



The Salmon Run:

A Restoration & Recreation Plan for the Valley
Creek Watershed in Port Angeles WA

The Salmon Run:

A Restoration & Recreation Plan for the Valley Creek
Watershed in Port Angeles WA

A Design Thesis Submitted to the
Department of Architecture and Landscape Architecture
of North Dakota State University

By

Ellie Nyquist

In Partial Fulfillment of the Requirements
for the Degree of
Bachelor of Landscape Architecture



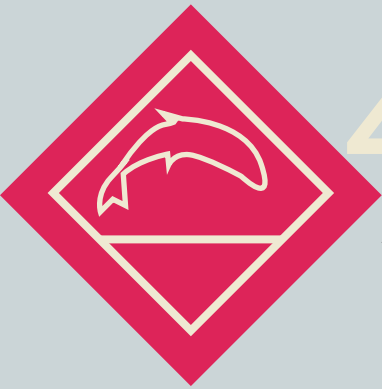
Primary Thesis Advisor



Secondary Thesis Advisor

May 2016
Fargo, North Dakota

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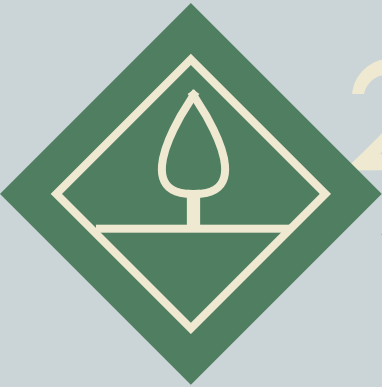
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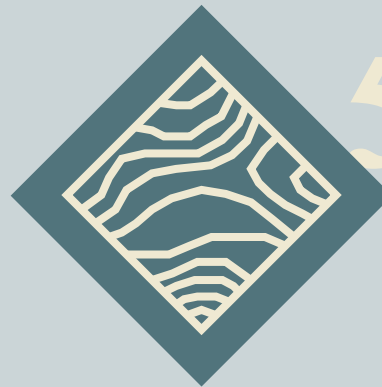
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Introduction

ABSTRACT

This thesis studies the life cycle needs of salmon and asks the question, how can we restore a river to be viable for salmon habitat as well as promote positive human interaction? As an indicator species, salmon are essential to the health of their surrounding environment as well as an indicator of water quality. This research seeks to answer this question by looking at salmon population changes, lifecycles, habitat needs, habitat disturbances, and public river interaction opportunities. The results of this study discuss how design interventions can both promote healthy salmon habitat and human interaction with the river and its corridor. This study shall conclude with a landscape master plan depicting these program elements.

STATEMENT
OF INTENT

Although there are many wildlife habitats at risk across the globe, salmon stream and river habitats are of great concern because of their sensitive ecosystems. Salmon population have decreased because of changes in their habitat which has put them on the Federal Endangered Species Act (ESA). Several species populations have been identified as endangered or threatened under the ESA depending on their location. North American salmon have a wide habitat, ranging from California to Alaska and are still seen in abundance in most of these areas. Many of these threatened and endangered populations are located within the Pacific Northwest region of the United States as well as within British Columbia, Canada. Washington State has seen a lot of this population decrease, especially within the major waterways such as the Columbia River as well as the Puget Sound. Washington State has always been a

major habitat for Pacific salmon and the state legislation is turning towards restoration and conservation actions by creating the Salmon Recovery Act (Wdfw.wa.gov, 2015). As an indicator species, salmon have a large effect on more than 200 different organisms in their surrounding ecosystem (Salmon: Running the Gauntlet, 2011). They are also important to humans because they can indicate the health of a river or stream ecosystem, which includes surrounding wildlife and vegetation. Landscape Architecture is capable of healing some of these injured ecosystems by implementing design strategies and solutions to restore and protect habitat. It can also create opportunities to educate people through positive and safe interaction, such as hiking, passive water recreation, sight seeing activities, and moderate fishing practices.



Literature Review

PROJECT
TYPOLOGY

Salmon River Habitat Restoration

Stream Restoration

Salmon Ecology Public Education

ANNOTATED BIBLIOGRAPHY & CRITICAL ANALYSIS

There is a need to study salmon habitats and environments because they are essential to the aquatic and land ecosystems that surround them. The following literature looks at how salmon habitats and ecosystems can be restored and how design can create a sustainable environment for these animals.

Annotated Bibliography 1:

Wenich E. Dramstad, James D. Olson, and Richard T.T. Forman, in their book “Landscape Ecology Principles in Landscape Architecture and Land-use Planning” (1996), claim that landscape ecology is an important and useful tool for land-use planners and landscape architects. The authors’ support their assertions by presenting and explaining the principles of landscape ecology; patches, edges and boundaries, corridors and connectivity, and mosaics. They provide numerous examples of how these principals can be applied in specific situations. Their purpose is to inform people of the importance of landscape ecology in order to spark interest in creating important new designs and solutions to maximize land degradation. The authors’ inform and educate the audience on landscape ecology principles and how to apply them to design solutions.

Critical Analysis 1:

Although this book has much information about ecological design, the section most relevant to this thesis is the section about corridors and connectivity. Corridors have a lot of impact on species movement and this book points out that river and stream systems are exceptionally significant in the landscape. As well as pointing out the importance of these types of corridors, the book discusses ways to maintain the ecological integrity of these areas. They point to four areas to do this; stream corridor and dissolved substances, corridor width for main stream, corridor width for a river, and connectivity of a stream corridor. This information is very beneficial to the research of this thesis and can easily connect to the salmon species and help understand the importance of corridor implementation. Salmon species habitat needs these types of corridors because they provide a lot of protection from temperature extremes and they regulate sediments in stream habitats.

Annotated Bibliography 2:

The National Research Council, in their book “Upstream: Salmon and Society in the Pacific Northwest” (1996), studies the ‘salmon problem’ within the Pacific Northwest. The author sets up the book to review the species of Pacific salmon through population status, habitat, and environmental requirements of the stocks. This leads to analysis of information about their genetics, history, management, and production by hatcheries, which leads to evaluating options for improving long-term sustainability of these species. Their purpose is to inform people of the importance of Pacific salmon and the need to give them protection. The author informs and educates the audience on salmon species, the status of populations, ocean and freshwater ecologies and habitats, as well as recommendations for rehabilitations and conservation of the species.

Critical Analysis 2:

Within this book there is a lot of information that can be very useful for this thesis. The book first starts out by presenting declines in salmon populations and explaining their habitat, and why these declines may be happening (disturbances). How disturbances are affecting these habitats will be helpful in this thesis to address these different disturbances within the thesis area. They then go on to introduce the value that these fish have on their surrounding environment as well as to people. This information is useful to back up why this thesis is important and what types of habitat disturbances we need to possibly fix or readjust. Towards the end of the book there is a great amount of information about how to manage and help these populations. Habitat management is discussed showing options for protection, restoration, rehabilitation, and substitution. In this thesis the information on how to restore these ecosystems and species habitat will be beneficial.

Annotated Bibliography 3:

The Federal Interagency Stream Restoration Working Group, in their handbook “Stream Corridor Restoration: Principles, Processes, and Practices” (1998), claim that stream corridors have great economic, social, cultural, and environmental value and these areas need restoration, rehabilitation, and reclamation. The author supports this by presenting an overview of stream corridors, their processes, characteristics, and functions, disturbances affecting stream corridors, identifying problems, developing goals and restoration alternatives, implementation, and restoration design options. They provide a lot of information on these subjects, intending for the document to be a handbook and guide on stream corridor restoration. Their purpose is to inform designers, the general public, and people involved in restoration work on the different approaches to stream corridor restoration. The author informs the audience on why these systems and corridors are important and how to make them better through design and biological interventions.

Critical Analysis 3:

There are many aspects to this handbook that will be helpful to the research and design of this thesis. There are many chapters that are more relevant. One of these is the chapter that talks about the disturbances affecting stream corridors. Because salmon live in these streams they are affected by many disturbances that happen in-stream as well as upland. This handbook points out natural and man-induced disturbances that affect stream corridors. The disturbances can be analyzed to see which ones will affect the salmon species the most. Another chapter that is very helping is restoration design. This chapter talks about how to restore plant communities, stream channels, streambanks, in-stream habitat, and how to deal with different land use surrounding the corridor. The chapter, analysis of corridor conditions, will be helpful in the future phases of this thesis. It will act as a guide to analyze the specific stream used as a site in this thesis, helping to create a design that is most beneficial to the area.

Annotated Bibliography 4:

David H. Johnson and Thomas A. O’Neil, in their book, “Wildlife-Habitat Relationships in Oregon and Washington” (2001), claim that understanding species and their habitat relationships is paramount to preceding species’ responses to past, present, and future land uses within a managed landscape. The authors support their claim by presenting 7 matrices. These are: Wildlife Habitat Types, Structural Conditions, Habitat Elements, Key Ecological Functions, Life History Characteristics, Management Activity Links and Salmon-Wildlife Relationships. The matrices are developed to give the reader an idea of the role that the species play within the ecosystem and what type of activities may affect them. The author informs the audience of ecosystem-based management as an abstract idea which tries to achieve sustainable conditions and provide wildlife habitat, outdoor recreation, wilderness, water, wood, mineral resources, and food while retaining the aesthetic, historical, and spiritual qualities of the land.

Critical Analysis 4:

This book presents a lot of the same ideas that this thesis is trying to achieve. As a starting point, we need to first understand the habitat and species that are still present in the environment and then continue trying to create an idea of management to support them, while supporting human interaction with the land as well. The information in this book will help this thesis in gathering more information about the salmon species and the wildlife they interact with in Washington State. The book presents species information, different habitat conditions, and wildlife case studies that are all useful information for this thesis. The book also present images and maps that help show the current and historic wildlife-habitat types on Washington.

Annotated Bibliography 5:

In the scientific article, “Pacific Salmon Extinctions” Quantifying Lost and Remaining Diversity” (2007), by Richard G. Gustafson and many other National Marine Fisheries Service employees, claim that widespread population extirpations and the consequent loss of ecological, genetic, and life-history diversity can lead to extinction of evolutionary significant units (ESUs) and species. The authors’ support their claim by trying to enumerate extinct Pacific salmon populations and characterize lost ecological, life history, and genetic diversity types among six species of Pacific salmon from the western contiguous United States. Their purpose is to inform people that because over one-third of the remaining Pacific salmon populations belong to the threatened or endangered species listed under the U.S. Endangered Species Act, it is apparent that an effort to preserve what remains of the Pacific salmon is needed.

Critical Analysis 5:

This scientific journal article will be very beneficial in presenting salmon population data. This study collects data from 13 different ecological regions within the Pacific Northwest United States, and collects data on the extinct and extant salmon populations. This thesis will use this information to address which Pacific salmon species will be in need of the most protection, based on extinct percentage. The data can be narrowed to include the parameters of this thesis: Washington region, and the five Pacific salmon species.

How can we restore a river so that it provides habitat resources and protection for salmon as well as promote safe human interaction and activity?

RESEARCH HYPOTHESIS

To restore a habitat for salmon it is necessary to restore the waterway system the fish take to complete their lifecycle. This can be done by creating places for predator protection, nesting, and safe navigation. Minimizing disturbances along this waterway is also important to keep water viable for habitation. This can be done by managing riparian forests that follow streams and rivers, and implementing regulation, through government policy, on development near or on the waterway. Not only will habitat be restored, but it will spread awareness and concern to the public by promoting good management practices for farmland, urban land, and recreational land.

Knowing the concerns of salmon and designing to address those concerns is important to promote a healthy habitat which includes stream canopy cover, oxygenated water, and unpolluted water (Building knowledge: the salmon life cycle, 1988). Human involvement is also a large part of the situation and safe interaction opportunities are incorporated as an educational tool. The public can be educated by safely interacting with the water and animals, as to not interfere with the natural lifecycle process of the salmon. These opportunities might include passive and active activities like kayaking, hiking, watching fish runs, and catch and release fishing practices. Management practices are to be put in place for short and long term management of the land and water that the animals interact with, as well as recreation use of the area.

Seattle Central Waterfront By The City of Seattle and James Corner Field Operations

SUMMARY

With the removal of the Alaskan Way Viaduct and the reconstruction of the Elliot Bay Seawall, the City of Seattle is poised to reclaim its Central Waterfront and reconnect to Elliot Bay. The Framework plan works at multiple scales to re-center the city and shape a new public realm. A robust Urban Framework utilizes character zones, nodes and linkages to acknowledge difference in adjacent neighborhoods and capitalize on unique waterfront conditions.



Figure 1. Seattle Central Waterfront master plan rendering (Design Summary: Concept design and framework plan for Seattle's central waterfront, 2012)

DESIGN GUIDELINES

- ◆ Create a Waterfront for all
- ◆ Put the shoreline and innovative design at the forefront
- ◆ Connect the city to its Waterfront
- ◆ Embrace and celebrate Seattle's past, present, and future
- ◆ Improve access and mobility
- ◆ Create a bold vision that is adaptable over time

PRIMARY OBJECTIVES

◆ Waterfront destinations

- ◆ The waterfront promenade is punctuated by new public destinations where people can gather to experience great views of the water and enjoy a variety of activities.
- ◆ There waterfront journeys will revitalize and energize the city center and bring life to the waterfront.

◆ Access and Mobility

- ◆ Must be a great place for all the people of the region
- ◆ Must function effectively for the movement of people and goods
- ◆ Serve a wide array of uses along the waterfront (lookouts, walkways, event locations)

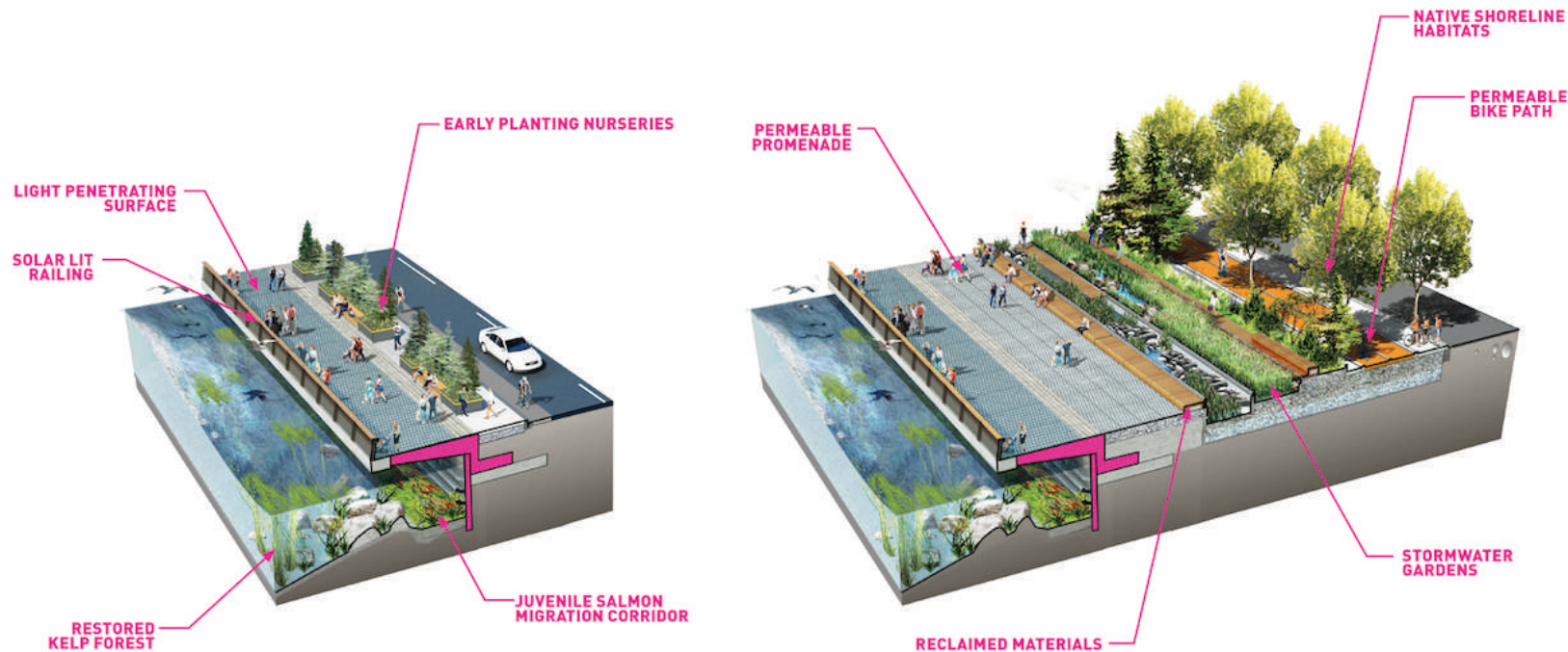


Figure 2. Seattle Central Waterfront seawall improvements (Design Summary: Concept design and framework plan for Seattle's central waterfront, 2012)

◆ Sustainability

- ◆ Bring people to the water's edge to experience the water and ecology of Elliott Bay.
- ◆ Improve shoreline ecology while preserving and enhancing maritime activities.
- ◆ To reflect Seattle's commitment to sustainability and innovation.



Figure 3. Seattle Central Waterfront Pier view (Design Summary: Concept design and framework plan for Seattle's central waterfront, 2012)

NOTES

There are many design strategies and objectives in this case study, but within these are details that are relative to this thesis. The first objective is Waterfront destinations. This idea can be used in a similar way on a river and stream front design. Multiple areas where people can congregate and experience is very important for visitation as well as education. The second objective is access and mobility. This objective can also be brought to a riverfront design by making it easily accessible to large amounts of people, and people of different mobility strengths. The third and final objective is sustainability, and more specifically bringing people into the realm of the aquatic ecology. This is very important for this thesis, bringing people into the river ecology and habitat to experience it, without necessarily disturbing it.

Cache La Poudre River Downtown Master Plan By City of Fort Collins Park Planning, Natural Areas and Stormwater Departments

SUMMARY

The Cache la Poudre River is treasured by a community that values it for a variety of recreational activities and the tranquility of a natural corridor, while also depending on it as a water source for municipal and agricultural uses. The Master Plan envisions nearly three linear miles of sustainable river corridor that provides habitat, recreation, and flood mitigation benefits. This plan integrates improvements to support many high-quality and safe recreational experiences, better protection against flood damage, and restored habitat connectivity for optimal river health and resiliency.



Figure 4. Poudre river character sketch (Poudre River Downtown Master Plan, 2014)

PRIMARY OBJECTIVES

◆ Habitat

- ◆ Conserve and restore the existing riparian ecosystem to promote river health and resiliency.
- ◆ Deliver continuous, connected aquatic and riparian habitat for fish, wildlife, trees and plants.
- ◆ Achieve and maintain diverse and sustainable native fish, wildlife and plant populations.

◆ Recreation

- ◆ Provide a mix of active and passive recreational amenities both in and along the river which encourage a safe, healthy, outdoor lifestyle.
- ◆ Provide community gathering places and promote connectivity between recreational opportunities along the river corridor.

◆ Floor Mitigation

- ◆ Improve public safety and protect properties from damaging floods from weather events.
- ◆ Eliminate 100-year flood over-topping of College Avenue and, if possible, eliminate the 100-year flow split along Vine Drive.
- ◆ Reconnect the river to its floodplain while maximizing the beneficial environmental and recreational uses of the river corridor.



Figure 5. Poudre river character sketch (Poudre River Downtown Master Plan, 2014)

REACH ZONES

- ◆ Reach 1- River Retreat
A place of refuge, seclusion, and privacy.
- ◆ Reach 2- River Parks
A place to reconnect with the outdoor world, to recreate with family and friends, and to gather with the community.
- ◆ Reach 3- Poudre Play Park
Whitewater: a stretch of frothy water with a broken foamy surface, as in rapids
- ◆ Reach 4- Fort Roots
Root: the basic cause, source, or origin of something
- ◆ Reach 5- River District
This district is “intended to reestablish the linkage between Old Town and the River through redevelopment in the Cache la Poudre River corridor
- ◆ Reach 6- Lincoln District
a building industrial and brewery district

Multiple section (or reach zones) of the river corridor have different program elements and land use



Figure 6. Poudre river design reach zones (Poudre River Downtown Master Plan, 2014)

DESIGN GUIDELINES

- ◆ River Bed Stabilization
- ◆ River Bank Stabilization and Restoration
- ◆ Rock Riprap Toe Stabilization
- ◆ Rock Riprap Toe Stabilization with Root Wads
- ◆ Stacked Boulder Toe Stabilization
- ◆ River Access
- ◆ Put-Ins/Take-Outs & In-Channel Whitewater Features

NOTES

There are many objectives that can be taken from this case study that are very relevant to this thesis. One of these objectives is habitat. These same strategies of restoring the riparian ecosystem and connecting aquatic habitat for fish and wildlife can be used with this thesis design. The other objective that is very important to this thesis is the idea of recreation. This case study does a great job at pointing out the different active and passive recreational amenities that are safe and healthy for people and the surrounding environment. Some of these different activities will be able to be put into the end design of this thesis. The primary objectives of this case study also pertain to the primary objectives that are needed in this thesis design, like habitat and recreation. The different reach zones are very informative and seem to work well within the river atmosphere.

Stanley Park Salmon Stream By PWL Partnership

SUMMARY

The Salmon Stream project is a human-made stream developed on the site of a former parking lot in Stanley Park in Vancouver, BC. Although the project wasn't a stream restoration project, it does help to highlight the importance of habitat restoration projects throughout the province. The Vancouver Aquarium uses the stream project as part of their mandate to promote public education and stewardship of wild salmon. The project calls attention to the life cycle of BC salmon and shows that habitat loss can be treated and designed for. It also shows that hard landscape areas can be changed to natural surfaces.

PRIMARY OBJECTIVES

◆ Habitat

- ◆ The demonstration stream is also functional salmon habitat for migration and spawning.
- ◆ Fish ladder helps the spawning salmon to pass through a culvert under the Stanley Park roadway.
- ◆ The Alcan Spawning Pool's water can be manipulated and it facilitates the removal of fish bound for the hatchery to spawn.

◆ Education

- ◆ Partner with the Vancouver Aquarium
- ◆ Offers extensive education programs
- ◆ Teaches Vancouver regional history as seen through the lens of salmon as a food source, spiritual element, and way of life in First Nations culture.

◆ Recycling

- ◆ Stream has replaced the former water-to-waste system with a recirculated water system, which also recycles the waste sea water from the aquarium's whale pools.

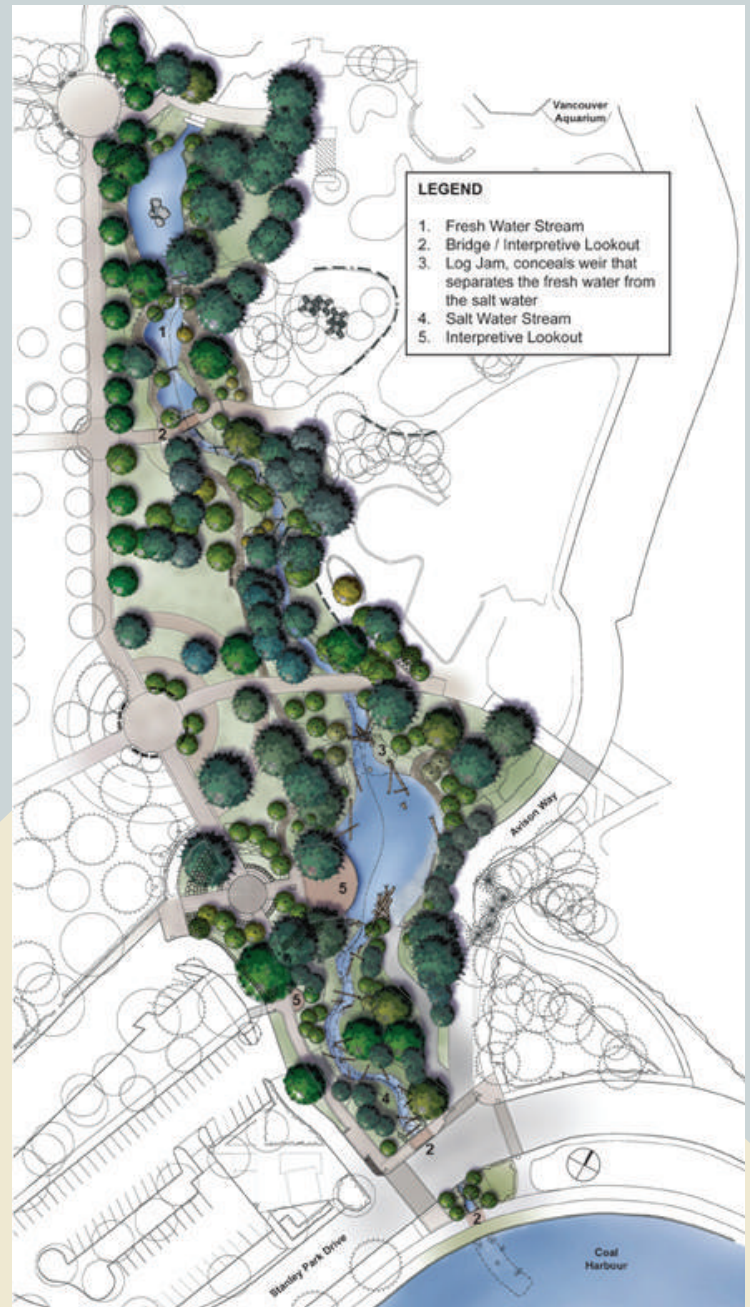


Figure 7. Stanley Park salmon river master plan render (Seatoskygreenguide.ca, 2015)

NOTES

This case study is a much smaller scale. It's also different because it doesn't include restoration, but instead creation, of a salmon stream. The objectives that are beneficial to this thesis are the habitat and educational objectives. The habitat was created, creating in stream habitat as well as riparian habitat from scratch. This stream also does a great job at incorporating educational interactions with the animals and environment. Some of these educational aspects could be added to passive activities within this thesis research.



Methodology

The methodology for this study will be a mixed method approach including qualitative (verbal data) and quantitative (measurable data) research. The gathering of research will seek to identify what salmon need in their river environments to thrive and reproduce. This research will also identify a way to promote the importance of salmon health through safe human interaction with the water and surrounding environment. Data will be collected in four different sections: salmon population, salmon lifecycle, salmon habitat needs, and public interactions with rivers. Each of these data groups will consist of qualitative, like population data, or qualitative research, like public recreational activities, to support the thesis question.

Salmon Population

Salmon Lifecycle

Salmon Habitat Needs

Habitat Disturbances

Safe Public Interactions with Rivers

This data group will look at the different species of Pacific salmon as well as their critical habitat. This group will also look at population change of Pacific salmon by researching extinct and extant populations and more specifically within Washington State.

PACIFIC SALMON SPECIES






Species	Average size	Rearing time	Run season	Spawning location	Facts
 Chinook	<ul style="list-style-type: none"> ◆ 10-15 Lbs ◆ up to 135 lbs 	<ul style="list-style-type: none"> ◆ 3 months-1 year ◆ Spring: 1 year 	<ul style="list-style-type: none"> ◆ Spring (March) ◆ Summer (June) ◆ Fall (August) 	<ul style="list-style-type: none"> ◆ Large rivers ◆ Streams with sufficient water flow ◆ Main-stem or river 	<ul style="list-style-type: none"> ◆ Fall runs spawn closer to the ocean and more often use small coastal streams.
 Coho	<ul style="list-style-type: none"> ◆ 6-12 lbs ◆ up to 31 lbs 	<ul style="list-style-type: none"> ◆ 18 months 	<ul style="list-style-type: none"> ◆ Fall (September) 	<ul style="list-style-type: none"> ◆ Small coastal streams ◆ Tributaries 	<ul style="list-style-type: none"> ◆ Can be found in urban settings if their needs of cold, clean, year-round water are met.
 Chum	<ul style="list-style-type: none"> ◆ 10-15 lbs ◆ up to 33 lbs 	<ul style="list-style-type: none"> ◆ Few days in a stream ◆ Several months in estuary 	<ul style="list-style-type: none"> ◆ Fall (October) 	<ul style="list-style-type: none"> ◆ Coastal streams ◆ Lower river 	<ul style="list-style-type: none"> ◆ Generally spawn closer to saltwater, which may be due to their poor jumping ability.
 Sockeye	<ul style="list-style-type: none"> ◆ 5-8 lbs ◆ up to 15 lbs 	<ul style="list-style-type: none"> ◆ 1-2 years 	<ul style="list-style-type: none"> ◆ Fall (September) 	<ul style="list-style-type: none"> ◆ Rivers with lake system ◆ Large rivers 	<ul style="list-style-type: none"> ◆ Most flavorful Pacific salmon. ◆ Require lake to rear in as fry.
 Pink	<ul style="list-style-type: none"> ◆ 3-5 lbs ◆ up to 12 lbs 	<ul style="list-style-type: none"> ◆ Several months in estuary 	<ul style="list-style-type: none"> ◆ Fall (September) 	<ul style="list-style-type: none"> ◆ Large rivers ◆ Main-stem of river ◆ Close to saltwater 	<ul style="list-style-type: none"> ◆ Smallest of the Pacific salmon. ◆ In WA, runs only occur in odd-numbered years.

Table 1. Average size, rearing time, run season, spawning location, and facts about the five Pacific salmon species. Spawning color also included Source: (Underwater World: Pacific Salmon, 2015), Salmon Facts, 2013).

* Rearing: grow and develop

Chinook salmon are the largest Pacific salmon species and also are the only species that can run as early as spring. These species still spawn in the fall, but may travel to freshwater during the spring, spending months in the river environment before spawning. Chinook also usually spawn in larger rivers and streams because of their size, but can also be seen in smaller coastal streams. Coho salmon can be found in most waters that drain into the Pacific Ocean, meaning there are more populations of coho than any other type of Pacific salmon. This species also prefers smaller coastal stream habitats for spawning. Coho juveniles can also be very territorial, defending their space with threatening color displays (Underwater World: Pacific Salmon, 2015). Chum salmon species are relatively large, like the Chinook, but are seen more in coastal streams and rivers. Unlike most Pacific salmon, young chum usually don't spend more than a few days in freshwater, they spend most of their rear (growth and development) time in estuaries. Sockeye salmon are unique in the way that they need a lake system to rear in. Sockeye also are part of a phenomenon called "Cyclical dominance", meaning that they are more abundant one of every four years (Underwater World: Pacific Salmon, 2015). Pink salmon also have a cycle for spawning, runs only occurring in odd-numbered years. They are also the smallest Pacific species. Like chum salmon, pink spend their rearing time in estuaries, although they usually spawn in larger river systems.

ECOLOGICAL REGION

- A **Georgie Basin**
- B **Coastal Rainforest**
- C **Northern Coastal**
- D **Klamath Mountains Province**
- E **Northern California**
- F **Southern California**
- G **California Central Valley**
- H **Willamette and Lower Columbia**
- I **Mid-Columbia River**
- J **Upper Columbia River**
- K **Lower Snake River**
- L **Upper Snake River**
- M **Columbia River Headwaters**

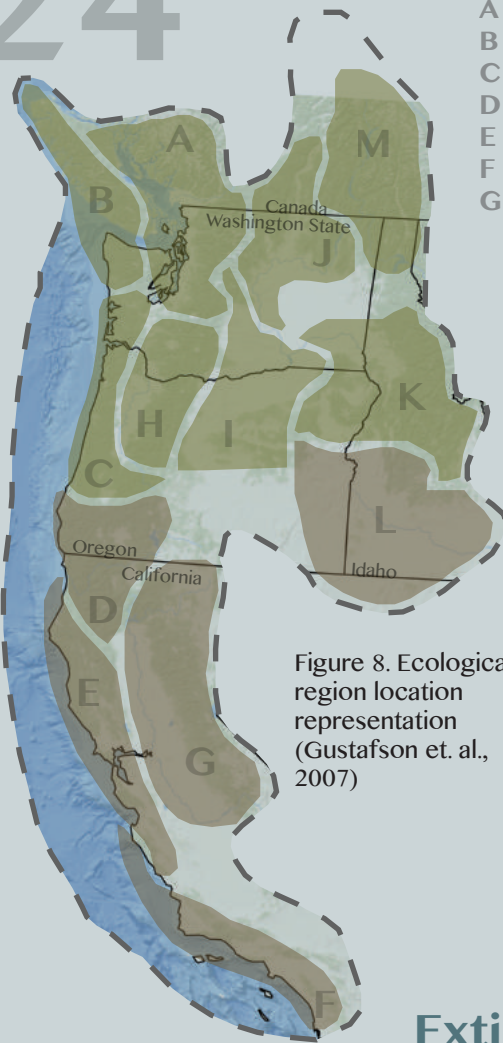


Figure 8. Ecological region location representation (Gustafson et al., 2007)

- Ecological regions within Washington State
- Remaining Ecological regions

This information in Table 2 looks at 13 ecological regions that exist within the Pacific coast. These ecological regions were organized by historical populations of Pacific salmon described by Waples et al. (2001). The regions cover Parts of Washington, Oregon, Idaho, Nevada, and California as well as portions of Canada. These study areas identify the extinct (no longer in existence) as well as extant (still in existence) of the five Pacific salmon species. According to the study Gustafson et al. (2007), “Populations were classified as extinct if the population no longer occurs in its historical habitat, have been replaced by a non-indigenous population, or the anadromous component of the population no longer exists”. Extinct populations can be seen across all of these ecological regions, ranging from 3-100%. The ecological regions within Washington State (A, B, C, H, I, J, K, M) were added together to calculate totals for each of the five species. Extinct populations can be seen across Washington regions as well, ranging from 13-45%.

Extinct vs. Extant Populations

	Chinook	Stream-type	Ocean-type	Sockeye	Coho	Chum	Pink	Total Extinct (%)
A	12(9)	28(6)	14(6)	50(0)	56(3)	36(6)	11	
B	8(0)	24(2)	21(1)	23(0)	14(1)	6(0)	3	
C	12(1)	25(5)	-	24(6)	15(7)	-	14	
D	6(6)	16(0)	-	11(1)	1(1)	0(1)	16	
E	0(6)	10(1)	-	15(4)	0(1)	0(1)	20	
F	-	0(2)	-	0(3)	-	-	35	
G	4(15)	15(17)	-	0(2)	0(1)	0(1)	7	
H	8(9)	15(2)	-	12(7)	3(8)	-	35	
I	11(9)	-	0(5)	0(10)	0(1)	-	52	
J	10(15)	-	2(5)	0(10)	-	-	62	
K	33(18)	-	1(6)	0(7)	-	-	36	
L	0(25)	-	0(3)	-	-	-	100	
M	0(11)	-	0(8)	-	-	-	100	
Total	104(124)	133(35)	38(34)	135(50)	89(23)	42(9)		
Total Extinct (%)	54	21	47	27	21	18		
WA Region Total	94(72)	92(15)	38(31)	109(40)	88(20)	42(6)		
Total Extinct (%)	43	14	45	27	19	13	● Top 3 percentages	

Table 2. Estimated extant and extinct (in parentheses) populations of the five Pacific salmon species within the 13 ecological regions. Source: Gustafson et al. (2007).

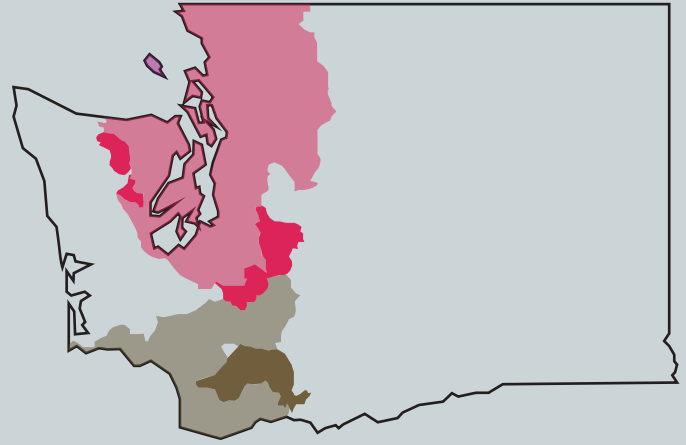
*Stream-type populations enter freshwater up to 9 months before spawning.

*Ocean-type populations spawn shortly after entering freshwater.

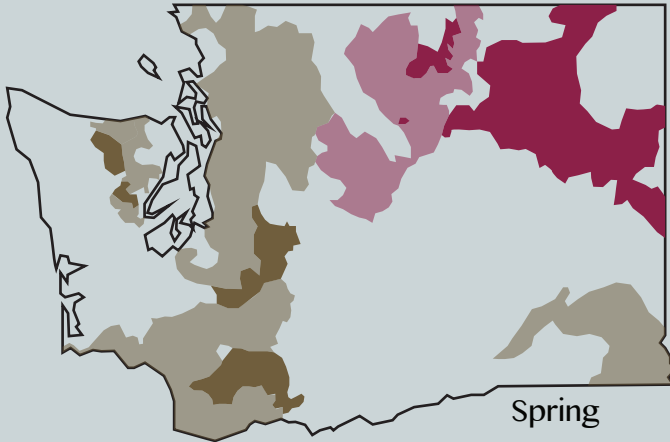
CRITICAL HABITAT

- Species of concern, accessible
- Species of concern, Historical watershed: man-made blockage
- Threatened, accessible
- Threatened, Historical watershed: man-made blockage
- Endangered, accessible
- Endangered, Historical watershed: man-made blockage

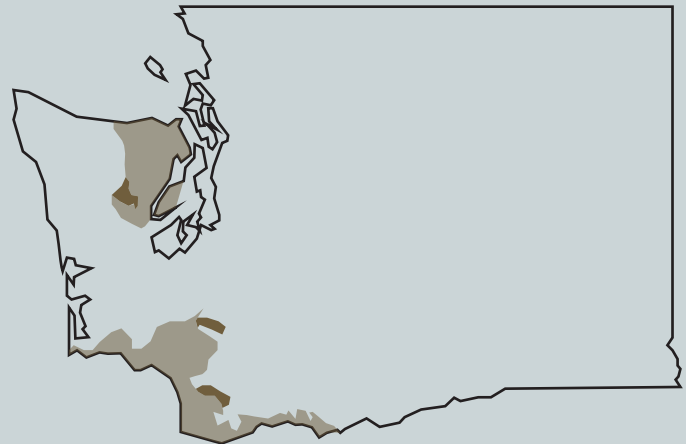
Coho



Chinook

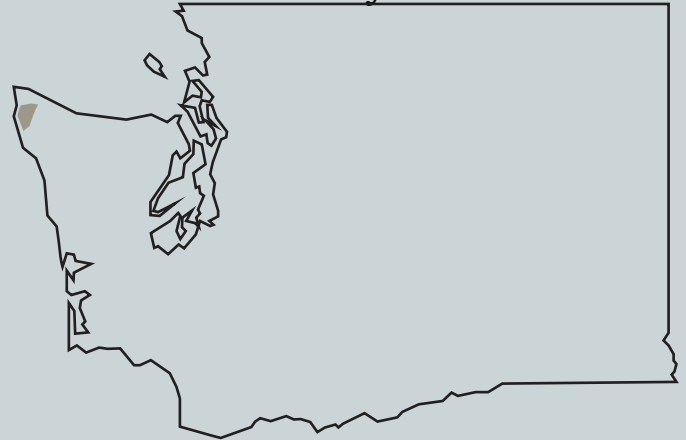


Chum

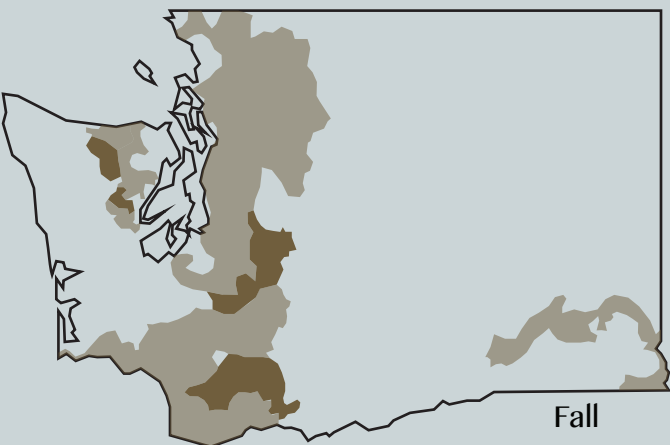
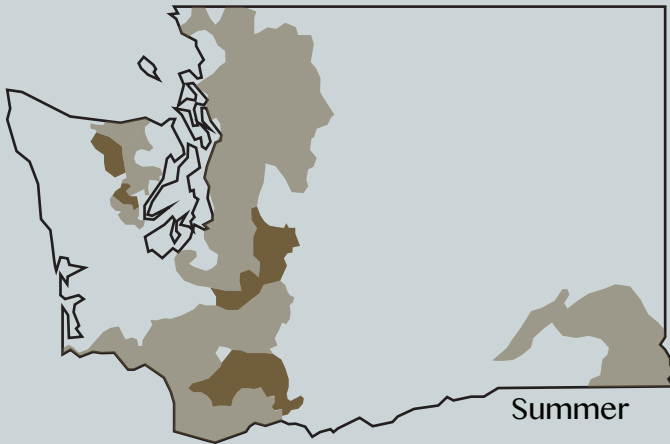


Spring

Sockeye



Summer



Fall

These four species of Pacific salmon are under the Endangered species act (ESA) and are marked as endangered, threatened, and species of concern. All of these species are at least threatened in the state of Washington. There are also many places where salmon historically habited, but has now been blocked by man-made things, for example, dams and levees. Because Chinook salmon usually travel farther when they run in the spring, they have more critical habitat within the eastern part of the state, while the other species are more affected on the western side. Pink salmon are classified as a species that is not warranted.

Figure 9. Critical salmon habitat maps of 3 Pacific salmon in Washington. (Apps.wdfw.wa.gov, 2015)

This group will identify the different salmon lifecycle stages to help better understand the positive impacts salmon have on their surrounding ecosystems. It will present what organisms are benefited by salmon as well as the environmental impacts salmon have on the ecosystem.

There are many different steps that are involved in the lifecycle of Pacific salmon. This whole cycle starts out in small streams where females and males lay and fertilize eggs. The cycle slowly moves to larger stream systems, rivers, estuaries, and eventually the ocean. This system is then repeated in reverse as migrating adult salmon travel back to the stream where they were born. Through this whole process, the fish go through drastic changes in their bodies and eventually die at the end of their spawning stage.

There are many different types of fish that occupy river and ocean habitats, but according to the U.S. Fisheries and Wildlife Service, "Pacific salmon belong to a group called anadromous fish that includes Atlantic salmon, sturgeon, lampreys, shad, herring, sea-run cutthroat trout, and steelhead trout". These types of species are unique because they live the first part of their lives in fresh water, then migrate to the ocean to spend their adult

lives. These species also return to freshwater once they reach maturity, to lay their eggs. All of these species are unique because of this aspect, but what is more interesting about Pacific salmon is that they eventually die after they spawn, Atlantic salmon may repeat the cycle several times before death (Wdfw.wa.gov, 2015). Each of these lifecycle stages are represented in Figure 10, describing the aspects of these different stages. Within Pacific salmon, there are multiple species. Each one of the five Pacific salmon species has the same lifecycle, but each species spends a different amount of time in each of these stages.

LIFECYCLE PROCESS

◆ Eggs and Alevins

- ◆ The cycle begins in freshwater when a female's nest of eggs is fertilized.
- ◆ Eggs remain in the gravel throughout the winter while the embryos develop.
- ◆ Once the eggs hatch, alevins emerge
- ◆ Alevins: tiny fish with the yolk sac of the egg attached to their bellies
- ◆ When they have consumed all of the yolk sac and have grown in size, they emerge from gravel

◆ Fry and Parr

- ◆ Fry swim to the surface of the water, fill up their swim bladders with oxygen, and begin to feed.
- ◆ Depending on the species, fry can spend up to a year in the stream they were born in.
- ◆ As fish change from fry to parr, they grow in size.

◆ Smolt

- ◆ Environmental cues cause fry to begin migration downstream towards the ocean.
- ◆ Smolting begins and scale grow as they turn a silvery color.
- ◆ Fish allow the river to take them tail-first downstream
- ◆ While allowing their bodies to adjust to the new conditions, they feed heavily.

◆ Adult

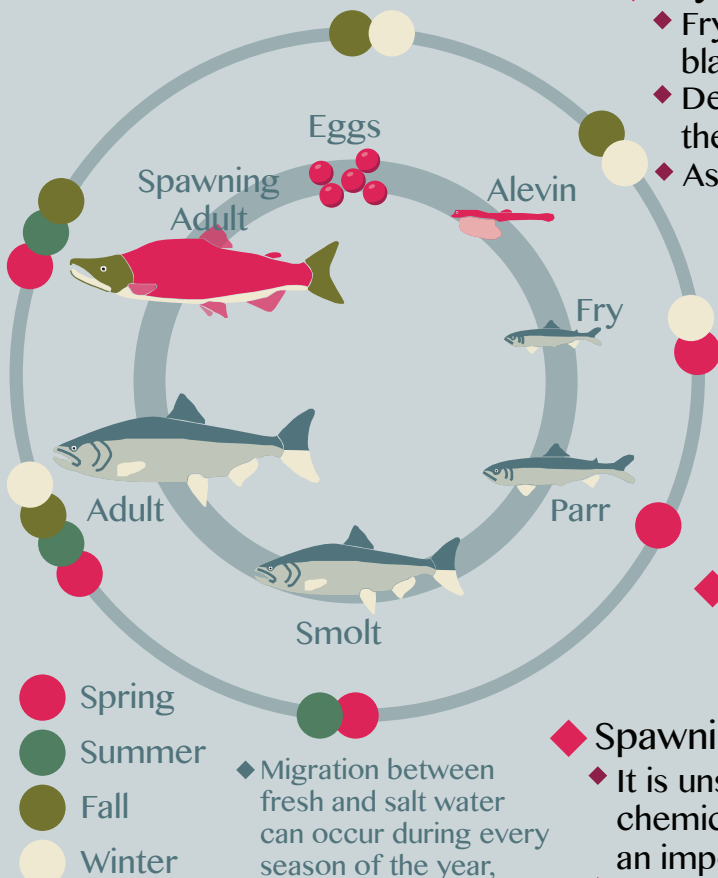
- ◆ Salmon may spend one to seven years in the ocean

◆ Spawning Migration

- ◆ It is unsure how salmon detect their natal streams. Scents, chemical cues, magnetic cues, and the sun are thought to play an important role.
- ◆ Once salmon reach freshwater, they stop feeding
- ◆ During the journey, their bodies prepare for spawning. Males produce hooked noses.
- ◆ The journey draws energy from fat storage, muscles, and organs.

◆ Spawning and Death

- ◆ When natal streams are reached, females build nests (redds).
- ◆ Redds are made by the female as she turns on her side and dislodges stones or pebbles with her tail.
- ◆ Males fight other males for spawning rights with a female
- ◆ The dominant male courts the female and upon spawning, they release eggs and milt simultaneously.
- ◆ The eggs settle into the gravel and the female covers them with loose gravel
- ◆ Eventually, both males and females die, supplying the river with nutrients.



◆ Migration between fresh and salt water can occur during every season of the year, depending on latitude and genetic characteristics of the fish. (US fish and wildlife service)

Figure 10. Lifecycle stages of Pacific salmon with correlating seasons.

ECOSYSTEM SUPPORT

The unique lifecycles of salmon lead to them being a keystone species, they supply food and life to many other species throughout their whole life. Figure 11, shows how each lifecycle stage supports different organisms and animals within the ecosystems that the animal lives in. These animals are essentially predators to salmon and have a negative effect on their survival, but the salmon supply such a essential supply of food to so many species that depend on them for life. Besides supplying food to animals such as the bears, seals, birds and many others, salmon also supply many nutrients to the riparian plant life as well as algae and biofilm. These nutrients mostly come from the transportation of nutrients through other animals that eat salmon but can also come from fish that die right in the stream. Decomposing carcasses that stay within the stream spread nutrients through the water and support other fish life and microbial organisms. When predators grab salmon from the stream and take them inland to feed, the carcasses that are left on the ground decompose and spread nutrients into the ground, which is taken up by vegetation. Even in death, salmon supply life to many different organisms.

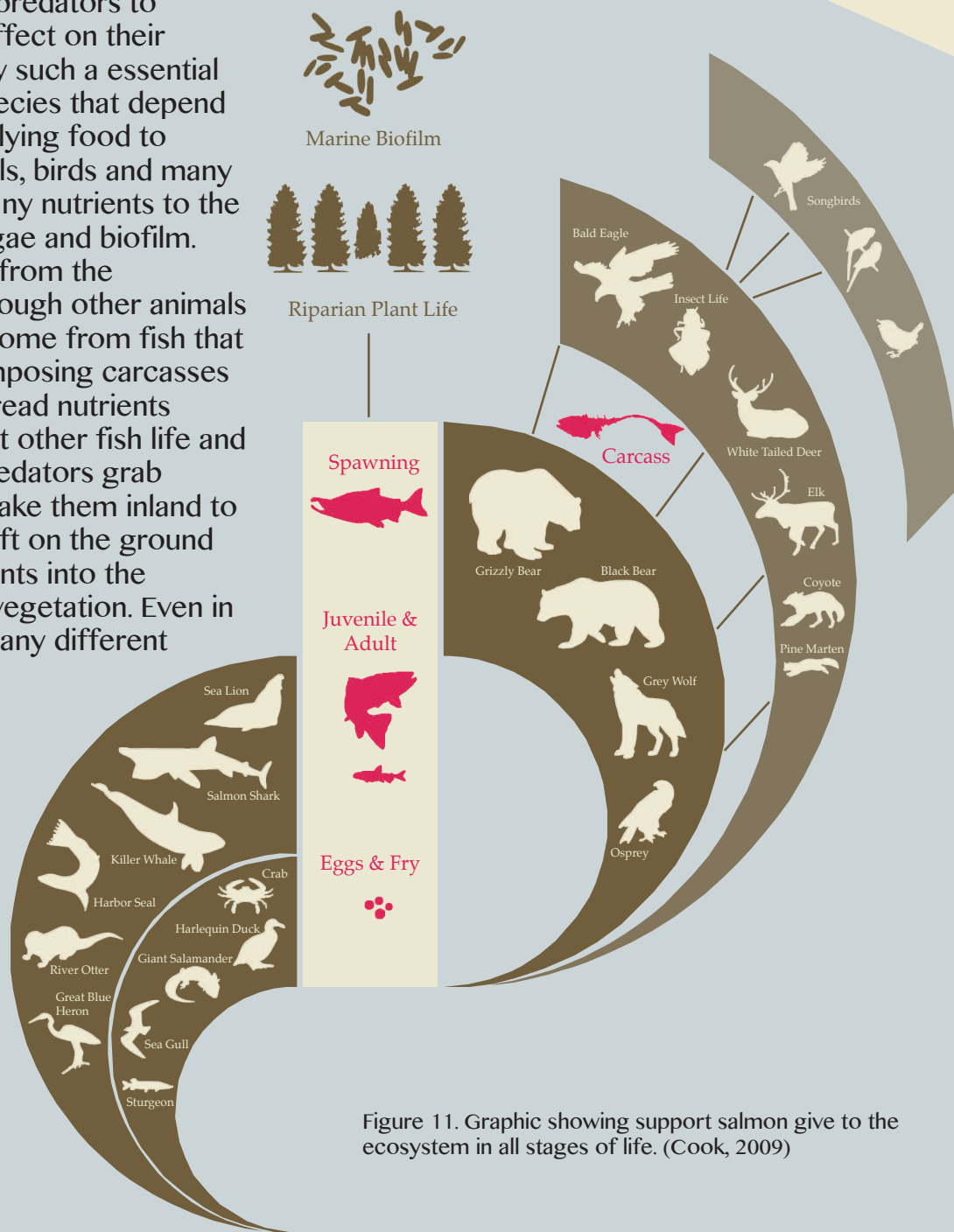


Figure 11. Graphic showing support salmon give to the ecosystem in all stages of life. (Cook, 2009)

This data will look at the aspects of healthy river habitats and specifically what salmon need to survive in the lifecycle stages that are spent in the river environments. These environments will include aquatic habitat as well as shoreline habitat needs and watershed systems.

MAJOR HABITAT ATTRIBUTES

Major habitat attributes were collected from (Larson, Kaufmann, Kincaid & Urquhart, 2004) and (Upstream: Salmon and Society in the Pacific Northwest, 1996). This literature presents habitat characteristics that are commonly agreed upon as important to salmon and other aquatic species.

◆ Water quality

- ◆ Temperature (41-47 degrees F)
- ◆ Dissolved oxygen
- ◆ Turbidity
- ◆ Nutrients
- ◆ Environmental contaminants

◆ Properties of flow

- ◆ Velocity
- ◆ Turbulence
- ◆ Discharge

◆ Geological and topographic features of the stream and it's valley

- ◆ Width and depth
- ◆ Stream bed roughness
- ◆ Particle size composition
Salmon juvenile as well as eggs hide in between cobbles and boulders on the stream bed.
- ◆ Riffle and pool frequency
Pools are calm waters and usually have a greater depth than the main stream channel.
- ◆ Floodplain characteristics

◆ Cover

- ◆ Shading
The trees and vegetation next to a stream help protect and shade from sunlight. This is necessary to keep water temperatures cool and livable for salmon. It also helps maintain the channel structure.
- ◆ Interstitial hiding spaces
- ◆ Undercut banks and ledges
- ◆ Woody debris
Large wood is defined as pieces greater than 10cm in diameter and 1.5 meters long. Large wood creates pools, provides cover for organisms, stabilizes stream banks, and fosters habitat diversity.
- ◆ Aquatic vegetation

Life Cycle	Habitat	Food
Egg	Oxygenated water Temperature from 41-48 Degrees C silt-free gravel bed steady water flow stream cover	Yolk of egg
Alevin	Oxygenated water Temperature from 41-57 degrees C silt-free gravel bed steady water flow stream cover	Yolk sac
Fry	Oxygenated water Temperature from 41-47 Degrees C Even water level and flow	Larval and adult terrestrial and aquatic insects Rotting fish carcasses Fish eggs
Smolt	Unpolluted water in river and estuary Estuary vegetation for shelter	Zooplankton Insects Worms Sandfleas Shrimp
Adult	Ocean water	Zooplankton Larval crustaceans Small fish
Spawner	Migration route free from obstructions Oxygenated water Cool clean water Silt-free gravel	None

Table 3. Habitat and food needs of Pacific salmon species throughout different lifecycle stages (Life Cycle and Habitat, 1988) (Building Knowledge: The Salmon Life Cycle, 1988).

This group identifies natural and human-induced disturbances that are affecting salmon populations and health within their stream, river, and ocean habitats. Natural disturbances can have an effect on each lifecycle stage of salmon and different aquatic life. However, ecosystems usually recover with little or no need for supplemental restoration (The Federal Interagency Stream Restoration Group, 1998). The book, Stream corridor restoration, points out that, “certain species of riparian plants have adapted their lifecycles to include the occurrence of destructive, high-energy disturbances, such as floods and droughts”. species on land as well as aquatic species have the capacity to recover from natural disturbances that occur. In table 4, you can see the relationship between the lifecycle stages of salmon and the disturbance associated with those stages.

On the contrary to natural disturbances, human-induced disturbances have the greatest potential for introducing changes to the ecological structure and functions of stream corridors (SCR). They have the ability to degrade and interfere with water quality and movement of water, which are important aspects for salmon life.

Because these disturbances can have the largest effects towards salmon life, they will be at the forefront of this design thesis. The following are descriptions of the top 10 human-induced disturbances:

- ◆ **Vegetation clearing**
 - ◆ This involves the removal of native, riparian, and upland vegetation. Vegetation removal from stream banks, floodplains, and uplands conflicts with the hydrological functions of stream corridors, leading to decreased healthy habitat for salmon and aquatic species.
- ◆ **Channelization**
 - ◆ Stream channelization and diversions can disrupt riffle and pool complexes needed in salmon and other aquatic species habitat. Instream modifications can also result in less habitat for in stream organisms.
- ◆ **Overgrazing**
 - ◆ Grazing domestic livestock can be seen across the nation. Unless carefully managed, livestock can overuse these areas causing damage. The primary impacts are loss of vegetation due to consumption and trampling, and stream-bank erosion.

NATURAL DISTURBANCES & OTHER THREATS

● Most threatened lifecycle stage

Lifecycle stage	Disturbance											Totals		
	Gravel Movement	water temperature (too high)	Water Level (too high or low)	Fine sediment	Disease	Pollution	Siltation	“Lost” nets	Predators	Drought	Landslides		Climate change	Flooding
Egg	◆	◆	◆	◆	◆	◆	◆		◆	◆	◆	◆	◆	12
Alevin	◆	◆	◆	◆	◆	◆	◆		◆	◆	◆	◆	◆	12
Fry	◆	◆	◆	◆	◆	◆	◆		◆	◆	◆	◆	◆	12
Smolt						◆			◆	◆		◆	◆	5
Adult		◆				◆		◆	◆			◆	◆	5
Spawner		◆	◆		◆	◆			◆	◆	◆	◆	◆	9

Table 4. Natural and other disturbances and associated Lifecycle stage (Building Knowledge: The Salmon Life Cycle, 1988), (The Federal Interagency Stream Restoration Group, 1998).

◆ Stream bed disturbances

- ◆ Often stream corridors are modified to help agricultural purposes. These disturbances can impair upland and floodplains, increase water temperatures, and create loss of habitat for aquatic and terrestrial species.

◆ Levees

- ◆ Levees usually replace riparian vegetation because they are next to streams. the loss of riparian vegetation results in changes in shading, temperature, and nutrients.

◆ Wood removal

- ◆ Large wood debris that is in stream support high density of aquatic micro-invertebrates, which is a food supply for stream salmon. The removal of the wood, removes habitat and food.

◆ Dredging

- ◆ Dredging removes and cleans out the bed of a river or water area. This can remove important nutrients and habitat structures.

◆ Dams

- ◆ Dams can have a profound and varying impacts on stream corridors. They can cause downstream effects like streambank erosion, loss of riparian habitat, and change water flow and supply. they affect migratory organisms like salmon, by blocking passage.

◆ Hard Surfacing

- ◆ Creation of impervious structures and paving can increase water runoff, This can carry pollutants and sediments into stream environments, which effects habitat health.

◆ Reduction of floodplain

- ◆ The floodplain gives the river an area to spread water during flood events. Taking away this area increases flooding and water damage. More frequent flooding increases fine sediment and disrupt instream habitat.

HUMAN-INDUCED DISTURBANCES

● Most effecting disturbances

Potential effects

Potential effects	Disturbance																			
	Vegetation clearing	Withdrawal of water	Stream bed disturbances	Channelization	Dams	Levees	Soil compaction	irrigation	Contaminants	Hard surfacing	Overgrazing	Circulation	Trails	Exotic species	Utility crossing	Reduction of floodplain	Dredging	Grading	Bridges	Wood removal
Pollution	◆		◆	◆	◆	◆		◆	◆	◆	◆	◆	◆		◆		◆	◆		◆
Increased surface runoff	◆						◆	◆		◆	◆	◆	◆					◆		
Increased fine sediment	◆		◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆		◆		◆	◆	◆	◆
Increased flood elevation	◆									◆	◆	◆	◆			◆				
Increased contaminants	◆		◆	◆				◆	◆	◆	◆	◆			◆			◆	◆	◆
Decreased stream filtration	◆		◆	◆		◆			◆									◆		◆
Increased stream bank erosion	◆	◆	◆	◆	◆	◆	◆				◆							◆		◆
Loss of in stream organic matter	◆		◆	◆	◆	◆					◆							◆		◆
Increased element exposure	◆	◆	◆	◆		◆	◆			◆	◆	◆	◆		◆		◆	◆	◆	◆
Increased water temperature	◆	◆	◆	◆	◆	◆				◆	◆						◆	◆		◆
Reduce invertebrate population	◆	◆	◆	◆	◆	◆		◆	◆	◆	◆			◆			◆	◆		◆
Reduced in stream oxygen	◆	◆	◆	◆	◆	◆				◆	◆						◆	◆		◆
Reduced gene pool of native species	◆	◆	◆	◆		◆					◆			◆						◆
Loss of riparian vegetation	◆	◆	◆	◆	◆	◆	◆				◆	◆	◆	◆	◆	◆	◆		◆	◆
Totals:	13	7	12	13	9	12	6	6	5	9	13	7	5	3	5	9	11	5	3	12

Table 5. Human induces disturbances and potential effects (The Federal Interagency Stream Restoration Group, 1998).

Safe Public Interactions with Rivers

This data group will compare case studies to find out different recreational opportunities, passive and active, the public can have with a river. The term safe interaction is considered an interaction that does not degrade salmon habitat in any lifecycle stage. In this thesis, active and passive interactions have specific definitions as well. Passive interactions are defined as interactions and activities that do not directly interact with the water of the stream. These interactions would happen in the upland region of the stream corridor. These interactions will have little affect on in-stream organisms and have more of an impact on the surrounding riparian habitat. Active interactions are defined as interactions and activities that directly interact with the water of

the stream. These activities have a larger affect on the in-stream organisms. some of these active activities, like swimming and water access have a larger impact because people come in contact with the stream bed, which can dislodge rocks and stir up the water. In Table 6, passive and active interactions are shown within 9 case studies. Case studies that focus more on restoration efforts (Stanley park Stream, Tassajara Creek Restoration, Westerly Creek at Stapleton, and Boneyard Creek Restoration) focus more on the passive activities. The other remaining case studies have attributes of restoration but also incorporate more public opportunities, which is why they have a mixture of passive and active interactions.

Case Study	Passive									Active								
	Public events	Educational programs	Bike paths	Jogging paths	Walking paths	Volunteer events	Overlooks	Sitting/observation	Public Parks	Horseback riding	Swimming	Whitewater Rafting	Kayaking	Canoing	Fishing	Boating	Tubing	Water access
Seattle Central Waterfront	◆	◆			◆		◆	◆			◆		◆		◆			◆
Cache La Poudre River	◆	◆	◆	◆	◆		◆	◆	◆		◆	◆	◆	◆	◆		◆	◆
Stanley Park Stream	◆	◆		◆	◆		◆	◆	◆									◆
Tassajara Creek Restoration			◆	◆	◆		◆	◆										
Westerly Creek at Stapleton				◆	◆			◆	◆									
Boneyard Creek Restoration	◆	◆	◆	◆	◆	◆		◆		◆								◆
Portage Lakefront & Riverwalk		◆		◆	◆		◆	◆			◆		◆		◆	◆		◆
'From Lake to Delta'							◆	◆			◆		◆	◆	◆	◆		◆
Fox River Corridor	◆	◆	◆	◆	◆	◆	◆	◆	◆		◆	◆	◆	◆	◆	◆		◆
	5	6	4	6	8	2	7	8	4	1	5	2	5	3	5	4	1	5

Table 6. Case study passive and active interaction comparison

SITE INTRODUCTION

Canada
Washington

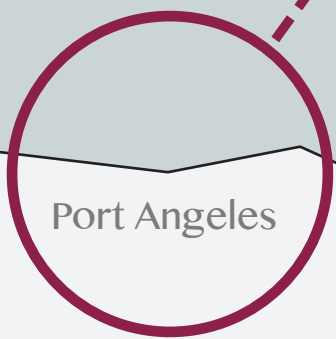
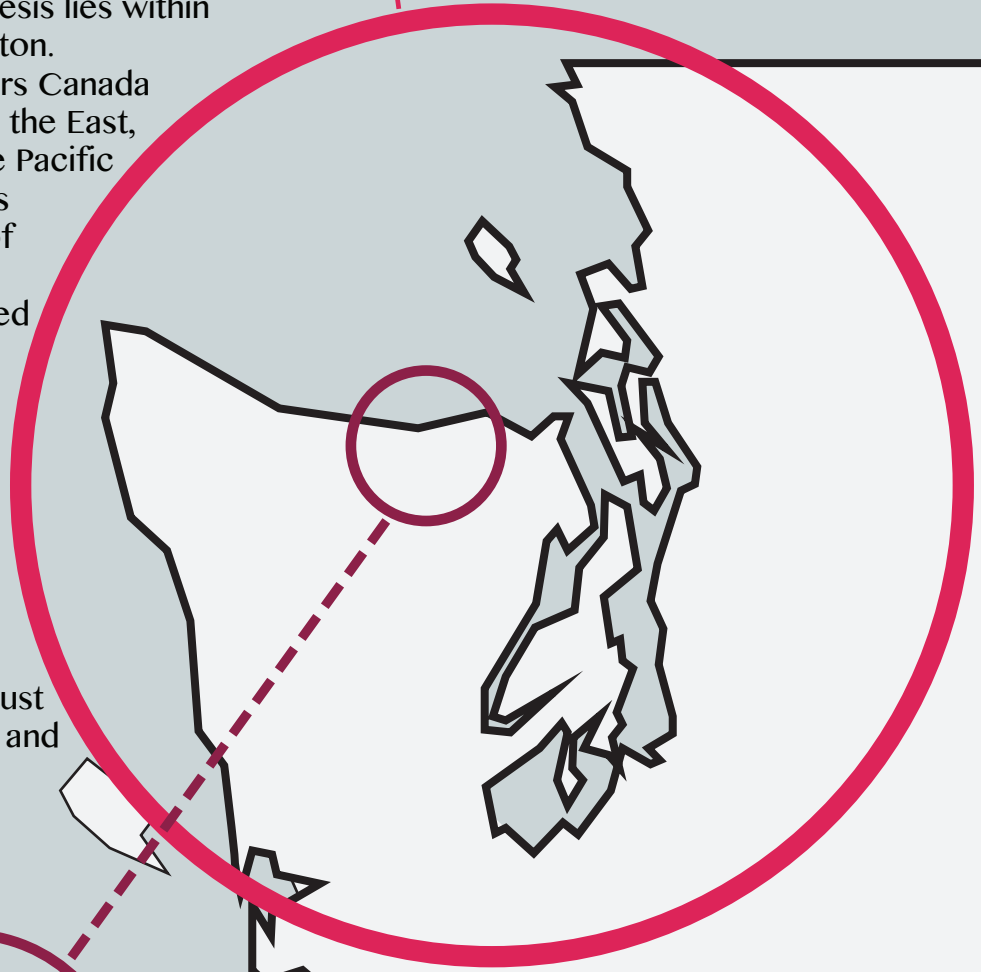
Pacific Ocean

Oregon

The site for this thesis lies within the state of Washington. Washington state borders Canada to the North, Montana to the East, Oregon to the South, and the Pacific Ocean to the West. The site was chosen because of its history of salmon migrations within its waterways and the growing need for their protection within the lower 48 states. The specific site is located in the town of Port Angeles, located on the Strait of Juan de Fuca, which is a main passageway for salmon migrating from the Pacific Ocean. The Strait of Juan de Fuca is considered part of the Puget Sound area. The town is just north of Olympic National Park and has a significant population to draw in tourists and people.

Strait of Juan de Fuca

Port Angeles



USER/CLIENT DESCRIPTION

Client:

City of Port Angeles
Clallum County
Washington State

Users:

Wildlife

Salmon are the main users of this site because they use the stream as their main spawning and rearing habitat. Other aquatic and upland wildlife that are part of the stream and riparian habitat ecosystem.

Humans

The intended users are the residents of Port Angeles. This would include families, school children, and people who enjoy the outdoors.

Users are also tourists that travel to port angeles and the surrounding area for its small town attractions and natural environment.



Results

Safe Public Interaction

The research on safe interactions have shown a lot about what types of activities are available in stream corridor areas. The case study interactions table in the safe public interactions section of the research, shows the top 5 passive interactions and the top 4 active interactions that are a result of case study comparison. These are:

◆ Passive

- 1 Walking/Hiking Paths
- 2 Sitting/Observation
(areas to relax and enjoy surroundings)
- 3 Overlooks (vantage points to view river from above)
- 4 Educational Programs
- 5 Jogging Paths

◆ Active

- 1 Swimming
- 2 Kayaking
- 3 Fishing
- 4 Water Access
(Beaches, put-ins, pull-outs, shallow walking and standing areas)

These passive and active interactions have different affects on upland and in-stream environments within the stream corridor. Passive interactions are more involved in the upland environment, such as the riparian habitat, although they can be involved downstream as well. Even though passive interactions don't affect salmon species directly, they can degrade the surrounding environment. These interactions will present a need for management, like keeping up with path maintenance and riparian habitat protection and restoration. Active interactions have more impact on the in-stream and aquatic environments, which salmon habitate in. Active interactions are more invasive to the salmon species, especially within different lifecycle stages, because they do interact with the water and stream bed itself. With the proper management of these types of interactions, they can become safer and can still be implemented and used within this project.

37 Lifecycle & Vulnerability

Life Cycle	Habitat	Vulnerability	Interaction
Eggs to Fry	Small stream to river system	High	Passive
Juvenile to Adult	Estuaries to Ocean	Low	Active
Spawning	River system to small stream	Medium	Passive and Active

Table 7. Lifecycle stage habitat, vulnerability and interaction type.

The table above shows simplified results from the research within this thesis. Salmon live in a lot of different habitats depending on their lifecycle stage. Each of these lifecycle stages have different needs when it comes to habitat and degree of protection. This research expresses the most vulnerable stages and connects those stages with the most appropriate public interaction activities.

Salmon are most vulnerable within the early stages of their life (eggs to fry). There are multiple reasons to support this claim:

- ◆ Small stream water quality can be effected by a lot of natural and man-made disturbances. These disturbances can majorly harm the survival percentage and development of eggs and alevins.
- ◆ Young salmon, and eggs, require certain temperature ranges within their habitat. If streams aren't properly protected, the salmon, and eggs, will not be able to survive.
- ◆ Salmon eggs sit on the stream bed while they develop. When animals or humans walk or move within the stream, eggs can be destroyed or dislodged.

Because of this vulnerability, public interaction with these smaller stream habitats should be passive. People should be out of the water and only be able to view the eggs and fry to keep them safe to develop and grow. The stream also needs a lot of protection that can be supplied by in stream structures such as wood as well as riparian forests for water quality and temperature.

Salmon are least vulnerable in their adult stages. (Juvenile to adult). There are multiple reasons to support this claim:

- ◆ In the ocean, salmon come across threats such as predators and human fishing practices. These threats are more manageable because the ocean holds a larger population of fish, giving predators many more options for food. There is also some regulation on fishing to manage a healthy relationship with humans and fish.
- ◆ The ocean also holds minimal migration disturbances compared to stream habitat.

This low vulnerability allows for people to be more involved in their habitat, they can be more active. The ocean is a large environment that can easily be shared with people and animal.

Salmon possess medium vulnerability when they are close to the end of their lifecycle (spawning). There are multiple reasons to support this claim:

- ◆ There are many disturbances within the stream habitat that hinder migration. Without safe passage to stream environments, salmon cannot spawn and reproduce.
- ◆ Salmon that re-enter the stream habitat have to deal with the change from salt water to freshwater, which takes a big tole on their body.
- ◆ Spawning salmon are fully grown fish and can withstand some water disturbances, such as human interaction, and not be effected drastically because of their strength and size.
- ◆ Salmon migration usually happens only once or twice a year, at these times the spawning salmon populate the stream. At all other times a year there are no large spawning salmon.

Because of the medium vulnerability, it opens up options for public interaction with the fish and the river. People can take a passive interaction, like watching the salmon runs but can also be active in the river at times that the salmon are not running.

Stream location & species

1 Sockeye

- Spawning
- Rearing

2 Chinook

- Spring
 - Spawning
 - Rearing
- Fall
 - Spawning
 - Rearing

3 Coho

- Spawning
- Rearing

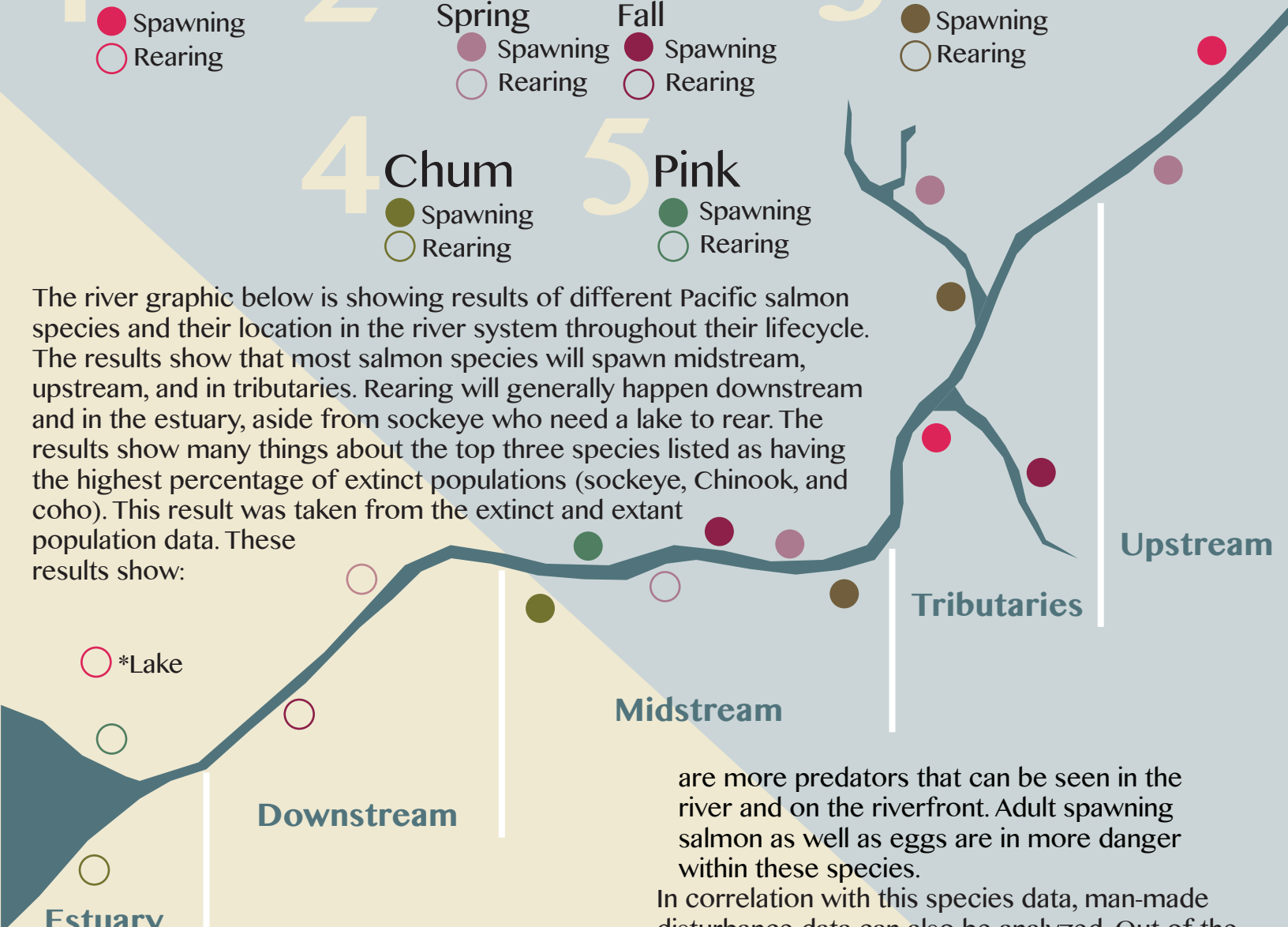
4 Chum

- Spawning
- Rearing

5 Pink

- Spawning
- Rearing

The river graphic below is showing results of different Pacific salmon species and their location in the river system throughout their lifecycle. The results show that most salmon species will spawn midstream, upstream, and in tributaries. Rearing will generally happen downstream and in the estuary, aside from sockeye who need a lake to rear. The results show many things about the top three species listed as having the highest percentage of extinct populations (sockeye, Chinook, and coho). This result was taken from the extinct and extant population data. These results show:



Estuary

- ◆ These species have a higher range of spawning locations
- ◆ All three species can be seen spawning in midstream, tributaries, and upstream.
- ◆ Rearing happens midstream to downstream

The results also show possibilities of why these species have higher extinct populations. These are:

- ◆ These species have to travel a longer distance to reach their spawning grounds, which makes them more susceptible to coming into contact with more disturbances
- ◆ Because upstream can be seen as more of a natural area, especially because cities and towns are usually towards coastal areas, there

are more predators that can be seen in the river and on the riverfront. Adult spawning salmon as well as eggs are in more danger within these species.

In correlation with this species data, man-made disturbance data can also be analyzed. Out of the twenty man-made disturbances presented, these are the top 10:

- | | |
|---------------------------|----------------------------|
| 1 Vegetation clearing | 6 Wood removal |
| 2 Channelization | 7 Dredging |
| 3 Overgrazing | 8 Dams |
| 4 Stream bed disturbances | 9 Hard surfacing |
| 5 Levees | 10 Reduction of floodplain |

These top disturbances can happen throughout the river system but are seen more within midstream to upstream habitat, as well as tributaries. The species that habitate mainly upstream have a higher percentage to come in contact with these disturbances, creating a larger need for protection from their affects.

Habitat rehabilitation recommendations

- ◆ Forestry, agricultural, and grazing practices should allow riparian zones to maintain a full range of natural vegetative characteristics, i.e., characteristics occurring in watersheds with natural disturbances regimes. Riparian zones should ideally be wide enough to fulfill all functions necessary for maintaining aquatic productivity.
- ◆ Sediment from all land uses should be reduced to magnitudes appropriate to the geological setting of a stream corridor. In practical terms, the goal is that human activities should cause no net increase in sediment over natural inputs. Likewise, water temperatures should reflect as closely as possible the normal regime of temperatures through the corridor.
- ◆ Patterns of water runoff, including surface and subsurface drainage, should match to the greatest extent possible the natural hydrological pattern for the region in both quantity and quality. Effects of consumptive water uses on both the timing and the quantity of flow should be minimized. Water-management technologies that promote the restoration of natural runoff patterns and water quality should be strongly encouraged. That will mean implementation of methods to reduce the volumes of water used for irrigation, industrial, and urban uses.
- ◆ Toxic waste products from industrial, mining, agricultural, and urban activities should receive the appropriate treatment before being discharged into any body of water.
- ◆ Habitat reclamation or enhancement activities should emphasize rehabilitation of ecological processes and functions, not artificial creation of habitat. Placement of permanent or semipermanent habitat structures in streams should be discouraged unless it can be clearly demonstrated that no other alternative is available. Existing artificial structures that appear to be impeding natural recovery should be removed.
- ◆ Beneficial long-term efforts of natural disturbances, such as flooding, should be preserved or restored whenever possible. Lowland slough and estuarine habitat rehabilitation should receive high priority in coastal regions.

APPLICABLE SITE VALUES

Environmental Value:

- Existing waterway
- Accessible to salmon populations
- Pacific ocean connection
- Soil suitable for vegetation

Social Value:

- Small town size
- Accessible to people

The results and conclusions of this thesis will be used and applied to the specific site within Washington State.

First, site inventory will be taken to understand the site and its context.

Second, research results will be applied to the site to produce program elements through analysis.

This will lead conceptual design, design development, and eventually a final design that is supported by the results of this research.

Finally, there will be discussion on the final design and how the research results were applied.

Implementation of habitat restoration practices to benefit salmon habitat.

Create opportunity for people to interact with the water and the environment in passive and active ways.

Educate the public on ecological systems of salmon and the environment through safe interaction.






Site Inventory

Port Angeles, WA

Clallam County
Olympic Peninsula

SITE MAP

Population: **19,190**
99% Urban
1% Rural

-  City of Port Angeles boundary
-  Olympic National Park
-  Valley Creek (Site Location)

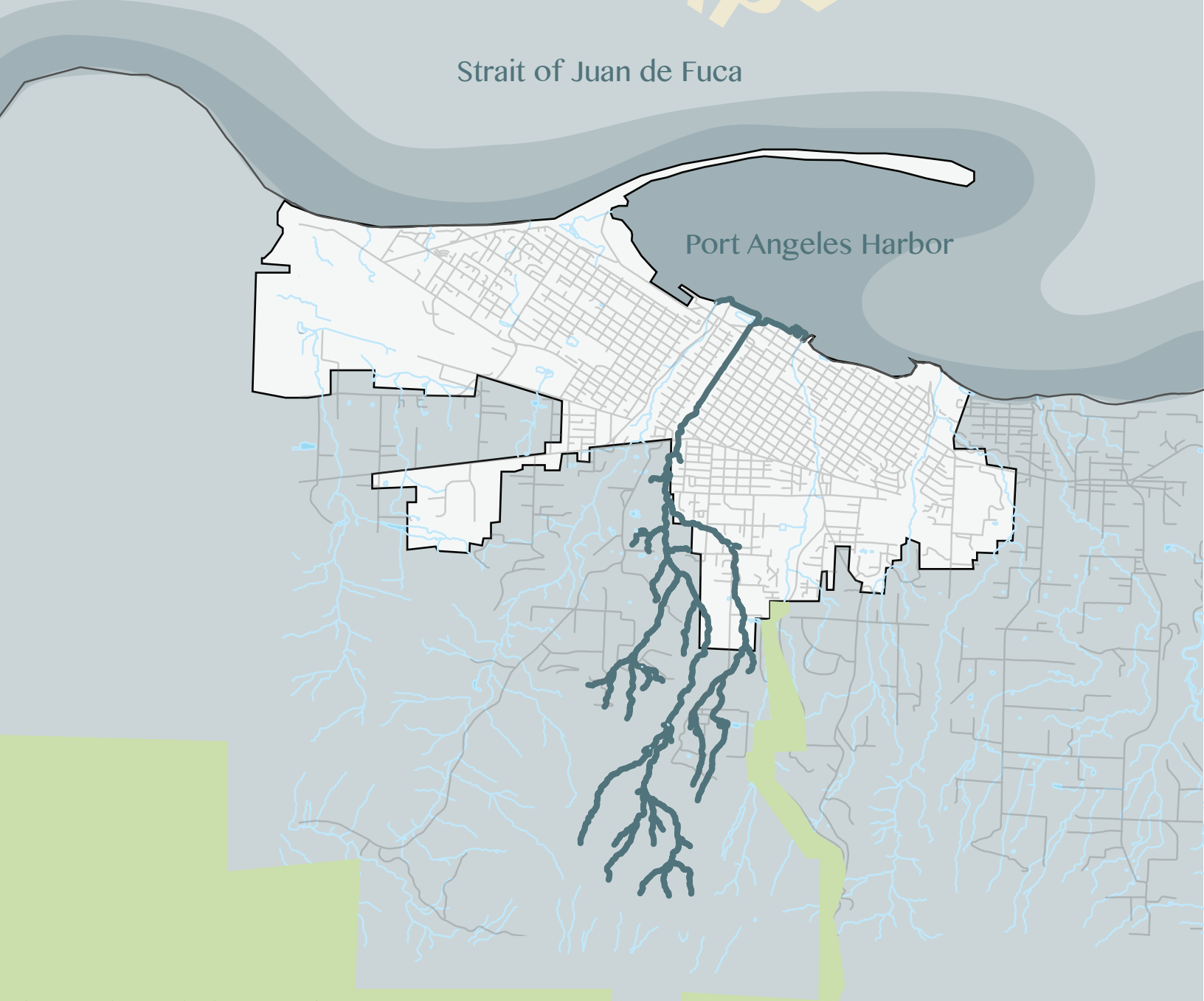


Figure 12. Site Location in Port Angeles, WA

Average Temperature

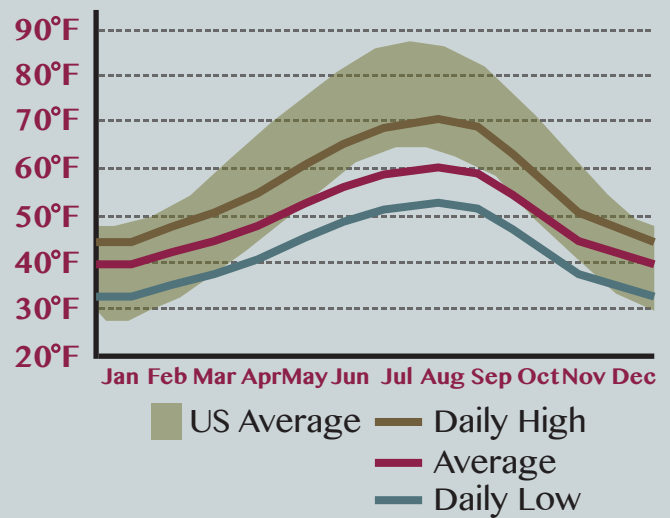


Figure 15. Average temperature in Port Angeles, WA (City-data.com, 2015)

Cloudy Days

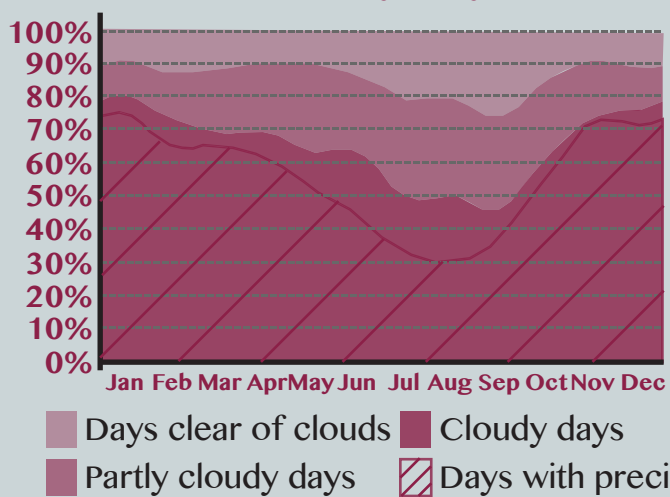


Figure 13. Monthly cloudy days in Port Angeles, WA (City-data.com, 2015)

Precipitation

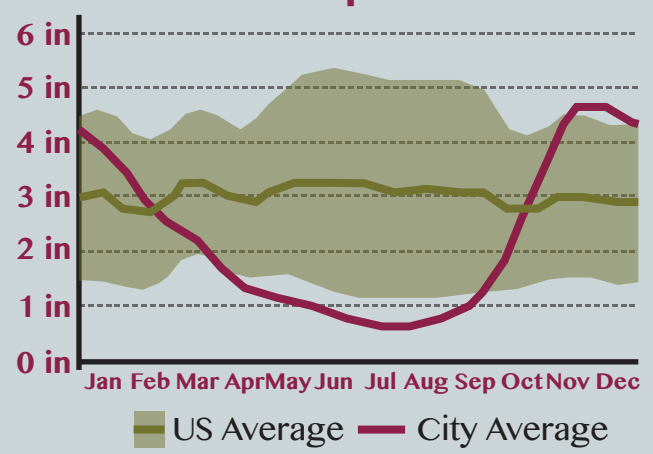


Figure 16. Average precipitation in Port Angeles, WA (City-data.com, 2015)

Sunshine

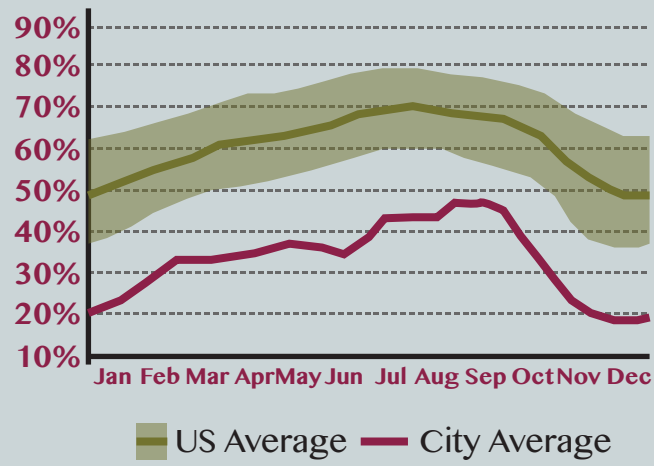


Figure 14. Sunshine in Port Angeles, WA (City-data.com, 2015)

Snowfall

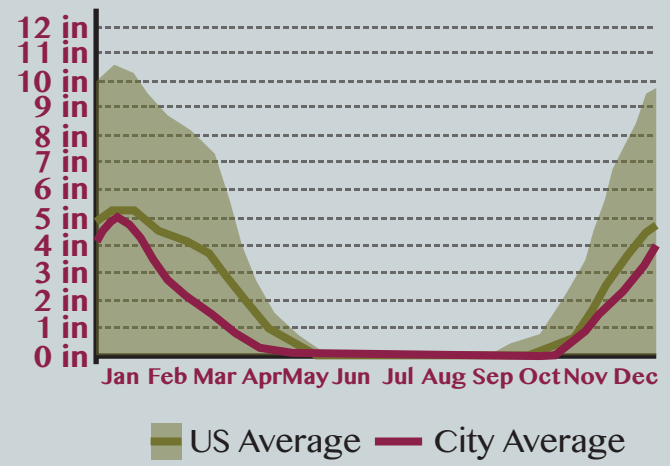


Figure 17. Average Snowfall in Port Angeles, WA (City-data.com, 2015)

CIRCULATION



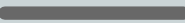

- Primary Vehicular 
- Secondary Vehicular 
- Tertiary Vehicular 
- Valley Creek (Site Location) 



Figure 18. Road circulation around stream site in Port Angeles, WA (Clallam.net, 2015)

- Urban ○
- Water body ●
- Public land ●
- Rural Low ●
- Rural Neighborhood Conservation ●
- Open Space ●
- Commercial Forest/Residential Mixed use ●
- Olympic National Park ●
- Rural character conservation ●
- Commercial forest ○
- Valley Creek (Site Location) —

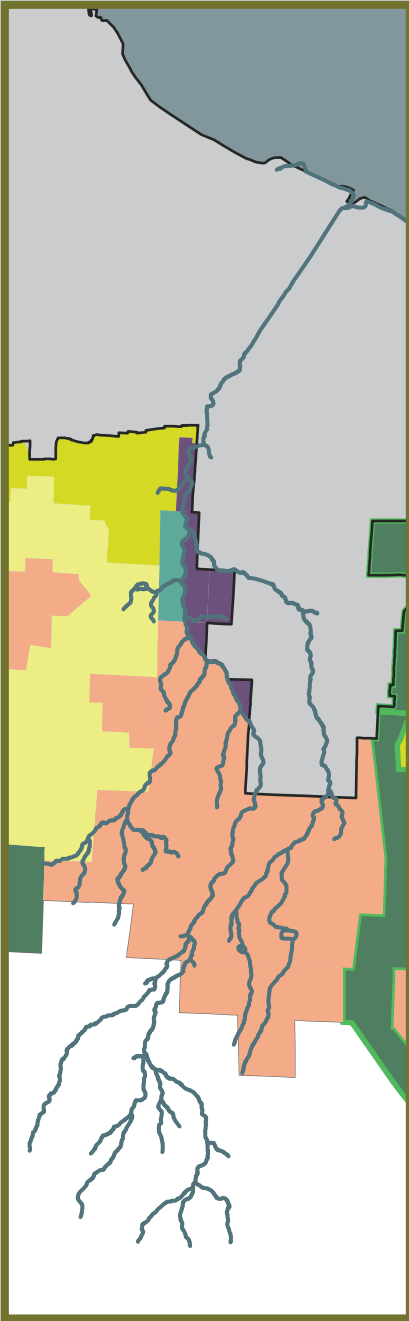


Figure 19. Land zoning outside city limits around site location (Clallam.net, 2015)

- Central Business District ●
- Central Business District ●
- Residential High Density ●
- Residential Single Family ●
- Commercial Arterial ●
- Commercial Shopping District ●
- Commercial Office ●
- Industrial Heavy ●
- Industrial Light ●
- Public Buildings & Parks ●
- Residential Single Family ●
- Valley Creek (Site Location) —



Figure 20. Land use and Zoning in city limits around site location (Clallam.net, 2015)

- 3** Beaches
- 4** Bellingham silty clay loam
- 12** Clallam gravelly sandy loam, 0-15% slopes
- 14** Clallam-Hoypus gravelly sandy loam, 0-15% slopes
- 19** Dystic Xerorthents, extremely steep
- 20** Elwha gravelly sandy loam, 0-15% slopes
- 21** Elwha gravelly sandy loam, 15-35% slopes
- 23** Hoypus gravelly sandy loam, 0-15% slopes
- 34** Louella gravelly loam, 10-30% slopes
- 35** Louella gravelly loam, 30-65% slopes
- 42** McKenna gravelly silt loam
- 44** Neilton very gravelly loamy sand, 30-70% slopes
- 45** Neilton very gravelly loamy sand, 5-30% slopes
- 59** Schnorbush loam, 0-20% slopes
- 70** Terbies very gravelly sandy loam, 30-65% slopes

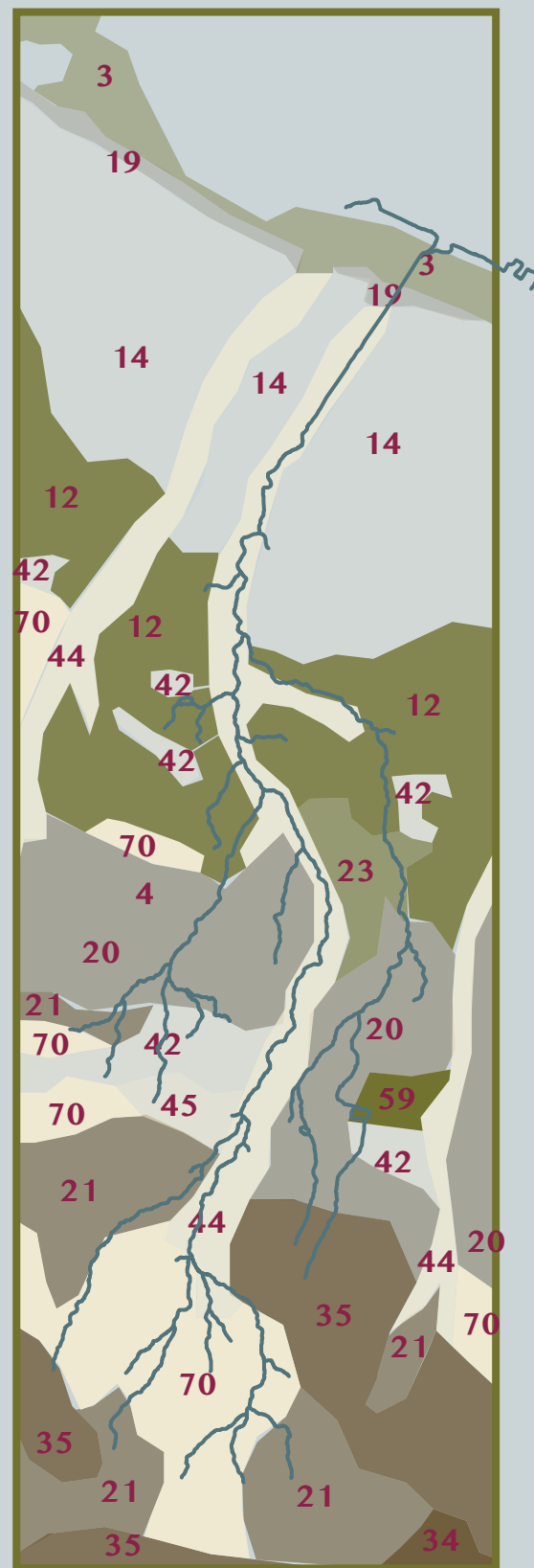
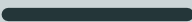


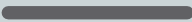






Figure 21. Soils around site location in Port Angeles, WA. (Websoilsurvey.sc.egov.usda.gov, 2015)

HYDROLOGY

- Valley Creek Mainstream 
- Valley Creek Tributaries 
- Valley Creek Estuary & waterfront 
- Secondary stream systems 
- Port Angeles Harbor (Leads to Strait of Juan de Fuca) 
- Inland water Bodies (Lakes and wetlands) 
- Valley Creek starts at the foothills of the Olympic Mountains 
- Fish passage obstruction
Culvert: 2000 ft 
Channelization: 2000 ft

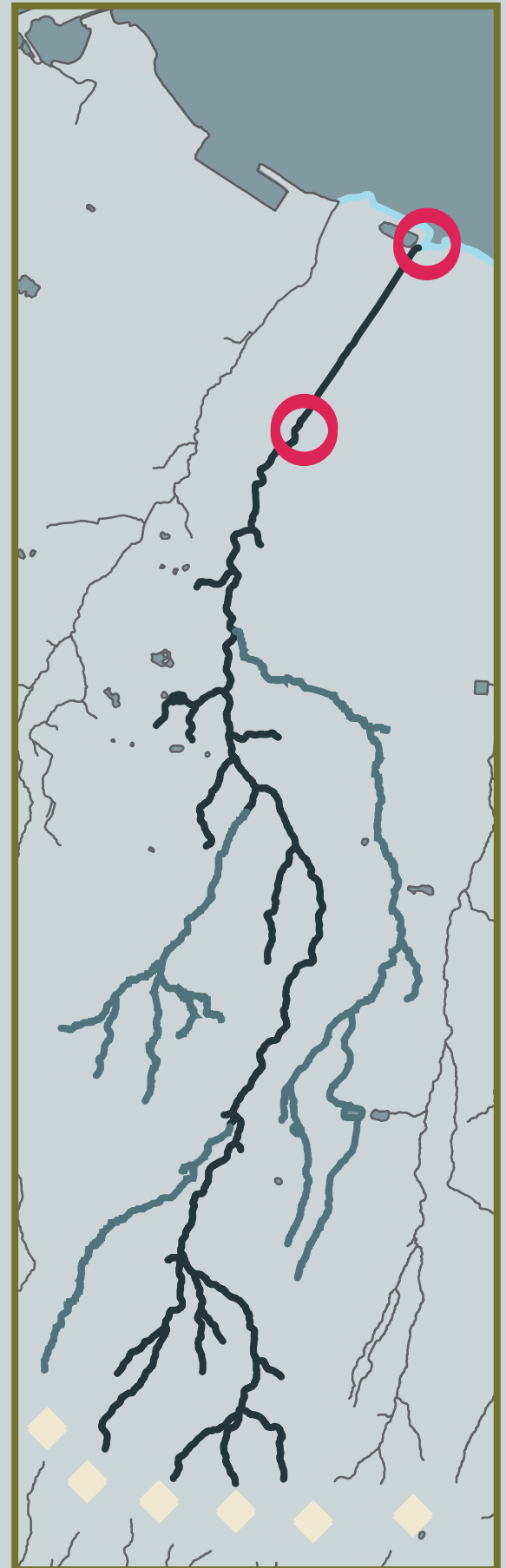


Figure 22. Hydrology of site location (Clallam.net, 2015)

Historic Wildlife Habitat Types Current Wildlife Habitat Types

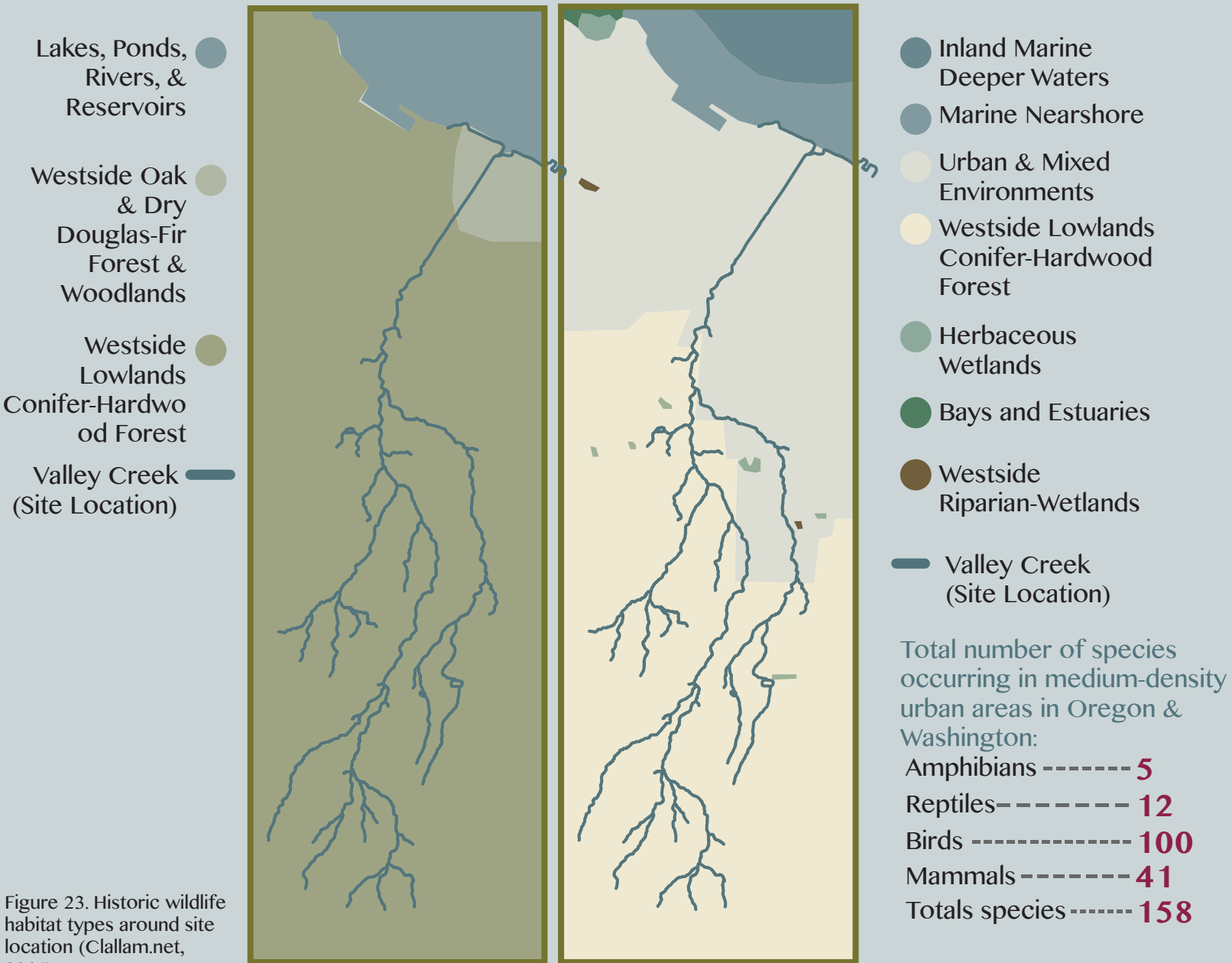


Figure 23. Historic wildlife habitat types around site location (Clallam.net, 2015)

Figure 24. Current wildlife habitat types around site location (Clallam.net, 2015)

51 Forest Composition

Conifer Hardwood Forest Dominated by evergreen conifers, deciduous broadleaf trees, or both. Abundance of large coniferous trees, a multi-layered canopy structure, large snags, and many large logs on the ground. Undersortories are structurally diverse and mosses are often a major ground cover (Johnson & O'Neil, 2001).



◆ Trees

- ◆ Western Hemlock
- ◆ Douglas-Fir
- ◆ Western Redcedar
- ◆ Sitka Spruce
- ◆ Red Alder
- ◆ Bigleaf Maple



◆ Shrubs

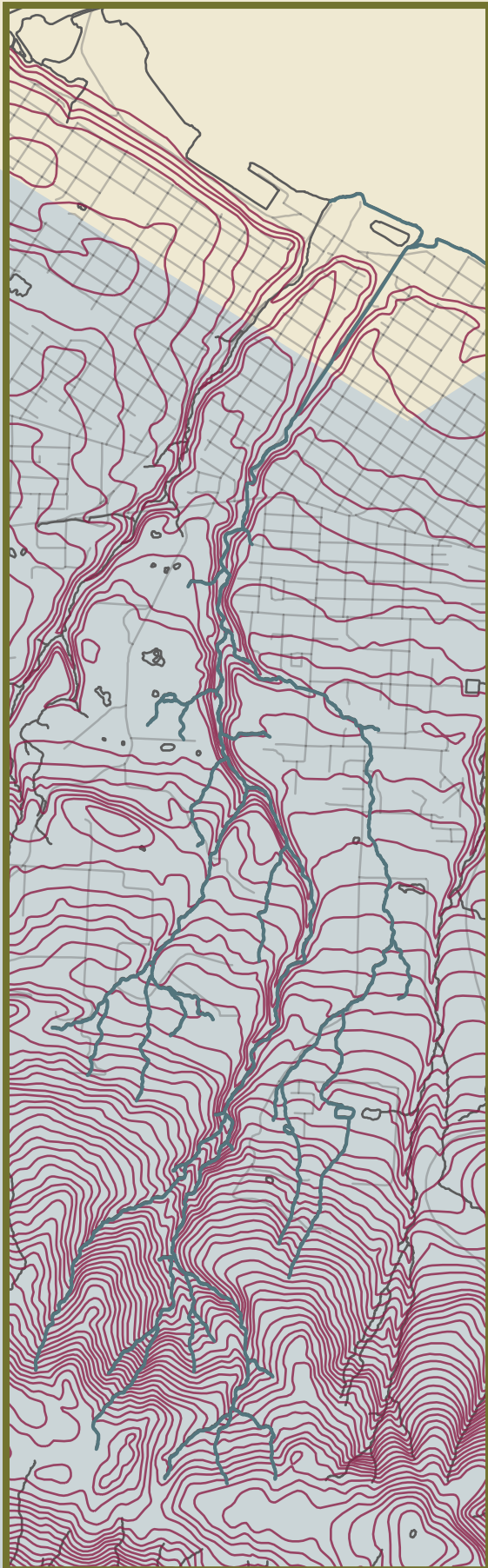
- ◆ Salal
- ◆ Dwarf Oregongrape
- ◆ Vine Maple
- ◆ Pacific Rhododendron
- ◆ Salmonberry
- ◆ Trailing Blackberry
- ◆ Beargrass
- ◆ Oval-leaf Huckleberry
- ◆ Evergreen Huckleberry
- ◆ Red Huckleberry
- ◆ Fools Huckleberry
- ◆ Red Elderberry



◆ Forbs

- ◆ Swordfern
- ◆ Oregon Oxalis
- ◆ Deerfern
- ◆ Bracken Fern
- ◆ Vanillaleaf
- ◆ Common Whipplea
- ◆ Western Springbeauty
- ◆ Foamflower
- ◆ Inside-out flower
- ◆ Moss
- ◆ Twinflower
- ◆ False Lily-of-the-valley

Figure 25. Forest vegetation examples



Total elevation gain from sea level to headwaters is 2500 ft. The mainstream of Valley Creek sits inside of a ravine with a minimum of 80 feet in elevation.

- Valley Creek (Site Location)
- Roads
- 40 ft Contours

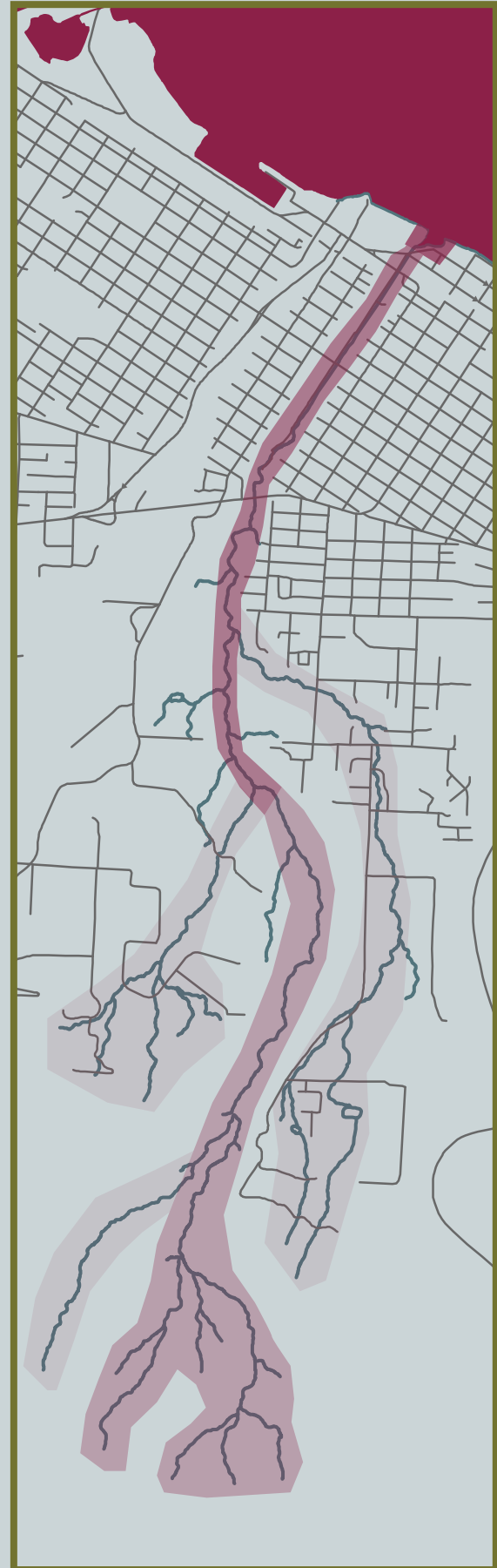
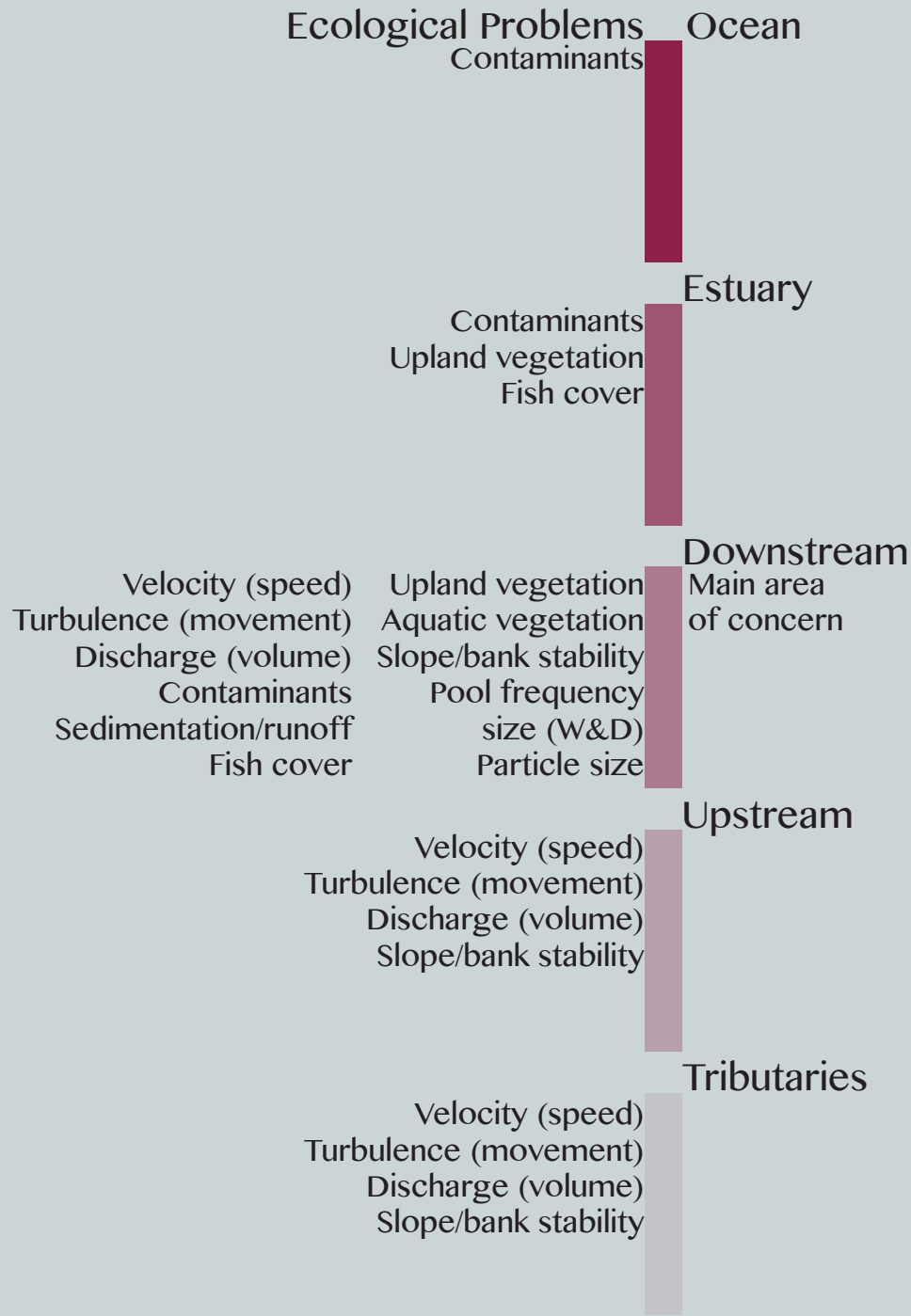
Figure 26. Topography in and around site location (Viewer.nationalmap.gov, 2015)



Discussion

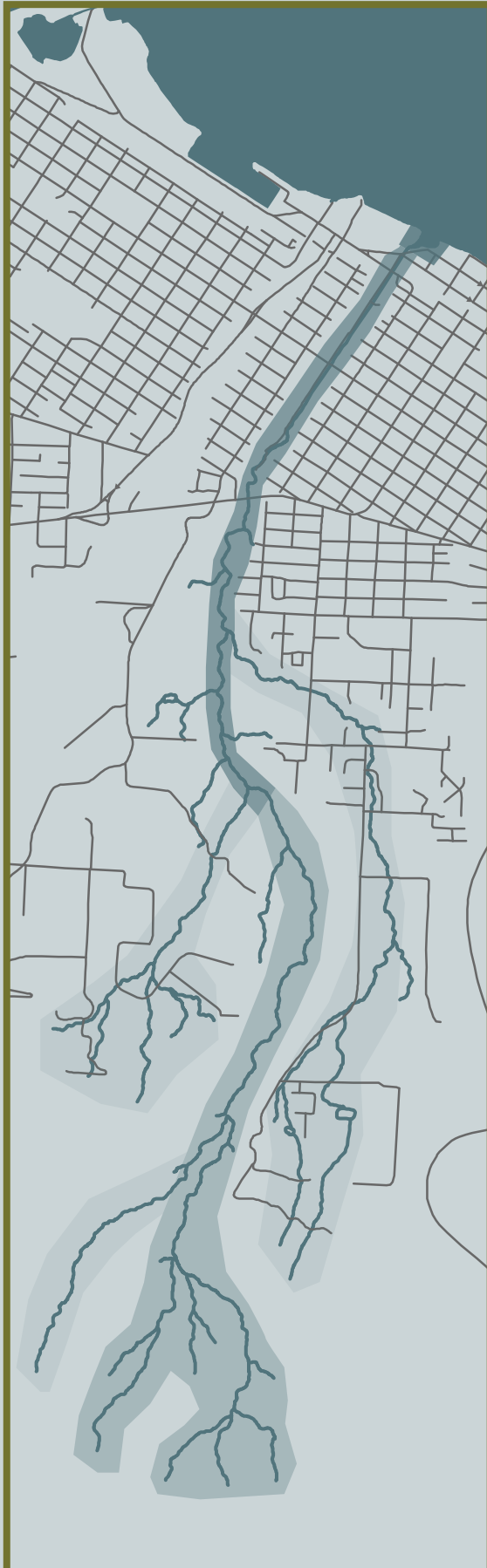
RESEARCH
RESULTS APPLIED

The research in this thesis has been applied to the specific site within the city of Port Angeles. With this research and the inventory, initial analysis can be done. Valley creek comes into contact with multiple types of human interaction throughout its length, consisting of rural and urban areas. This creates an opportunity to incorporate the research of this thesis; restoration efforts as well as human interactions with the water and the salmon.



In-stream habitat needs initial restoring. Daylighting and meandering the urban portion of the stream brings more natural and historic habitat to the migrating salmon and other aquatic life. The estuary also needs protection from the port industry that happens within Port Angeles. Having a natural stream inlet brings emphasis to the importance of aquatic life and salmon. when you move upstream and to the tributaries, restoration is needed as well for in-stream processes. Protection of the water flow is also important to insure that the stream can supply enough water for salmon migrating and spawning.

Figure 27. Site analysis map (Clallam.net, 2015)



Ocean

Active interaction area (Boating, swimming, kayaking, fishing)

Estuary

Estuary Park (Existing)
Active interaction area (Swimming, kayaking, fishing)

Downstream

Verne Samuelson Trail (Existing)
Active and passive interaction areas (Lookouts, fishing, trails)
Area to bring urban community together
Manage land use around stream corridor

Upstream

Foothills trail (Existing)
Passive interaction areas (Lookouts, trails)
Area to bring urban community together
Manage land use around stream corridor
Trail system opportunity

Tributaries

Passive interaction areas (Lookouts, trails)
Manage wildlife in riparian habitat
Manage land use around stream corridor

Each section of the stream creates different opportunities for out-of-stream activities for humans and wildlife. Up and middle stream are in more rural areas, promoting more natural areas. The riparian habitat can attract people with a natural park setting that can hold trails and viewing areas. The area can also promote native wildlife habitat. When you move downstream, the stream gets more urban, merging into the city of Port Angeles. Daylighting the stream will bring opportunities to attract the community and bring them closer to each other and nature. This gives them a chance to witness salmon and their lifecycles.

Figure 28. Site analysis map (Clallam.net, 2015)

Declaration of Interdependence

This We Know.

We are the earth, through the plants and animals that nourish us. We are the rains and the oceans that flow through our veins. We are the breath of the forests of the land, and the plants of the sea. We are human animals, related to all other life as descendants of the firstborn cell. We share with these kin a common history, written in our genes. We share a common present, filled with uncertainty. And we share a common future, as yet untold. We humans are but one of thirty million species weaving the thin layer of life enveloping the world. The stability of communities of living things depends upon this diversity. Linked in that web, we are interconnected - using, cleansing, sharing, and replenishing the fundamental elements of life. Our home, planet Earth, is finite, all life shares its resources and the energy from the sun, and therefore has limits to growth. For the first time, we have touched those limits. When we compromise the air, the water, the soil and the variety of life, we steal from the endless future to serve the fleeting present.

This We Believe.

Humans have become so numerous and our tools so powerful that we have driven fellow creatures to extinction, dammed the great rivers, torn down ancient forests, poisoned the earth, rain and wind, and ripped holes in the sky. Our science has brought pain as well as joy; our comfort is paid for by the suffering of millions. We are learning from our mistakes, we are mourning our vanished kin, and we now build a new politics of hope. We respect and uphold the absolute need for clean air, water and soil. We see that economic activities that benefit the few while shrinking the inheritance of many are wrong. And since environmental degradation erodes biological capital forever, full ecological and social cost must enter all equations of development. We are one brief generation in the long march of time; the future is not ours to erase. So where knowledge is limited, we will remember all those who will walk after us, and err on the side of caution.

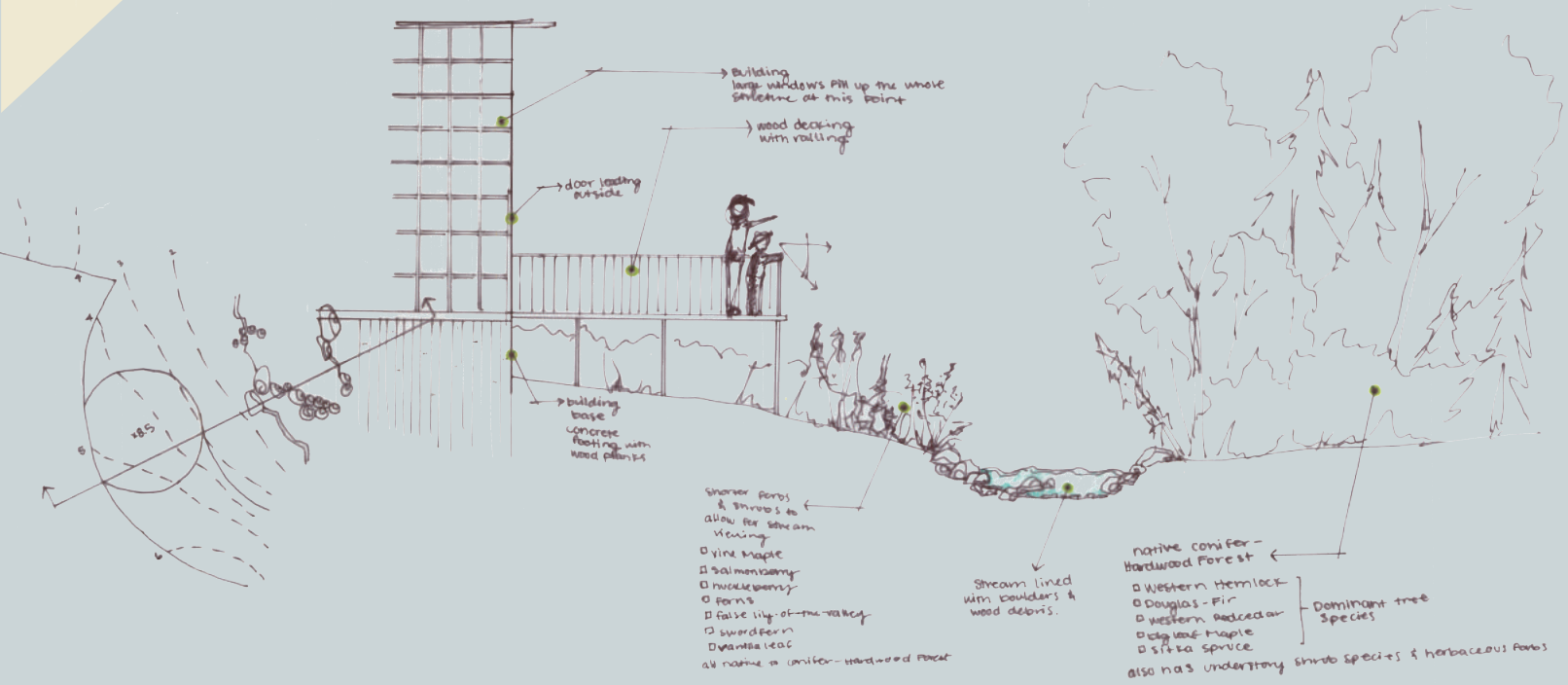
This We Resolve.

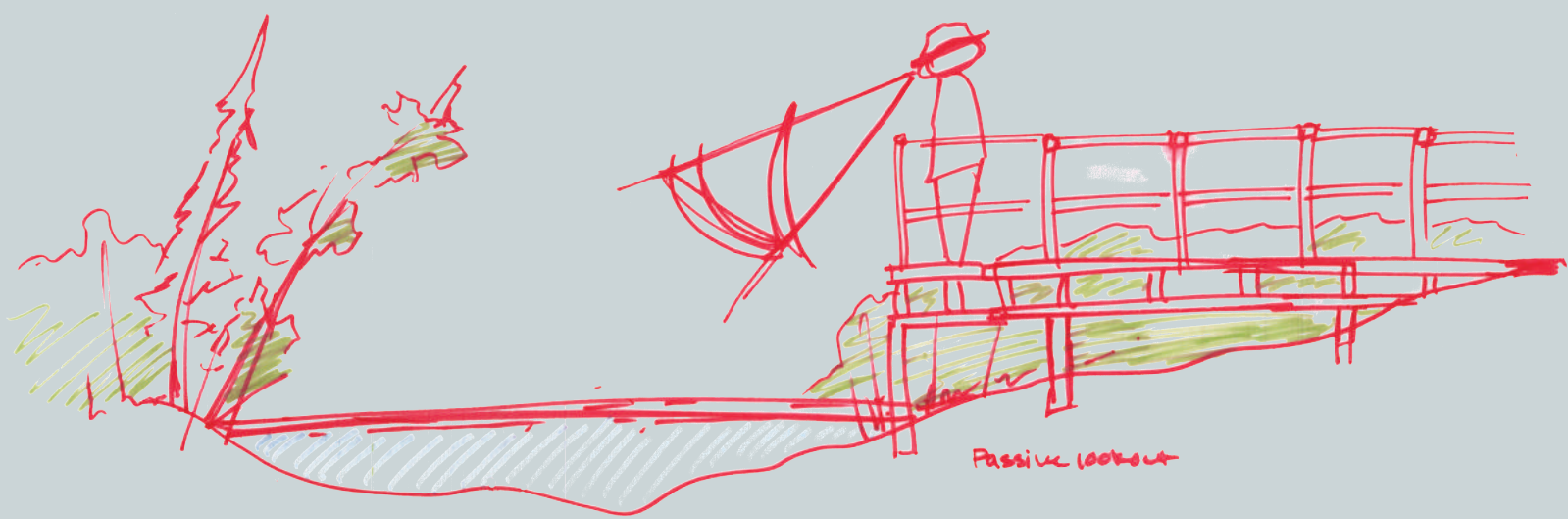
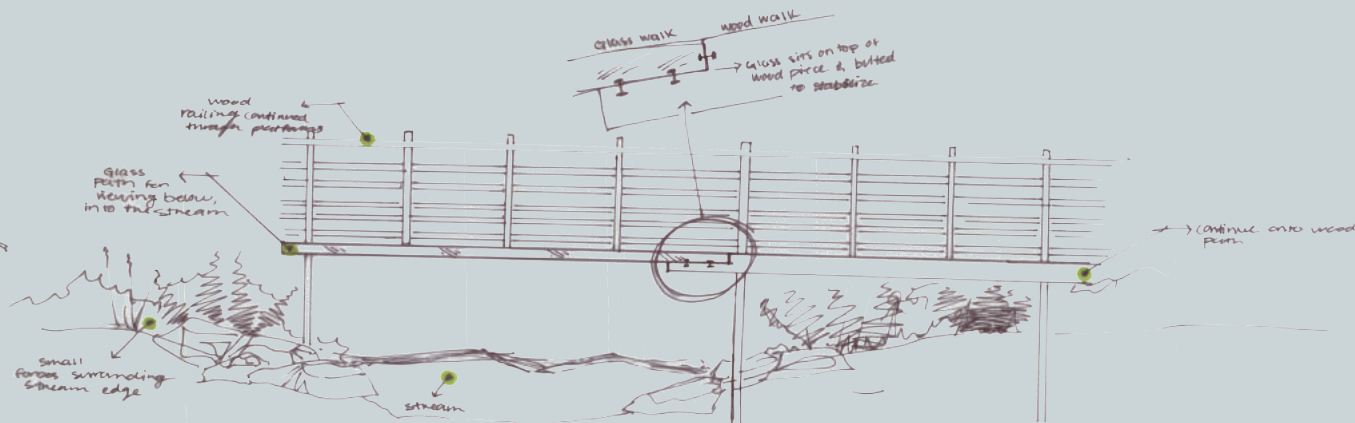
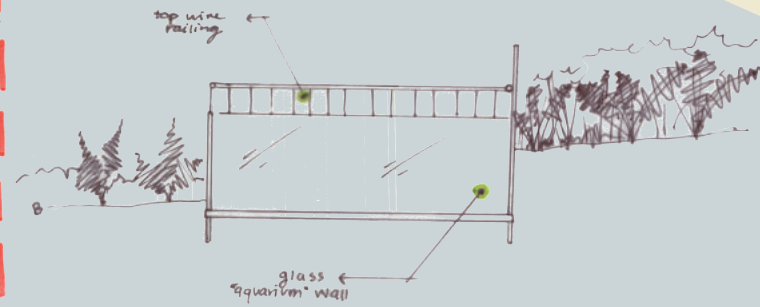
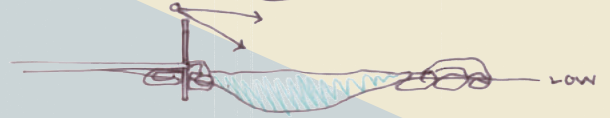
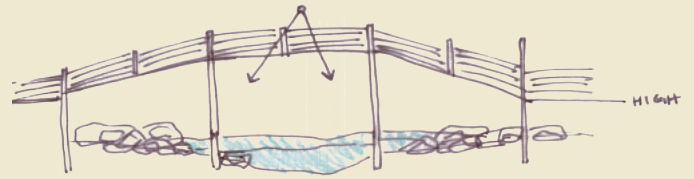
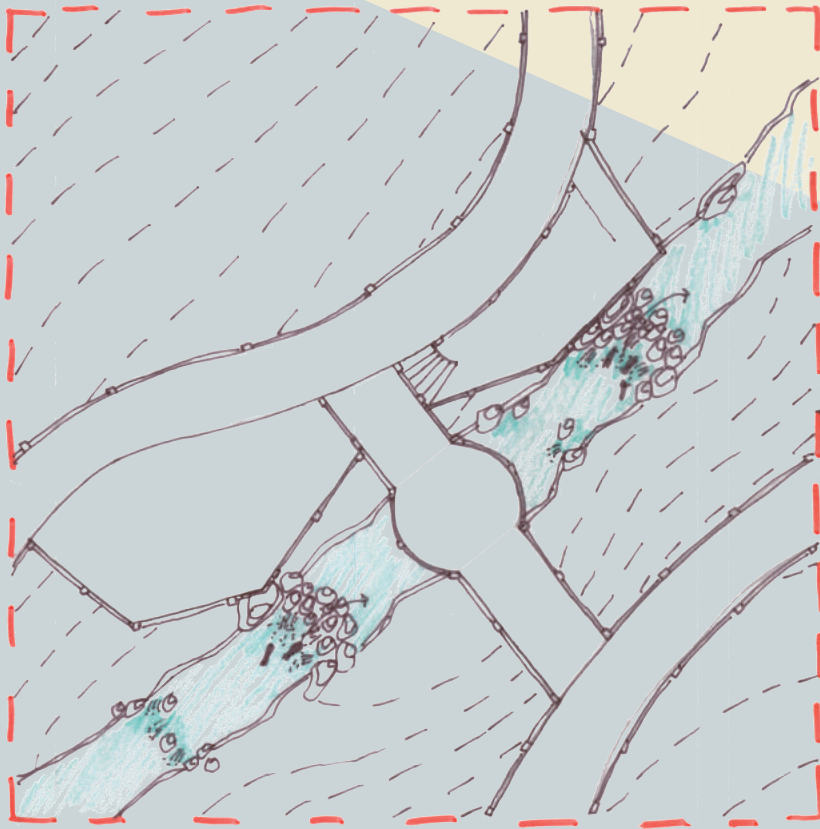
All this that we know and believe must now become the foundation of the way we live. At this turning point in our relationship with Earth, we work for an evolution: from dominance to partnership; from fragmentation to connection; from insecurity, to interdependence.

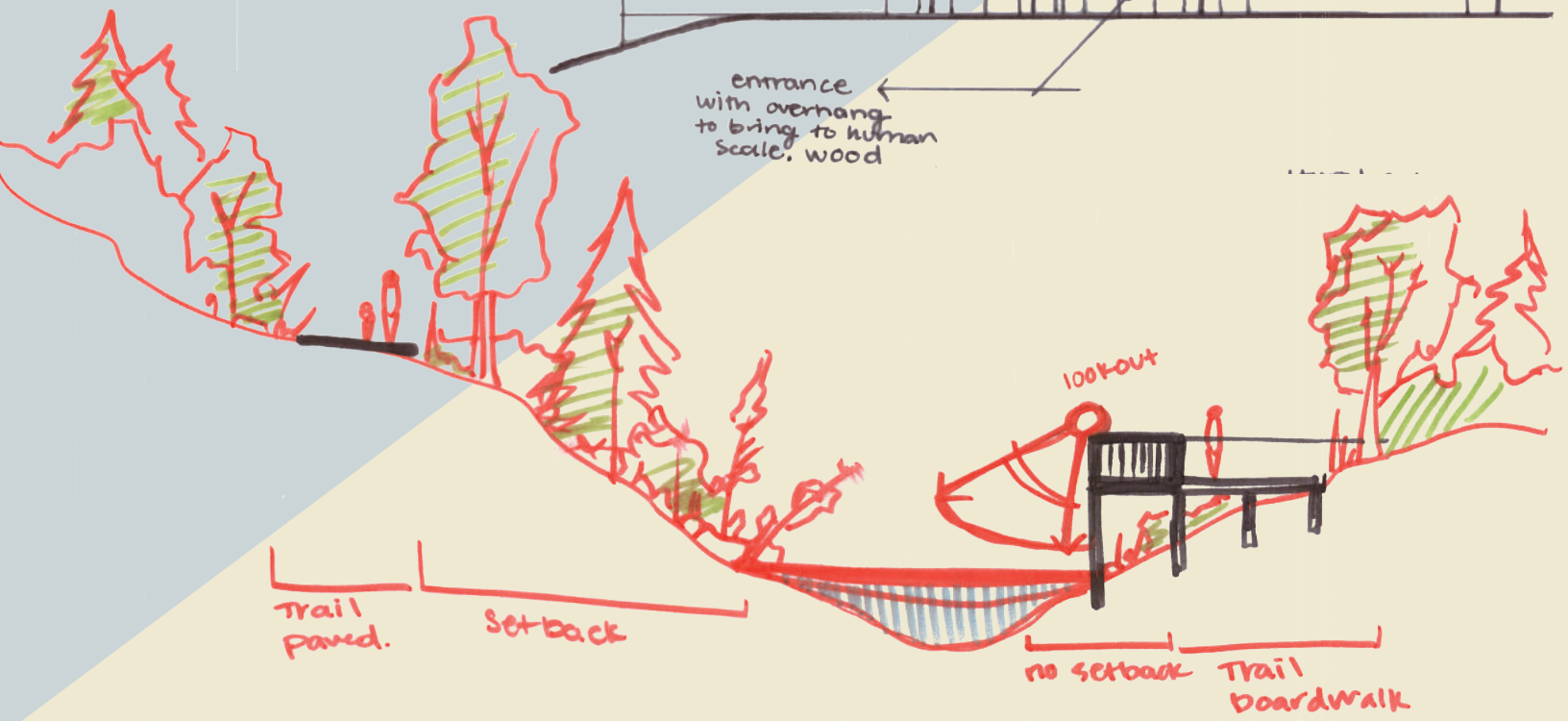
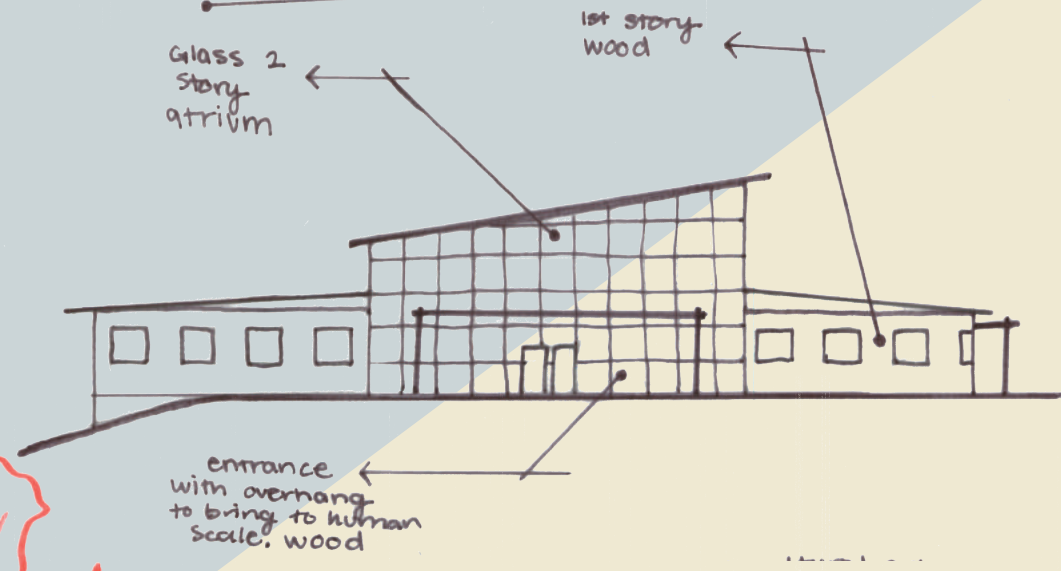
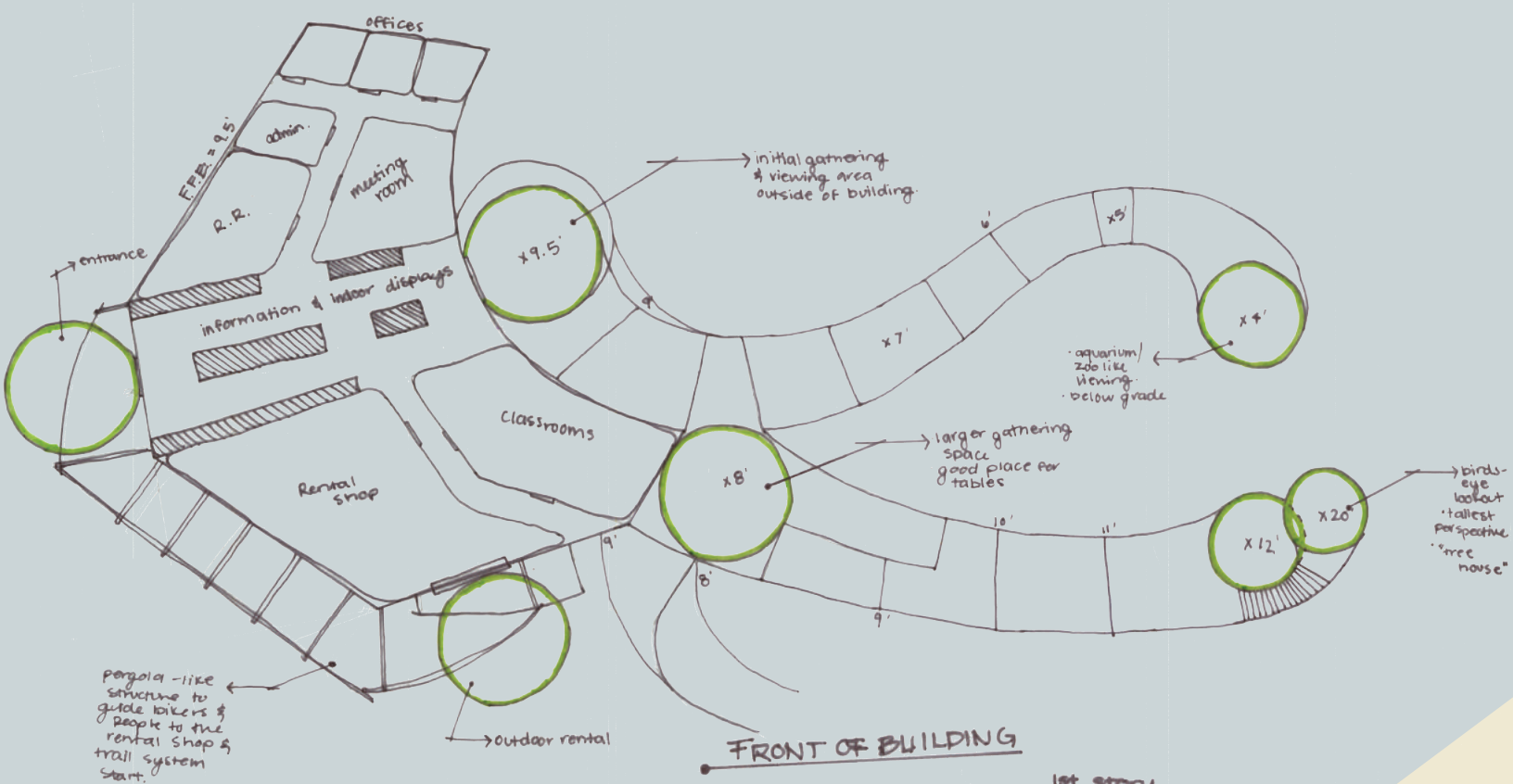


Design Development

CONCEPT SKETCHES









Design Solution

This finalized design focuses on the safe connection between the environment and humans. Throughout the Valley Creek corridor, different ecological and recreational improvements are implemented. These improvements provide a better habitat for the salmon species and support their lifecycle. The trail system and recreational improvements provide avenues for people to interact with the environment and salmon in safe ways, educating them on the importance of these animals.



Trail Access Points



Figure 29. Master plan

Ecological Improvements



Water Flow Improvements



Erosion Control



Riparian Vegetation Restoration



Pollution Control



Stream Habitat Restoration

The ecological improvements were focussed downstream within the more urban environment, although some upstream and tributary improvements were implemented as well.

- ◆ Within the ocean environment pollution control methods were introduced to control the pollution coming from the ships and industry in the Port Angeles Harbor.
- ◆ In the estuary, pollution control and riparian vegetation improvements were implemented. The City of Port Angeles has already started restoration on the Estuary Park. These processes are to continue to fully restore the estuary.
- ◆ The downstream section of the creek has the most ecological improvements; water flow, erosion control, riparian vegetation restoration, pollution control and stream habitat restoration. The existing culvert and channilization was removed and the stream was restored back to its natural meandering. This helped restore the natural water flow. Because the topography changed with the restoration, erosion control methods were used to stabilize the stream bank. Part of this was restoring the riparian vegetation. Vegetation also helps to keep the stream at the right temperature and supplies habitat for upland wildlife. Vegetation also helps with pollution control, filtering runoff from the surrounding

development. Stream habitat restoration makes stream environments suitable for salmon with the right conditions for their lifecycle stages. These area things like streambed particle size and aquatic vegetation for cover and food.

- ◆ The tributaries of valley creek needed water flow improvements, erosion control and riparian vegetation restoration, especially in areas where people are residing. Riparian habitat buffers were created to protect the stream from runoff from development. This riparian restoration essentially fixed the erosion and pollution problems.
- ◆ In the upstream section water flow and erosion control were the main improvements implemented. Water flow and erosion control were controlled through the implementation of rock vanes and root wads.

Rock vanes are boulders set in a stream to 1) protect the streambank by redirecting the flow away from the streambank and towards the center of the channel, and 2) improve in-stream habitat through pool creation, oxygenation, and cover. Vanes are orientated upstream with angles off the bank from 20 to 30 degrees. All rocks should be touching in the single line with footer rocks downstream. J-hook rock vanes have two or three extra rocks not touching to form the “J”. These types of rock vanes create large pools for aquatic habitat. In these pools, fish will sit for shelter because of the deeper water (Harman & Smith, 2004).

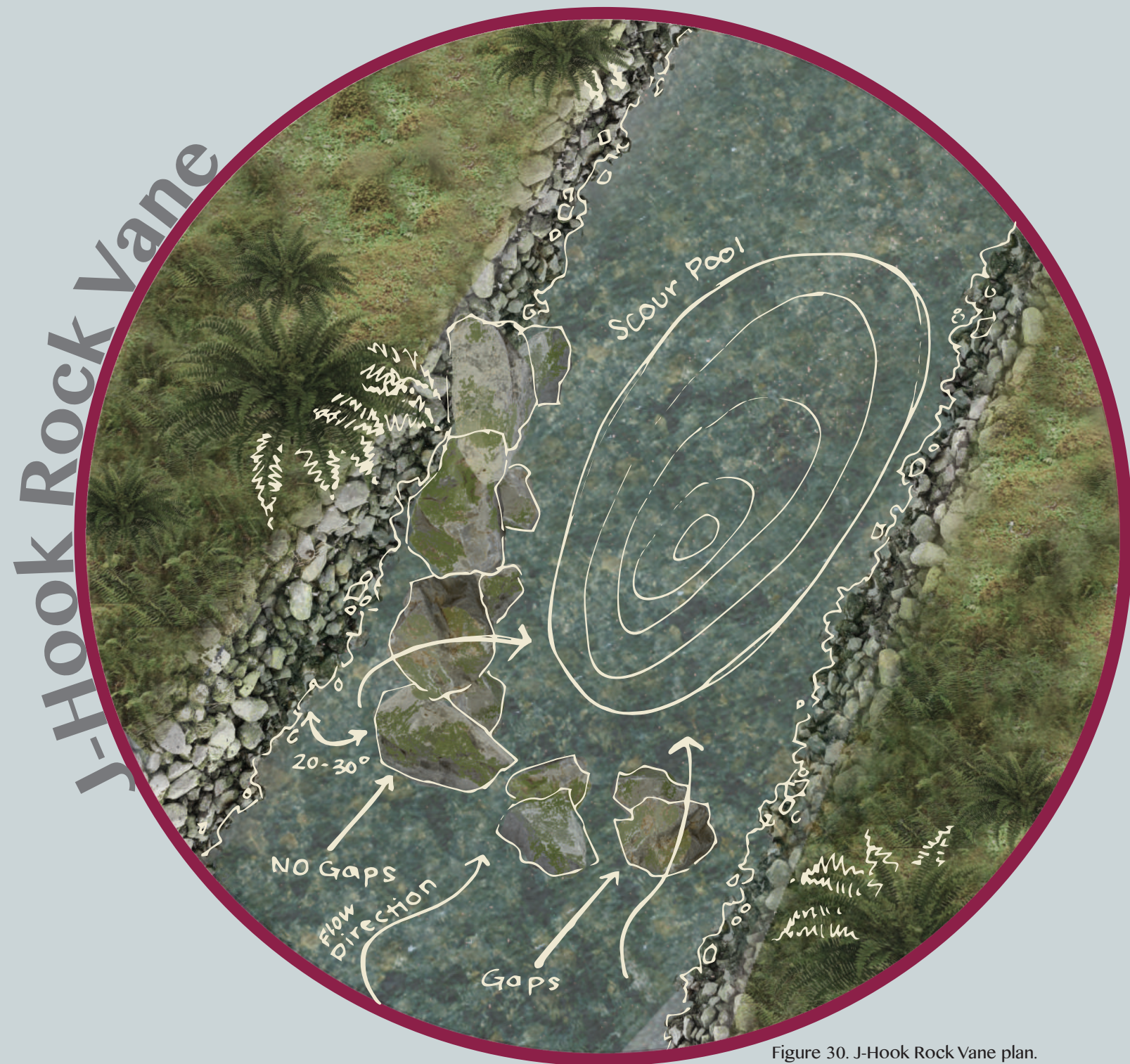


Figure 30. J-Hook Rock Vane plan.

Root wads incorporate the root ball or root mass of a tree and a portion of the trunk to provide structural support to the streambank, habitat for fish, as well as a food source for aquatic insects. The root wad should be placed at an acute angle with the streambank, angled upstream. A footer log should be placed below the root wad for stability, as well as large boulders on top of the wad under the soil. These root wads will be replicated along the bend of a stream to reduce erosion. Live cuttings are also placed about the root wad to stabilize the soil (Harman & Smith, 2004).

Root Wads

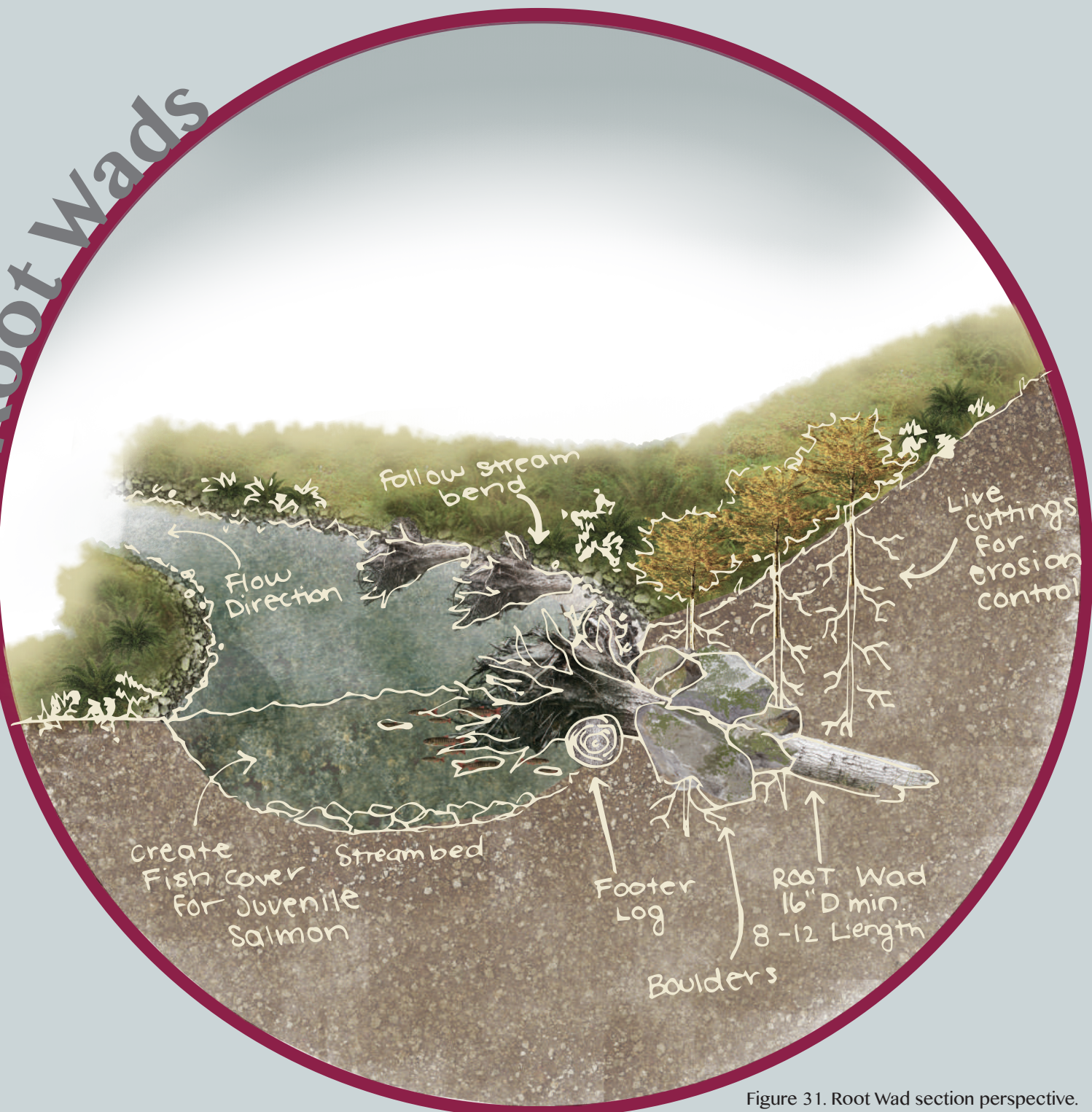
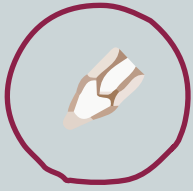


Figure 31. Root Wad section perspective.

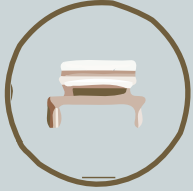
Recreational Improvements



Education



Water Sports



Observation



Hiking

The recreational improvements of the site strive to bring people back to the natural environment. There are more active areas in the downstream, ocean and estuary locations. As you move upstream, less recreational opportunities exist. The recreational improvements work with the environment and are chosen to sustain healthy habitat areas for wildlife.

- ◆ The ocean environment already has some of this recreation. Because it is a harbor, there is a lot of water sports available like boating, swimming, and fishing. Along the lands edge as well as from boats, there are opportunities to observe the environment.
- ◆ The estuary has similar opportunities. Swimming as well as kayaking are an option in this area, as well as observation. Because the estuary was restored by the city, there is opportunity to educate people on why this was important.
- ◆ when you move to the downstream area, water sports decrease because Valley creek isn't deep enough for people to kayak or swim in. There are more options for walking and hiking as well as observing the environment. Education is also important in this area to inform people on the importance of the riparian forest, wildlife, and the salmon species.

- ◆ As you move upstream, intentional observation areas decrease because there are less areas to access the stream. This is intentional, leaving the area to restoration and conservation. There are still opportunities to hike on the foothills trail, at the start of Valley Creek.
- ◆ The tributaries are also left to restoration and conservation, with no opportunities for recreation.

WAYFINDING

The wayfinding signs will be scattered throughout the master plan. The wayfinding will include maps to orientate people as well as mile markers for people to track their walk or hike. The information signs will be placed at specific areas where people have the opportunity to view the natural environment and learn about the processes of the riparian forest, the salmon species, and other wildlife species.

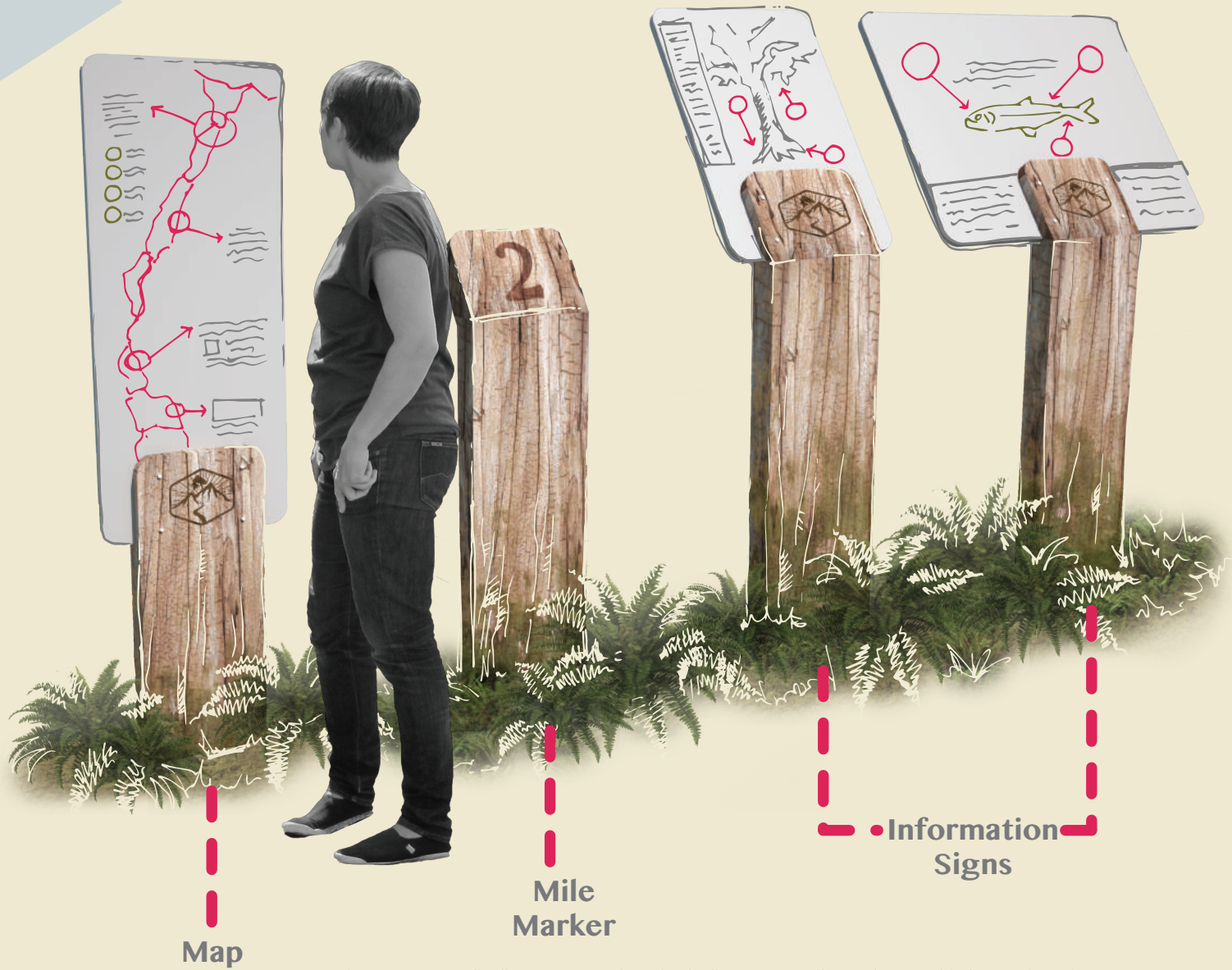


Figure 32. Wayfinding perspectives including map, milemarker, and information signs.

INTERACTION
AREAS

Along the trail system there are four different areas for people to interact with the environment. Each of these areas are located in the lower trail loop (Chum salmon loop) and the upper trail loop (Coho salmon loop) having a total of eight. These interaction areas are paired with a salmon lifecycle stage, creating opportunity for education on the different stages and their vulnerability.

- A** Salmon Migration
- B** Spawning & Beginning of Life
- C** Juvenile Stream Bend
- D** Salmon Investigation

Figure 33. Master plan trail system with interaction areas.

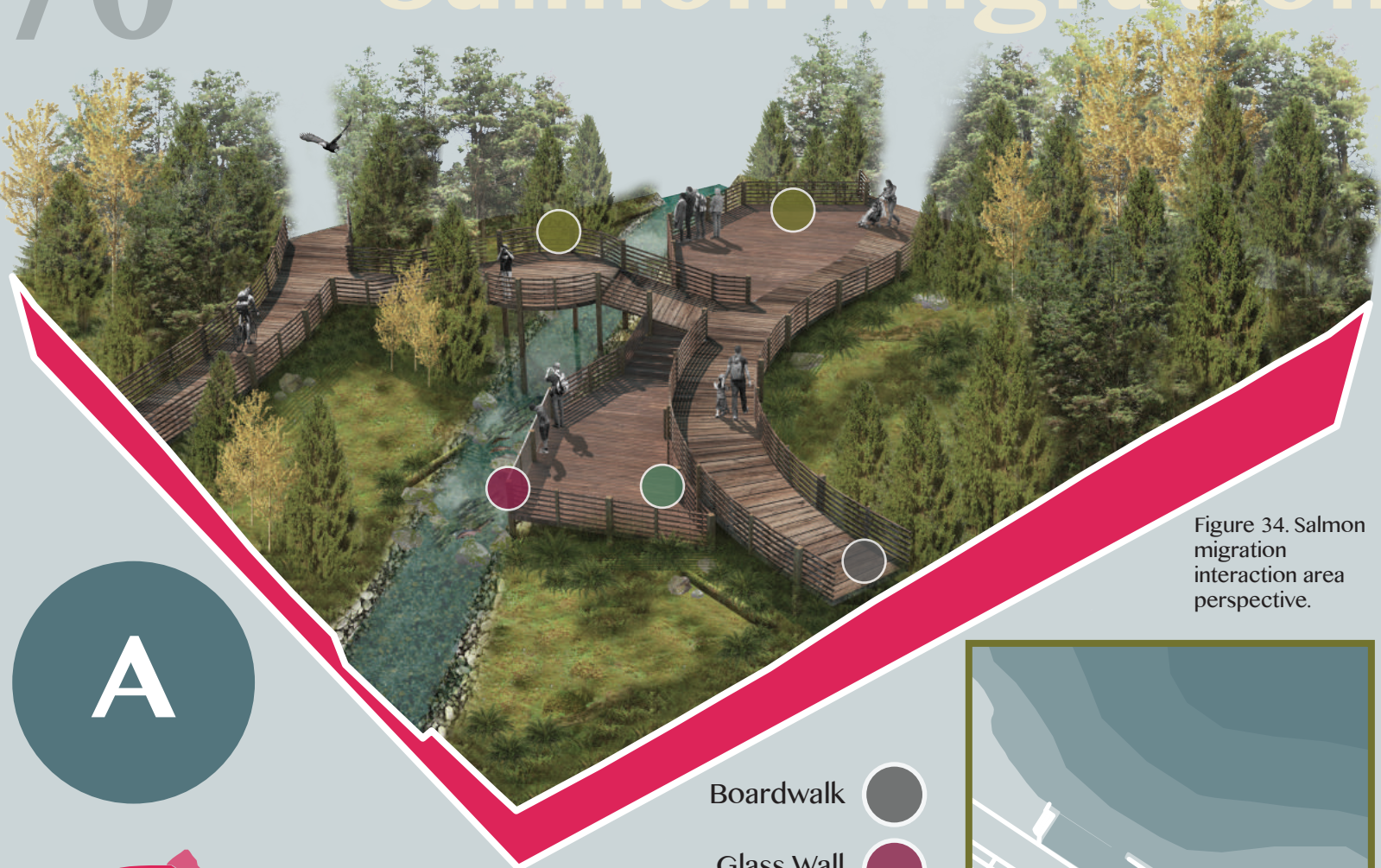
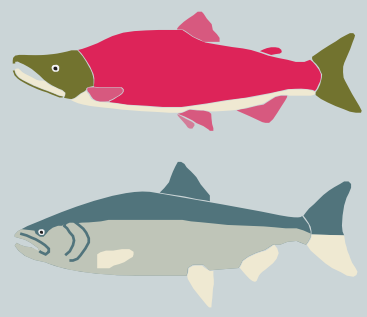




Figure 34. Salmon migration interaction area perspective.



- Boardwalk 
- Glass Wall 
- Viewing Platform 
- Outdoor classroom 

The salmon migration interaction area supports salmon in their adult and spawning stages. In these stages, the species are classified as having a medium vulnerability. Because of this vulnerability, the interaction area is passive. The stream in this area includes rock vanes for spawning salmon to jump over. While the salmon are running, people can view them jumping from different platform areas, all at different elevations.

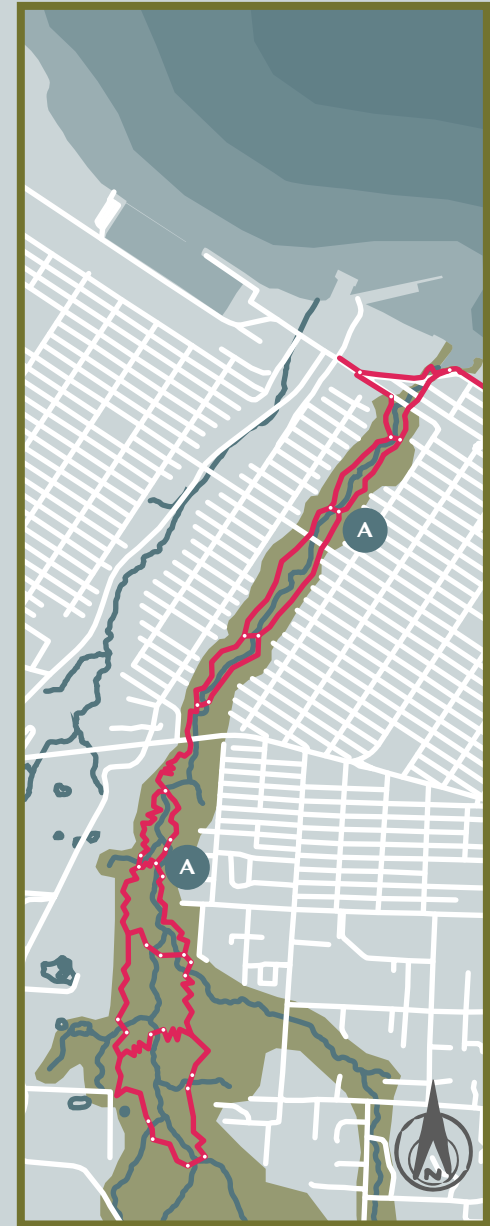


Figure 35. Master plan trails with salmon migration interaction areas.

7.1 Spawning & Beginning of life

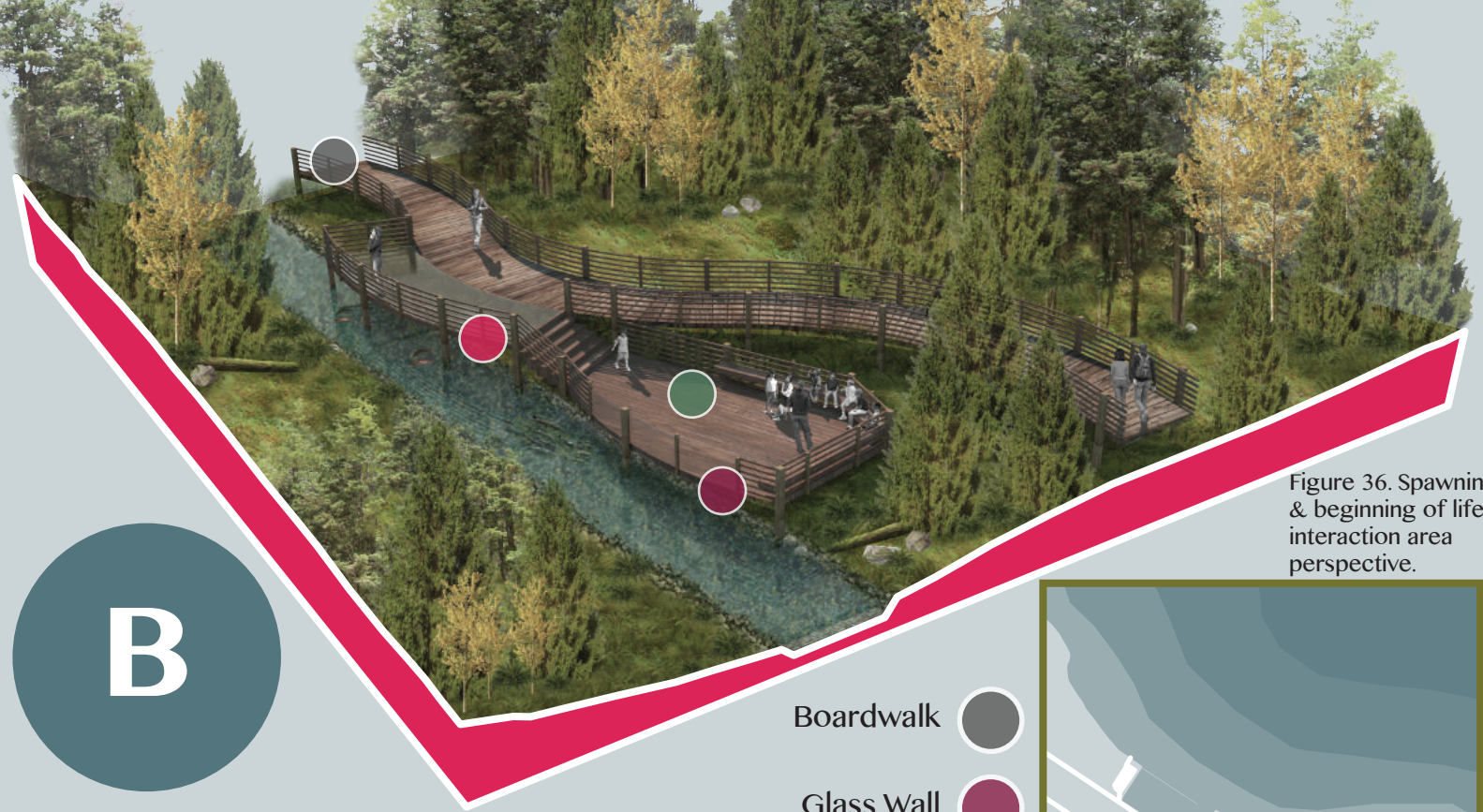
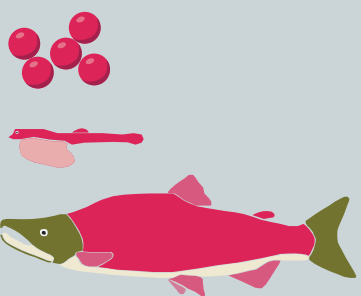


Figure 36. Spawning & beginning of life interaction area perspective.

B



- Boardwalk
- Glass Wall
- Glass Platform
- Outdoor classroom

This interaction area supports salmon eggs, alevins, and spawning adult stages. These stages have a high vulnerability, which is why this area is also passive. The stream habitat is made to accommodate spawning salmon. People have the opportunity to view salmon spawning in the stream and their bright pink eggs. The glass platform gives people an overhead view of this process. There is also an outdoor classroom that brings people closer to the water for viewing.

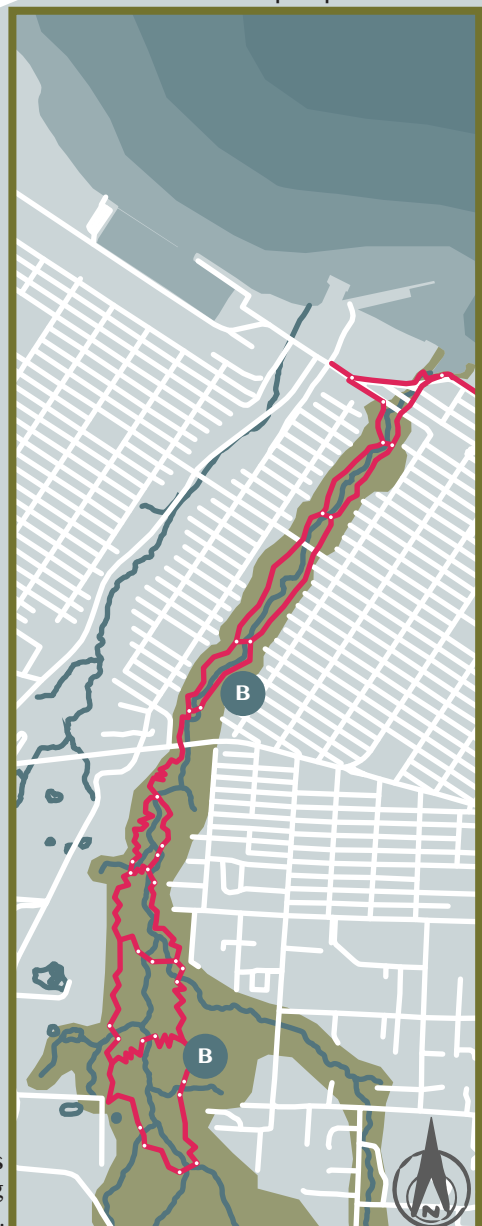


Figure 37. Master plan trails with spawning & beginning of life interaction areas.

72 Juvenile Stream Bend



Figure 38. Juvenile stream bend interaction area perspective.



- Boardwalk
- Hiking Trail



The juvenile stream bend supports juvenile salmon. This includes fry, parr, and smolt stages. These stages are considered medium to low vulnerability, which is why this interaction area is active. Root wads are installed in this area to help with erosion control and it also provides great fish habitat and shelter. This creates good conditions for fishing and this interaction area has different platforms for people to fish for salmon. Fishing in the area is catch and release to add to the preservation of the species. The path system turns into gravel or a hiking path, and follows the inside of the bend as not to add to erosion. This area also gives people the opportunity to view the stream from a higher platform on the outside of the bend.

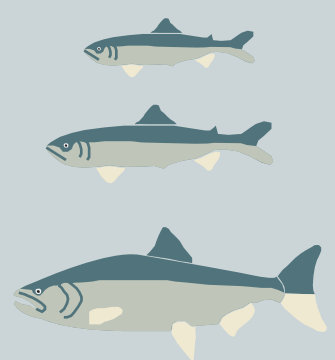


Figure 39. Master plan trails with Juvenile stream bend interaction areas.

73 Salmon investigation

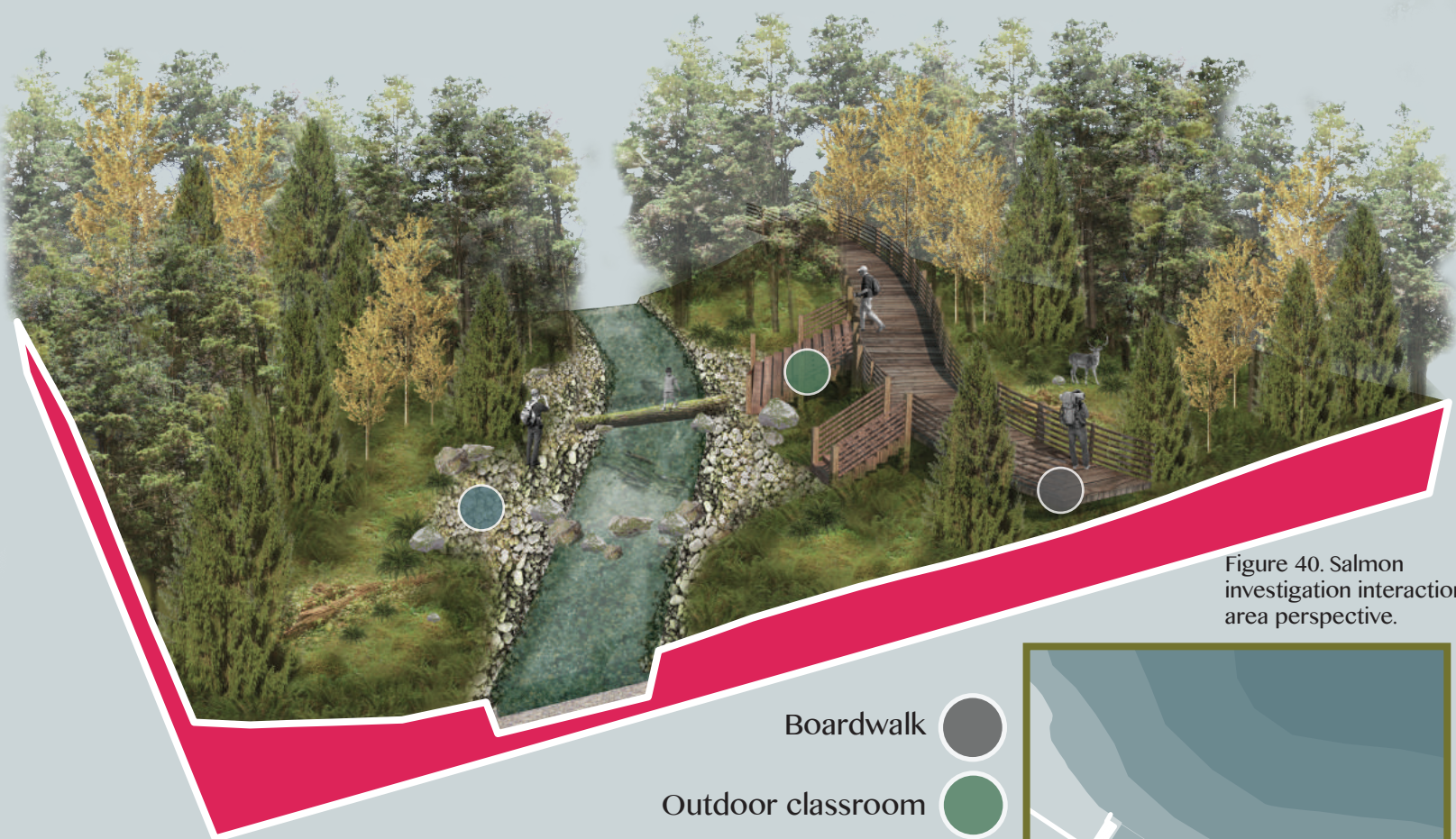
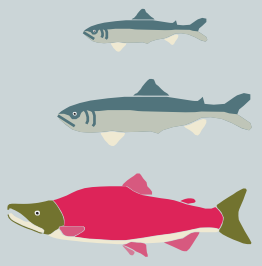


Figure 40. Salmon investigation interaction area perspective.

D



The salmon investigation area promotes interaction with the water and the fish. It also provides conditions for parr, smolt, and spawning stages of salmon. Because of the low vulnerability, this area is active as well. The small outdoor classroom provides an area where children can sit and learn about the water and the salmon in their natural environment. This area is a great space for volunteers or classes to gather water quality samples to monitor the stream for the salmon species. The log and boulders create a natural bridge where someone can study the fish within the water.

- Boardwalk (grey circle)
- Outdoor classroom (green circle)
- Rock stream bank (blue circle)

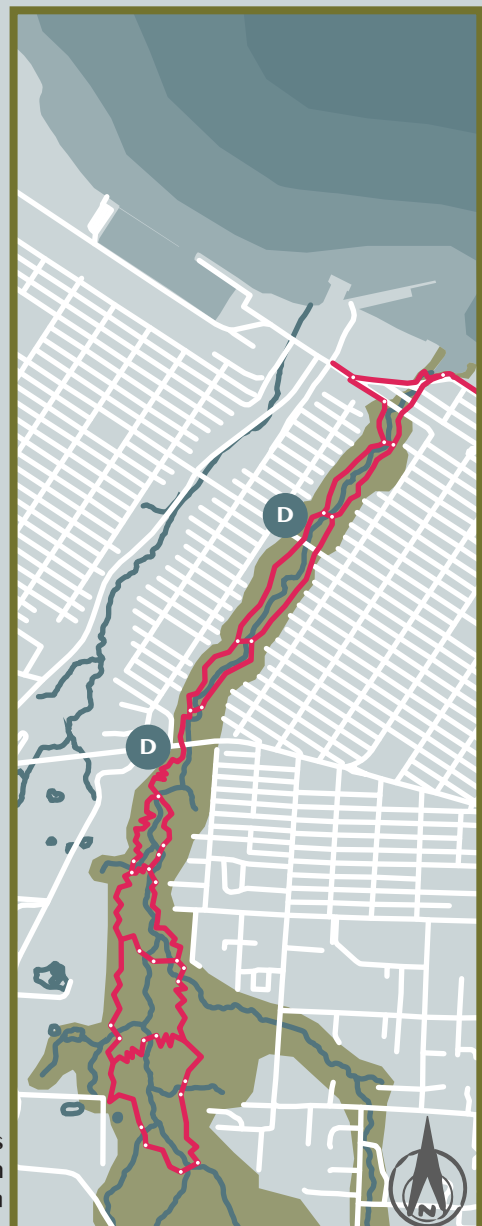


Figure 41. Master plan trails with salmon investigation interaction area

SITE PLAN

The site scale is located at the “entrance” to the park or trail system. This is close to the downtown area of Port Angeles in the urban environment. The site brings the natural environment close to a lot of people in the urban area, promoting the coexistence of people and wildlife. The site includes a visitor center as well as a platform system for people to relax for lunch, congregate for classes or volunteering, or view salmon in the stream. The trail system starts in the south side of the site, with paths leading to the trail system and a boardwalk path leading to the north and connecting to the existing Olympic Discovery Trail.

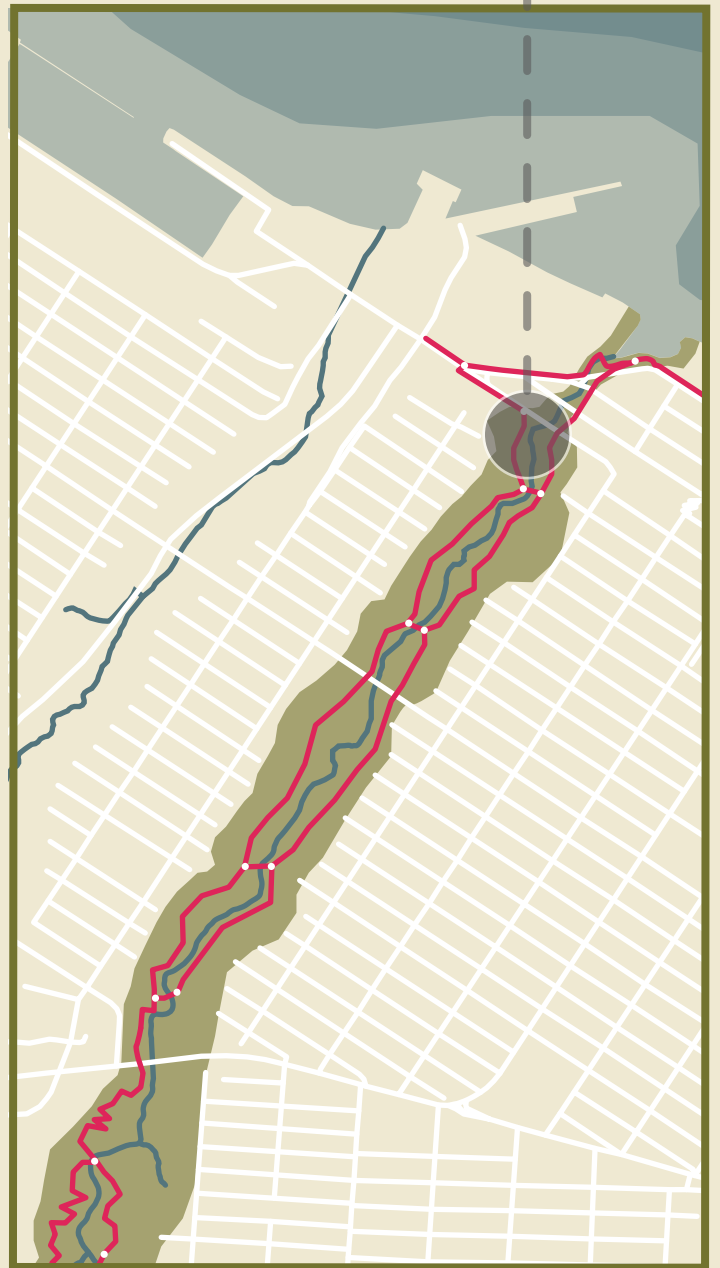
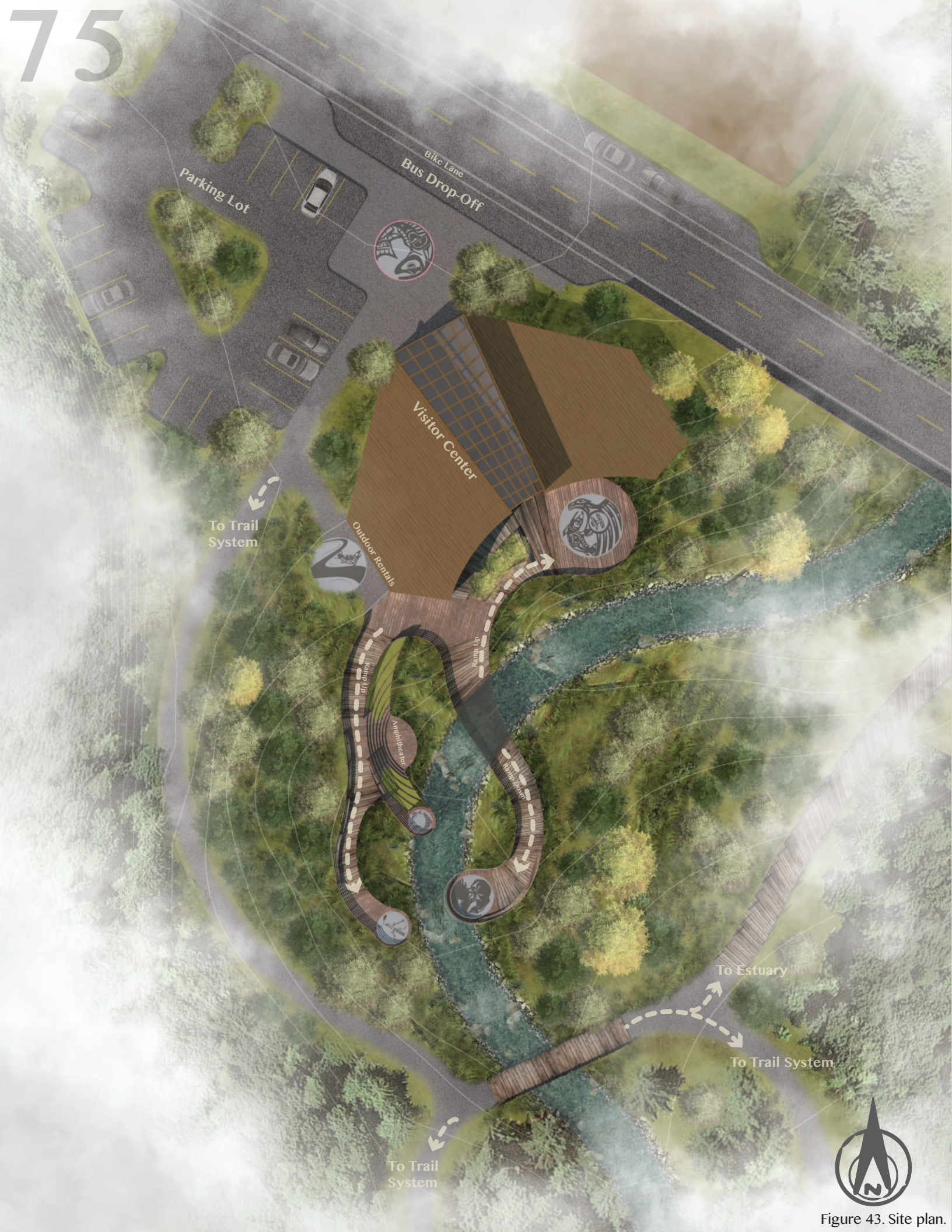


Figure 42. Site plan location.



Parking Lot

Bike Lane
Bus Drop-Off

Visitor Center

To Trail System

Outdoor Rentals

Amphitheater

Ramp Up

Ramp Down

To Estuary

To Trail System

To Trail System



Figure 43. Site plan.

When you first enter the visitor center, you enter a two story atrium where there are indoor displays to learn about the forest environment, salmon, and the history of the native tribes from the area. The center also includes a rental shop, offices, and two meeting rooms. When you leave the backside of the building you step onto a platform system. This system of gathering areas gives people different areas to view the world around them. The platform is ADA approved as it ramps down to the glass walk and further to the aquarium wall area on the east side of the platform. On the west side, the platform ramps up to the amphitheater area and further to the tree lookout point. throughout the site there is also ground plain art, inspired by the native tribes that were historically in the area. These art pieces go through the story of the salmon lifecycle and what they support in their ecosystem. Accompanied with the ground plain art, there is information about each of them; Salmon themselves, water quality, bird species, ocean species, mammal species, and riparian plant life.

Ecosystem Support Story



Water Quality



Bird Species



Ocean Species



Mammal Species



Riparian Plant Life



Salmon are known as a keystone species because of their unique lifecycle. They supply food to a variety of species within their ecosystem as well as nutrients to the water and surrounding riparian vegetation.

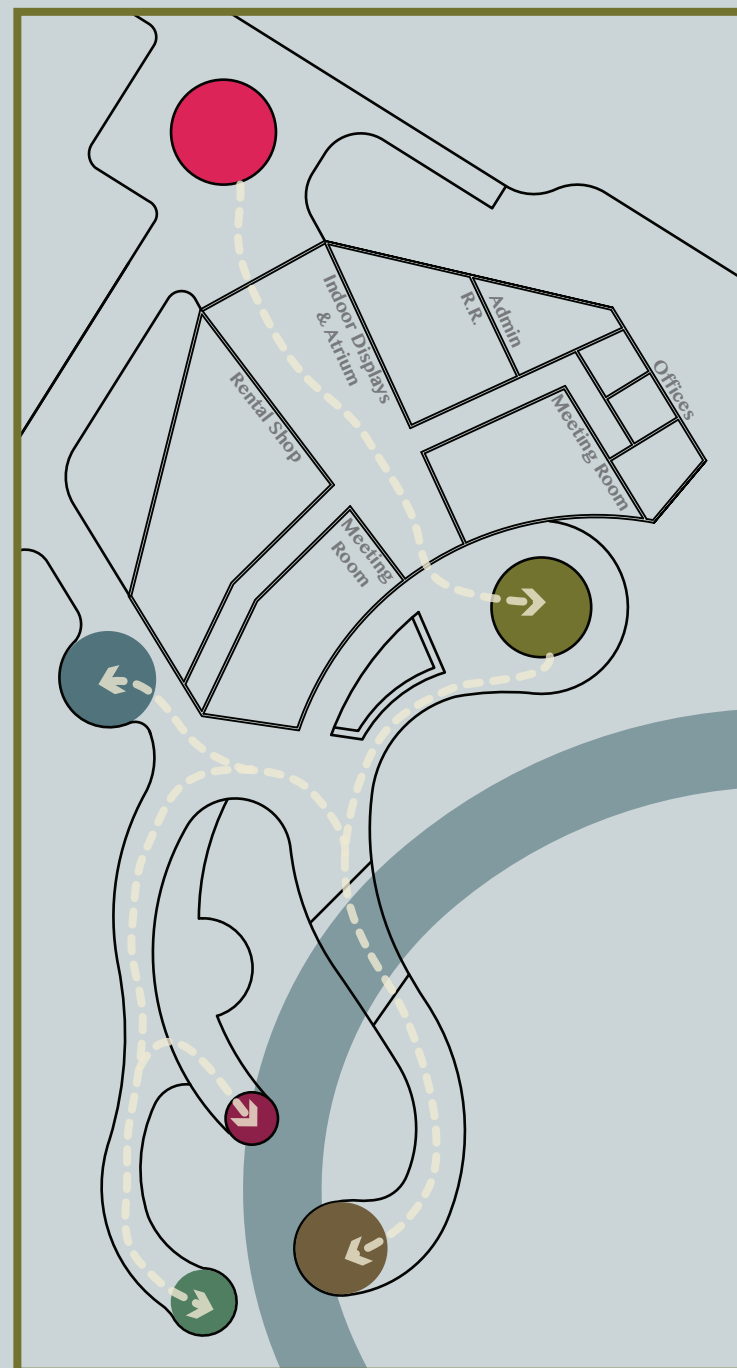


Figure 44. Platform and building layout.

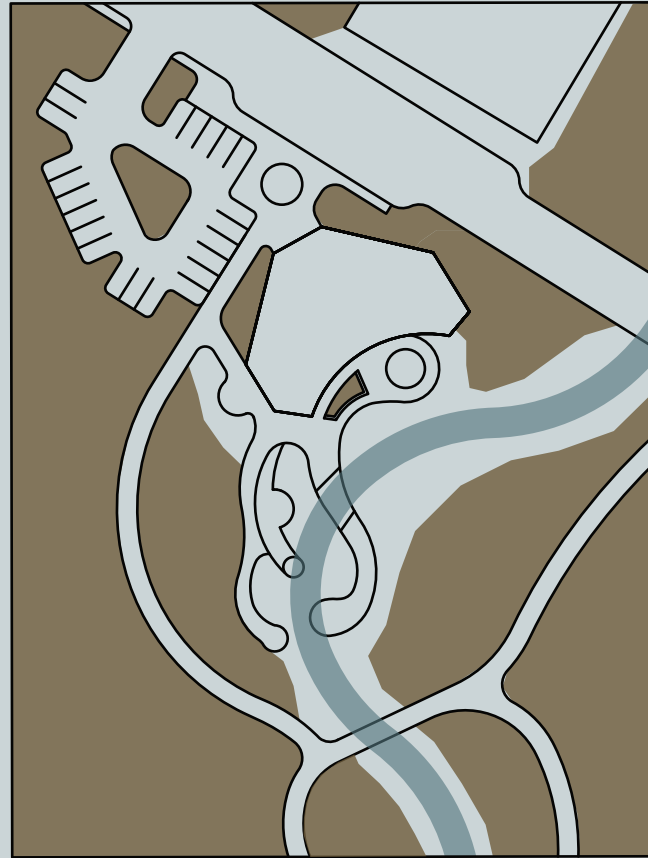


Figure 45. Tree areas on site plan.

The vegetation within the site brings back the original conifer-harwood forest that used to surround the area of Port Angeles. Site lines from the platform were considered when vegetation was planned. Trees should be set back from the stream, past the platform areas so that people can always see the stream from the platforms. Shrubs will fill in most of the rest of these empty spaces along the stream and platform areas, staying away only from the shortest platform areas. The forbs fill in the rest of the vegetation areas. Because of the forest structure of the conifer-harwood forest, where there are trees there will also be shrubs and forbs, to complete the forest structure.

Shrubs

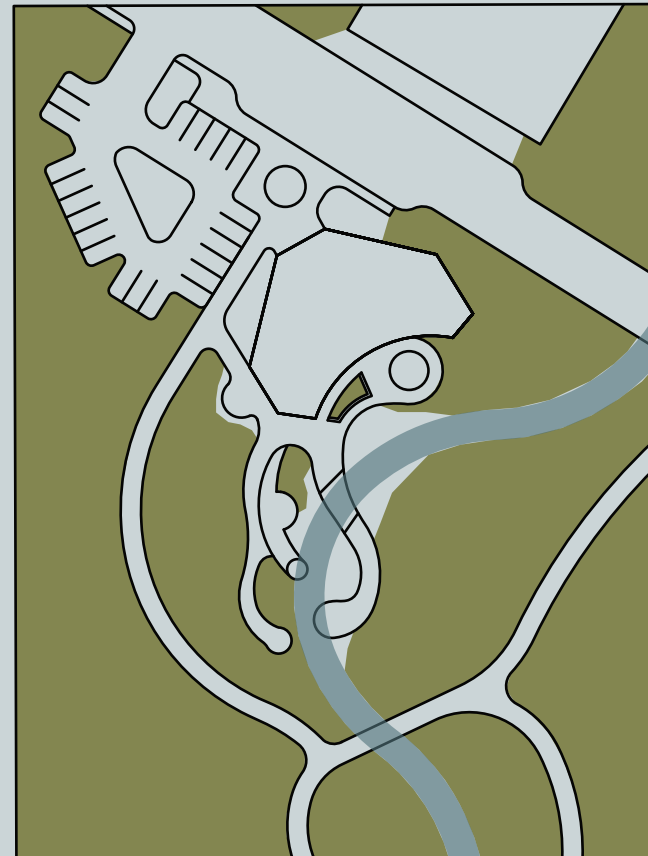


Figure 46. Shrub areas on site plan.

Forbs

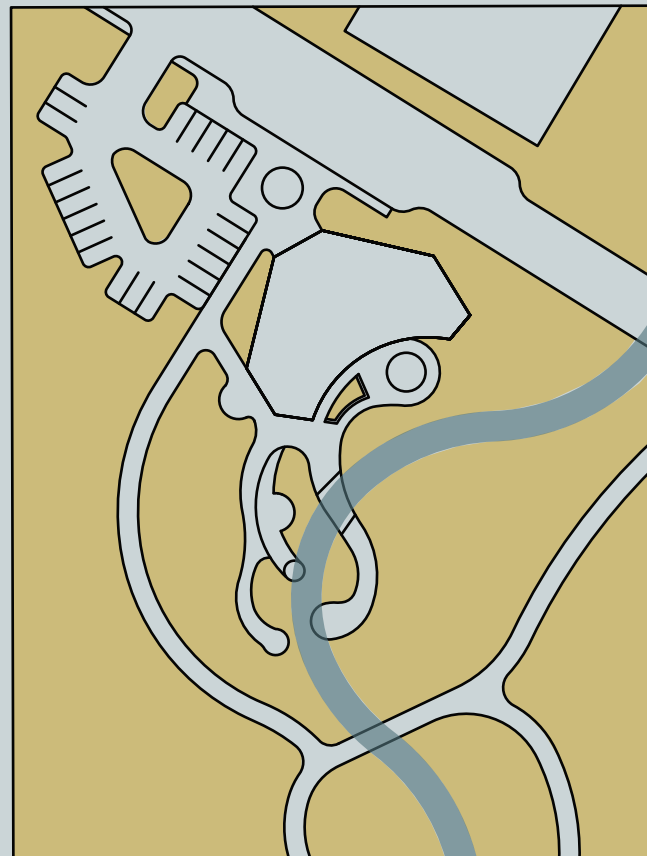
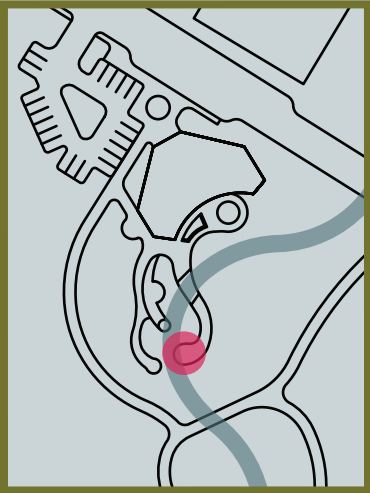


Figure 47. Forb areas on site plan.



The aquarium wall is the lowest platform area, located on the end of the east platform. This area is set below grade and close to the stream. The glass wall accompanied with the platform creates an opportunity to view the salmon underwater, just like you would in an aquarium. The native salish art ground plain piece is also in this area, indicating a gathering spot.

Figure 48. Aquarium wall location on site.

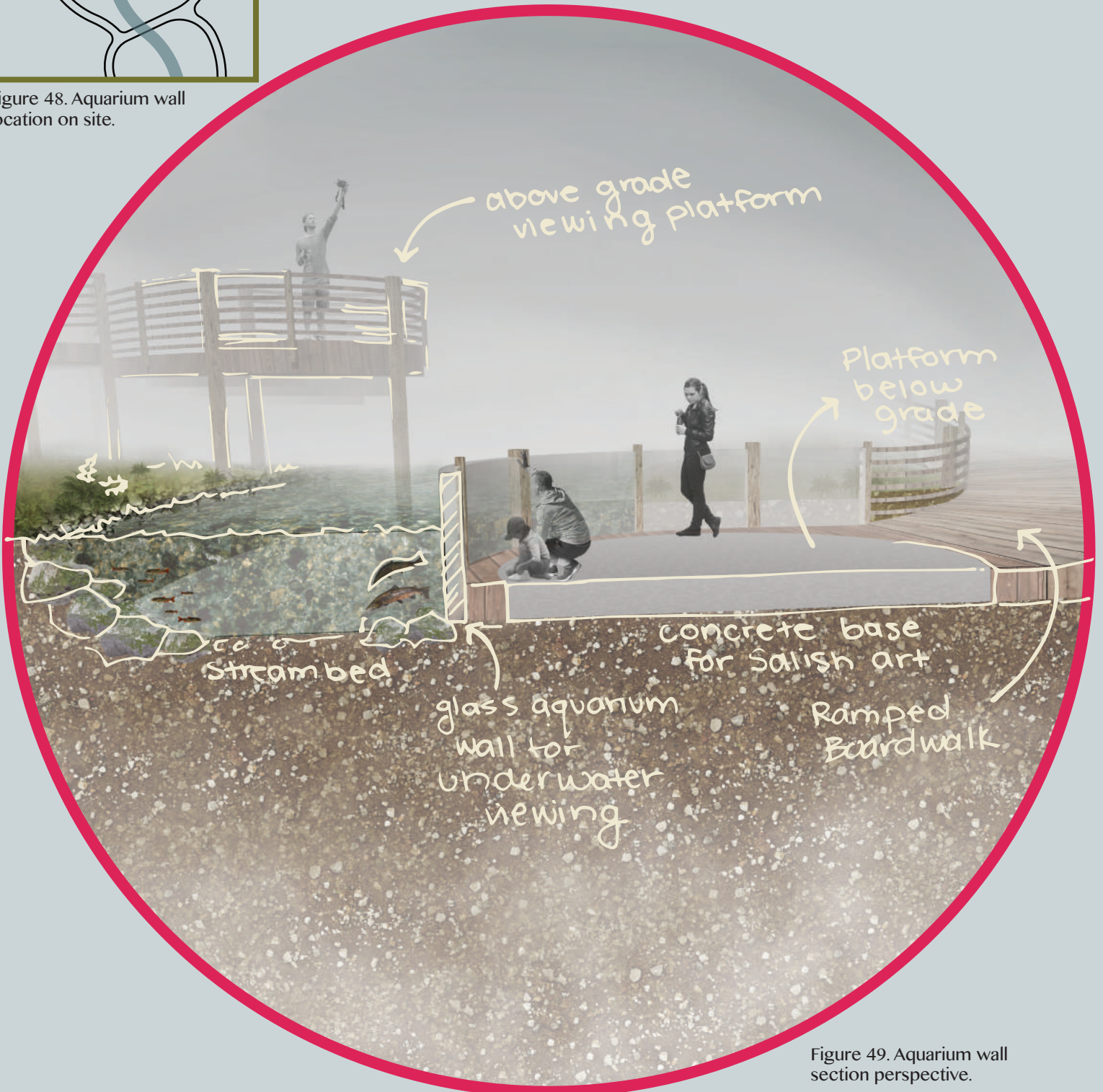
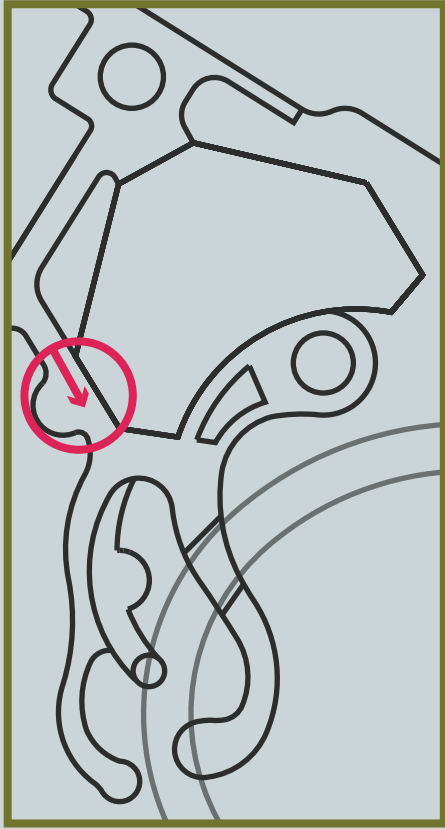


Figure 49. Aquarium wall section perspective.



The visitor center has a rental shop inside, which also has an outdoor area. There is a large garage like door that opens up onto a gathering area. The rental shop supplies fishing poles and supplies, bike rentals, and other sports rentals. It also has food and clothing associated with the area. Even though Washington sees a lot of rain and cloudy weather, the rental area will always be open to promote activity even in the bad weather.

Figure 50. Outdoor rental in area on site.

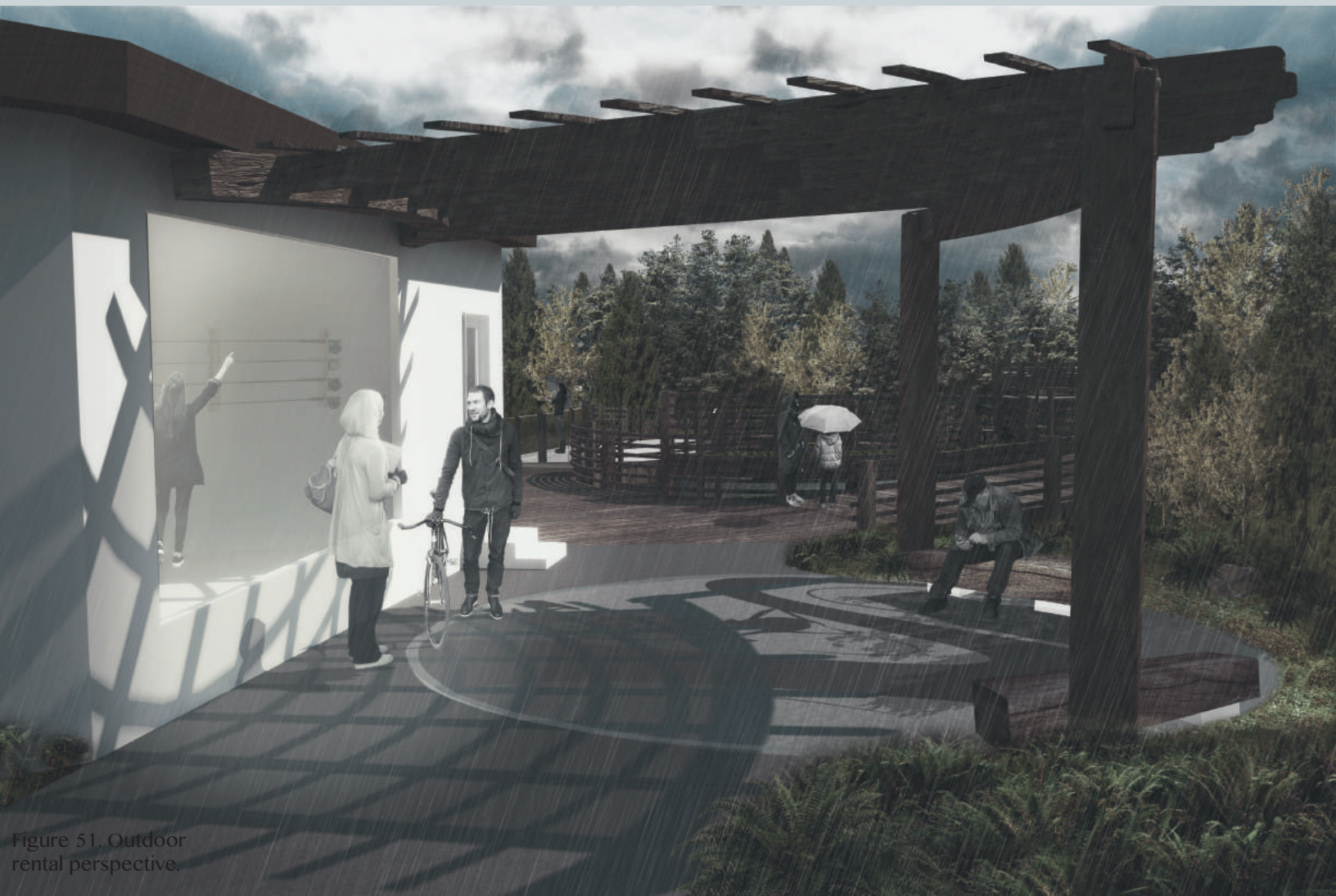
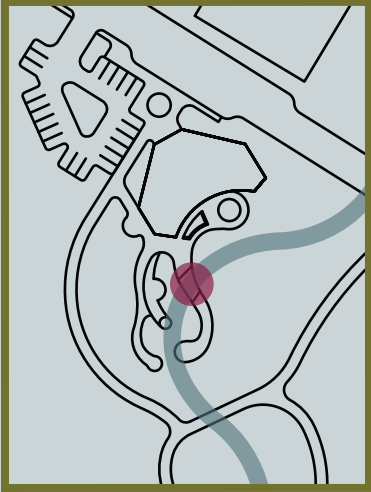


Figure 51. Outdoor rental perspective.



The glass walk area is halfway along the east platform. This area creates a different perspective for viewing the salmon in the stream and the surrounding environment. When you walk across the glass you will be immersed in the natural environment around you, because you can see everything around you through the glass.

Figure 51. Glass walk location on site.

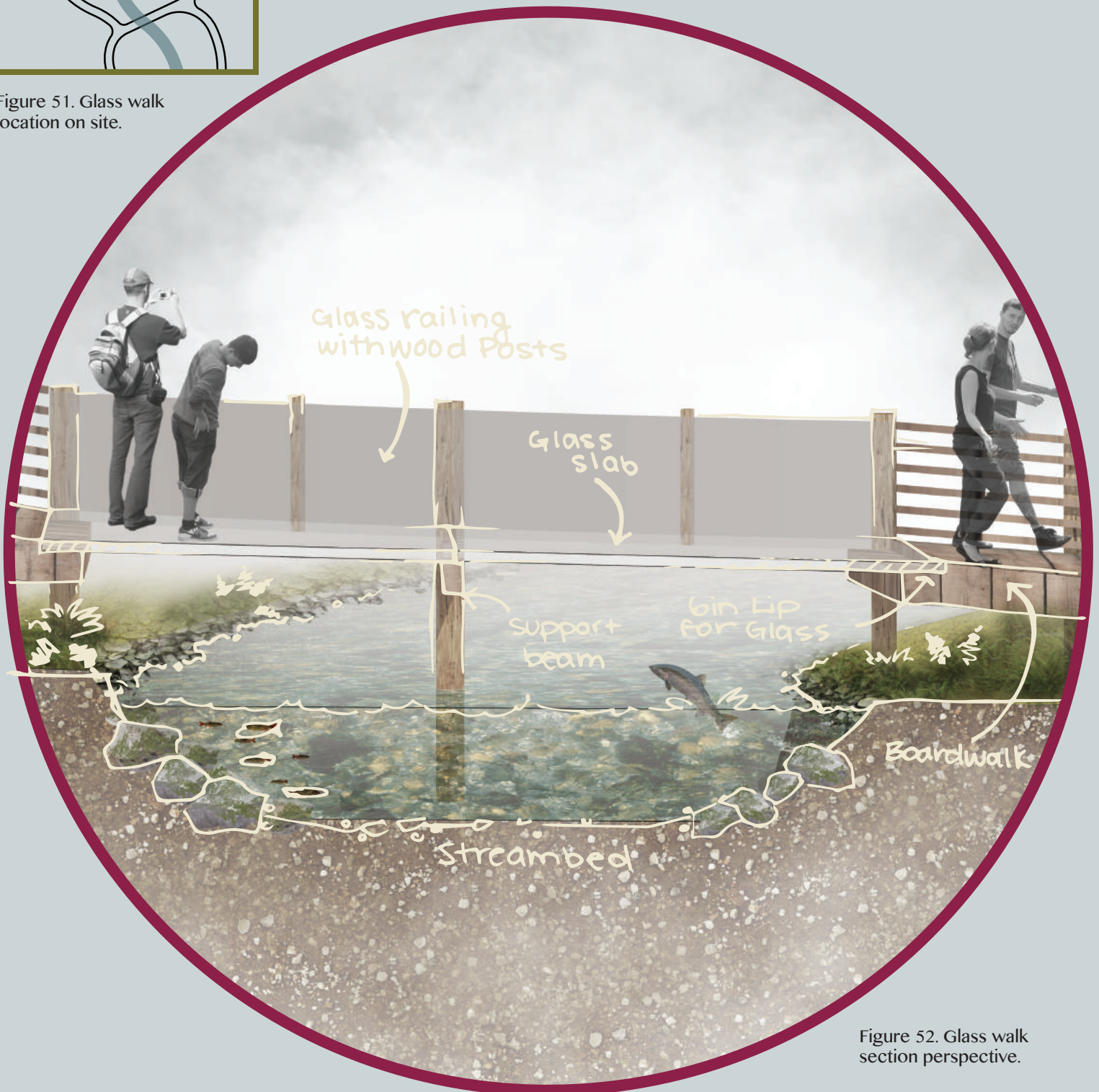
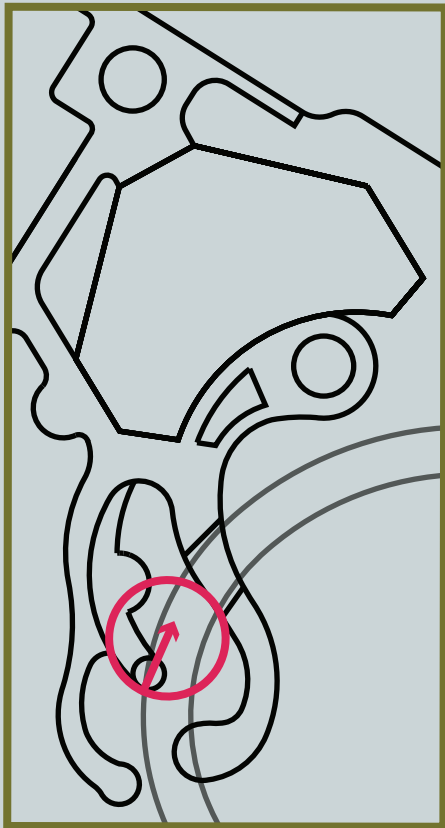


Figure 52. Glass walk section perspective.



This view is looking from the Amphitheater platform looking downstream. You can see the visitor center, the glass walk, and Valley Creek. The viewing platforms create different perspectives for people to enjoy the environment, as well as just relax and people watch. maybe if you are lucky, you will see an eagle swoop in and catch a salmon.

The restoration of Valley Creek will improve its ecological functions & performance as well as add to the beauty of the Pacific Northwest.

Figure 53. Platform viewing location on site.



Figure 54 Platform viewing perspective

The design solution for Valley Creek strives to connect people back to the natural environment. To conserve the beauty of the Pacific Northwest, we must bring back our connection to the animals as well as the environment in a harmonious way.



Figure 55. People, salmon and environment system connection.

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