries Commission (NWIFC) in partnership with the Washington Department of Fish and Wildlife (WDFW). It began in 1995 to provide stock assessment and habitat data to tribal and state planning agencies to help prioritize habitat protection and restoration measures.

In 2018, Salmon Defense, a coalition of the twenty western Washington Treaty Tribes, held the inaugural Billy Frank, Jr. Pacific Salmon Summit, bringing together a broad coalition of groups working to accelerate salmon recovery in the region. The coalition focuses on protecting and restoring habitat, increasing production of hatchery fish until natural habitat can be restored, and making recommendations on the management of sustainable seal and sea lion populations, with the aim of ensuring salmon recovery and thereby upholding treaty rights. Harbor seals in Puget Sound are the main predators of salmon, taking as much as six times more than tribal and non-tribal fishers combined (Loomis and Anderson, 2019). The coalition is advocating that federal legislation allowing for the lethal removal of pinnipeds in the Columbia River be extended to Puget Sound (Acone, 2019).

Some recent Native-led restoration efforts across the Salish Sea include the Nisqually Tribe's Delta Restoration Project, the Tulalip Tribes' Qwuloolt Estuary Restoration Project, and floodplain acquisition by the Stillaguamish Tribe for restoration ("About the Nisqually Delta Restoration Project," Nisqually Delta Restoration; Tulalip Tribes, 2021; Stillaguamish Tribe, 2020).

In the Green/Duwamish watershed, the Muckleshoot Indian Tribe has been collaborating extensively with state and federal agencies to restore the watershed and increase salmon populations. Their recent projects include planting a twenty-mile-long riparian corridor along the Green River through Kent and Tukwila to improve habitat for salmon by reducing water temperature. They also aim to expand their hatchery production at their two hatchery facilities: Keta Creek and White River (Muckleshoot Indian Tribe, 2016). According to the Tribe, "coordination and alignment of the regulatory and programmatic efforts of jurisdictions with the goals and objectives of the recovery plans

has not occurred. For example, Shoreline Master Programs governing land use and habitat protection have yet to be updated and made consistent with habitat recovery strategies" (Muckleshoot Indian Tribe, 2016).

Despite a lack of federal recognition, the dxʷdəwʔabš people, or Duwamish Tribe, continues to play an intimate role in protecting the LDR, as exemplified by Tribal Chair Cecile Hansen standing in front of bulldozers to stop the destruction of a Duwamish shell midden at what is now Kellogg Island. The last remaining natural bend in the LDR lies between Kellogg Island at the shore (Thrush, 2007). Duwamish Tribal Services (DTS), the organization representing the Tribe, runs the Duwamish Tribal Longhouse and Cultural Center and operates programs to support Tribe members, as well as historical and current projects to protect and restore the water and land. They initiated the Ridge to River Trail project in 2017, collaborating with community partners to monitor water quality and complete an assessment of cement kiln dust contamination in the Puget Creek watershed. Their ultimate goal is to remediate the watershed and to build and maintain a system of trails connecting the Duwamish Longhouse to schools and neighborhoods in the area ("New Projects," Duwamish Tribe). They are active in additional restoration efforts around the Longhouse and həʔapus ("ha-ah-poos") Village Park.

2.3 Water Resource Inventory Area 9

The Green-Duwamish watershed and the Vashon-Maury Island subwatershed are designated as Water Resource Inventory Area 9, or WRIA 9, under the Water Resources Act of 1971 (**Figure 8**). WRIA boundaries are based on natural watersheds; the legislation designated sixty-two WRIAs throughout Washington State (WAC 173-500-040). It also gave the state's Department of Ecology management responsibility of water resources within each WRIA (RCW 90.54). To successfully manage WRIAs, Ecology authorizes planning units for each WRIA to assess water resources and decides how to manage them (RCW 90.82).

In 2009, Ecology established the Watershed Ecosystem Forum (WEF) planning unit of WRIA 9 to direct efforts to restore watershed health and protect salmon habitat by implementing the Salmon Habitat Plan ("Watershed Ecosystem Forum of WRIA 9," WRIA 9). The WEF comprises nearly thirty local governments, along with federal and state agencies, NGOs, and businesses (**Table 1**).

The revised code of Washington 90.82 on watershed planning directs that when a planning unit completes a watershed plan, WEF members shall approve it by consensus, or by consensus of members who are appointed representatives from involved governments and a majority vote from the members who are non-governmental representatives (RCW 90.82). The statute further states that agencies, counties, and organizations that agree to uphold the obligations within the plan may implement policies to fulfill obligations and annually review implementation budget and staffing needs (RCW 90.82.130).

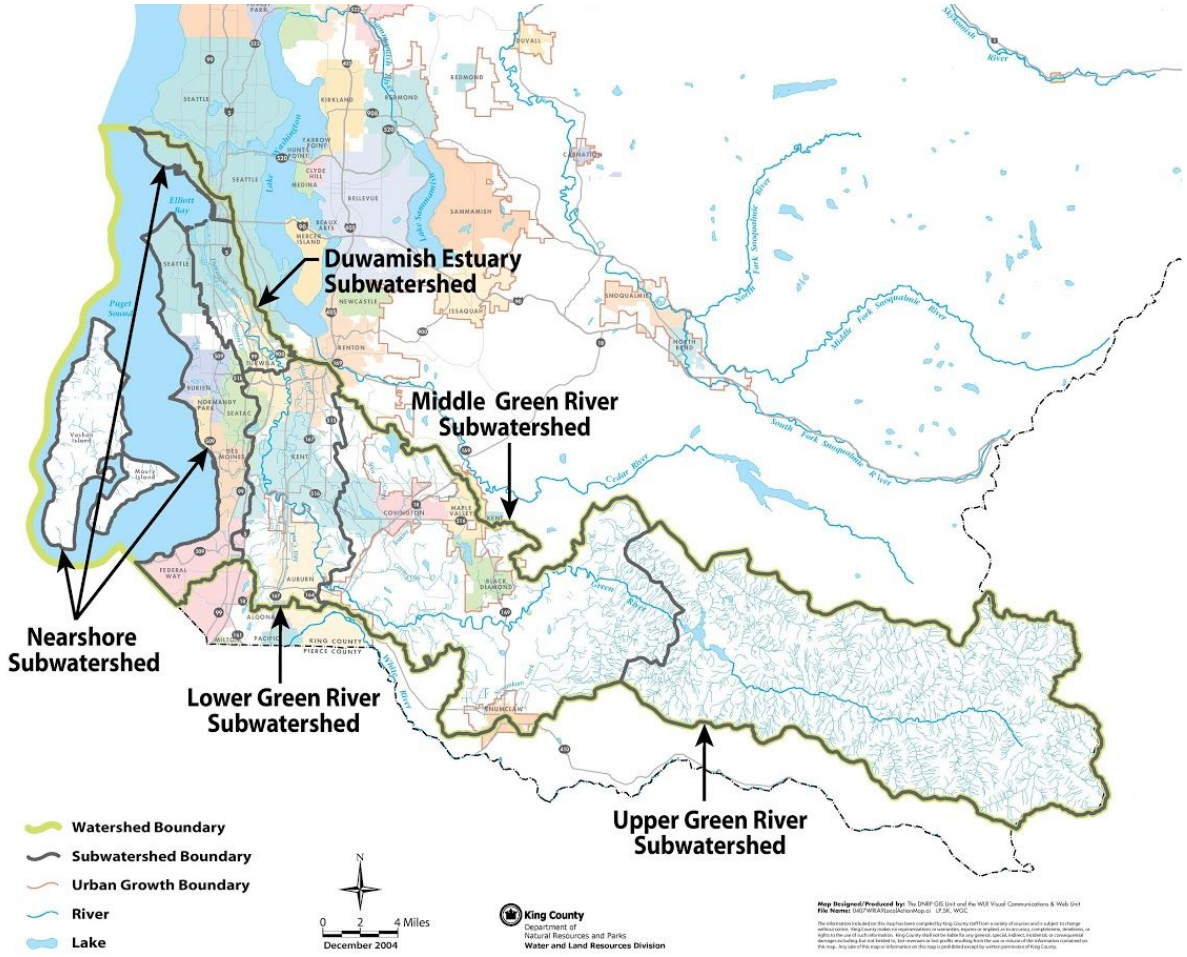

Figure 8. Map of WRIA 9 Green/Duwamish watershed. *The Lower Duwamish River comprises roughly all of the northern two-thirds of the Duwamish Estuary Subwatershed. (King County, Department of Natural Resources and Parks, Water and Land Resources Division)*

The WEF was formed to coordinate efforts to implement the WRIA 9 Salmon Habitat Plan, which was written by the steering committee in 2005 in response to declining salmon populations in the Green-Duwamish watershed and as mandated by Ecology's WRIA management system. From 1989 to 2001, there were between 2,450 and 11,500 adult Chinook salmon naturally returning to the river in the fall to spawn. The Salmon Habitat Plan's fifty- to hundred-year population goals are 17,000 spawning adults as the lower limit and 37,000 as the upper limit (WRIA 9 Steering Committee, 2005).

The Salmon Habitat Plan must abide by the standards for water quality and water supply for fish stated by the statute's water quantity component and habitat component (RCW 90.82.070, RCW 90.82.100). It uses a holistic, ecosystem approach to restore salmon

habitat and watershed health by focusing on restoring habitat in order to benefit the entire ecosystem, not just salmon species (Water Resource Inventory Area 9, 2016).

Table 1. *Members of the WRIA 9 Watershed Ecosystem Forum.*

Governments	**Governments (cont'd)**		**Federal and State Agencies**
City of Algona	City of Kent		U.S. Army Corps of Engineers
City of Auburn	City of Maple Valley		Washington Department of Ecology
City of Black Diamond	City of Normandy Park		Washington Department of Fish and Wildlife
City of Burien	City of Renton		Washington Department of Natural Resources
City of Covington	City of SeaTac		
City of Des Moines	City of Seattle		**Select Businesses and NGOs**
City of Enumclaw	City of Tacoma		American Rivers
City of Federal Way	King County		Boeing
			Mid-Sound Fisheries Enhancement Group

The recommendations in the plan are based on a strategic assessment done between 2002 to 2005 by King County's Department of Natural Resources and Parks (DNRP). The assessment includes original scientific research that addresses gaps in understanding for salmon habitat recovery. This report indicated that there is limited salmonid habitat in the Duwamish estuary transition zone, the middle Green River, and the marine nearshore environment, leading to a decline in productivity and survival in the juvenile life stage of the salmon populations (King County DNRP, 2005).

The Salmon Habitat Plan aimed to target these areas by reducing shoreline armoring, promoting low impact development such as bioswales and porous pavement, removing and replacing culverts, improving water quality by addressing pollution from nonpoint sources like stormwater runoff, and ensuring adequate stream flow (WRIA 9 Steering Committee, 2005). A draft update to the Salmon Habitat Plan was completed and released at the end of 2020 and the public comment period for the document closed in January of 2021 (WRIA 9 Steering Committee, 2020).

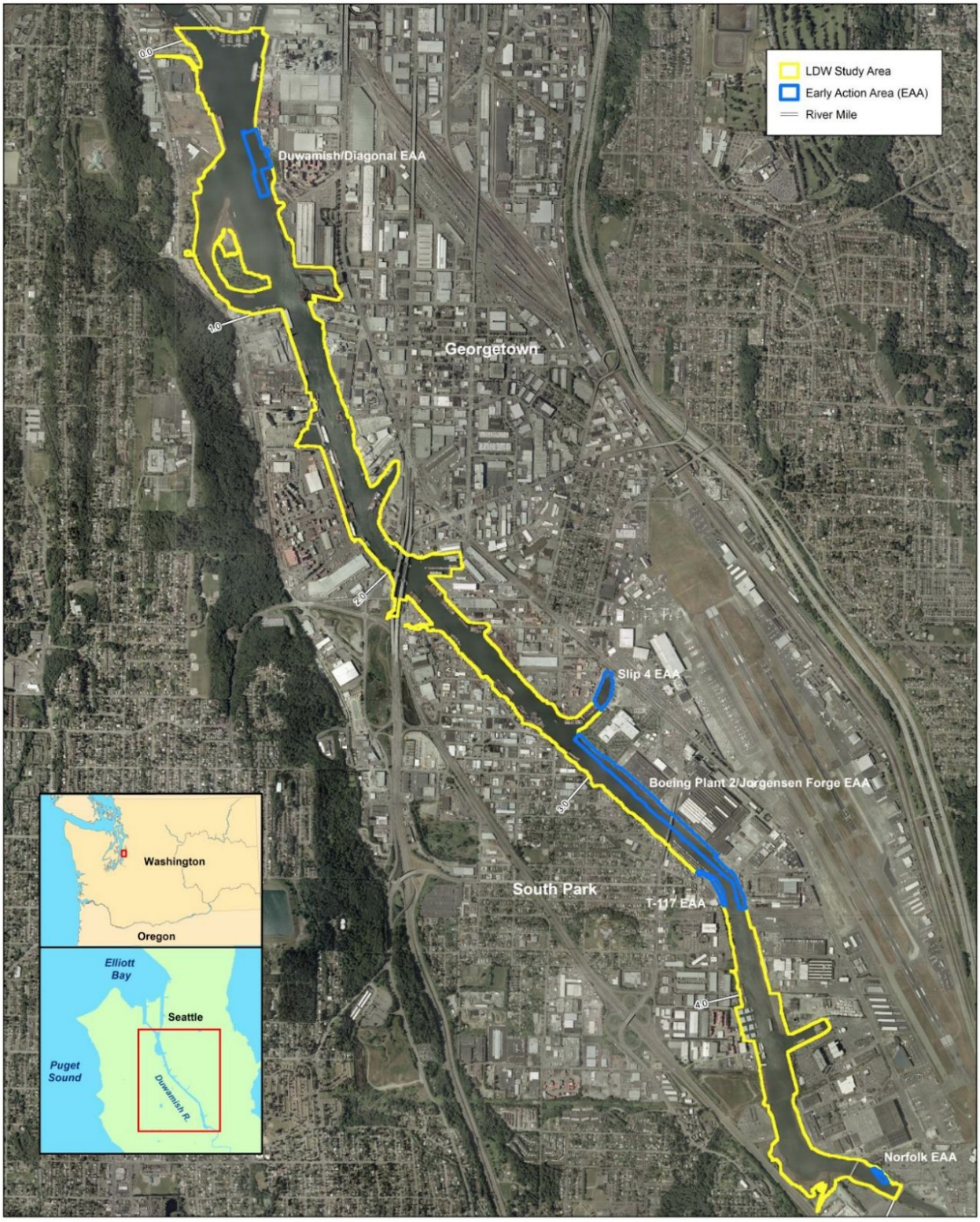

Figure 9. The Lower Duwamish Superfund study area. *Map outlining the Superfund study area in blue, with early action areas highlighted in blue. (US EPA, 2014)*

2.4 Superfund Cleanup and Pollution Control

Decades of industrial pollution resulted in contamination so toxic that the EPA designated the first five river miles of the LDR as a Superfund site, requiring urgent remediation (**Figure 9**). Below, we review the working groups involved in the planning, implementation, and financial resources designated for cleaning up and monitoring the LDR. While the Lower Duwamish Waterway Group is responsible for river bottom sediment cleanup and restoration, the Source Control Work Group controls upland pollution sources that impact the LDR.

Lower Duwamish Waterway Group

After the EPA listed the LDR as a Superfund site in 2001, four potentially responsible parties for contamination—King County, the City of Seattle, the Port of Seattle, and Boeing—came together as an organization called the Lower Duwamish Waterway Group (LDWG). As a group, LDWG produced a remedial investigation and feasibility study (RI/FS) for the Superfund area cleanup ("Cleanup Activities," US EPA).

In 1980, Congress enacted the Comprehensive Environmental Response, Compensation, and Liability Act, or CERCLA, which established the federal Superfund program (H.R. 7020, 1980). The EPA oversees LDWG's work because CERCLA designates EPA to administer the program. However, Ecology also has authority over LDWG's Superfund work through its participation in the National Environmental Performance Partnership System (NEPPS). NEPPS allows state agencies like Ecology to enter into "Performance Partnership Agreements" (PPAs) with the EPA to jointly develop goals for environmental protection and streamline efforts to meet them ("NEPPS," US EPA). Ecology's PPA establishes and implements a joint work plan for administering the grant money it receives from the EPA to manage air quality, water quality, and hazardous wastes (Ecology, 2019). After LDWG identified EAAs for river sediment cleanup through the RI/FS, both the EPA and Ecology selected EAAs within the Superfund site for action.

Source Control Work Group

The Source Control Work Group (SCWG), a multi-agency partnership in which Ecology serves as the lead agency, controls upland pollution sources that impact the LDR. Besides King County, SCWG's primary members include the US Environmental Protection Agency (EPA), the Port of Seattle, and Seattle Public Utilities (US EPA, 2012).

The Clean Water Act (CWA) is the federal statute that established the National Pollutant Discharge Elimination System (NPDES), a permit system for regulating the point sources of pollution that fall under SCWG's purview. The key state level statute regulating discharges is the Washington State Water Pollution Control Act, chapter 90.48 RCW (Ecology, 2016). The Water Pollution Control Act empowers Ecology to ensure compliance with pollution standards, to make and administer grants relating to the construction and

improvement of facilities necessary to control pollution, and to issue permits for the disposal of waste materials into state waters (RCW 90.48.039, RCW 90.48.158, and RCW 90.48.162). Other state laws that empower Ecology to control for pollution sources discharging into the Green-Duwamish watershed include the Model Toxics Control Act (RCW 70.105D), which sets cleanup regulations and directs Ecology to control and manage hazardous wastes (Ecology, 2016).

Decision-Making Authority

Although both LDWG and SCWG consist of multiple public entities with policymaking capabilities of their own, ultimately only one agency has true decision-making power in each partnership. While LDWG identifies EAAs within the Superfund site, CERCLA gives the EPA decision-making authority over the Superfund process ("Cleanup Activities," US EPA). Although both the EPA and Ecology select which EAAs are a priority for cleanup and restoration, that authority is rooted in the EPA's NEPPS and the PPA Ecology has signed with the EPA (Ecology, 2019). As for SCWG, lead agency authority clearly lies with Ecology through various statutes in the Revised Code (RCW 90.48, RCW 70.105D), as well as Section 401 of the CWA which enables Ecology to issue certifications for NPDES permits (33 U.S.C. § 1341; "Section 401 Water Quality Certifications," Ecology).

The Superfund designation for the LDR only applies to the first five miles of the Duwamish River, starting from where the river empties into Puget Sound at Elliott Bay and going upstream ("Cleanup Activities," US EPA). However, Ecology's jurisdiction over pollution sources means that it regulates all such discharges into the Green-Duwamish watershed, which ultimately impacts the condition of the five-mile Superfund site area (Ecology, 2016).

A number of actors participate in both LDWG and SCWG. For example, King County, which encompasses the entire Green-Duwamish watershed, funds cleanup and restoration efforts in the LDR, traces and controls pollution sources that discharge into the waterway, and promotes safe seafood consumption practices. King County's participation in LDWG allows it to have input into the EPA's EAA selection process, while its participation in SCWG allows the county to collaborate with Ecology in monitoring pollution sources across the entire watershed.

Decision-making Criteria

Many forms of scientific research informed LDWG's remedial investigation (RI). The RI was a comprehensive study that identified EAAs, which are some of the most contaminated areas in the Superfund site. This research included a conceptual site model for the LDR, an assessment of the nature and extent of sediment contamination, and an evaluation of sediment transport processes affecting the LDR (LDWG, 2010). The state's sediment management standards also provide a scientific foundation for assessments by

describing the limits set for heavy metals and organic compounds and by naming specific biological tests that can be performed to assess sediment quality (Chapter 173-204 WAC).

Another key decision-making criterion crucial to LDWG's RI and the EAA identification process was an assessment of health risks to humans and other animals from eating resident seafood species that are highly contaminated. Many of those who eat fish from the river are low-income recreational or subsistence fishers, Indigenous, or first-generation immigrants. Seafood consumption from the LDR is therefore a driver of environmental and health inequities based on income, race, and Indigeneity ("Fish Consumption in the Lower Duwamish Waterway," UW Superfund Research Program).

Although Chinook salmon are less contaminated due to the short time they spend in the LDR before heading out to sea, their flesh still contains elevated PCB levels. Additionally, Blackmouth salmon, a type of Chinook, spend an extra year in the river and other inside waterways before heading out to the open waters of the Pacific. Blackmouth salmon make up about thirty percent of the total Chinook population in Puget Sound, meaning that nearly a third of all Chinook in the Sound will accumulate higher levels of these persistent, bioaccumulative contaminants (O'Neill et al., Oct. 2015; O'Neill et al., Nov. 2015). These toxicants can bioaccumulate in southern resident killer whales (SRKWs) when they feed on Chinook, reducing the fitness of orca calves that drink milk with high PCB levels (LDWG, 2012).

Science also informs SCWG's work through the NPDES permit program. Washington's Industrial Stormwater General Permit (ISGP) is a NPDES permit which helps industrial facilities like Boeing's comply with CWA standards. The ISGP designates which EPA methods, or analytical procedures, water quality monitors must use to quantify toxicants like heavy metals, PCBs, and volatile organic compounds (Ecology, Nov. 2019). State regulations set water quality standards for ground and surface waters (Chapters 173-200 and 173-201A WAC), and included in the surface water criteria are limits for the toxicants that the ISGP addresses. The regulations go so far as to list a recognized set of standard equations and conversion factors for calculating acceptable toxicant levels.

The Waste Discharge General Permit program outlines procedures for Ecology for issuing NPDES general permits and includes economic impact as a key decision-making criterion (Chapter 173-226 WAC). Regulations require that any draft general permit must also include a comprehensive economic impact analysis before approval. This analysis must provide descriptions of permit compliance requirements, compliance costs, and a costs comparison between small and large businesses.

2.5 Accountability Mechanisms

Although the citizen suit provision of the Clean Water Act empowers Ecology and other government agencies within SCWG to hold polluters accountable by bringing a suit on behalf of citizens, it has been Tribes as well as community and advocacy groups that

have led enforcement efforts. For example, Puget Soundkeeper is a 501(c)(3) non-profit organization that operates in the Puget Sound to reduce water pollution and improve water quality human and wildlife communities living in the Puget Sound region. This organization monitors water quality, engages the public, and enforces environmental regulations by taking legal action against firms that violate the Clean Water Act. They have been active in litigating against companies that pollute the Duwamish River. They also participate in federal- and state-level permitting and rulemaking processes.

Puget Soundkeeper and the Waste Action Project brought a lawsuit against Boeing in 2018 for the discharge of PCBs from one of their working properties in Tukwila, WA (Moreno, 2018). The case was ultimately settled in March of 2020, with a financial penalty and shoreline restoration work as main components of the agreement. The restoration project will allow the Green River to rejoin a historic floodplain and create more than twenty acres of salmon habitat in South King County (Whale, 2020). At the end of 2019, a year after they initiated their lawsuit against Boeing, Soundkeeper began the process of suing Ardagh Glass in South Seattle under the citizen suit provision of the CWA (The Skanner News, 2019).

Meanwhile, the Muckleshoot and Suquamish Tribes play a central role in enforcing accountability in the LDR through the National Oceanic and Atmospheric Administration's (NOAA) Natural Resources Damage Assessment (NRDA) process. "The ultimate goal of NRDA is to restore, replace, rehabilitate, or acquire the equivalent of injured natural resources and resource services lost due to the release of hazardous substances" (Elliott Bay Trustee Council, 2019).

Under the NRDA program, the Tribes are part of a government partnership called the Elliott Bay Trustee Council; there are many NRDA Trustee Councils, but the Elliott Bay Trustee Council is the NRDA council for the LDR. Besides the Tribes and NOAA, other members of the Elliott Bay Trustee Council are the U.S. Department of Interior, Ecology, and WDFW ("Who is Who in the Lower Duwamish Waterway," EPA).

In 2013, NOAA prepared a restoration plan and programmatic environmental impact statement for the Trustee Council to determine the damage to natural resources in the LDR, and to provide direction on how to restore these resources and services (NOAA, 2013). The Trustee Council's final injury assessment plan, which quantified natural resource injuries in the LDR, was published in 2019 (Elliott Bay Trustee Council, 2019).

In January of 2021, the U.S. Department of Justice filed a consent decree, proposing a settlement of $48.4 million to fund restoration in the LDR Superfund area (86 FR 7418). The consent decree would resolve a lawsuit filed by the Elliott Bay Trustee Council against Vigor Industrial, LLC and the Exxon Mobil Corporation for polluting the LDR with discharges of hazardous substances and oil. Per the decree and a restoration plan and environmental assessment drafted by the Trustee Council, Vigor must construct, monitor, and maintain in perpetuity two habitat restoration projects that will create three acres of off-channel wetland habitat at its shipyard facility (Elliott Bay Trustee Council, 2021). The

settlement also requires Vigor Industrial and Exxon to pay their equitable share of assessment costs incurred by the Trustee Council, in excess of $800,000 (*United States v. Vigor Industrial LLC*, 2021).

2.6 Assessment of Problem's Scope and Severity

The effects of the industrialization and input of toxicants into the Duwamish estuary are not limited to the sediments and waters of the LDR: they impact human and more-than-human populations as well. Pollution from industries along the LDR is the reason that residents in the Georgetown and South Park neighborhoods are more likely to contract illnesses and have a mean life expectancy up to thirteen years shorter than that of residents in wealthier parts of Seattle (Gould and Cummings, 2013). The surrounding neighborhoods also include fishers and recreational boaters whose health is put at risk by the polluted river.

Beyond the LDR, Puget Sound itself is considered a "PCB hotspot" that accumulates PCBs and other toxicants from the air and from runoff inputs. Endangered fish species that inhabit the LDR for some part of their lifecycle, such as salmon, are negatively impacted by pollutants in estuarine systems (Hodgson, Wilson, and Moore, 2020). Research also indicates that pollutants in the LDR get absorbed by bacteria or plankton, which then are consumed by larger and larger fish in regional waters (Dunagan, 2016), such as the Chinook salmon SRKWs prefer to eat. Bioaccumulation of toxicants is evident not only in SRKWs, which feed primarily if not exclusively in the Salish Sea, but also in free-ranging orcas (Ross et al., 2000).

2.7 Need for Analysis

Given decades of polluting activity by industry and insufficient enforcement of environmental protection by government agencies, it is imperative for experts in government agencies and research institutions to collaborate with experts in the community to determine ways to mitigate toxicants entering the LDR, and it is of utmost necessity for non-governmental actors to hold industry in check through legal challenges.

Boeing and other companies will continue manufacturing practices that produce toxic substances, which must be disposed of. Superfund cleanup efforts have already removed a significant amount of legacy pollution from the LDR, but much of that pollution remains. Meanwhile, insufficient efforts to curtail current pollution inputs from stormwater runoff and other sources adversely impacts water quality and salmon habitat.

Sea level rise, too, poses a risk. In nearshore environments such as the LDR, salt water sits below fresh water in the inland water table. As sea level rises, it pushes fresh water to the surface, where it can bring up contaminants that have lingered underground for years (Klivans, 2021).

Furthermore, the EPA plans to spend 2020-2023 preparing the remedial design and the clean-up of the remaining area will only begin in 2023 (LDWG, 2019). As other stressors like climate change and urban growth further threaten marine life and human life, mitigating toxics in and around the LDR will become even more essential for human and non-human communities.

In addition to removal and remediation of contaminated sediment and organisms in the Lower Duwamish River, massive ecological restoration efforts must be undertaken to improve aspects of ecological function. These aspects include water filtration, sediment renewal, invertebrate production, flood prevention, and provision of suitable habitat for wildlife. Moreover, these restored areas will provide safe and healthy places for the people living along the Duwamish River to recreate and work. Currently however, restoration work is implemented in piecemeal fashion, and in a manner that's not always responsive to community needs. For future efforts to be successful, multiple actors must coordinate and align their regulatory and programmatic efforts.

3. Restoration Techniques in Novel Ecosystems

In urban ecosystems highly modified by settler activity, the natural functions that one expects to observe in a healthy ecosystem are often lost, or at best profoundly altered. Conventional or "traditional" riparian or wetland restoration aims to return the targeted area to a state that closely resembles its pre-development state. These projects usually involve some removal of shoreline armoring or other hard infrastructure, then re-grading the bank, depositing sediment and large woody debris (LWD), and planting native wetland plants. In urban areas conventional methods of restoration are highly costly, politically unfeasible, and extremely unlikely to reach full implementation in time to mitigate some of the most pressing negative impacts of climate change and environmental pollution. Additionally, the idea of "returning" an ecosystem back to some historic baseline, particularly one where only species "native" or "authentic" to that baseline are allowed to flourish, is a widely accepted ideal in conventional restoration work that is increasingly being questioned (Egan, 2006; Kopf et al., 2015). These conventional ideas become even more problematic when superimposed over real-life contexts that challenge the usual expectations of what qualifies as being essential to "ecosystem restoration."

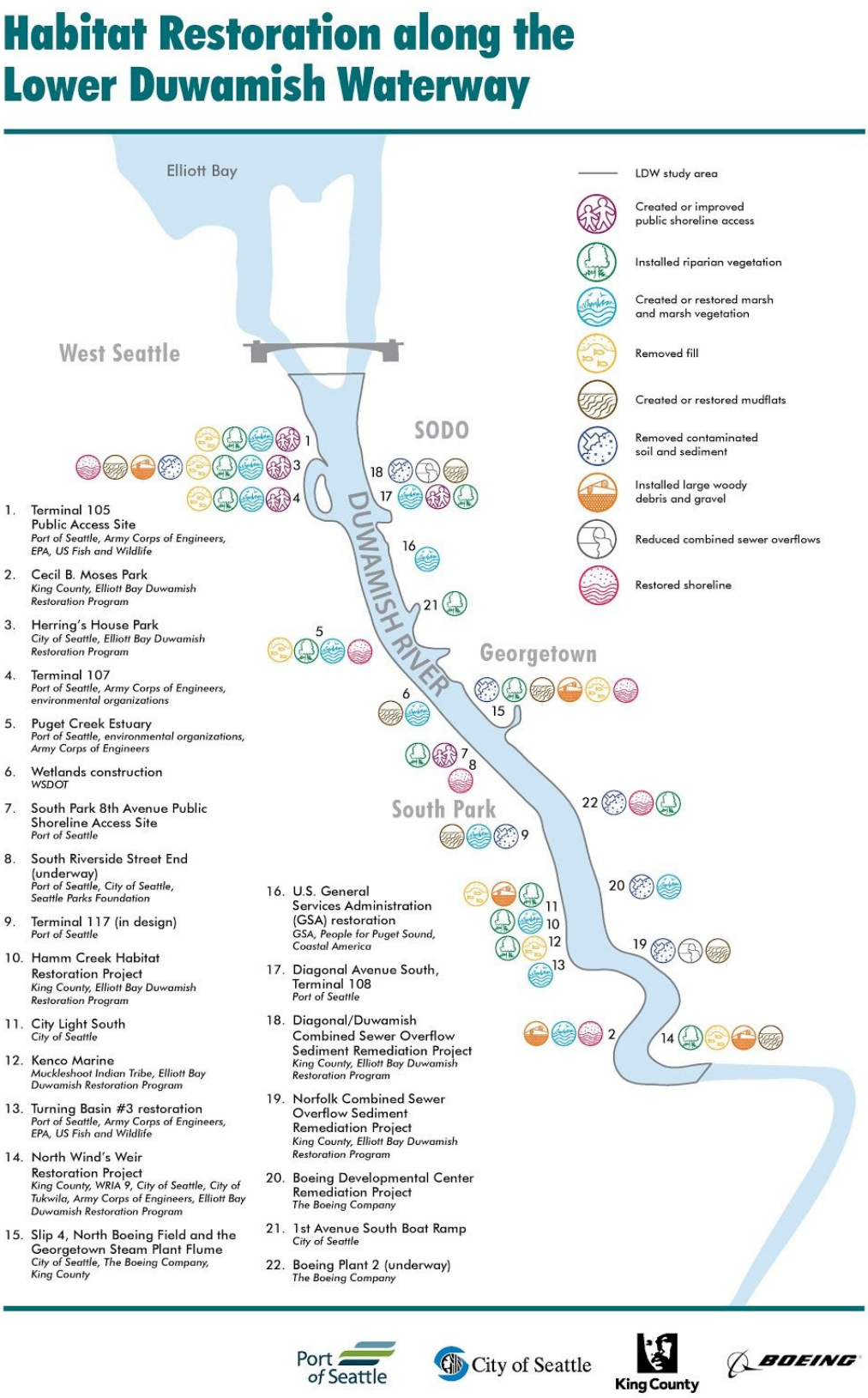

Figure 10. Restoration projects in the Lower Duwamish River. *("Habitat Restoration along the Lower Duwamish Waterway," King County)*

The Lower Duwamish River (LDR) is an area that fits this description exactly (**Figure 2**). A concretized, channelized, and urbanized stretch of river, the LDR was once a highly productive and complex estuary system. Now it is known for industrial traffic on its water as well as for industrial activities upland that continue to negatively impact the river and proximate communities. Although traditional restoration projects can and have been implemented in the area, such as salt marsh restoration at həʔapus ("ha-ah-poos") Village Park and the Turning Basin (**Figure 10**), there are long stretches of the LDR that are not amenable to such projects due to the level of hard armoring, private or corporate land ownership, and continued and intense industrial uses. In places like the LDR, novel ecosystem restoration techniques (NERTs) can play a role in filling the gaps that conventional restoration cannot address. In the following we will define novel ecosystems and describe how novel ecosystem restoration techniques can be used in urbanized areas.

3.1 Definition of Novel Ecosystems

The concept of novel ecosystems first appears in the literature about twenty years ago (Chapin and Starfield, 1997). According to Higgs (2017), novel ecosystems arise from ecosystems that are modified beyond a point past which traditional restoration efforts are not feasible, and they generally do not receive regular management. This definition contrasts novel ecosystems with designed ecosystems, which are ecosystems that are assembled intentionally in service of specific goals and are often heavily managed (Higgs, 2017). This particular definition will be used in this report as guidance when discussing novel ecosystems and NERTs.

3.2 Novel Ecosystem Restoration Techniques

Urbanization has transformed rivers and watersheds around the world, especially in the Duwamish Valley, and extensive research has been done to investigate what restoration techniques are best. Conventional restoration often begins with the regrading of shorelines (**Figure 11**). Other conventional techniques include revegetating sites with native plants, habitat enhancement, remediation, and mitigation (Vaughn et al., 2010). Among the numerous restoration projects in the LDR, the Boeing restoration site, where toxicants were removed and native vegetation replanted, features multiple conventional techniques, as do other projects throughout the Superfund site (**Figure 10**).

In contrast, the Wild Mile Chicago project is an example of a restoration project using NERTs not to restore the ecosystem back to some assumed historic baseline, but to create more public open space by literally creating new environments. The project aims to be the first-ever mile-long floating eco-park in the world, building on a vision of "renewed urban ecology" ("The Wild Mile Chicago," Wild Mile Chicago).

To be clear, we do not aim to present projects like the Wild Mile Chicago as being more exciting or worthwhile than conventional restoration; instead, we present such examples to show how restoration can look in highly urbanized environments where conventional restoration efforts may be prohibitively expensive or lack political feasibility. Below, we discuss some criticisms of the novel ecosystem framework before exploring the Duwamish Floating Wetlands Project, a temporary restoration project in the LDR that relied solely on NERTs.

Figure 11. Restoration work by the Port of Seattle. *A "conventional" restoration project in the LDR begins with regrading of the shoreline. ("Lower Duwamish River Habitat Restoration Plan," Port of Seattle)*

3.3 Criticisms of the Novel Ecosystem Framework

Based on Higgs' definition, it could easily be argued that any ecosystem that has been profoundly impacted by human activity is a novel ecosystem of sorts. The case can be made that the rapid nature of environmental change in recent human generations requires that restoration practitioners as well as policy and decision makers rethink the conventional norms around conservation and restoration. This rapid change also renders the idea of restoring an ecosystem back to some historic baseline increasingly less feasible or relevant, particularly to the communities that are a part of these ecosystems and require

alternative solutions to prepare for pending climate impacts and mitigate recent and ongoing damages to the local environment (Hobbs et al., 2009).

While Kattan, Aronson, and Murcia (2016) argue that novel ecosystems are too imprecisely defined and too grounded in theory to be useful in real-world setting, Miller and Bestelmeyer (2017) take a balanced approach in addressing some of the ongoing debates over the use of the novel ecosystems framework in restoration ecology and restoration work. While Miller and Bestelmeyer acknowledge the critiques and the shortcomings of the framework, they ultimately find it useful and make the case for the use of NERTs in specific contexts.

In a review of the performance of constructed wetlands, a type of NERTs, in improving biodiversity, Zhang et al. (2020) describe how constructed wetlands have shown promise in that their microbial communities remove contaminants from wastewater and stormwater, they often provide suboptimal habitat for wildlife. It is still unclear how constructed floating wetlands could replicate the hydrological regime and floodplain-level complexity that natural wetlands depend on to provide ecosystem services.

The following case study using NERTs in the LDR is provided below to provide a firsthand account of the use of NERTs in an applied setting, and to show practitioners, policy makers, and decision makers in the LDR what can be learned from this case study.

3.4 Case Study – Duwamish Floating Wetlands

In 2020 we participated in the most recent and final iteration of the Duwamish Floating Wetlands Project (DFWP). This was a continuation and culmination of a project initiated in 2013 by the Green Futures Lab (GFL), which is housed in the Department of Landscape Architecture in the University of Washington's College of Built Environments. The DFWP's 2020 study was led by an interdisciplinary team that included students and faculty from the university's School of Marine and Environmental Affairs (SMEA). It was funded by King County, the Port of Seattle and The Rose Foundation.

The goal of the DFWP was to determine if constructed floating wetlands (CFWs) can increase salmon habitat and improve water quality to support the survival of out-migrating juvenile salmon. The project also provided an opportunity to research the potential feasibility and benefits of providing "stepping stones" for juvenile salmon in urbanized locations where there aren't options to implement traditional restoration. These CFWs were deployed in the LDR as a demonstration of a much less expensive form of habitat restoration for juvenile salmon along hardened shorelines. The CFWs were not meant to replace established restoration methods, which should be prioritized where possible. If the LDR is a novel ecosystem, the CFWs could be thought of as designed ecosystems.

The scientific objectives of the monitoring program were to gather information about juvenile salmon interactions with the CFWs, as well as the CFWs' ability to produce invertebrates, grow native wetland sedge species, and improve water quality. Structurally

the design was developed not only to create floating wetlands but also to provide flotation for researchers to access the prototypes to monitor their establishment and effects.

The social objective of the DFWP was to use shared field research experiences to encourage collaboration between students and community scientists, and to connect community scientists to the research and ultimately to the LDR itself. In essence, the DFWP is a continuation of decades of work by communities and specific stakeholders in the LDR to restore the health and ecological function of the river for human and non-human communities. Below we report general findings from the 2020 round of monitoring for the floating wetlands. A complete report of the findings can be found in the 2020 Monitoring Report (Klein et al., 2021).

3.4.1 Project Sites

The DFWP team designed, deployed, and monitored CFWs called "BioBarges" in the LDR during two field seasons in 2019 and 2020 (**Figure 12**). Based on recommendations from the 2019 DFWP team, in 2020 the BioBarges were deployed farther upstream at the end of the transition zone of the Duwamish River. This is where salinity levels are lower than at 2019's field sites in the lower estuary zone but where juvenile fish would still benefit from added food production and refuge.

Figure 12. BioBarges deployed at the Tukwila site. *Biofilters 1.0 are placed within the BioBarges' wooden frames, while biofilters 2.0 are placed along the outside edges.*

Two BioBarges were placed at the end of a private dock owned by Waste Management (WM), on the right bank of the LDR by the Georgetown Pump Station (roughly RM 3.5). The other two BioBarges were placed at the end of a homeowner's private docks on the western side of the river in Tukwila, near the Seattle/Tukwila border (roughly RM 5.5) (**Figure 13**).

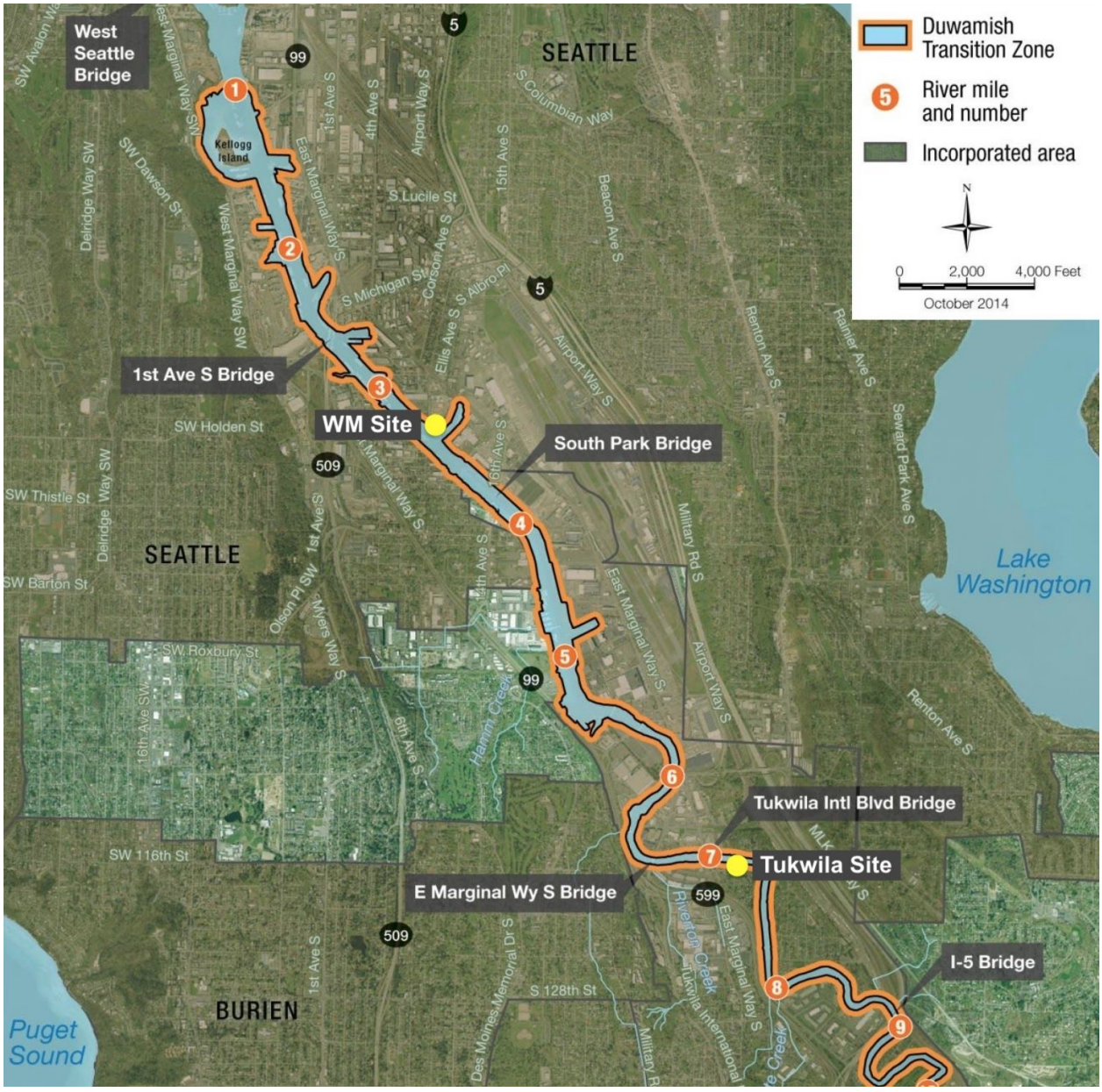

Figure 13. - Research sites. *Two views of the LDR indicating river mile markers, with a closeup (right) of the two research locations, WM and Tukwila. (Ostergaard et al., 2014)*

Informal guidance from scientists in the University of Washington's Wetland Ecosystem Team, who have deep knowledge of juvenile salmon behavior, also led to the

placement of the BioBarges closer to the shore than they were the previous year, in an attempt to position the barges closer to the salmon's preferred travel corridors in shallow waters. The 2019 study found that juvenile salmon hug the shoreline, but with the large tidal and river flow fluctuations in the LDR, there are limited opportunities to locate the Biobarges where they won't bottom out. That suggested placing the CFWs at docks or in deep water next to sheet piling or other vertical walls. The extreme tidal fluctuations were major design and siting considerations.

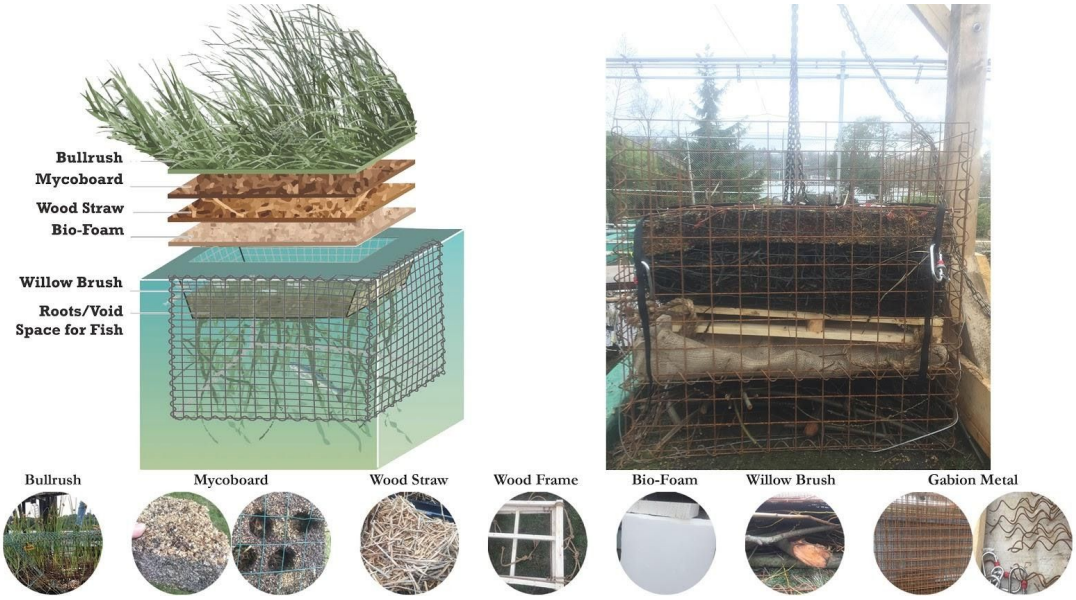

Figure 14. Wetland biofilter 1.0 design. *Diagram courtesy of the Green Futures Lab.*

Figure 15. Wetland biofilter 2.0 design. *Diagram courtesy of the Green Futures Lab.*

3.4.2 BioBarge Structure

Each BioBarge included a buoyant wooden frame that held floating elements called "wetland biofilters," or biofilters for short. Each biofilter contained substrate into which native wetland sedge plants were installed. The BioBarges were designed to be towable research platforms; they also provided the external structure for the biofilters that comprised the CFWs. Biofilters 1.0 were deployed as part of the BioBarges in 2019; in 2020, Biofilters 2.0 were added to the 2019 configuration (**Figures 14** and **15**).

3.4.3 Project Results

Fish

From the in-person overwater fish monitoring and GoPro videos all five native species of juvenile salmonids, Chinook, Chum, Coho, Pink, and Steelhead/Rainbow trout were observed using the BioBarges to take refuge, feed, establish territories and migrate through. The positive and neutral reactions observed from fish far exceeded any observed avoidance behavior (**Figure 16**). From the GoPro video monitoring possible predatory sculpins sheltering within the Biobarge were observed twice. No other predatory fish were observed using the BioBarges for foraging.

The 2020 results also showed that there were more sightings of fish at the BioBarges compared to the control dock at the WM site and more sightings of fish at the BioBarges compared to the control and reference site (natural shorelines with riparian plant communities) at the Tukwila site. However, this difference was not statistically significant. The difference in the number of juvenile salmonid sightings between the BioBarges compared to the reference site and between the BioBarges compared to the control site had no statistical significance (Klein et al., 2021). However, in both overwater and GoPro fish surveys, juvenile salmon were observed spending substantial time feeding and resting underneath and along BioBarges.

Other fish species heavily used the BioBarges for feeding and shelter. The BioBarges supported large populations of adult and juvenile sticklebacks (*Gasterosteus aculeatus*) and shiner perch (*Cymatogaster aggregata)* which were observed feeding on the periphyton growing on the barges. Additionally, adult perch were frequently observed sheltering and swimming within the empty Biofilter 1.0 structures. Furthermore, during the 2020 field season one muskrat (*Ondatra zibethicus)* made a nest and gave birth to young within a Biofilter 1.0 structure at the Tukwila site (**Figure 17**).

Invertebrates

Results from the March-August 2020 monitoring season showed that the constructed floating wetlands supported the growth of both terrestrial and aquatic

invertebrates, including Ceratopogonidae and other species of Diptera which are known food items for juvenile salmon smolts. Terrestrial invertebrate densities and population diversity were typically lower at the BioBarges than natural shorelines.

Figure 16. GoPro images of juvenile Chinook salmon at a BioBarge. *The images show fish resting and feeding by a biofilter 1.0 at Tukwila, June 26, 2020.*

Plants

The 2020 iteration of the project also showed that all eight species of native sedges survived the growing season, although only common spikerush (*Eleocharis palustris*), a nitrogen-fixing species, managed to flower out of the four species planted on the biofilters 2.0. Some plants declined over the study period at the Seattle field site as the salinity of the Duwamish River increased with the onset of the dry season and as the cumulative impacts of intense boat wakes and reflecting waves affected the integrity of some of the biofilters 2.0 and the survival and biomass production of the plants therein (**Figure 18**).

Figure 17. Muskrat nest and juvenile sticklebacks at a BioBarge. *Left: A muskrat on nest inside a Biofilter 1.0 (June 25, 2020). Right: Juvenile sticklebacks resting near the BioBarge (July 27, 2020). Both images from the Tukwila location.*

Water Quality

Water quality field measurements showed that temperature, dissolved oxygen, and luminosity levels were within tolerable ranges for juvenile salmon, and at no point reached lethal levels during the 2020 monitoring period. However, it was not clear whether the BioBarges reduced or improved these water quality measures. Laboratory analysis of the rooting substrates of the CFWs revealed the accumulation of metals of concern (e.g. Cu, Pb, Zn), as well as nitrogen. Cadmium, another metal considered harmful to juvenile salmon survivability, was not detected.

Community Science Program

The COVID-19 crisis forced a significant reduction in the scope of the DFWP's community science program in 2020. But while the pandemic may have prevented the research team from joining in-person outreach and education endeavors or community events, community scientists were still successfully recruited and given multiple, varied opportunities to participate in the floating wetlands project. Collectively, more than 31 individuals participated in weekly field monitoring, remote data collection and analysis, socially distanced microscope work, science communication, and other educational activities and independent projects for early career researchers.

Figure 18. Biofilter damaged by boat wakes at Waste Management. *BioBarge (left) sheltered from boat wakes. A biofilter 2.0 (right) which had undergone structural damage from exposure to boat wakes.*

3.4.4 Recommendations – Floating Wetlands

The DFWP produced many insights into the design, deployment, performance, ecological, and human community benefits of artificial floating wetlands. From weekly monitoring of the floating wetlands at two very different sites in the Lower Duwamish River, we were able to observe how the Biobarges performed structurally and biologically under varying conditions. This project demonstrated that CFWs can provide habitat for juvenile salmon by providing a foundation for enhanced novel ecosystem functions critical to salmonid survival, including aquatic and terrestrial invertebrate production and the creation of rest areas for the salmon. Recommendations for future studies include:

- placing BioBarges in sheltered locations with low wave action and protection from boat wakes to prevent the structure from being jostled and compromised, which leads to high plant mortality;
- deploying BioBarges at more sites and cover larger areas to increase replication, statistical power, and habitat creation for further monitoring; and
- deploying a juvenile salmon acoustic telemetry system (JSATS) to more accurately monitor salmonid behavior in the vicinity of the biobarges (assuming that hatcheries upstream release these fish have already tagged them).

3.5 Perspectives of Practitioners and Community Members

After the monitoring period was completed, we interviewed multiple people who work and in some cases live near the Lower Duwamish to capture their perspectives on the floating wetlands project and of novel ecosystems in general. A University of Washington Human Subjects Approval Number was applied for but not provided because none of our interviewees were determined to be human subjects as defined by the IRB. However, all interviewees signed a consent form in order to be a part of our research.

For these interviews, a semi-structured elite interviewing method was employed (Dexter, 1970). A qualitative analysis using software like Atlas.ti to identify common themes and areas of interest in the interview data was not performed, as such work was considered beyond the scope of this report. The following key informants were interviewed as part of this study:

- Mason Bowles, environmental scientist with King County's Ecological Restoration and Engineering Services Unit in the Rural and Regional Services Section of the Water and Land Resources Division in the Department of Natural Resources and Parks.
- Edwin Alberto Hernandez Reto, community liaison for the Green Futures Lab's floating wetlands project.
- Adrienne Hampton, Climate Policy and Engagement Manager for the Duwamish River Cleanup Coalition (DRCC) and former Community Science Program Manager for the Green Futures Lab's floating wetlands project.
- James Rasmussen, Superfund Manager for the DRCC and member of the Duwamish Tribe.

3.5.1 Living Shorelines vs. Novel Ecosystems

One immediate commonality apparent between two interviewees was general support for constructed floating wetlands (CFWs) in the lower Duwamish and for smaller, creative projects that employ novel ecosystem restoration techniques (NERTs).

An interesting commonality was that each interviewee expressed either skepticism or ignorance of the concept of novel ecosystems. When asked about the subject, Bowles balked and said that he preferred to think of these NERTs and projects like the DFWP as "living shorelines techniques," as opposed to anything related to novel ecosystems. Hernandez Reto responded to the same question about novel ecosystems posed to Bowles by referring to the DFWP and projects like it as a "community project."

Bowles, as an employee and regulator working for King County, explained that one reason for framing floating wetlands as living shoreline infrastructure instead of novel ecosystems is that the concept of novel ecosystems is very academic and hard to define. He stated that, "Novel ecosystems are a very hot topic right now. There's a lot of controversy around it. My concern is when you use terms like 'novel ecosystem' it becomes

academic-speak. What is the difference between hybrid and novel? I don't want to get mired in that."

Bowles added that living shorelines are also easier to implement because there is already a precedent in the policy to do so: "My preference right now is treating them as living shorelines. And the reason I'm doing that is that there's a lot of work around that concept of combining living with engineered materials. That concept has been widely accepted as a paradigm." Bowles cited H.R. 3115 (Living Shorelines Act of 2019), a Congressional bill which would have directed NOAA to award grants to state and local governments, Tribes, and NGOs to implement climate-resilient projects and, "encourage innovation in the use of natural materials to protect coastal communities, habitats, and natural system functions." Although the bill did not receive a vote, Bowles argued that living shorelines being included in the title of proposed federal legislation was a sign of their mainstream acceptance. He added: "There's a lot of traction around [living shorelines] and CFWs have been included in that paradigm, so to me that's more useful."

There are already policies in place to permit living shorelines whereas there are none for novel ecosystems implementation in restoration work. Mason explained that for living shorelines "there's regulatory support for it under the CWA and there's a Nationwide Permit (NWP #54, issued by the Army Corps) that gives you a regulatory approach or 'cover' for what you want to do."

Hampton and Rasmussen of the DRCC expressed that targeted usage of these CFWs in stormwater outfall areas could be useful for cleaning stormwater, but emphasized that if the CFWs do not have clear benefits to community health and habitat, grant funding and focus should be directed elsewhere. Hampton explained: "At the end of the day, the river needs to be cleaned up, so anything on the river should add to the cleanup. Is [a novel ecosystem] the right place to be allocating funds and investing time? From my knowledge of the pilot of the first project, there wasn't a dramatic [beneficial] impact [due to] the wetland. I would be wary of bringing the policy maker to the wetland or should they be going somewhere else, acting on priorities of the community, like clean air, take a big step back and analyze is this the area we should be investing resources. If it does not support the clean-up we may need to move on to something else."

Hernandez Reto lives in Georgetown and works with the DRCC as a community liaison with local fishers in order to educate them about pollution in the fish. He also worked with the Duwamish Floating Wetlands team to recruit youth to participate in the community science program and he performed weekly maintenance on the wetlands during the 2020 field season. Hernandez Reto said that this project was good because it was a "new idea for using natural plants, and that Latinos and Cambodians are going to fish in the river. So if plants are put in the river at different locations, it's better for the salmon, and maybe the communities will fish." He expressed that he felt that, "Georgetown is too industrial. Maybe we can use CFWs in other places" as well.

3.5.2 Conventional, Land-based Restoration vs. Floating Wetlands

Bowles was particularly enthusiastic about the speed at which CFWs or unconventional restoration techniques could be implemented. He referenced the 2020 State of the Salmon report, which warns that salmon remain on the brink of extinction ("Executive Summary," State of Salmon in Watersheds). "It's inconceivable to me that any land-based approach will be implemented in time to make a difference for them." Bowles defined land-based shoreline or wetland restoration as being, "like conventional restoration, let's grade this area, etc." Typically these land-based projects take many years and are very expensive. He explained, "The project I'm working on now is $500 per sqft. Usually land-based restoration is less than $100/sqft. So you've got that price tag and then the longer time scale it takes to get things done." Complicating matters is the fact that all land-based restoration projects in the LDR are potentially exposing more toxic sediment: "The challenge is that with land-based restoration is that everything is contaminated, so every time you touch the soil it's considered a release of contaminants by Ecology." An example of the length of time it takes for land-based restoration in contaminated sites is the LDR Superfund upper reach remedial clean-up process for which the design process began in 2019 and cleanup will begin in 2024 (**Figure 19**).

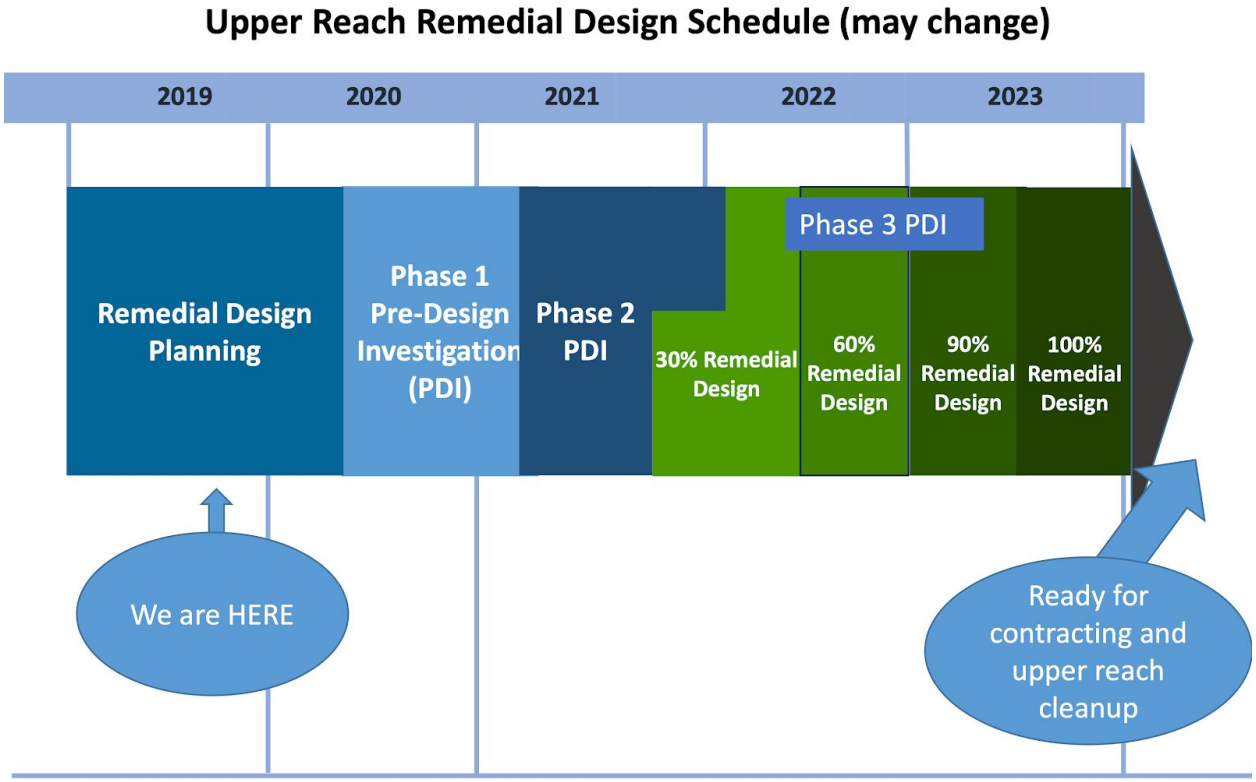

Figure 19. Timeline of Lower Duwamish Superfund remediation. *Timeline of land-based restoration of one of the contaminated sites. (Triangle Associates, 2019)*

The Duwamish Floating Wetlands were able to be deployed faster than conventional restoration approaches because "the BioBarges are vessels and they're not regulated the same way land-based wetlands are. So it's perfectly legal you know, it's just that it's not been done. It's unconventional."

However, Rasmussen and Hampton felt that the benefits of floating wetlands had not yet been proven and more deployment and testing needs to be done before restoration and clean up resources are diverted to fund more floating wetlands. Rasmussen suggested that these floating wetlands can be used as a pollution source control tool telling us that "if you can prove that this will help with source control, then you have something that is needed on the river. That's what we need to focus on." Hampton further highlighted the need to focus on pollution sources stating "at this point it's all hands on deck. It's a balancing act. How can we do the novel project while also focusing on the nitty gritty of assessing the root causes of how we got to where we are today. We don't want anyone to go out of business, we want to encourage better practices and enforcement."

3.5.3 Strategic Placement and Visibility of Floating Wetlands

Another common theme throughout the interviews was that it would be best if CFWs were deployed strategically in parks or shoreline areas accessible to the public or directly in front of stormwater outflows. Specifically Duwamish Waterway Park and T-117 were highlighted as places where CFWs would be more beneficial for public education and stormwater outflow treatment. Bowles explained that if "you want to restore plants, e.g., bulrushes for cultural value, a good example is Duwamish Park. There's no plants there. We could totally do something there. Parks do a lot of things well but they don't take these kinds of things on, but that to me would be a perfect site! I don't know why they wouldn't install plants there. Get some Nisqually elders to show you how to manage *Schoenoplectus americanus* (chairmaker's bulrush)."

Hampton stated that from her involvement in the pilot study for the Duwamish Floating Wetlands project she "would amplify the point of having things that can be seen. We did our best with signage, but access to the river is still an ongoing environmental justice issue. In creating these (CFWs), we need to think about the whole picture."
When asked if fifty or more CFWs would be better than the four deployed in 2020 Hernandez Reto responded " yes, all for it. In South Park, Duwamish Waterway Park, maybe we can use that area. The water is calm. Also, there's new park construction. Place CFWs near the new rain garden." He also highlighted that at the "T-117 new park created by the Port of Seattle, they are creating natural habitat. Maybe CFWs would be good there. We can use wetlands to create habitat." Rasmussen noted that there are two outfall points that would have potential for placing floating wetlands to filter stormwater outflow. These points are the Duwamish/Diagonal CSO and the Norfolk CSO upriver from the Turning Basin (RM 5.3).

3.5.4 Community Benefits

The CFWs not only have potential as restoration tools but also offer a pathway for community members to engage with research and the river through wetland monitoring programs. Hernandez Reto singled this factor out as a benefit of the DFWP, saying that, “It's a good project because UW involved the community. It had a good methodology and was easy to understand the project. [We] improved [our skills] in Excel and [in] using the instruments.” When asked for future recommendations for CFWs, Hernandez Reto suggested to put the wetlands near where people fish because the urban development along the river creates too much pollution.

Bowles brought up that the implementation of CFWs or other living shoreline projects could provide further community benefits through employment opportunities, saying that “it could create jobs too because they’ll require continued maintenance!” He provided an example that “in the fall they can go out and deadhead the plants. One of the things we learned from Indigenous Knowledge that a lot of native plants have co-evolved to be managed. There has to be people engaged in the management.”

3.5.5 Policy Avenues

Bowles suggested that CFWs could serve as a form of compensatory mitigation in King County’s in-lieu fee program (King County, 2021). Bowles described that “the way the in-lieu fee program works is that if you are doing this project that might impact wetlands, you don’t want to maintain a restoration site in perpetuity. If you can pay a fee and make that problem go away because that fee funds government agencies to put in things like CFWs. Additionally, large stakeholders, such as the Port of Seattle could install CFWs as an intermediate solution to pollution.” He added, “The Port is responsible under the cleanup, so if there was a possibility of getting these accepted as a form of compensatory wetland mitigation. Hey, I want to restore this shoreline, but it’s a burning dumpster, it’s a mess, they spend five years doing studies instead of getting shit done, and in the meantime they could have populated the whole bank with CFWs that provide ecosystem function. It doesn’t get them off the hook for the land-based restoration that needs to happen but it could be a good intermediate solution.”

The DRCC representatives took a bigger-picture perspective when asked about policy recommendations for restoration in the LDR. Hampton emphasized community health outcomes saying that she is working for a “just transition—moving away from extractive practices and toward cooperative movement for just recovery.” She noted that “even in a pandemic, industry is not slowing down for anyone. People are spending more time in polluted neighborhoods. Think of cumulative impact. Enough is enough. We really need to enshrine [environmental justice] that into our systems, into the way we do business. Without it I'm very concerned about the future. The life expectancy is thirteen years shorter in the Duwamish Valley. Policies need environmental justice principles,

health equity. How can we expect a floating wetland to improve someone's health?" Rasmussen spoke about improving enforcement of regulations with an environmental justice lens. He explained that "we're also looking at [federal] partnerships to help put a little more steel in regulations, [working with] the Forest Service and National Parks Conservation Association." He expressed that with the new administration coming in there may be more support for environmental justice incorporation into environmental regulation.

4. Policy Analysis

In order to provide robust recommendations in the next section, we provide in this section an examination of policy grounded in our survey of policies that inform restoration in the LDR, the current dialogue around novel ecosystems and restoration therein, our firsthand experience with the Duwamish Floating Wetlands Project, and our interviews with key informants.

Below, a brief policy problem statement identifies the issues of concern in the LDR through two separate lenses for analysis: ecosystem restoration and community health. The City of Seattle's Duwamish Valley Action Plan is then presented and evaluated across six metrics to provide an understanding of the current status of environmental policy in the LDR. A feasibility analysis is then presented for two policies we have proposed: a reconfiguration of the in-lieu fee agreement for King County's mitigation reserves program, and a payroll tax that would fund green jobs in the county. These policies serve as representative examples of how policy and decision makers can address multiple levels of need in the LDR, in line with the recommendations we provide in the next section.

4.1 Problem Statement

The ongoing environmental degradation, environmental inequities, and lack of coordination (Muckleshoot Indian Tribe, 2016) among the many responsible agencies make cleanup and restoration of the LDR and the Duwamish Valley region a classic "wicked" or "ill-structured" problem that involves many decision makers, conflicting value systems, and an overabundance of potential solutions (Dunn, 2018). To tackle this ill-structured problem, we narrow our focus to two lenses or goals through which the problem can be better understood and assessed to identify solutions. These two goals are ecosystem restoration and community health.

It is important to point out that these two goals are not meant to be viewed in opposition or in parallel to each other. There are clear intersecting values and issues at play between ecosystem restoration and community health, and advancing one requires the advancement of the other (Breed et al., 2020). For the purposes of our analysis, however,

we have drawn an artificial distinction between the two so that we can provide a clearer focus for discussion.

Viewing the problem through the lens of ecosystem restoration, which was the original focus of our research, reveals that, unsurprisingly, plans for resilient shorelines are not designed with floating wetlands or other such new or experimental structures in mind. Meanwhile, the partnership organizations like WRIA 9 and LDWG only target specific areas for restorative action and arguably do not provide an overarching plan for restoring ecosystem function in the LDR.

Outside of early action areas, the Superfund cleanup process is relatively slow and its efficacy limited by ongoing pollution impacts to the LDR. Local programs that fund restoration work exist, like King County's Mitigation Reserves Program which collects in-lieu fees from developers and consulting firms (King County, 2021). However, such programs are limited in scope and funding and do not solve the problem of "temporal loss," a term describing the significant amount of time in between when a net loss of ecosystem function due to unavoidable negative impacts occurs and when the mitigation site that is funded becomes fully functional (King County, 2019).

Viewing the problem through the lens of community health reveals that the policy problem in the LDR is not only about shorelines and restoration, but about larger concerns of general welfare and public health, of which healthy river ecosystems can be a part. The COVID-19 pandemic's impacts on Duwamish Valley communities include, but are not limited to, a widespread loss of jobs and employee-based health insurance, and increased exposure to the poor air quality of the region since workers no longer leave their communities for the day to go to work. The closure of the West Seattle Bridge has also led to an estimated total of 100,000 more car trips in residential areas, making air quality worse than before (Cheam, 2020; Davis, 2020; West Seattle Blog, 2020). Community organizations in the area have expressed in personal communications that they are doing more direct assistance work, giving cash to those in need. In such a scenario, it is unacceptable to present policy proposals for restoration of the LDR without also proposing policies that can restore community well-being.

4.2 Case Study – Duwamish Valley Action Plan

In this section we evaluate the City of Seattle's 2018 Duwamish Valley Action Plan (DVAP) in its effectiveness at addressing community needs and environmental outcomes using the metrics provided in *Public Policy Analysis* (Dunn, 2018, Table 7.2). The DVAP was chosen for this evaluation for its comprehensiveness in addressing issues related to the LDR and surrounding communities, its high level of community input and guidance, and its relatively recent publication (City of Seattle, 2018).

The DVAP was designed by Seattle's Duwamish Valley Program (DVP), a collaboration between the City's Office of Sustainability & Environment (OSE) and the

Office of Planning & Community Development (OPCD). This plan was designed to implement the City's environmental justice and equitable development goals for the Duwamish Valley neighborhoods of South Park and Georgetown. It was guided by community input from more than 500 Duwamish Valley residents, workers, and businesses. The DVAP is organized into seven priority areas: Healthy Environment, Parks & Open Spaces, Community Capacity, Economic Opportunity & Jobs, Mobility & Transportation, Affordable Housing, and Public Safety. The plan cites thirty-seven mid-term opportunities and five long-term strategies that it began implementing in 2018.

Of the three approaches to policy evaluation that *Public Policy Analysis* proposes, the decision-theoretic evaluation was chosen because it aims "to link information about policy outcomes with the values of multiple stakeholders" (Dunn, 2018, Table 7.3). We chose this evaluation method in contrast to the pseudo-evaluation and formal-evaluation methods because it specifically prioritizes outcomes that matter to stakeholders.

It is important to note that a comprehensive evaluation of the DVAP is beyond the scope of this report. What is presented below is only an evaluation of the DVAP to the extent that it furthers an understanding of what has failed and succeeded to date in the Duwamish Valley, as well as an understanding of how these outcomes to date should inform policy recommendations. Below, the DVAP is evaluated using Dunn's six metrics: effectiveness, efficiency, adequacy, equity, responsiveness, and appropriateness (*Public Policy Analysis*, 2018).

4.2.1 Effectiveness

A policy has proven effective if it has achieved a valued outcome (*Public Policy Analysis*, 2018). Some stated outcomes for environmental improvement in the Duwamish Valley are an increased amount of tree canopy and green infrastructure in the Duwamish Valley, improved outdoor and indoor air quality, decreased asthma rates, increased access to affordable, healthy, culturally appropriate foods.

Among the near-term accomplishments cited in the DVAP is the City's outreach to 1,600 households in Georgetown and South Park in a tree canopy improvement project, as well as the cleanup of Terminal 117, which is within the Lower Duwamish Superfund site. The City also worked with stakeholders to protect community members from toxic slag at Duwamish Waterway Park. In the fall of 2020, Seattle Parks and Recreation began contaminated soil remediation. Restoration and improvement work is expected to be completed in mid-2021.

In 2019, the City reported that under the DVAP a new trail to connect South Park and Georgetown is being built. The City also awarded a grant of $575,000 to Duwamish Tribal Services for upgrades to the Duwamish Longhouse. $1.5 million was secured for new river access and parks, and $1.1 million was awarded to fifteen community-led projects. However, this allocated funding and targeted projects do not seem to have accomplished

the goals the DVAP has stated, such as reducing asthma rates or increasing tree canopy in the Duwamish Valley.

4.2.2 Efficiency

Dunn directs the analyst to consider how much effort was required to achieve the valued outcome to evaluate the efficiency of a policy (*Public Policy Analysis*, 2018). The planning and community engagement for the DVAP took place in 2017 and the plan was published in 2018. From 2016 to early 2018, the City has accomplished fifty of its near-term actions meant to address the immediate priorities of communities. In 2019, an end-of-year progress report was released highlighting the City's progress towards its five long-term strategies: anti-displacement, workforce development, climate change, parks and open space, and health. The plan is efficient in achieving its near-term actions, but not in implementing its long-term strategies.

4.2.3 Adequacy

The city established the Duwamish River Opportunity Fund (DROF) in 2014 for projects initiated by neighborhood groups, community organizations, informal groups, individuals, or business groups that improve the quality of life for communities living in the Duwamish Valley. The fund is designed to address "safe fishing or fish consumption, environmental development or restoration," and other goals beneficial to the community. The annual funds total $250,000. This amount of funding is not adequate to accomplish the long-term goals stated by the plan, such as providing place-based appropriate housing, implementing a strategy to mitigate and adapt to climate change caused flood risk, and improve community health.

In order to evaluate the adequacy of a policy, Dunn asks whether the achievement of an outcome resolves the stated problem (*Public Policy Analysis*, 2018). In this case, the achievement of near-term goals and funding provision via the DVAP is not adequate for restoring ecosystem benefits to the Duwamish Valley or resolving community health problems.

4.2.4 Equity

To analyze the equity of a policy, it is important to evaluate whether benefits have been distributed equitably among different groups (*Public Policy Analysis*, 2018). Quantifying the benefits of DVAP distributed to each group represented in the Duwamish Valley is beyond the scope of this report. However, it is undeniable that the DVAP team sought guidance and participation from the community early on, an approach that can help foster equity during the creation and implementation of policy.

Beginning with the establishment of the DVAP itself, the City used its racial equity toolkit (City of Seattle, 2012) to shape that process and the DVAP's deliverables. The City employed an independent firm, Equity Matters, to lead shared decision making workshops in the Duwamish Valley community. Workshops included representatives from Latinx, Vietnamese, and Somali communities, as well as small businesses. Through this work, the DVAP team identified racial equity outcomes: Healthy communities, thriving neighborhoods, prosperity in place, employment and economic opportunity, equitable access to city resources, accountability and decision making, community leadership and capacity building.

The DVAP reports that in order to create the plan, the City's team engaged 500 Duwamish Valley residents and businesses, with the majority of participants from refugee, immigrant, or communities of color. This methodology fulfills the City's goals of increasing Duwamish Valley residents' access to city resources and improving accountability in city decision-making.

4.2.5 Responsiveness

In order to assess responsiveness, Dunn suggests that analysts determine whether or not policy outcomes have addressed the needs or priorities of different groups (*Public Policy Analysis*, 2018). Due to the City's efforts to host workshops with Duwamish Valley residents, review extensive survey information from community members, and incorporate community priorities into plan outcomes, we consider the DVAP to be highly responsive to the different groups it aims to serve.

Additionally, much of the DVAP draws on the work of the Duwamish River Cleanup Coalition. Based in Seattle's Duwamish Valley, the DRCC is a community group that not only monitors the cleanup of the LDR but also serves as a voice for the community on matters of environmental, social, and economic well-being. The Duwamish River Cleanup Coalition Technical Advisory Group is recognized by the EPA as a community advisory group for the Duwamish River Superfund site, and it provides community input regarding cleanup of the river and pollution source control.

The DRCC's Duwamish Valley Vision Map and Report serves as a guiding document that identifies priorities for action to improve the health of the river and proximate communities. It outlines four broad categories that the community highlighted as important: environmental features (air, water quality, parks, habitat, open space); community amenities (housing, social services, public art and recreation); transportation; and economic development (DRCC, 2009). These categories and features were all highlighted as important action areas in the DVAP (City of Seattle, 2018).

4.2.6 Appropriateness

When it comes to the concept of appropriateness in policy evaluation, Dunn guides the analyst to evaluate if the fulfilled goals of the policy are worthy or valuable (*Public Policy Analysis*, 2018). The work outlined by the DVAP and already underway seems appropriate and valuable for addressing the City's stated goals, including equity, but it seems to be lacking in efficiency. Although the DVAP team has already accomplished many of its near-term goals, the work done already will not be enough to improve health outcomes for the community and adapt in response to climate change impacts. Some long-term strategies that have yet to be completed include ensuring place-based affordable housing for Duwamish Valley residents, improving job opportunities, building infrastructure to adapt to climate-induced flood risks, and acquiring and developing parks and open space. More resources and funding will be required to accomplish these long-term strategies.

4.2.7 Conclusions

The DVAP is an ambitious and comprehensive plan for improving the social, economic, and environmental health of the Duwamish Valley. The plan succeeds in responding to community priorities, highlighting equity in its goals and actions, and efficiently completing short-term actions. The areas where this policy is lacking in its effectiveness and adequacy. The funding provisioned in this plan and the policies in place are not adequate to accomplish the plan's most ambitious long-term strategies. For example, for their goals to address river access and ecosystem health, remediation work has begun in only one out of the DVAP's six proposed candidate waterfront park properties. One possible use of floating wetlands is for the City to implement these structures to increase green infrastructure in the Duwamish Valley.

Another goal that has not been achieved is the affordable housing goal. Funds have not been allocated for public housing and grants are not available to help low-income residents. In order to help achieve the goals laid out in the DVAP and address the problems we learned about in our interviews with our key informants, we propose two policies below and analyze their feasibility.

4.3 Feasibility Analysis

4.3.1 Proposed Policies

Two policies are proposed and discussed in detail below to address a wide array of need in the LDR and surrounding communities: a reconfiguration of the in-lieu fee agreement for King County's mitigation reserves program, and a payroll tax that would fund green jobs in the county. Although the two proposals might seem quite different to

each other in that one addresses ecosystem restoration while the other addresses community health, both are informed by our evaluation of the DVAP, our research into the existing policy landscape, the results of the Duwamish Floating Wetlands Project, and semi-structured elite interviews with subjects who had deep knowledge of the DFWP. In particular, our second policy idea is inspired in large part by our interview with Hampton and Rasmussen of the DRCC.

After each policy proposal is described, the feasibility of each is assessed to provide policy and decision makers an insight into the sorts of opportunities or barriers they might face in attempting to enact these policies.

Policy 1 (P1): Expand the King County Mitigation Reserves Program (MRP)

Under this policy (P1), the interagency review team for the MRP's in-lieu fee instrument (King County, the Army Corps, and Ecology) would revise the agreement for the instrument by allowing for the deployment of floating wetlands near CSOs as part of the process of estimating need for compensatory mitigation.

Currently, developers or consultants pay an in-lieu fee to the county to compensate for "unavoidable impacts" to wetlands, streams, and rivers. This fee then goes into a reserve fund to pay for mitigation projects (King County, 2021; King County, 2019). P1 would lessen the impact of temporal loss identified in the MRP and would provide direct benefit to water quality, provided that such wetlands were deployed at a large scale at key CSO locations like the Duwamish/Diagonal and Norfolk early action areas (EAAs).

Crucially, P1 does not add to the cost that developers who participate in the MRP already bear. Expanding the MRP to include floating wetlands or other NERTs would merely expand the available options for mitigation. Additionally, any language inserted into the in-lieu fee agreement will need to be carefully written to avoid a situation where participating developers only pay for NERTs so that they can avoid long-term maintenance of conventional restoration projects.

One exciting potential consequence of P1 is the expansion of options when it comes to where mitigation projects can be situated, creating more opportunities for restoration to occur in places where the shoreline and the communities living nearby need them most. As a mostly hardened shoreline, the LDR has limited options when it comes to the siting and implementation of traditional restoration projects. Again, the language inserted into the in-lieu fee agreement would have to be crafted with care, but if floating wetlands were to become part of the MRP's in-lieu fee agreement, there could be far more opportunities to "keep restoration local" and expand compensatory mitigation efforts in South Seattle, as well as in other communities throughout the watershed.

Policy 2 (P2): Reintroduce and pass an amended Washington House Bill 2948

House Bill 2948 is a Washington State House bill that died in committee in the 2019-2020 legislative session; if passed, it would have authorized King County to levy a

payroll tax on businesses with highly paid employees (An Act Relating to Granting Additional and Progressive Tax Authority, 2020). Under our proposal (P2), H.B. 2948 would be reintroduced with two amendments: the first rules out a preemption clause, allowing cities to retain municipal taxing authority. The second would raise the proposed payroll tax increase from 0.25% to 0.35%, with the revenue generated from the additional 0.1% being used to fund jobs related to river cleanup and ecosystem restoration in the Green-Duwamish watershed, which sits wholly within King County.

House Bill 2948 is the 2020 iteration version of a 2019 bill that also died in committee. Under both versions of the legislation, the payroll tax would have funded affordable housing and homelessness services throughout the county, with forty percent of the taxes raised in Seattle going back to Seattle (Seattle City Council Insight, 2020). Indeed, even without the amendments we propose in P2, passage of H.B. 2948 would likely have provided funds that would have been used to address the many goals the City of Seattle's DVAP hoped to accomplish.

However, in addition to opposition from businesses interests that were concerned about an additional tax, the bills received opposition from progressive groups and local governments due to heavy and successful lobbying by large businesses to write in a preemption clause that would prevent cities in participating counties from exercising their own municipal taxing authority. For community organizers and advocacy groups in cities like Seattle, where vibrant movements for progressive taxation exist, H.B. 2948 represented a complication that would hamper their own efforts to enact similar, but stronger legislation at a more local scale (Carder, 2020; Seattle Socialist Alternative, 2020). Ultimately, H.B. 2948 died in the House Finance Committee in the 2020 legislative session and a new bill has not yet been introduced as of March 1, 2021. Meanwhile, the City of Seattle passed its own employee hours tax, also called the "JumpStart tax," to address the wide-scale economic precarity caused by the COVID-19 pandemic (Mosqueda, 2020).

By calling for two key amendments to H.B. 2948, P2 would remove progressive opposition and opposition from local governments to the bill. P2 would also provide funds for green jobs, allowing cities like Seattle to access funds that can be used to advance community goals like the ones identified in the DVAP (City of Seattle, 2018), and to redirect resources to the communities in South Seattle communities that need them.

4.3.2 Actors in the Feasibility Analysis

Policy actors who would be in some way impacted by or be involved in the policy process for at least one of our two proposed policies (P1 and P2) were identified (**Table 2**). We defined primary actors as actors who would be directly impacted by or directly involved in the policy process for P1 or P2. Secondary actors are defined as those who would not be directly impacted by or directly involved in the policy process, but have direct access to and influence over primary actors. Tertiary actors are neither directly impacted

or directly involved, nor do they have direct access to and influence over primary actors. However, tertiary actors can influence the policy process in other ways.

Table 2. *Policy actors included in the feasibility analysis.*

Primary Actors
Amazon and similar megacorporations
U.S. Army Corps of Engineers
The Boeing Company and similar industries operating along the shores of the LDR
Duwamish River Cleanup Coalition and similar community advocacy groups in the LDR
Duwamish Tribal Services
Washington Department of Ecology
King County Council
Muckleshoot Indian Tribe
Seattle City Council
South Seattle communities
Washington State House Finance Committee
Secondary Actors
Business interest groups including chambers of commerce
U.S. Environmental Protection Agency
Labor unions
Port of Seattle
Washington Department of Fish and Wildlife
Tertiary Actors
Puget Soundkeeper and similar environmental NGOs

4.3.3 Goals and Objectives

The main goals and principal rationale for addressing the policy problems we've identified through our two proposed policies is to improve the health of communities in South Seattle, as well as to restore ecosystem function in the LDR. One objective to meet that goal is to improve water quality in the LDR and to expand King County's mitigation program to provide a wider palette of options for restoration techniques and sites where compensatory mitigation can occur. Another objective is to fund green jobs through a payroll tax to address job loss and healthcare loss in the community, while establishing a larger workforce that can complete and monitor funded mitigation projects. By enhancing the ability of King County to implement mitigation efforts, and by funding the in the area workforce necessary to implement that work, the proposed policies we have presented would enable the community to meet these main goals. Ultimately, an improvement in overall water quality as well as a reduction in negative health outcomes and economic precarity in the region would be a sign of success for our proposed policies.

4.3.4 Methodology

To quantify the anticipated position of each policy actor on each of the proposed policies (P1 and P2) and the power each actor would have to influence the policy process in relation to each policy, PolicyMaker 4, a computer-assisted tool, was utilized (PoliMap, 2015). PolicyMaker provided an efficient and reasonably quantitative method of determining the position and power of each actor in a standardized fashion. To ensure that this tool was used in a consistent, standardized way, data analysis was done individually before we consulted as a team to discuss any discrepancies and ensure uniformity of methods.

Quantification of Position

Actor position was analyzed based on their position as of February 2021. It is important to emphasize that actors' positions were quantified at a specific moment in time, and that position will change as conditions change.

Questions drawn from PolicyMaker were used to guide analysis:

Q1) How strong would be the actor's commitment to the issue, where low means minimal or no commitment, and high means total commitment?
Q2) What percentage of the actor's total resources would be committed to working on this policy?

Additional criteria were used to quantify actor position and ensure consistency between group member analysis on a variety of actors:

- Has the actor released public statements?
- Has the actor testified in a public hearing?
- Is something similar to the proposed policy mentioned on the actor's website?
- Has the actor campaigned for similar issues?
- Did the actor support previous, similar bills?
- Is the issue outlined in the proposed policy in line with the actor's mission?

A variety of resources, including official websites, press coverage, and testimony in legislative hearings, were all used to help quantify actors' positions. Actor position was placed on a continuous scale from opposition (low, medium, high) to support (low, medium, high) for the proposed policy, with neutral or non-mobilized actors being those who would neither support nor oppose the policy. These positions were first entered into a summary table. We then completed position analysis in PolicyMaker as a team to ensure consistency across all actors. Rationale for placement on the position scale was provided verbally. Wherever discrepancies arose in logic and rationale, a group discussion commenced to align on thinking. Once consensus was reached, appropriate adjustments were made as necessary and position was recorded in PolicyMaker.

Quantification of Power

Actor power was analyzed based on their position as of February 2021. Questions drawn from PolicyMaker were used to guide our analysis:

Q1) Does the actor have substantial financial resources that can be used to influence the policy?
Q2) Does the actor have significant organizational resources?
Q3) Does the actor have significant symbolic resources?
Q4) Does the actor have easy and direct access to the decision-maker on the policy?
Q5) Does the actor have easy and direct access to the mass media?

When answering these questions in order to quantify power, what was examined was the level of power the actor could exert to influence passage of the policy, not whether or not they had actually exerted that power. For example, when considering Question 5 on media access, power was measured not by asking to what extent the actor would or had utilized media access to make statements in the media about the proposed policy, but by exploring how easily an actor could make a public statement that is amplified by the media should they desire to do so.

Actor websites, press coverage, social media presence, Internal Revenue Service documents, campaign finance documents, and legislative hearings, among other resources, were used to help quantify power.

Decision makers in our analysis were assigned the highest level of power in response to Question 4. Other actors had varying degrees of access to these decision makers, determined by their organizational status, sector and role in the development of the policy.

Power was notated in a summary table for each actor on a continuous scale from low to high power. We then completed power analysis in PolicyMaker for each actor together to ensure consistency across all actors. As with position, rationale for placement on the power scale was provided verbally. Where discrepancies arose in logic and rationale, a group discussion commenced to align on thinking. Once consensus was reached, appropriate adjustments were made as necessary and power was recorded in PolicyMaker.

4.3.5 Results and Discussion

The predicted feasibility of the proposed policies described in Section 4.3.1 was determined by quantifying policy actors' position and power, and these categories were assessed along clearly defined principles of economic value or equity, along with well-recognized patterns of actor responses.

For our first policy (**P1, Expand the King County Mitigation Reserves Program**), a medium level of support is expected across multiple policy actors, but low levels of support are expected from South Seattle communities and community groups like the DRCC, as might be expected for a policy proposal that is limited to changing a relatively obscure interagency agreement. Opposition is anticipated to be limited to business groups averse to any changes to existing law that may impact their cost of doing business in the LDR, even if assurances are made that no additional costs would be levied against businesses as part of this policy. Individual, large businesses like Boeing that have operations or properties on the Duwamish River itself, or are already obligated to fund or complete restoration work in the LDR, are anticipated to oppose anything that might agreements they've already made efforts to fulfill. Non-mobilized actors include those that do not view this policy proposal as relevant to their interests or concerns, or actors who view this proposal as outside their purview (**Figure 20**).

For our second policy proposal (**P2, Reintroduce and pass an amended Washington House Bill 2948**), a medium level of support is expected across multiple policy actors; in particular, support for P2 from South Seattle communities and community groups like the DRCC are higher than they are for P1. Support from elected officials is much higher for P2 than P1 as well, as might be expected for a policy proposal that involves state-level legislation designed to generate revenue at the county level. Opposition is anticipated to be limited to business groups that will be affected by the payroll tax, but these groups also possess high levels of power to impact feasibility. Government agencies not directly involved in the creation and passage of the legislation are predicted to be

non-mobilized because they are likely to view the action of weighing in on this proposed policy as stepping outside of their purview (**Figure 21**).

PolicyMaker multiplies the assigned values of actors' position and power, takes the absolute value of the product, and sums those values to get the total value of supporters, non-mobilized, and opponents. This value is rounded to the nearest whole number and reported below as a "feasibility value." The feasibility values are represented on bar plots for each policy proposal, with feasibility value on the *y*-axis and the type of stance ("Supporters," "Non-mobilized," and "Opponents") on the *x*-axis (**Figures 22** and **23**).

2A. Player Table

Click on the 'Add' button. Enter player information. Indicate the position on the policy (extent of support, non-mobilized, opposition). Determine the level of power of the players on the policy relative to other players. Assign a trump weight to the most powerful player (optional). This can be done by clicking on the 'Trump' button above.

Position: Opposes ... Supports Power: Low ... High

Player name	Level	Sector	Position	Power
Puget Soundkeeper	Other Groups	Local Non-Governmental	Medium Support	Medium
King County Council	Local	Governmental	Medium Support	Medium
WA Department of Ecology	State and Federal	Governmental	Medium Support	Medium
U.S. Army Corps of Engineers	State and Federal	Governmental	Medium Support	Medium
Muckleshoot Tribe	Local	Governmental	Medium Support	Medium
WA Department of Fish and Wildlife	State and Federal	Governmental	Medium Support	Medium
Duwamish Tribal Services	Local	Local Non-Governmental	Low Support	Low
City of Seattle	Local	Governmental	Low Support	Medium
DRCC	Local	Local Non-Governmental	Low Support	Medium
Port of Seattle	Local	Governmental	Low Support	Medium
South Seattle Communities	Local	Local Non-Governmental	Low Support	Low
Amazon	Other Groups	Donor	Non-Mobilized	High
WA State House Finance Committee	State and Federal	Governmental	Non-Mobilized	Low
U.S. Environmental Protection Agency	State and Federal	Governmental	Non-Mobilized	Medium
Labor Unions	Local	Local Non-Governmental	Non-Mobilized	Low
Business Interest Groups	Other Groups	Private	Low Opposition	Medium
Boeing	Local	Private	Medium Opposition	High

Figure 20. Actor table for Policy 1. *Actors are sorted by level of support for P1. (PoliMap, 2015)*

2A. Player Table

Click on the 'Add' button. Enter player information. Indicate the position on the policy (extent of support, non-mobilized, opposition). Determine the level of power of the players on the policy relative to other players. Assign a trump weight to the most powerful player (optional). This can be done by clicking on the 'Trump' button above.

Position: Opposes ... Supports Power: Low ... High

Player name	Level	Sector	Position	Power
Duwamish Tribal Services	Local	Local Non-Governmental	Medium Support	Low
King County Council	Local	Governmental	Medium Support	Medium
WA State House Finance Committee	State and Federal	Governmental	Medium Support	Low
DRCC	Local	Local Non-Governmental	Medium Support	Medium
Labor Unions	Local	Local Non-Governmental	Medium Support	Low
South Seattle Communities	Local	Local Non-Governmental	Medium Support	Low
City of Seattle	Local	Governmental	Low Support	Medium
Puget Soundkeeper	Other Groups	Local Non-Governmental	Low Support	Medium
Muckleshoot Tribe	Local	Governmental	Low Support	Medium
Port of Seattle	Local	Governmental	Non-Mobilized	Medium
WA Department of Ecology	State and Federal	Governmental	Non-Mobilized	Medium
U.S. Army Corps of Engineers	State and Federal	Governmental	Non-Mobilized	Medium
U.S. Environmental Protection Agency	State and Federal	Governmental	Non-Mobilized	Medium
WA Department of Fish and Wildlife	State and Federal	Governmental	Non-Mobilized	Medium
Amazon	Other Groups	Donor	High Opposition	High
Boeing	Local	Private	High Opposition	High
Business Interest Groups	Other Groups	Private	High Opposition	Medium

Figure 21. Actor table for Policy 2. *Actors are sorted by level of support for P2. (PoliMap, 2015)*

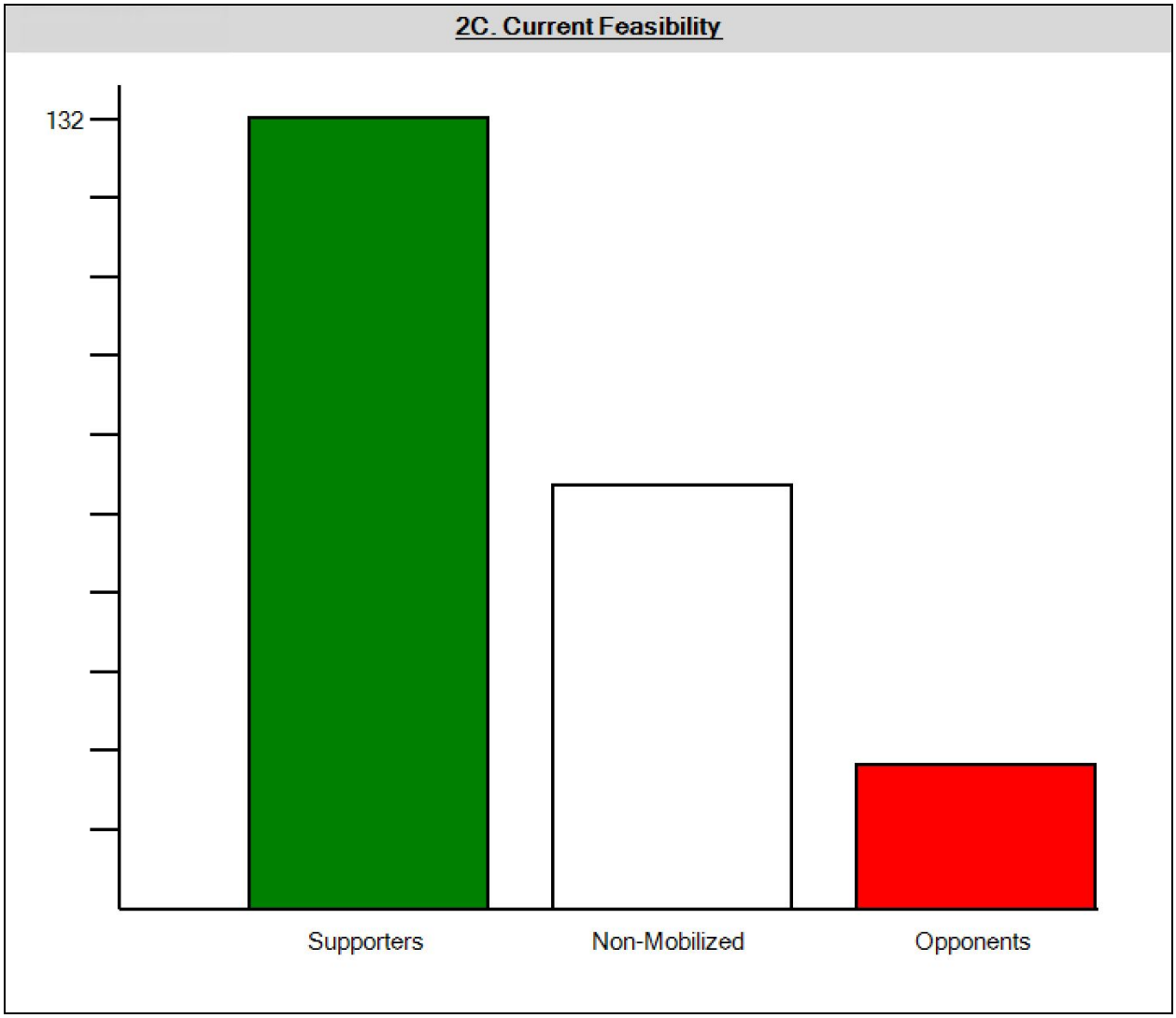

Figure 22. Feasibility plot for Policy 1. *Generated by PolicyMaker, the plot displays the relative level of support to opposition for the policy. (PoliMap, 2015)*

The generated results displayed in **Figure 22** show that P1 is currently politically feasible. The supporter feasibility value (132) is significantly higher than that of the non-mobilized (71) or opponent (24) groups. These values show that even if all of the non-mobilized groups were to change position and re-mobilize in opposition to P1, it would not be likely that opposing actors could stop the enactment of this policy (71 + 24 = 95). It would therefore not be in the interest of actors who would be opposed to P1 to spend time or resources in attempting to re-mobilize those who are non-mobilized. Overall, P1 is quite feasible and the only possible way in which P1 would not pass if presented to the relevant agencies involved in the agreement for the in-lieu fee instrument would be if there were important actors in opposition to the policy that were accidentally excluded from the feasibility analysis. This seems to indicate that it would be worthwhile for policy

makers to look into expanding King County's MRP so that floating wetlands and other NERTs can be deployed in the LDR and other hardened shoreline areas in the county as part of compensatory mitigation plans.

Meanwhile, **Figure 23** shows that P2 is currently politically feasible, in that the supporter feasibility value (115) is higher than that of the non-mobilized (95) or opponent (83) groups. However, these values show that if even about a third of the non-mobilized groups were to change position and re-mobilize in opposition to P2, it would be likely that opposing actors could stop the enactment of this policy.

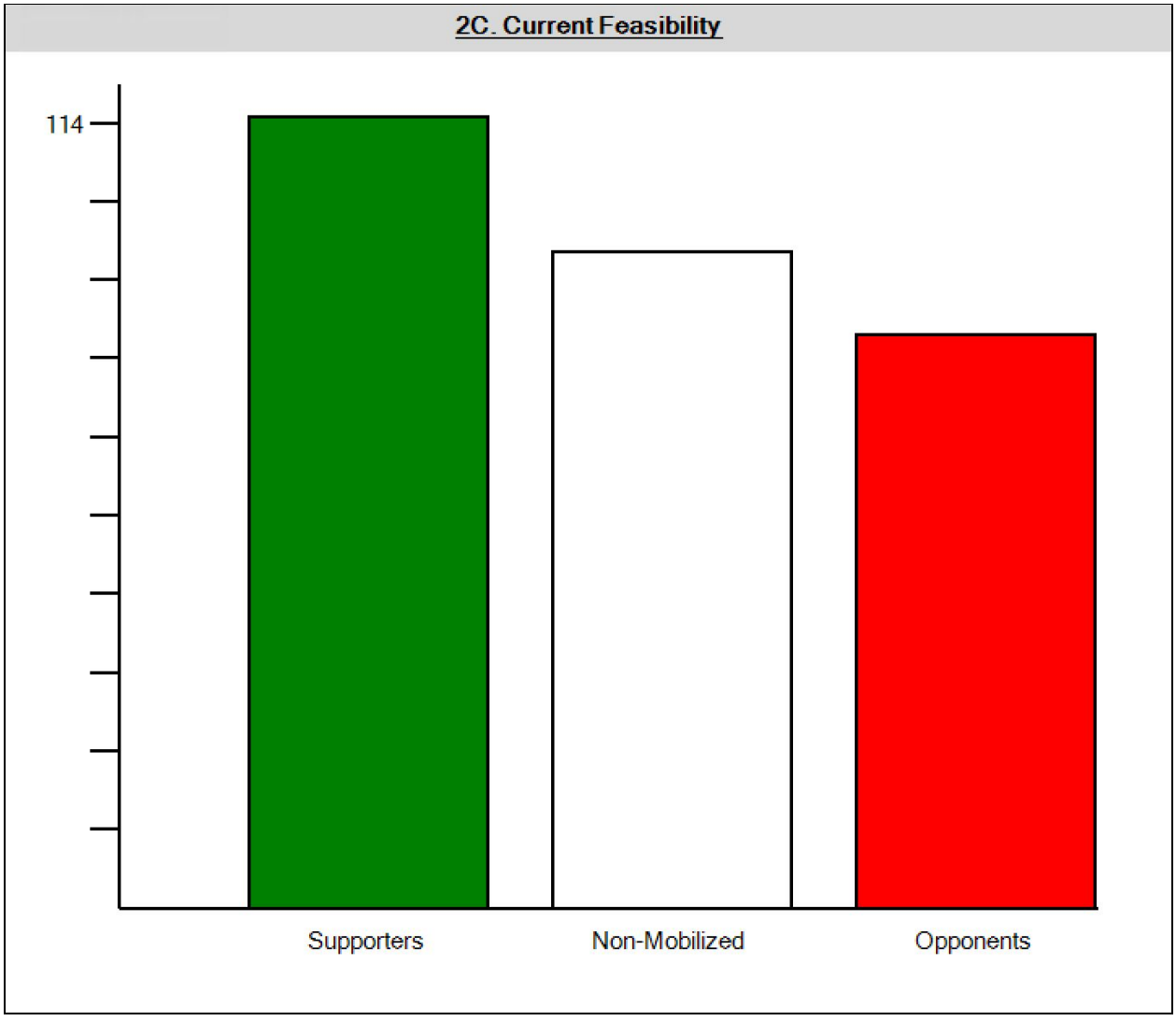

Figure 23. Feasibility plot for Policy 2. *Generated by PolicyMaker, the plot displays the relative level of support to opposition for the policy. (PoliMap, 2015)*

It is important to note that previous iterations of the bill have already failed twice in the House Finance Committee, and business groups who were initially tentatively supportive of the bill because of the preemption clause will be highly opposed to any amended version of the bill that allows local governments to retain municipal taxing authority. Since such actors will be highly motivated to oppose such a bill, successful passage will require re-mobilizing non-mobilized groups in support of the bill, or at the very least preventing them from being re-mobilized in opposition to the bill.

The future of P2 within the House Finance Committee and beyond may also depend highly on the position of key implementing agencies. While multiple government agencies included in our analysis are currently non-mobilized and cannot make P2 politically infeasible, their position may change and their power may become greater farther along in the policy process as implementation becomes a more imminent consideration for decision-makers. This means that there is the potential for a single actor to become a "trump player," which is defined by PolicyMaker 4 as the most powerful actor in the feasibility analysis (Polimap, 2015). The trump player would be an actor who has the ability to stop the enactment of a policy if their concerns are not addressed.

This phenomenon emphasizes the one key limitation of feasibility analyses: their dependence on temporal factors. The political feasibility of a policy can shift depending on where in the policy process it is being considered, and how politically feasible a certain policy is determined to be is therefore highly dependent on the specific point in the policy process at which researchers choose to conduct their analyses. For this reason it is vital that legislators write policy in coordination and consultation with implementing agencies and other policy actors, like community representatives, not just to maximize a policy's effectiveness but to ensure its feasibility in the first place.

5. Recommendations

Below, we present two sets of recommendations to address two areas of need in the LDR that intersect: ecosystem restoration and community health. These recommendations are presented to the reader with the understanding that as newcomers to the LDR and proximate South Seattle communities, the authors of this report lack the deep, place-based knowledge that those in the community possess. The recommendations provided below are both grounded in and limited by the multiple forms of research detailed in the previous sections of this report, and should be viewed as being reflective of that combined knowledge.

5.1 Ecosystem Restoration

Based on feedback from the interviews that were conducted and personal reflections of experiences with the Duwamish Floating Wetlands Project (DFWP), this report recommends prioritizing deployment of floating wetlands or similar structures in a few specific, targeted locations. Potential locations include the CSOs at the Duwamish/Diagonal and Norfolk early action areas (EAAs), and similar locations where the floating wetlands might have a beneficial impact on water quality. The DFWP has also made it clear that floating wetlands will need to be protected from wakes, and constructed in a way that allows them to maintain integrity on shorelines with dramatic tidal range. Tethering within a substrate that might still be polluted are among other criteria that should also be taken into consideration when considering placement.

The policy process that governs conventional, land-based restoration happens on a timeline that is often too long for restoration to keep pace with continued environmental damage and new harmful impacts brought on by development. This mismatch, often termed "temporal loss," could be mitigated by deploying floating wetlands or similar structures in the short term, at locations identified and given priority by community experts. Updating existing policies to include such structures in mitigation plans, such as by revising the in-lieu fee instrument for the King County Mitigation Reserves Program, could be a straightforward and politically feasible way to incorporate such novel ecosystem restoration techniques (NERTs) into existing practices. Incentivizing landowners to permit the deployment of floating wetlands from their shoreline would also ensure that many more suitable locations could be identified in the LDR where NERTs could be placed.

Compared to traditional restoration efforts, NERTs also are generally less costly. For example, the City of Seattle's Duwamish Valley Action Plan mentions that the annual funds for the Duwamish River Opportunity Fund (DROF), which is designed to address safe fishing or fish consumption as well as environmental restoration and other goals beneficial to the community, total $250,000. By comparison, the total cost of design, materials, production, deployment, field monitoring, and management of the project in 2019 and 2020 for the DFWP came out to just over $100,000. The money came from a King County WaterWorks grant of $83,780, plus a Rose Foundation grant of just under $25,000 that came from the 2018 Puget Sound Stewardship and Mitigation Fund.

It must be noted that the scope of the DFWP was far more narrow than that of the DROF, and that this report does not argue that vital funds should be removed from important programs like the DROF to finance the deployment of floating wetlands in the LDR. However, the significant cost difference between the two suggests that there are opportunities to augment conventional restoration efforts with NERTs, and that a programmatic and river-wide deployment of these smaller-scale floating wetlands could prove to be of high value to the LDR at relatively low cost. A project utilizing NERTs that focuses more on community benefits and less on research could be even more

cost-effective, since there would not be research design or field monitoring costs associated with the project.

Crucially, however, in the process of gathering information for this report it has been made abundantly clear that communities around the LDR in the Duwamish Valley region have more important priorities than NERTs and floating wetlands. Unless structures like floating wetlands can provide direct, immediate, tangible benefit to the people of these communities, buy-in for such projects will likely remain low. This strongly suggests the need for floating wetlands to be designed in ways that are more aesthetically pleasing and walkable than wooden frames and black plastic netting, and to be designed in ways that improve public shoreline access.

Shoreline access could be enhanced by integrating floating wetlands or other NERTs into existing shoreline parks along the LDR where conventional restoration work is already occurring, particularly if the floating wetlands provide opportunities for visitors to walk closer to the river or along more of the shoreline. Floating wetlands would work particularly well in places where the shoreline is hardened and fairly vertical, or at docks. Attaching floating wetlands to docks or bulkheads, such as at Harbor Island Marina which sits just downstream of the Duwamish/Diagonal EAA, would be another way to add more walkable green space in the LDR.

Ultimately, floating wetlands should have a place in restoration strategies and can be useful and implemented with relative ease. However, they are not in and of themselves an overarching, programmatic strategy for restoration, nor are they a comprehensive plan that will address why ecosystem restoration projects aren't moving or working as fast as they should in the LDR. It would be a mistake to scale up efforts to implement NERTs like floating wetlands without greater community consultation.

5.2 Community Health

As alluded to previously in this report, until aspects of community health are addressed, achieving awareness, let alone buy-in for novel approaches to ecosystem restoration, will be difficult. South Seattle has had a long history of inequity, from the forced removal of the Duwamish Tribe, to the generations of redlining that funneled investment away from the area, and the decades of wanton pollution that residents today continue to confront. Local governments and community groups have been working to minimize pollutant discharges into the LDR while keeping industries open; however, they remain highly constrained by low financial and operational resources and by the high resources of businesses along the LDR that continue to pollute.

During the course of research for this report, these existing inequities were exacerbated by the onset of COVID-19, the impacts of which disproportionately hit communities of color like those in South Seattle. Massive job losses have led not only to increased economic precarity but also unfavorable health outcomes. With people staying at

home all day breathing in the poorer air quality in the Duwamish Valley region, and with the increase in local car trips due to the failure and closure of the West Seattle Bridge, there has been a marked increase in the rate of respiratory issues in the region's population (Cheam, 2020; Davis, 2020; West Seattle Blog, 2020).

The takeaway is not that ecosystem restoration is impossible under these conditions or that communities under duress cannot address more than one issue at a time; if anything, observations suggest that the opposite is true in the LDR and the Duwamish Valley region. However, the current status of communities in the area highlights the need for increased efforts in allowing communities to take the lead and be given real opportunities to provide direction on where and in what way ecosystem restoration is implemented in the LDR. The idea of a green jobs program funded by a payroll tax, presented as a policy proposal in the previous section of this report, was presented as a challenge to policy and decision makers to think of holistic ways in which to address multiple levels of community concern, from job loss to environmental degradation.

A payroll tax of the type proposed is just one way to address the issue of community health, and as outlined in the previous section, passing such laws in the face of strong opposition from well-heeled policy actors will be a challenge. However, it is clear that increased funding is a major need for the intersecting problems in the LDR and surrounding communities to be addressed, and movements for wealth redistribution in cities like Seattle are making such transformative ideas seem increasingly possible. Unless policy and decision makers are willing to commit to that challenge of taking back the generational wealth stolen from the LDR and its proximate communities, and of putting that wealth and decision-making power back into the hands of community members, problems will continue to persist and restoration, research, and policy will ultimately not be implemented in a way that is in service to shorelines, to the river, or to the people.

6. Conclusion

In this report, a summary of the decision-making frameworks governing ecosystem restoration in the LDR was provided, along with a brief overview of the dialogue around novel ecosystems and novel ecosystem restoration techniques (NERTs). The discussion of NERTs was contextualized through a description of the Duwamish Floating Wetlands Project (DFWP) and elite interviews with select individuals who had deep knowledge of the DFWP. Finally, the City of Seattle's Duwamish Valley Action Plan was evaluated to provide grounding and context for two proposed policies, and a feasibility analysis was conducted to provide a starting point for discussion on policy recommendations.

When it comes to the LDR and restoration of ecosystem function to hardened shorelines, we recommend, among other things, placement of these structures in specific,

targeted locations until a programmatic solution can be implemented, such as expanding the King County MRP's in-lieu fee agreement to allow for the use of NERTs in compensatory mitigation. When it comes to the communities that live near the LDR and the restoration of their health, and well-being, we call for nothing less than brave, bold action to transfer stolen wealth back into the hands of the communities it was taken from.

Improving the health and ecosystem function of the Lower Duwamish River is an arena with many intersecting agencies, policies, and stakeholders. Much of the work on the river is already underway with millions of dollars of government funding from multiple sources, being used to remove contamination, restore salmon populations, and improve health and wellbeing of communities in the Duwamish Valley. Federal agencies, such as the EPA and members of NRDA have been planning and implementing large scale restoration projects to remove contamination from the river and reduce damage to natural resources and human communities. However, much more funding and work is needed to produce necessary outcomes, such as correcting health disparities, returning Green/Duwamish salmon runs to viable populations, and ensuring climate change resilience for the Duwamish Valley community and ecosystem.

Living shorelines and floating wetland projects are innovative ideas for restoration work that has provided some beneficial outcomes. While land-based restoration projects are costly and can take years to implement, floating wetlands can be constructed and deployed within months and at relatively low cost, providing benefits including uptake of toxic metals while at the same time providing habitat to ESA-listed juvenile salmon and steelhead. These structures would be best used in areas visible to the public or in storm water outflow areas. However, focus may be better directed towards long-term community based restoration projects.

Under the Duwamish Valley Action Plan, the City of Seattle seems to be making important strides in promoting environmental justice by prioritizing community needs such as affordable housing, green-space and river access, and air quality. Based on an understanding of this plan, as well as the other avenues of research pursued and outlined in this report, potential policies were proposed. While procedural changes to existing programs related to ecosystem restoration in the LDR are probably politically feasible and uncontroversial, ultimately greater consultation with communities is needed before such actions are taken. Such changes also do not address wider scale community concerns that place constraints on the broad-scale change required to pave the way for a much healthier LDR and Duwamish Valley region. Meanwhile, larger efforts to transfer wealth and power back to communities of need will be much more challenging, but essential to ensuring that ecosystem restoration is implemented in an ethical, holistic, and effective manner.

The COVID-19 pandemic and ever-present impacts of climate change have made racial and environmental inequities increasingly, starkly apparent. Addressing environmental degradation in the LDR is a task that cannot be effectively done without addressing community health and economic security. Creating a path to clean air, clean

soils, clean water, thriving salmon, and thriving people requires an integrated approach and actions from decision-makers that address the problem at multiple levels. The two speculative policy proposals discussed in this report, together with our other recommendations for restoration, represent an example of how a holistic and truly sustainable suite of environmental policies might look for the LDR and its many communities, human and otherwise.

7. Acknowledgments

We thank the Duwamish, Muckleshoot, Suquamish, and Yakama Tribes for their hospitality and recognize that our research has been conducted in their traditional homelands and usual and accustomed fishing grounds. Our field work, conducted last year in the LDR, took place minutes from the Duwamish Longhouse, and as part of our work we've had the privilege to engage with members of the Duwamish Tribe, including James Rasmussen of the Duwamish River Cleanup Coalition, and Russell Beard from Duwamish Tribal Services. We strongly support the Duwamish Tribe's efforts to earn the federal recognition they have long been denied and to finally have their treaty rights honored, and are proud to support the Real Rent Duwamish movement as individuals.

We thank Nancy Rottle, director of the Green Futures Research and Design Lab, for the opportunity to participate in the Duwamish Floating Wetlands Project, and project manager Leann Andrews and graduate student Jenn Engelke for their support during the DFWP's field monitoring season and the completion of the DFWP technical report. We'd like to thank fellow SMEA colleague Daniel Roberts for his work alongside us during the field monitoring season and the completion of the DFWP technical report. We'd also like to thank Ashley Mocorro Powell for their excellent work in spearheading a robust community scientist program in the face of major, unanticipated challenges brought on by COVID-19, as well as the community scientists who worked with us within the restrictions of King County's "Phase Two" of lockdown in the summer of 2020. We'd also like to thank King County and the Rose Foundation for their financial support of the DFWP.

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Finally, we thank the human and more-than-human communities living in the LDR and the Duwamish Valley region, for their generosity, their hospitality, their teachings, and for keeping us company on the river.

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