

TECHNICAL MEMORANDUM

Date: May 8, 2025
To: Olin Anderson, City of Lake Stevens
Copy to: Shannon Farrant, City of Lake Stevens
From: Jenn Schmidt, Herrera Environmental Consultants, Inc.
 Brian Busiek, Herrera Environmental Consultants, Inc.
Subject: Lake Stevens Basin Plan for Salmonid Basins: Summary Report of Preliminary Results for Available Data and Models

Contents

Executive Summary	3
Introduction.....	3
Background Review.....	4
Surface Waters	4
Regulatory Requirements	6
Growth Management Act.....	6
Shoreline Management Act	6
Endangered Species Act.....	6
Clean Water Act.....	6
National Pollutant Discharge Elimination System Phase II Permit.....	7
Previous Planning Efforts	7
Shoreline Master Program.....	7
Stormwater Management Action Plan.....	8
Snohomish Basin Salmon Recovery Plan	9
Lake Stevens Comprehensive Plan	9
Model Development.....	10
Guiding Questions	10

Opportunity Identification.....	10
Assessment Tools.....	24
Model Comparison.....	26
Model Selection.....	27
Model Recommendation	29
Bibliography.....	1
Inventory	2

Appendices

Appendix A Bibliography, Data Set Inventory, and Model Comparison Matrix

Tables

Table 1.	SMAP Watershed Assessment Units and Associated Catchments.....	8
Table 2.	Applications of the Fishery Habitat Model for Climate Resilient Salmon Recovery.....	12
Table 3.	Applications of the Fishery Habitat Model for Public Education and Engagement.....	14
Table 4.	Applications of the Model for NPDES Permit Compliance.....	15
Table 5.	Applications of the Fishery Habitat Model to Support the CSPP.....	16
Table 6.	Model Contributions to the Comprehensive Plan.....	18
Table 7.	Opportunity Types Identified by Model Output.....	21
Table 8.	Application of Model Output to Integrate Built Infrastructure.....	23
Table 9.	Fishery Habitat Assessment Tool Categories.....	25
Table 10.	Fishery Habitat Assessment Tool Categories.....	27

Figures

Figure 1.	City of Lake Stevens Streams and Catchment Areas.....	5
Figure 2.	Recovery Actions in the Snohomish River Basin Linked to Habitat-Forming Processes and Conditions (Snohomish County 2005).....	11

Executive Summary

The City of Lake Stevens is undertaking the Lake Stevens Plan for Salmonid Basins to advance salmon habitat recovery, improve watershed health, and integrate climate resilience into long-term land use and stormwater planning. As part of this initiative, a GIS-based Fishery Habitat Model will be developed to assess current habitat conditions, prioritize restoration and protection actions, and support adaptive management under future land use and climate scenarios. This technical memorandum summarizes the regulatory requirements, background studies, planning objectives, and available GIS-based models that will guide model selection and development. The analysis concludes that an integrated modeling approach, combining watershed-scale, reach-scale, and climate resilience tools, is necessary to meet the City of Lake Stevens' project goals, comply with regulatory mandates, and align with Comprehensive Plan priorities. This memorandum identifies the key management questions the GIS-based Fishery Habitat Model will address; details expected applications for regulatory compliance, public engagement, and capital project prioritization; and provides a recommended modeling framework to support strategic, science-based decision-making for salmonid recovery and watershed management.

Introduction

The City of Lake Stevens (City) is a rapidly growing community with a clear long-term vision outlined in its 2024–2044 Comprehensive Plan: to become a vibrant, sustainable city that fosters positive development, protects environmental resources, and supports strong neighborhoods and schools (City of Lake Stevens 2024). Central to this vision is the protection of natural systems—particularly aquatic systems that support salmon populations, which serve as key indicators of ecosystem health, climate resilience, and community well-being. Habitat that sustains salmon also provides valued community amenities, including clean water, open space, scenic shorelines, and recreational opportunities such as fishing, boating, and trail access. These co-benefits directly support the City's goals for livability, public health, and equitable access to nature, especially around Lake Stevens—the largest natural lake in Snohomish County.

Salmon management is both an environmental priority and a foundational element of the City's broader planning strategy. In partnership with the Snohomish Basin Salmon Recovery Forum, the City is supporting implementation of the *Snohomish River Basin Salmon Conservation Plan* (2019), a regional framework focused on habitat restoration, harvest regulation, and hatchery management to recover Endangered Species Act (ESA)-listed species, including Chinook salmon, steelhead, and bull trout. The Snohomish Basin, the second-largest river system in Puget Sound, plays a vital role in sustaining these populations, but faces increasing pressure from urbanization and a sensitive rain-snow transitional hydrology. As such, targeted recovery efforts are essential to safeguard ecological function, meet regulatory mandates, and increase watershed resilience.

To advance these objectives, the City is launching the Lake Stevens Plan for Salmonid Basins (Basins Plan), an initiative that will apply Best Available Science to guide policies and land use planning related to salmon habitat protection and restoration. A key component is the development of a GIS-based Fishery

Habitat Model (Model), which will assess, map, and characterize current salmonid habitat conditions within the City and nearby watersheds. The Model will be used to identify high-quality habitat, degraded areas requiring restoration, and opportunities for multi-benefit projects that align with Comprehensive Plan goals. This data-driven approach will inform planning decisions across several integrated elements of the Comprehensive Plan, including Land Use, Climate Change and Resiliency, Capital Facilities, and Parks and Recreation. Public outreach and engagement will ensure that community values inform the City's habitat preservation priorities. The resulting Basins Plan will help balance economic growth with water quality protection and natural resource stewardship.

The Model will serve as a decision-support tool to guide land use strategies, infrastructure investments, and environmental policies that restore and/or protect riparian corridors, water quality, habitat, and habitat connectivity. These actions support both salmon recovery and the recreational landscape that defines quality of life in Lake Stevens. Through this proactive, science-based approach, the City is integrating environmental resilience into future growth planning. Salmon recovery—and the healthy ecosystems it relies on—is central to Lake Stevens' long-term vision for a connected, sustainable, and thriving community.

This technical memorandum summarizes the existing data, resources, and contextual background that will support the development of the Model. It also reviews GIS-based fish habitat restoration models, describes how model selection will be guided by the City's goals and priorities, and outlines a structured approach for selecting the most suitable model(s) for informed decision-making and project planning. A recommended modeling approach and next steps are provided at the conclusion of this document.

Background Review

Surface Waters

Approximately 78 percent of the City lies within the Lake Stevens watershed. The City's drainage is divided between two major systems. The western portion drains toward Ebey Slough, while the eastern portion flows into Catherine Creek and the Pilchuck River. All three of these waterways are tributaries of the Snohomish River, contributing to its broader watershed. Several named tributaries flow directly into Lake Stevens itself, including Stevens Creek, Lundeen Creek, Kokanee Creek, and Stitch Creek. The outlet for Lake Stevens is located at the northeastern corner, where water exits through Lower Stevens Creek, an engineered drainage channel designed to control water discharge from the lake. In addition to these major features, the City contains numerous smaller streams and drainage pathways. Collectively, these watercourses span 28 distinct catchment areas, as shown in Figure 1.

Figure 1.
City of Lake Stevens Streams and Catchment Areas.



File Path: K:\Projects\2025\25-0806\4-0000 Pro GIS - Working\LakeStevens\Simmon\BasinPlan\LakeStevens\Simmon\BasinPlan.aprx; Figure 1
 Date: 5/7/2025
 Author: zblener

Regulatory Requirements

Growth Management Act

Under the Washington State Growth Management Act (GMA; RCW 36.70A), the City is required to protect critical areas as defined in its Critical Areas Ordinance (CAO). These include salmon-bearing streams, wetlands, riparian corridors, and other habitats that support ESA-listed species such as Chinook salmon, steelhead, and bull trout. The GMA also mandates the use of Best Available Science (RCW 36.70A.172) to identify these critical areas and to develop policies and regulations to ensure their protection. Additionally, the GMA mandates development of a Comprehensive Plan that must integrate habitat protection and restoration with key planning elements, including Land Use, Stormwater Management, Capital Facilities Planning, and Climate Change Adaptation, to promote sustainable growth while safeguarding natural ecosystems.

Shoreline Management Act

The Shoreline Management Act (SMA; RCW 90.58) requires the City to develop and implement a Shoreline Master Program (SMP) that balances environmental protection, public access, and water-dependent uses. The SMP governs the use, development, and restoration of shoreline areas, including Lake Stevens, its tributary streams, and adjacent riparian corridors, many of which provide critical habitat for ESA-listed salmonids.

Under the SMP, the City must ensure that shoreline ecological functions including riparian vegetation and in-stream conditions are maintained or improved through the principle of no net loss. The SMP also identifies priority areas for habitat restoration, including opportunities to enhance degraded shorelines, restore natural floodplain processes, and remove fish passage barriers. The SMP must align with state guidelines and be periodically updated to incorporate Best Available Science, as well as respond to changing environmental conditions and land use pressures.

Endangered Species Act

The federal and state ESA requires the protection and recovery of species listed as threatened or endangered, along with their critical habitats. In Lake Stevens, this applies to ESA-listed salmonids, including Chinook salmon, steelhead, and bull trout, which rely on local streams, riparian areas, and Lake Stevens itself for spawning, rearing, and migration.

Clean Water Act

Several waterbodies in the Lake Stevens area are listed as impaired under Section 303(d) of the Clean Water Act. This includes Lake Stevens itself, which is classified as a 303(d) Category 5 impaired waterbody for hexachlorobenzene, polychlorinated biphenyls (PCBs), and methyl mercury, and Little Pilchuck Creek, which is classified as a 303(d) Category 5 impaired waterbody for temperature. These impairments

require the development of Total Maximum Daily Loads (TMDLs) to restore water quality, such as the Pilchuck River TMDL focused on temperature and dissolved oxygen.

National Pollutant Discharge Elimination System Phase II Permit

The National Pollutant Discharge Elimination System (NPDES) Phase II Permit, administered by the Department of Ecology (Ecology), regulates stormwater discharge from municipal separate storm sewer systems. Under the NPDES Phase II Permit (2024–2029), Sections S5.C.1 and S5.C.4 establish requirements that directly support stormwater management and fish habitat protection in the City.

Section S5.C.1 requires the City to develop a Stormwater Management Program (SWMP) that integrates stormwater controls with land use planning, while prioritizing low-impact development (LID) and green infrastructure to reduce runoff, improve water quality, and maintain natural hydrologic functions essential for fish habitat. It also requires the City to develop a Stormwater Management Action Plan (SMAP) that identifies and prioritizes catchment areas for targeted stormwater management actions to protect and improve receiving water quality. Additionally, the City is required to map and assess urban tree canopy and integrate findings into the SWMP to support runoff reduction and water quality goals by the end of 2027.

Section S5.C.4 mandates the mapping and inventory of stormwater infrastructure, including outfalls and receiving waters, to identify where stormwater discharges may impact sensitive or impaired waterbodies.

Previous Planning Efforts

The City has conducted the following planning efforts to comply with state and federal regulations and to improve water quality in the City's surface waters.

Shoreline Master Program

The City of Lake Stevens Shoreline Master Program (SMP; 2013) regulates all new, repaired, replaced, and modified shoreline uses and developments. The SMP provides a framework to guide both current and future activities, ensuring that development around Lake Stevens preserves the natural character and ecological integrity of the lake and its shorelines. A Cumulative Impact Analysis, conducted during the SMP development, concluded that implementation of the SMP is expected to achieve no net loss of shoreline ecological functions within the City.

The SMP includes detailed policies and regulations for shoreline restoration and ecological enhancement, with Appendix B specifying critical areas regulations within the shoreline jurisdiction. These regulations for fish and wildlife habitat conservation areas outline requirements for habitat classification, boundary determinations, species and habitats of local importance, permitted activities, buffer standards, and mitigation measures.

These provisions will inform the Model by identifying and prioritizing critical habitat areas along the Lake Stevens shoreline, ensuring that model development aligns with SMP conservation goals and regulatory requirements.

Stormwater Management Action Plan

In 2023, the City of Lake Stevens developed a Stormwater Management Action Plan (SMAP) to comply with previous NPDES Phase II Permit requirements. A key component of the SMAP was identifying a priority catchment area for targeted stormwater planning and management. Using data from the Puget Sound Watershed Characterization Project, the City analyzed eight Watershed Assessment Units (WAUs) representing hydrologically distinct catchments, as shown in Table 1.

Table 1. SMAP Watershed Assessment Units and Associated Catchments.

WAU ID	Associated Catchment(s)
WAU-7147	Upper Catherine Creek
WAU-7178	Machias Catchment
WAU-7182	Not specified
WAU-7183	Mitchell (Kokanee) Creek, Lower Stevens Creek, Lower Catherine Creek, and Catherine Creek (receiving water)
WAU-7184	Upper Stevens Creek, Lundeen Creek, Nydin Farms, East Lake, South Lake, Stitch Creek & Lake, South Davies, North Davies, Springbrook, Lake Stevens (receiving water)
WAU-7216	Kuhlman Creek
WAU-7231	Mosher Creek
WAU-7233	East Everett, Carleton Farms, Burri Creek, Frontier Creek, Hulbert Creek

Each WAU was evaluated based on factors such as fish and aquatic habitat conditions, impervious surface coverage, flow control and LID opportunities, stormwater treatment potential, environmental justice, and stormwater infrastructure influences. This analysis produced a prioritized ranking of receiving waters, with the Lower Catherine Creek and Lower Stevens Creek catchments identified as high-priority areas for future action. The SMAP also notes that Lake Stevens is a 303(d) Category 5 impaired waterbody and includes a Category 4C listing for non-pollutant impairments.

To address these concerns, the SMAP outlines short-term (6-year Capital Improvement Plan) actions, including enhancing fish habitat, improving stormwater quality, and upgrading critical infrastructure. Subsequent efforts include the redesign of the Lake Stevens outlet weir (Clear Creek Solutions 2023) and planning for the Lake Stevens Downtown Improvements project (DCG 2023). Currently, the City has prioritized a detailed hydrology and base conditions study, followed by preliminary restoration planning that would lead to restoring the historic flow path and floodplain of Lower Stevens Creek between 20th Street Northeast and Catherine Creek, where it flows adjacent to Hartford Drive. Additionally, the City established long-term (20-year) goals for watershed-scale data collection and adaptive management to support ongoing improvements.

The SMAP provides critical context for selecting a fish habitat model by identifying stormwater-related stressors on aquatic systems and prioritizing management actions to improve water quality and habitat conditions. Integrating SMAP findings into fish habitat modeling ensures that stormwater impacts are fully considered when evaluating habitat suitability, restoration potential, and fish population recovery strategies.

Snohomish Basin Salmon Recovery Plan

The Snohomish Basin Salmon Recovery Plan (Snohomish Basin Salmon Recovery Forum 2005) provides a regional framework for restoring salmon populations, including ESA-listed salmonids, by improving habitat conditions throughout the Snohomish River Basin, which includes the Lake Stevens watershed. For Lake Stevens, the plan emphasizes the protection and restoration of spawning and rearing habitats in key tributaries such as Stevens Creek and Catherine Creek, reducing impacts from urbanization, improving water quality, enhancing riparian and floodplain connectivity, and addressing fish passage barriers. The plan guides local actions in Lake Stevens to align with broader recovery goals, ensuring that habitat restoration efforts contribute to the basin-wide objective of supporting self-sustaining salmon populations and resilient aquatic ecosystems. This plan will significantly influence the selection of a fish habitat model by ensuring alignment with regional recovery priorities, supporting consistent methodologies, and focusing on actions that address limiting factors identified at the basin scale.

Lake Stevens Comprehensive Plan

The Lake Stevens Comprehensive Plan (2024–2044) establishes a long-term vision for sustainable growth while protecting the City’s natural resources, including critical fish habitats. Key policies emphasize the preservation and restoration of salmon-bearing streams, wetlands, and riparian corridors, which provide essential habitat for ESA-listed species. The Plan mandates the use of Best Available Science in land use planning and critical areas protection, in compliance with the GMA.

Relevant goals include the following:

- **Goal NE 1:** Protect and enhance critical areas and fish and wildlife habitats.
- **Policy NE 1.5:** Preserve and enhance riparian corridors to improve water quality and habitat.
- **Goal LU 6:** Manage urban growth to minimize impacts on sensitive natural systems.

The Plan also integrates stormwater management with habitat protection, promoting LID and green stormwater infrastructure (GSI) to reduce runoff and improve water quality in streams and Lake Stevens. Additionally, climate resilience strategies focus on maintaining ecosystem health through adaptive management and restoration of degraded aquatic habitats.

The Comprehensive Plan will influence fish habitat model selection by ensuring that chosen tools support integrated land-use decisions, comply with regulatory requirements, and align with the City’s broader goals for sustainability, stormwater management, and habitat restoration.

Model Development

The following sections outline the key questions that will guide model development and selection, review relevant assessment tools and available models, and highlight important considerations for selecting the most appropriate model.

Guiding Questions

The following sections outline guiding questions regarding how the model output will be used and the specific issues it is intended to address. Key supporting background information pertaining to the guiding questions are also described. A more detailed analysis of the data sets required for the selected model, along with any data gaps, will be provided in a separate memorandum. The functionality described herein represents desired capabilities; actual functionality will depend on the final model selected and its output capacity.

Opportunity Identification

How can the Model help identify areas of opportunity for salmonid habitat preservation and recovery?

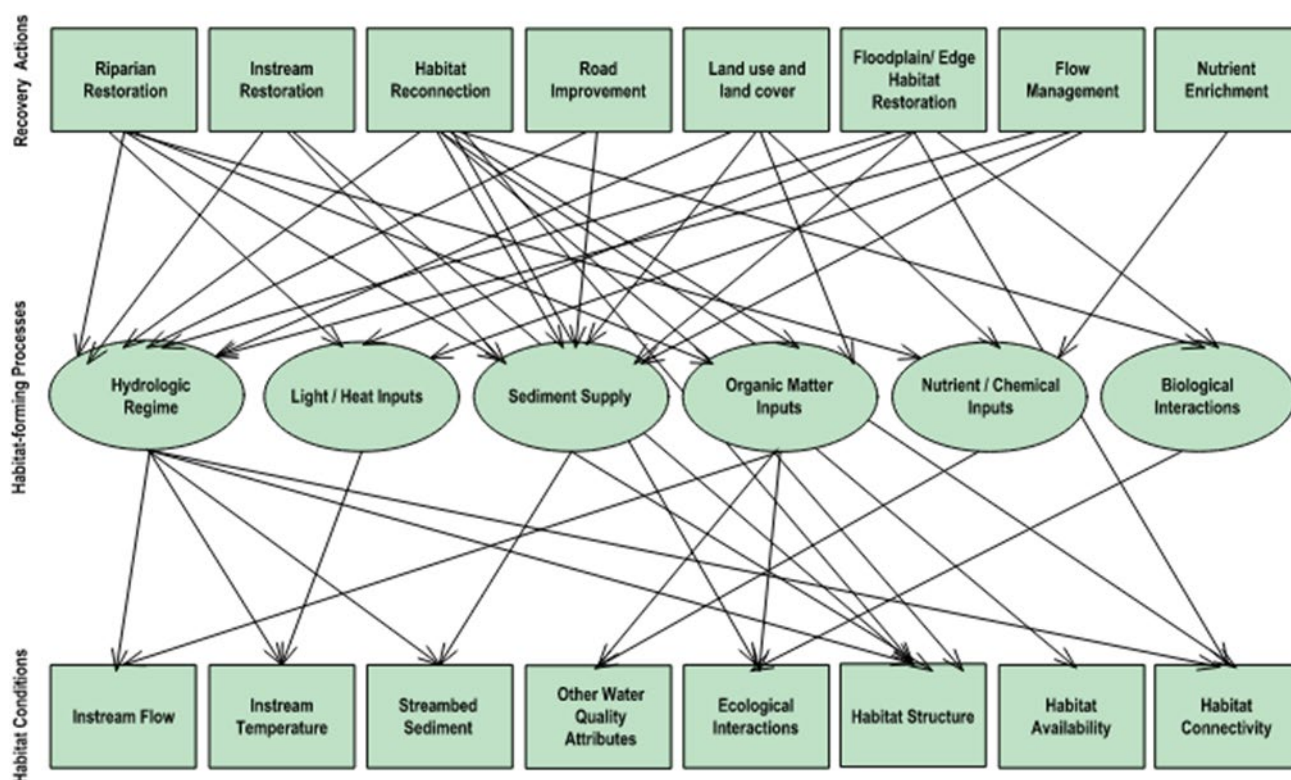
The Model will utilize a combination of existing data sets (Appendix A), including land use, remotely sensed imagery, and hydrologic and geomorphic inputs, to identify both high-functioning and degraded habitats. High-functioning areas may include intact riparian corridors, connected floodplains, and low-gradient alluvial reaches that support key salmonid life stages. Degraded habitats with strong restoration potential, such as disconnected floodplains and areas lacking riparian vegetation or in-stream structural complexity, will also be identified.

Where available, species-specific presence/absence data and habitat requirements across life stages (e.g., spawning gravels, rearing pools, migration corridors) will be incorporated to prioritize areas for protection based on ecological integrity, landscape context, and conservation value. Priority protection areas may include habitats supporting ESA-listed species, climate-resilient refugia, or rare and limiting habitat types such as cold-water tributaries or off-channel wetlands. These areas could be targeted for land use protections, conservation easements, riparian buffer establishment, or zoning overlays to preserve habitat quality and prevent further degradation.

Model outputs will also guide restoration planning by identifying locations suitable for specific actions, such as riparian reforestation, in-stream habitat enhancements (e.g., large wood placement), and connectivity improvements (e.g., fish passage barrier removal or culvert upgrades). Additionally, the Model will support the identification of integrated, multi-benefit projects that address both ecological and community needs—for example, stormwater retrofits that improve water quality and baseflows, or floodplain reconnection projects that enhance habitat while providing urban green space and climate adaptation infrastructure.

Figure 2 details recovery actions linked to salmonid habitat-forming processes and conditions (Snohomish County 2005).

Figure 2. Recovery Actions in the Snohomish River Basin Linked to Habitat-Forming Processes and Conditions (Snohomish County 2005)



How can the Model help track salmonid population recovery?

Nine salmonid species inhabit the Snohomish River system, including ESA-listed Chinook salmon, steelhead, and bull trout. Chinook salmon returns have declined significantly since the mid-2000s, reaching a record low of 1,023 wild Chinook in 2019, with current populations estimated at less than 10 percent of historic levels (Snohomish Basin Salmon Recovery Forum 2019). Restoring these populations to sustainable levels through adaptive management is a central goal of the Snohomish Basin Salmon Conservation Plan.

Beyond identifying and prioritizing habitats for protection and restoration, the Model can serve as a critical tool for evaluating the effectiveness of salmonid recovery actions over time. By providing a consistent, spatially explicit framework that integrates habitat and biological data, the Model can help assess whether restoration efforts are leading to measurable improvements in both habitat conditions and population outcomes. When paired with monitoring data, such as smolt outmigration, Redd counts, and adult returns, the Model can support evaluations of habitat use and effectiveness across salmonid life stages. This enables adaptive management by identifying successful interventions and areas needing adjustment. It also helps reveal limiting factors, such as elevated stream temperatures, lack of cold-water refugia, or impaired habitat connectivity, that may constrain recovery despite localized restoration gains.

While monitoring is not included as part of this project’s scope, the Model could be used in the future to support ongoing monitoring (including identifying areas that may need monitoring) and evaluation efforts by providing a framework for integrating new biological and habitat data as they become available. Additionally, the Model can help support scenario-based planning by simulating future habitat conditions under varying land use, climate, and policy scenarios. These projections can inform long-term resilience planning and guide updates to regulatory frameworks, including Comprehensive Plans, watershed strategies, and climate adaptation plans. Model outputs can also help prioritize capital projects and provide technical justification for funding proposals aimed at advancing salmon recovery and watershed health.

How can the Model help mitigate the effects of climate change on salmonid populations?

The Model will provide a framework for evaluating how salmonid habitats will respond to various climate scenarios and help prioritize restoration efforts that enhance long-term ecological resilience. By integrating climate projections with habitat data, the Model will allow for scenario-based planning, support adaptive management, and guide policy development aligned with both salmon recovery goals and climate adaptation strategies. Table 2 below outlines key potential applications of the Model in addressing climate-related risks.

Table 2. Applications of the Fishery Habitat Model for Climate Resilient Salmon Recovery.

Key Use	Description	Benefits
Identifying vulnerable habitats	Simulates habitat conditions under different climate scenarios (e.g., temperature, precipitation).	Prioritizes restoration in areas most vulnerable to climate change; protects culturally significant salmon habitats.
Assessing long-term resilience	Evaluates how climate change stressors (e.g., warming temperatures) affect habitat suitability.	Focuses restoration on resilient habitats such as cold-water refugia critical for salmon survival.
Guiding adaptive management	Integrates monitoring data to track climate impacts on salmonid populations and habitat.	Enables timely adjustments to management actions based on real-time data and evolving climate trends.
Optimizing habitat connectivity	Identifies fragmentation risks and barriers that climate change may exacerbate.	Prioritizes barrier removal and restoration of migration corridors; reduces flood risks and improves infrastructure.
Supporting climate-smart restoration	Identifies climate-resilient habitats and species most at risk from climate stressors.	Directs restoration to areas with high climate resilience potential; promotes GSI and urban cooling.
Scenario-based planning for future conditions	Simulates future climate conditions (e.g., temperature increases, altered stream flows).	Tests management strategies under different climate scenarios; supports alignment with climate adaptation and equity goals.
Incorporating climate change into policy and planning	Provides data to update climate adaptation and watershed management plans.	Ensures long-term planning and policies are responsive to projected climate impacts; justifies funding for multi-benefit projects.

Background Information

WRIA 7 Climate Change Impacts to Salmon Issue Paper

The WRIA 7 Climate Change Impacts to Salmon Issue Paper (LeDoux et al., 2017) highlights significant climate-related stressors already affecting the Puget Sound region, including declining summer precipitation and a reduction in snowpack. These trends are attributed to an increase in rain-on-snow events transitioning to rain-dominated precipitation patterns, leading to notable changes in hydrological regimes. The region is projected to experience more rainfall, less snow accumulation, more frequent and intense rain-driven flooding events, and lower summer baseflows.

These hydrological changes are expected to further degrade salmon populations in the coming decades by affecting critical aspects of salmon life history, including spawning success, migration timing, feeding opportunities, growth, and overall health. The paper outlines several key pathways through which climate change is anticipated to impact salmon in the Snohomish Basin:

- **Hydrology** – shifting timing of life cycle transitions, scouring or smothering redds, stranding, increased disease, loss of thermal refugia, loss of food refugia, migration barriers due to extreme low and/or high flows
- **Temperature** – lethal high temperatures, developmental abnormalities, altered growth rates, non-fertilization of eggs, altered food web, migration timing, altered predator/prey relationship, increased disease
- **Stormwater** – increased water pollution causing decreased oxygen, food web alterations, pre-spawn mortality
- **Sedimentation** – lethal conditions caused by turbidity, interference with migration cues, altered/decreased habitat

These climate-related impacts underscore the need for adaptive, climate-resilient salmon recovery strategies in WRIA 7 (the Snohomish Basin).

How can the Model help the public understand and engage in salmonid population recovery and habitat preservation?

While the primary purpose of the Model is to inform technical planning and regulatory compliance, it also offers valuable applications for public engagement and community outreach. By translating complex ecological data into accessible formats, such as maps and scenario-based visualizations, the Model can help communicate the importance of salmon habitat restoration to a broader audience. This enhances public understanding of ecosystem processes, demonstrates the local benefits of restoration actions, and supports more transparent and inclusive decision-making. Table 3 summarizes key community engagement uses of the Model and the associated benefits for building support and participation in salmon recovery efforts.

Table 3. Applications of the Fishery Habitat Model for Public Education and Engagement.

Activity	How the Model Supports Engagement	Public Benefit
Visualizing Complex Data	Produces maps and graphs that illustrate habitat conditions, trends, and risks over time.	Makes abstract or scientific data more relatable and understandable, increasing public awareness of ecosystem processes and threats to salmon.
Demonstrating Local Impact	Models the effects of site-specific actions (e.g., culvert removal, riparian buffer restoration) on habitat.	Shows residents and landowners how their actions contribute to habitat improvement, fostering a sense of ownership and pride.
Informing Community Decision-Making	Evaluates different planning or policy scenarios, illustrating trade-offs and benefits of various actions.	Promotes transparent, equitable public input by helping the community understand outcomes of policy choices and restoration priorities.
Supporting Education and Outreach	Supplies data and visuals for use in schools, public workshops, interpretive signage, and online platforms.	Increases ecological literacy through hands-on, place-based learning that connects salmon recovery to community values.
Highlighting Community Co-Benefits	Demonstrates additional benefits of restoration (e.g., reduced flooding, improved water quality, green space).	Aligns ecological goals with public interests such as safety, recreation, and environmental justice, building broader support.

Background Information

Stormwater Management Program

The Stormwater Management Program (SWMP; City of Lake Stevens 2025) outlines a series of public outreach and education initiatives planned for 2024 to increase awareness of stormwater management, water quality, and best management practices (BMPs). A key component of these efforts is green stormwater infrastructure (GSI) outreach, which targets private stormwater systems. This program provides technical assistance, maintenance recommendations, and training to homeowners, with the objective of ensuring private systems meet maintenance standards and contribute to improving the City’s overall water quality.

The City’s “I Love Lake” campaign is another prominent outreach effort, aimed at raising public awareness about the impacts of stormwater runoff on urban landscapes. The campaign promotes behavioral change by educating residents on actions they can take to reduce stormwater-related pollution and protect local waterways. In addition, the City has implemented youth education and outreach programs in partnership with the Lake Stevens School District, delivering classroom lessons, field trips, and outdoor environmental education to foster early ecological awareness. In 2025, the City will be reevaluating the Stormwater Education and Outreach program and updating the plan based on community input.

Model output could be integrated into community education sessions, used to develop school curriculum content, and support ongoing public outreach campaigns such as “I Love Lake.” By translating habitat conditions and restoration opportunities into clear, visual information, the Model will help communicate how healthy salmonid habitats directly benefit the community. The overarching goal is to reinforce the connection between salmon recovery and community well-being, encouraging greater public engagement and stewardship.

How can the Model support the City's NPDES Permit Compliance?

The Model will serve as a valuable tool in supporting the City's compliance with various elements of the NPDES Phase II Permit. By integrating habitat data with stormwater impacts, the Model can inform planning, prioritize restoration and retrofit actions, and support public education efforts. Specifically, the Model will provide spatially explicit outputs that align with key permit requirements related to stormwater source control, stormwater management planning, retrofit identification, and public engagement. Table 4 below outlines how the Model supports compliance with specific sections of the NPDES permit

Table 4. Applications of the Model for NPDES Permit Compliance.

NPDES Permit Section	How the Fishery Habitat Model Supports Compliance
S5.C.1 – Stormwater Planning	Provides watershed-scale data summarizing where stormwater runoff adversely affects fish habitat to support catchment inventory, prioritization, and the development of Stormwater Management Action Plans (SMAPs).
S5.C.2 – Public Education & Outreach & S5.C.3 – Public Involvement and Participation	Provides habitat visualizations and predictive scenarios for use in community engagement tools, including Story Maps and outreach materials highlighting salmon recovery and stormwater management goals.
S5.C.4 – MS4 Mapping and Documentation	The City is required to map tree canopy by no later than December 31, 2026, to support stormwater management on City-owned or operated properties. Canopy mapping data will be created as an input to the Model to help assess riparian habitat conditions.
S5.C.5 – Illicit Discharge Detection and Elimination	Provides watershed-scale data to support the detection of illicit discharges and their sources, for the purpose of eliminating them.
S5.C.6 – Controlling Runoff from New Development, Redevelopment, and Construction Sites & S5.C.7 – Stormwater Management for Existing Development	Assists in identifying high-priority areas for stormwater retrofits and Best Management Practice (BMP) implementation to reduce impacts on salmon habitat.
S5.C.8 – Source Control for Existing Development	Identifies areas where stormwater runoff has the greatest impact on critical salmonid habitat, enabling prioritization within Source Control Plans and SMAPs.
S5.C.9 – Operations & Maintenance	Supports asset management and inspection targeting by identifying key areas affecting salmon habitat. Outputs can also track habitat changes over time and assess the effectiveness of BMPs and restoration projects.

Background Information

Stormwater Management Program

The SWMP (City of Lake Stevens 2025) provides the current framework, program status, and planned projects designed to achieve compliance with the regulatory requirements of the NPDES Phase II Permit. Among the nine core program elements specified in the permit, the Model will provide direct support for stormwater planning, public education and outreach, public involvement and participation, MS4 mapping and documentation, and stormwater management for existing development.

The Model has the potential to assist the City in meeting the following NPDES permit requirements:

- Support the development of long-range planning programs that ensure watershed and water quality protection policies, strategies, codes, and stormwater management measures are effectively implemented.
- Promote the continued use of LID as the preferred approach for stormwater management in site development.
- Enhance public awareness about methods to address and reduce the impacts of stormwater runoff on water quality and habitat.
- Create stewardship opportunities that encourage community engagement in addressing stormwater impacts.

The outputs generated by the Model, particularly those aligned with the first three key questions outlined in this memorandum, will support the City’s implementation of strategies to meet the permit requirements listed above. Additionally, the Model’s potential to enhance public education and community involvement is further detailed in the response to the fourth key question.

How will the Model support the goals and objectives of the Snohomish Basin Conservation and Salmon Protection Plan?

The Model will support the implementation of the Conservation and Salmon Prioritization Plan (CSPP) by providing data-driven insights into habitat conditions, fish population needs, and restoration priorities. The Model will enable the City and its partners to align habitat protection and restoration actions with the overarching goals of the CSPP, particularly those focused on recovering ESA-listed Chinook, steelhead, and bull trout. By integrating spatial habitat data, species-specific requirements, and future land use and climate scenarios, the Model will help guide adaptive management, prioritize multi-benefit projects, and foster collaboration among stakeholders. Table 5 summarizes how the Model supports key CSPP goals and the resulting benefits for effective salmon recovery planning.

Table 5. Applications of the Fishery Habitat Model to Support the CSPP.

CSPP Goal	How the Model Supports It	Benefits
Protect and restore priority salmonid habitats.	Identifies high-quality habitats for protection and degraded areas for restoration, based on habitat function and fish use.	Ensures restoration efforts and investments focus on areas with the highest biological value or restoration potential.
Support recovery of ESA-listed Chinook, steelhead, and bull trout.	Maps habitat conditions critical to various life stages of ESA-listed species and simulates potential restoration outcomes.	Directs actions to address life-stage-specific limiting factors and achieve recovery benchmarks.
Integrate habitat and population data to guide adaptive management.	Combines spatial habitat data with fish monitoring (e.g., redd counts, smolt outmigration, adult returns) to track progress.	Provides a feedback mechanism to refine strategies and measure effectiveness over time.

Table 5 (continued). Applications of the Fishery Habitat Model to Support the CSPP.

CSPP Goal	How the Model Supports It	Benefits
Address limiting factors across the watershed.	Highlights areas where temperature, sedimentation, connectivity, or flow alterations constrain fish populations.	Enables targeted, factor-specific interventions that address the most critical barriers to recovery.
Plan and prioritize multi-benefit projects.	Supports scenario-based planning to evaluate restoration effectiveness and climate resilience under various land use conditions.	Aligns habitat restoration with broader objectives such as floodplain function, water quality, and equity.
Support land use and climate adaptation planning.	Simulates future conditions (e.g., urban growth, climate change) and their effects on salmon habitat distribution and quality.	Informs policy updates, including comprehensive plans, shoreline regulations, and climate adaptation strategies.
Promote collaboration and shared priorities among stakeholders.	Provides a transparent, consistent framework to evaluate and prioritize restoration needs across jurisdictions.	Fosters coordination and consensus among tribes, local governments, NGOs, and state/federal agencies.
Secure funding through data-driven prioritization and monitoring.	Supplies technical justification and outcome-based metrics to support grant proposals and project evaluations.	Enhances competitiveness for funding and strengthens accountability through measurable outcomes.

Background Information

Snohomish River Basin Salmon Conservation Plan

The Snohomish River Basin Salmon Conservation Plan (Snohomish Basin Salmon Recovery Forum 2005) outlines a long-term vision for achieving salmon recovery in the Snohomish River Basin, focusing on three key areas: habitat, hatchery management, and harvest practices. The Plan emphasizes targeted recovery actions aimed at the following:

1. Improving the quantity and quality of habitat in nearshore areas, estuaries, and river mainstems to restore populations of ESA-listed species
2. Minimizing further habitat loss and achieving habitat gains through restoration efforts throughout the broader basin

A status update from the Snohomish Basin Salmon Recovery Forum (2019) identified emerging challenges and highlighted the need for updated strategies based on new scientific findings. Notably, recent studies underscore the increased mortality of salmon due to toxic stormwater runoff, which can cause pre-spawn death, preventing successful reproduction. Additionally, the proliferation of invasive species continues to degrade riparian habitats, while populations of coho and chum salmon have shown significant declines. The Forum suggests considering strategies to identify and control sources of toxic contaminants, improve riparian conditions, protect habitat restoration investments, minimize invasive species reinfestation, and support the recovery and rebuilding of salmon stocks.

Snohomish Basin Protection Plan

The Snohomish Basin Protection Plan (SBPP; Snohomish County 2015) builds upon the foundation established by the Snohomish River Basin Salmon Conservation Plan (Snohomish County 2005). The primary objective of the SBPP is to identify and implement protection strategies aimed at preventing the degradation of hydrologic processes that are critical to supporting salmon populations and their habitats.

The SBPP recommends strategies that focus on strengthening and enhancing existing outreach, technical assistance, and incentive programs. Key recommended strategies include the following:

- Developing localized information on hydrologic importance within individual jurisdictions
- Protecting and maintaining instream flows essential for salmon life cycles
- Enhancing compliance with NPDES requirements by promoting the use of LID and GSI
- Improving outreach and providing technical assistance to rural residential landowners
- Offering technical support to farmers to promote sustainable land use practices
- Expanding water typing efforts and increasing resources for accurate stream classification

The output of the Model, as addressed in the first three key questions of this memorandum, will directly support the implementation of these strategies. By identifying critical hydrologic functions and potential risks to habitat quality, the Model will contribute to the SBPP’s goal of preventing hydrologic degradation and advancing the recovery and rebuilding of salmon stocks in the Snohomish Basin.

How will the Model support the integration of new policies and goals into the City's Comprehensive Plan?

The Model will help support the implementation and refinement of the Comprehensive Plan by providing spatially explicit data that links land use planning with habitat protection and climate adaptation goals. By aligning habitat assessment outputs with various Comprehensive Plan elements, the Model can inform zoning decisions, guide infrastructure investments, and enhance environmental policies. Additionally, the Model will contribute to long-term resilience planning and support community engagement through accessible data visualization. Table 6 outlines how the Model contributes to specific elements of the Comprehensive Plan.

Table 6. Model Contributions to the Comprehensive Plan.

Comprehensive Plan Element	Model Contribution
Land Use	Informs zoning and development regulations to protect key habitat areas.
Climate Change and Resiliency	Identifies vulnerable areas for adaptation and long-term conservation.
Environment and Natural Systems	Supports ecosystem-based management and resource protection policies.
Capital Facilities and Utilities	Guides infrastructure investments that reduce habitat impacts.
Community Engagement	Provides accessible maps and data to inform and involve the public.

Supporting Background Information

Climate Sustainability Plan

The City adopted its Climate Sustainability Plan (2023) to guide emission reductions and enhance community resilience through a comprehensive vision for greenhouse gas reduction and climate preparedness. The Plan addresses five key focus areas: buildings and energy, transportation, water and natural systems, waste management, and community resilience.

Within the water and natural systems focus area, the Plan emphasizes promoting a climate-resilient natural landscape by preserving and expanding the urban tree canopy, enhancing green spaces, protecting natural resources, encouraging LID, and conserving water resources. Example actions identified for this focus area include the following:

- **Action ID 1.1:** Develop LID policies and guidelines tailored to the City, aimed at reducing water usage and improving stormwater management.
- **Action ID 2.2:** Establish urban forestry and tree preservation guidelines to expand, protect, and enhance green spaces and natural ecosystems.
- **Action ID 2.3:** Increase aquatic habitat resilience during low summer flows through public education on techniques to extend water residence time, promote landscape-level water storage, support water conservation, and improve water quality protection.

These actions are designed to align with the City's broader climate adaptation objectives while directly supporting habitat health, stormwater management, and ecosystem resilience. The Model can further support these efforts by identifying vulnerable natural areas, informing conservation priorities, and integrating with LID and GSI planning.

Comprehensive Plan

The City of Lake Stevens Comprehensive Plan (2024) was updated in accordance with the requirements of the GMA. The Plan addresses both mandatory and optional elements through individual chapters, while the Climate Sustainability Plan (City of Lake Stevens 2023) is included as a supporting document. Long-term planning efforts are coordinated with Snohomish County, local school districts, regional fire and rescue, utility providers, neighboring jurisdictions, and other key stakeholders. Many of the City, County, and Basin-level planning documents referenced in this technical memorandum informed the development of the Comprehensive Plan.

Land Use Element

Chapter 2 outlines the City's land use strategy for managing growth over the next 20 years. It addresses the location, intensity, and density of land uses, and considers how traffic, drainage, and community services interact with development patterns. Key considerations include zoning for waterfront development, development potential in existing growth centers, and challenges within unincorporated

urban growth areas (UGAs), where topography, critical areas, and infrastructure limitations present constraints.

Relevant goals include the following:

- **Goal 2.9:** Optimize land use to balance economic benefits with the protection of natural resources, while minimizing risks to health, safety, and welfare.
- **Goal 2.10:** Where feasible, utilize natural drainage systems to reduce the impacts of stormwater runoff.

Environment and Natural Resources

Chapter 4 focuses on environmental protection and resource management, including critical areas regulations, Best Available Science, shoreline management, tree retention, and stormwater management.

Key environmental goals include the following:

- **Goal 4.1:** Preserve and conserve natural resources, ensuring that development is responsive to site characteristics and protects ecological and cultural assets.
- **Goal 4.2:** Implement the Shoreline Management Act, enhancing public access and protecting shorelines of statewide significance within city limits.
- **Goal 4.3:** Protect surface water, groundwater, aquifer recharge areas, and all critical areas (e.g., wetlands, lakes, streams, geological hazard zones, and wildlife habitats) through geologically appropriate development and alignment with regional, state, and federal policies.
- **Goal 4.4:** Collaborate with public and private partners to develop strategies for mitigating and adapting to climate change impacts affecting both City operations and the broader community.

Parks, Recreation, and Open Space

Chapter 5 sets forth policies for the acquisition, development, and enhancement of parks, recreation areas, and open spaces. Of particular relevance:

- **Goal 5.3:** Preserve and enhance open spaces and natural resource areas, including fish and wildlife habitats, migration corridors, natural meadows, and water resources.

The outputs of the Model, as detailed in the first three key questions of this memorandum, will directly support the implementation of goals outlined in both the Comprehensive Plan and Climate Sustainability Plan. The Model will provide Best Available Science and decision-support tools to guide both short-term actions and long-term planning. Specifically, the Model will aid in promoting sustainable growth, protecting natural resources, and informing policy development to align with the City's objectives for restorative land use and climate resilience.

How will the Model help identify areas of opportunity for water quality preservation or habitat/population recovery where there might be a nexus to salmonid habitats?

The Model will produce a range of spatial outputs that support the identification and prioritization of habitat restoration and protection opportunities. These outputs will enable the City to focus efforts on areas where ecological benefits to salmonids will be most significant. Table 7 highlights key opportunity types, the specific model outputs used to inform them, and the associated benefits to salmonid health, habitat quality, and population resilience.

Table 7. Opportunity Types Identified by Model Output.

Opportunity Type	Model Output Used	Benefit to Salmonids
Riparian Restoration Zones	Canopy cover, stream temperature, buffer width	Provides shade, regulates thermal conditions, and improves dissolved oxygen (DO) levels.
Stormwater Retrofit Prioritization	Impervious surface extent, runoff loading, proximity to outfalls	Reduces pollutant inputs, enhances water quality, and mitigates stormwater impacts on critical habitats.
Wetland or Floodplain Reconnection	Topography, land cover, channel confinement	Supports flow attenuation, increases habitat complexity, and restores natural hydrologic processes.
Habitat Corridor Enhancement	Connectivity metrics, land use data, in-stream cover conditions	Improves migration pathways, reduces habitat fragmentation, and supports population connectivity
High-Return Restoration Areas	Cumulative stressor mapping, life-stage-specific habitat overlays	Enables strategic investment in high-priority areas for the recovery of ESA-listed salmonid species.

Supporting Background Information

SMAP

As part of the SMAP, the City of Lake Stevens (2023a) assessed local watersheds, focusing on factors such as fish and aquatic habitat conditions, impervious surface coverage, flow control and LID opportunities, stormwater treatment potential, environmental justice, social equity, and broader stormwater management influences.

To prioritize catchment areas for stormwater planning and restoration, the City applied a ranking methodology based on two key categories: importance and degradation.

- Importance metrics evaluate the existing resource value of a catchment and identify opportunities to preserve or enhance these values.
- Degradation metrics assess factors that contribute to the disturbance or loss of natural resources and forest systems.

Opportunities for Green Stormwater Infrastructure in the Pilchuck Watersheds

The Snohomish Conservation District (2024) completed a spatial suitability assessment to identify optimal locations for implementing GSI practices within the Pilchuck Watersheds. The study evaluated the potential for rain gardens, roadside bioswales, street trees, and de-paving of impervious surfaces, with

the objective of prioritizing projects that provide the greatest water quality improvements. Key metrics analyzed in this assessment included the following:

- Soil infiltration capacity
- Site topography
- Hydrological significance
- Proximity to priority sites

Each site was scored based on these criteria, resulting in a prioritized list of GSI project types and locations across the watershed.

The goal of the model output analysis is to prioritize areas most in need of water quality protection and salmonid habitat restoration, and to further identify site-specific opportunities for mitigation and restoration practices. This will be accomplished by applying scoring criteria to model outputs developed through the analysis of Questions 1 to 3 in this memorandum.

The Model will support the evaluation and ranking of various preservation and habitat improvement practices, such as the following:

- Identifying high-priority locations for GSI implementation to improve water quality
- Determining parcel-level needs for shoreline restoration
- Highlighting opportunities for large-scale capital improvement projects aimed at enhancing fish habitat and watershed health

By integrating these analyses, the Model will help guide strategic investment in restoration actions and ensure alignment with both stormwater management and salmon recovery goals.

How will the Model integrate built infrastructure into the analysis of the above goals?

Integrating built infrastructure into fish habitat restoration is essential for identifying habitat constraints, improving restoration feasibility, and prioritizing infrastructure retrofits that provide co-benefits for water quality and habitat. This approach supports climate adaptation by aligning infrastructure upgrades with ecological objectives, informs land use planning to maintain habitat connectivity in urban areas, and enables balanced decision-making by highlighting trade-offs between growth and ecosystem function.

Table 8 summarizes types of built infrastructure that can be incorporated into the model and their role in supporting fish habitat restoration efforts.

Table 8. Application of Model Output to Integrate Built Infrastructure.

Integration Type	Infrastructure Data Used	Potential Model Application
Barrier Identification	Road/culvert network	Locate fish passage barriers that fragment habitat or restrict upstream movement.
Stormwater Impact Zones	Outfall locations, impervious surface data	Identify pollutant entry points and prioritize retrofits to improve water quality.
Conflict/Constraint Mapping	Utility corridors, urban land use	Highlight areas where infrastructure may limit restoration feasibility.
Green Infrastructure Opportunities	Public ROWs, vacant parcels, zoning overlays	Locate places for LID and nature-based stormwater solutions.
Thermal Pollution Risk Areas	Pavement cover, shade analysis	Assess urban heat island effects on adjacent stream segments.
Retrofit Prioritization	Infrastructure age/condition, drainage networks	Target aging systems for upgrades that also support water quality and habitat goals.

Following the analysis of salmonid habitat conditions and population status (as outlined in Questions 1 and 2), further evaluation can identify specific stormwater networks and developed areas that may be contributing to water quality degradation. This information can guide policymakers in promoting the integration of LID practices in future developments and help prioritize capital improvement projects aimed at improving water quality and habitat conditions within the City.

Supporting Background Information

Guidance on Integrating Stormwater Solutions Into Comprehensive Plans

The Puget Sound Regional Council (PSRC) published guidance titled *Integrating Stormwater Solutions Into Comprehensive Plans* (2023), highlighting that stormwater is a leading source of pollution in Puget Sound water bodies. The document emphasizes that land use and transportation development can either contribute to the degradation or improvement of water quality and hydrologic function. While stormwater management has traditionally been the responsibility of public utilities, the guidance notes that effective stormwater BMPs must also be implemented across private properties, roadways, parks, and other areas not solely designated for stormwater infrastructure. Comprehensive plans that integrate watershed-scale information, including data on floodplains, wetlands, streams, wildlife, and both natural and built infrastructure, can better inform land use designations, programs, and projects aimed at protecting and enhancing natural resources.

City of Lake Stevens Design Guidelines

The City of Lake Stevens Design Guidelines (City of Lake Stevens 2019) establish design standards for new construction and substantial alterations to reinforce the City's desired identity and promote the efficient use of developable land. The guidelines strongly encourage developers to utilize required landscape areas to enhance on-site stormwater management through the implementation of LID techniques.

Assessment Tools

One of the key challenges in watershed restoration is selecting the right assessments and tools to support informed planning and project development. Successful restoration efforts, particularly in urbanizing watersheds, depend on understanding where natural processes have been disrupted, which habitats have been lost or degraded, and what factors are limiting fish populations. Assessment tools available to help support different stages of the restoration planning process generally fall into five categories (Roni et al. 2018):

1. Life cycle models
2. Watershed assessments
3. Reach-scale assessments
4. Prioritization and decision-support frameworks
5. Monitoring and evaluation tools

These tools serve distinct purposes throughout the restoration planning process, including the evaluation of watershed conditions, identification of limiting life stages and habitat constraints, and diagnosis of ecological impairments. Additionally, these tools aid in the selection of targeted restoration actions, prioritization of restoration investments, and support for project design. No single tool is applicable to every step, so selecting the appropriate combination of tools is critical to developing cost-effective, science-based restoration strategies.

Table 9 provides a summary of model or framework types that fit into the first three assessment tool categories. The final two categories are beyond the scope of this analysis.

Table 9. Fishery Habitat Assessment Tool Categories.

Assessment Tool Category	Model or Framework Type	Description	Question Answered	Examples
Life Cycle Models	Limiting-Factor	Identify critical constraints in the life cycle or habitat limiting population growth or survival.	Which habitat conditions are limiting fish survival and productivity, and should be prioritized for restoration?	Ecosystem Diagnostic and Treatment (EDT), NetMap
	Life Cycle	Simulate fish survival across life stages to estimate population performance.	Which restoration actions will most effectively increase fish populations across their life cycle?	EDT, Salmon Population Model (SALMOD)
	Intrinsic Potential	Predict habitat suitability based on long-term physical characteristics like slope, elevation, and confinement.	Which areas have the highest ecological potential if restored?	NetMap (incorporates NOAA Intrinsic Potential Model for Salmonids)
	Climate Change Models	Project how climate-driven changes (temperature, precipitation, streamflow) affect habitat, life cycle timing, and survival.	How will future climate conditions impact habitat suitability and population viability, and how should restoration adapt?	NetMap, NorWeST (USFS)
Watershed Assessment Tools	Sediment Supply	Identify and quantify sediment delivery from watershed sources and assess its impact on fish habitat quality.	Where is excess sediment coming from, and how is it degrading fish habitat?	NetMap, Water Erosion Prediction Project (WEPP)
	Hydrology	Evaluate watershed flow patterns and how they influence fish habitat; assess impacts of land use and climate change.	How do changes in streamflow patterns (e.g., timing, magnitude, duration) affect fish habitats, and how can flows be restored or protected?	Soil and Water Assessment Tool (SWAT), HEC-HMS (Hydrologic Modeling System)
	Nutrients	Analyze nutrient (nitrogen and phosphorus) movement through the watershed and its effects on water quality and fish habitat.	How do watershed-scale nutrient inputs affect water quality in ways that impact fish habitat, and where should management be focused?	SPARROW (USGS), SWAT, BASINS (EPA)

Table 9 (continued). Fishery Habitat Assessment Tool Categories.

Assessment Tool Category	Model or Framework Type	Description	Question Answered	Examples
Reach-Scale Assessment Tools	Riparian Processes	Assess and simulate how riparian vegetation and processes influence stream conditions, including shading, erosion control, and nutrient filtering.	How do riparian processes influence water quality, habitat complexity, and fish habitat suitability, and where should restoration efforts be focused?	NetMap, Riparian Ecosystem Evaluation Tool (RIP-ET)
	Floodplain and Fluvial Processes	Simulate interactions between water, sediment, and channel dynamics with the floodplain to evaluate habitat creation or degradation.	How do floodplain dynamics and fluvial processes at the reach scale influence fish habitat quality, and how can floodplain restoration improve conditions?	HEC-RAS, NetMap
	Channel and Habitat Conditions	Quantify the physical structure and characteristics of a stream reach and link these metrics to fish habitat suitability.	What are the physical characteristics and habitat features of a stream reach, and how do these influence fish habitat quality and guide restoration?	River2D, Habitat Suitability Index (HSI) mapping
	Water Quality	Evaluate reach-scale water quality parameters (e.g., temperature, DO, turbidity, nutrients) and their effects on fish health and habitat.	How do water quality parameters vary within a stream reach, and how do these conditions affect fish habitat suitability and life-stage requirements?	BASINS, SPARROW, Water Quality Analysis Simulation Program (WASP)
	Biological Assessments	Assess habitat condition using biological indicators (fish, macroinvertebrates) to evaluate ecological health, degradation, or recovery.	What is the biological condition of a specific stream reach, and how does it compare to expected conditions, informing restoration priorities?	EPA Rapid Bioassessment Protocols (RBP), Fish Habitat Decision Support Tools (e.g., EDT Lite)

Model Comparison

A comparison matrix of GIS-Based Fishery Habitat models is provided in Appendix A. This matrix provides a structured evaluation of various watershed- and reach-scale assessment tools relevant to fish habitat recovery, water quality improvement, flood risk reduction, and integrated stormwater management. It summarizes the core functions, strengths, and applicability of each model or tool in relation to key project objectives identified in the Lake Stevens Salmonid Basins planning effort. The matrix highlights how each tool addresses specific processes—such as hydrology, sediment transport, riparian and floodplain dynamics, water quality, fish passage, and climate resilience—and identifies opportunities for integrating components from multiple models.

Model Selection

The Lake Stevens Plan for Salmonid Basins is intended to develop basin-level management solutions that inform decision-making, guide program development, shape policy, and prioritize capital projects focused on enhancing water quality and restoring salmon habitat. The Basin Plan will support the City’s long-term efforts to minimize water quality degradation, sustain a natural lake fishery, restore Lower Stevens Creek, reduce flooding of residential areas and public infrastructure, enhance climate resilience, improve and expand fish habitat, and restore fish passage. It will also ensure the City remains compliant with Best Available Science in implementing its Comprehensive Plan.

Based on the regulatory requirements summarized in the previous section and the planning objectives and goals outlined in the Project Charter, the selected Fishery Habitat Model must meet the following evaluation criteria:

Table 10. Fishery Habitat Assessment Tool Categories.

Evaluation Criteria	Required Functionality
Basin-Level Management Support	<ul style="list-style-type: none"> Operates at the basin scale, integrating watershed-wide land use data. Supports policy development, project planning, and capital project prioritization.
Water Quality Enhancement	<ul style="list-style-type: none"> Models water quality parameters (e.g., temperature, nutrients, turbidity). Identifies sources of degradation and areas for water quality improvements relevant to salmonid habitat.
Habitat Restoration Capability	<ul style="list-style-type: none"> Simulates in-stream and riparian habitat conditions. Assesses habitat suitability for different salmonid life stages. Integrates tree canopy cover.
Flood Risk and Hydrology	<ul style="list-style-type: none"> Integrates with hydrologic modeling to evaluate flow regimes, floodplain connectivity, and the impacts of residential and infrastructure flooding.
Climate Change Resiliency	<ul style="list-style-type: none"> Incorporates climate scenarios (e.g., future flow, temperature, precipitation). Evaluates habitat vulnerability and resilience under climate projections. Supports adaptive management planning for long-term resilience.
Fish Habitat and Passage	<ul style="list-style-type: none"> Identifies and evaluates fish passage barriers (culverts, weirs, dams). Prioritizes fish passage restoration projects. Maps current and potential habitat connectivity.
Regulatory and Science Alignment	<ul style="list-style-type: none"> Uses or supports Best available Science. Compatible with regulatory frameworks (e.g., SMP, ESA, GMA). Aligns with Comprehensive Plan goals and requirements.
Economic and Environmental Balance	<ul style="list-style-type: none"> Analyzes trade-offs between economic development and habitat protection. Supports scenario modeling for growth impacts on habitat and water quality. Helps define areas for preservation versus development.
Outputs for Decision-Making	<ul style="list-style-type: none"> Generates actionable output. Supports future integration with prioritization frameworks for restoration and infrastructure projects.

Based on the evaluation criteria in the table, the most appropriate type of Fishery Habitat Model for the City is a hybrid model that combines elements of the following model types:

1. **Watershed Assessment Model:** The evaluation criteria emphasize basin-level management, water quality, hydrology, and flood risk, all of which are core components of watershed assessment tools. These models integrate land use, stormwater impacts, and watershed-scale processes, aligning with the Capital Improvement Planning and policy development goals of the Plan.
2. **Reach-Scale Assessment Model:** The need to evaluate in-stream and riparian habitat conditions, fish passage, and habitat connectivity at finer scales fits well with reach-scale models. These models help assess specific restoration sites and fish habitat quality, supporting actionable output for prioritizing projects.
3. **Climate Change Modules:** The criteria require incorporation of climate scenarios, resilience evaluation, and adaptive management, which are key strengths of models with climate modules.

Less appropriate model types for this application include the following:

- **Limiting-Factor Models:** These are useful for diagnosing specific biological bottlenecks but may lack the broader land use, stormwater, and policy planning components needed here.
- **Life Cycle Models:** Valuable for population dynamics but typically less focused on land use integration and infrastructure planning at the basin level.
- **Intrinsic Potential Models:** These are more static, based on long-term physical features, and less suited for modeling urbanization, stormwater impacts, or adaptive management needs.

Model Recommendation

This project will require the use of both watershed-scale and reach-scale assessment tools to support fish habitat recovery, enhance water quality, and reduce flood risks within the Lake Stevens Salmonid Basins. A review of available models and tools has been conducted, including life cycle models, intrinsic potential models, climate change models, sediment and hydrology models, riparian and floodplain assessment tools, water quality frameworks, and biological assessment tools. While each offers valuable capabilities, none individually address all of the project's objectives.

Given the project's complexity, including the need to evaluate watershed hydrology and sediment processes, assess localized habitat constraints, restore fish passage, and integrate stormwater management and GSI, a flexible, integrated modeling approach is required. To meet this need, Herrera proposes using a "framing questions" approach, drawing on components from multiple models to address specific management questions. Each framing question will identify the purpose, required data inputs, the most appropriate model or custom analysis, and the expected outcomes.

For example, a framing question might be:

"Where will specific restoration actions (e.g., riparian plantings, GSI retrofits) most effectively reduce temperature stress on fish populations?"

The objective is to prioritize reaches where elevated temperatures limit habitat quality and target shading or stormwater cooling interventions. Data inputs include stream temperature, riparian vegetation cover, fish thermal tolerance thresholds, stormwater infrastructure, land use, and elevation data. Expected outputs include maps highlighting priority reaches based on thermal stress and riparian condition.

By combining elements from various models, we will develop a customized assessment framework that supports basin-level planning and generates output that can be used in the future to prioritize restoration investments and informs project design. This approach enables the strategic combination of tools tailored to restoration priorities and generates data sets that could be integrated into more detailed species life-stage models if needed in the future.

This framework will address climate resilience, stormwater impacts, and fish habitat connectivity. The specific framing questions, data needs, and modeling methods will be detailed in the forthcoming Task 1.5A Summary Memorandum.

References

- City of Lake Stevens. 2023. City of Lake Stevens Climate Sustainability Plan.
- City of Lake Stevens. 2024. City of Lake Stevens 2024 Comprehensive Plan.
- City of Lake Stevens. 2019. City of Lake Stevens Engineering Development and Design Standards.
- City of Lake Stevens. 2025. City of Lake Stevens Stormwater Management Program.
- City of Lake Stevens. Lower Stevens Creek Restoration - Project Priorities and Elements. Figure.
- City of Lake Stevens. 2013. Shoreline Master Program (SMP) - City of Lake Stevens approved Shoreline Master Program.
- City of Lake Stevens. 2023a. Stormwater Management Action Plan (SMAP).
- Clear Creek Solutions. 2023. Lake Stevens Weir Design. Memorandum.
- DCG. 2020. Lake Stevens Outlet Study. Final Technical Memorandum.
- EPA. 2014. Visualizing Ecosystem Land Management Assessments (VELMA) Model. User Manual.
- National Oceanic and Atmospheric Administration (NOAA) Fisheries. 2000. Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units. NOAA Technical Memorandum NMFS-NWFSC-42. Washington, D.C. (as cited in Snohomish Basin Salmon Recovery Forum 2005).
- Puget Sound Institute (EPA). 2018. Puget Sound Integrated Modeling Framework (PSIMF). Presentation.
- Puget Sound Regional Council. 2023. Guidance on Integrating Stormwater Solutions Into Comprehensive Plans. Vision 2025 Planning Resources.
- Roni, P., Anders, P.J., Beechie, T.J., & Kaplowe, D.J. (2018). Review of tools for identifying, planning, and implementing habitat restoration for Pacific salmon and steelhead. *North American Journal of Fisheries Management*, 38(2), 355–376. <<https://doi.org/10.1002/nafm.10035>>.
- Snohomish Basin Salmon Recovery Forum. 2005. Snohomish River Basin Salmon Conservation Plan. Snohomish County Department of Public Works, Surface Water Management Division. Everett, WA. June.
- Snohomish Basin Salmon Recovery Forum. 2019. Snohomish River Basin Salmon Conservation Plan Status and Trends. Snohomish County Department of Public Works, Surface Water Management Division. Everett, WA. December.
- Snohomish Conservation District. 2024. Opportunities for Green Stormwater Infrastructure in the Pilchuck Watersheds.
- Snohomish County. 2015. Snohomish Basin Protection Plan.

Appendix A

Bibliography, Data Set Inventory, and Model Comparison Matrix

Bibliography

Table A-1. List of Additional Reviewed Documents.

Document	Author	Year
Lake Stevens/Catherine Creek Watershed Management Plan	Gray & Osborne	1999
Lake Level Management Plan	City of Lake Stevens	2011
Governor's Salmon Strategy Update	Office of the Governor	2021
Lake Stevens Outlet Channel - Fish Relocation Summary	Greg Johnston	2021
Lake Stevens Downtown Storm Construction Drawings	DCG	2022
Sound Choices Implementation Checklist	Puget Sound National Estuary Program	2023
Stakeholder Kick-off Meeting	City of Lake Stevens	2025

Inventory

Table A-2. List of Available Data for Developing the Fisheries Habitat Model.

Data Set	Content	Source	Date
Fish Use Data	Stream specific fish and habitat data, stock status, recovery evaluations	SalmonScape (WDFW) ^a	January 1, 2024
Statewide Washington Integrated Fish Distribution	Salmonid presence, runtime, time of year, spawning time	NWIFC and WDFW ^b	October 5, 2024
Priority Habitat and Species (PHS) Data	Inventory of salmonid species, inventory of harmful/invasive species	WDFW	October 5, 2024
Fish Streams	Streams with salmonids	WA Ecology	July 2024
Land Cover	Land cover classification	WA Spatial Data	January 1, 2021
National Hydrography Dataset (NHD)	Data on streams (type, erosion and confinement status), wetlands (type) and waterbodies (type, hydrographic category)	WA Ecology	July 2024
CHAMP Streams	Channel Migration Potential data	WA Ecology	February 2015
Areas of Environmental Concern	Streams, rivers, and watersheds of concern	WA Ecology	March 5, 2025
Lake Bathymetry	Lake Stevens bathymetry	WA Ecology	2020
Lake Stevens WQ Assessment	WA Ecology 305b and 303d compliance related water quality parameter data	WA Ecology	May 23, 2023
TMDL Boundaries	Total Maximum Daily Loads for pollutants in rivers and watersheds	WA Ecology	May 23, 2023
Unstable Slopes	Locations of unstable slopes and their slope class	WA Ecology	January 2008
Dam Locations	General information, hazard classification	WA Ecology	November 2011
Stormwater Network	Stormwater pipes, stormwater structures, BMPs, stream crossings, and culverts	Snohomish County	April 1, 2025
City of Lake Stevens UGA	Urban growth area boundaries	Snohomish County	March 13, 2025
Zoning Data	Zoning information with abbreviations and descriptions	Snohomish County	March 13, 2025
Lake Stevens Critical Areas	Stream buffers, shoreline designations, and TRS zones	City Database	July 6, 2024
Shoreline Buffers	Lake Stevens shoreline buffers with mapping of the Ordinary High-Water Mark	City Database	November 6, 2024
Catchments	Subbasins to the creeks in the study area	City	July 6, 2024
Fish Passage Barriers	The location and types of barriers, and the potential of fish and specific species detected	WDFW	January 1, 2024

^a Washington Department of Fish and Wildlife (WDFW)

^b Northwest Indian Fisheries Commission (NWIFC)

Table A-3. Fishery Habitat Model Comparison Summary.

Model Name	Primary Model Type	Source	Purpose	Scale
NOAA HARP	Reach & Watershed Assessment	NOAA	Habitat Assessment and Recovery Planning using physical and biological data.	Reach & Watershed Scale
HEC-RAS	Reach Assessment	U.S. Army Corps of Engineers	Simulate floodplain dynamics, channel processes, and hydraulic connectivity.	Reach Scale
River2D	Reach Assessment	University of Alberta	Habitat suitability modeling under varying flow conditions.	Reach Scale
CHAMP	Reach Assessment	NOAA, Bonneville Power Administration	Standardized habitat monitoring protocol for condition assessment.	Reach Scale
Riparian Ecosystem Evaluation Tool (RipET)	Reach Assessment (Riparian Processes)	Washington Department of Ecology (Ecology), partners	Evaluates riparian conditions and restoration potential.	Reach Scale
WASP	Reach Assessment (Water Quality)	EPA	Simulates water quality processes, including pollutants and temperature.	Reach Scale
NorWeST	Reach & Watershed Assessment	U.S. Forest Service Rocky Mountain Research Station	Predicts stream temperature regimes across large spatial scales.	Reach & Watershed Scale
NetMap	Reach & Watershed Assessment	TerrainWorks	Watershed assessment for habitat condition, sediment, and connectivity analysis.	Watershed & Reach Scale
SWAT	Watershed Assessment	USDA & Partners	Hydrology and water quality modeling, sediment and nutrient transport.	Watershed Scale
SPARROW	Watershed Assessment	U.S. Geological Survey	Watershed-scale nutrient and sediment transport modeling.	Watershed Scale
VELMA	Watershed Assessment	Environmental Protection Agency (EPA)	Eco-hydrological model for watershed processes, including LID impacts.	Watershed Scale
BASINS	Watershed Assessment	EPA	Watershed analysis for water quality modeling and planning.	Watershed Scale
WEPP	Watershed Assessment (Sediment Supply)	U.S. Forest Service, USDA	Predicts soil erosion and sediment yield at the watershed scale.	Watershed Scale

Table A-3 (continued). Fishery Habitat Model Comparison Summary.

Model Name	Target Species	Green Infrastructure Integration	Climate Resiliency Integration	Data Requirements
NOAA HARP	ESA-listed Salmonids	Indirect, informs habitat recovery in urban systems	Moderate - integrates some climate projections with habitat analysis.	Habitat surveys, flow data, species presence, land use
HEC-RAS	Salmonids (migration and spawning habitats)	Can assess floodplain reconnection for GSI planning	Moderate - evaluates floodplain reconnection, resilience to flow changes.	Cross-sections, DEM, flow data, land cover
River2D	Salmonids (spawning and rearing habitat)	Indirect, focuses on physical habitat under hydraulic conditions	Moderate - can test habitat suitability under varying flow regimes.	Hydraulic data, DEM, substrate type, flow regimes
CHAMP	Salmonids (focus on Chinook)	Indirect, through habitat condition monitoring	Low - baseline monitoring, not predictive for climate.	Field-based habitat surveys, stream morphology
Riparian Ecosystem Evaluation Tool (RipET)	Indirect for salmonids via riparian health	Indirect - informs riparian restoration as GSI	Low - static evaluation of riparian zones	Riparian vegetation, land use, stream proximity
WASP	General aquatic species (temperature, DO, pollutants)	Supports stormwater and GSI impacts on water quality	Moderate - models water temperature and pollutants under scenarios.	Water quality parameters, flow data
NorWeST	Salmonids (temperature-sensitive)	Indirect, supports thermal GSI planning	High - provides future stream temperature projections.	Stream temperature, flow data, air temperature
NetMap	Salmonids (Chinook, Steelhead, Bull Trout)	Indirect (can inform GSI opportunities through runoff and erosion data)	Moderate - assesses erosion, connectivity impacts, and habitat vulnerability indirectly.	DEM, land cover, hydrology, roads, fish presence, channel data
SWAT	General fish habitat (supportive, not species-specific)	Supports scenario testing for LID/GSI BMPs	High - simulates future scenarios for climate, land use, and BMP effects.	Climate data, soil, land use, management practices, topography
SPARROW	Indirect, water quality for general fish habitat	Supports watershed-wide GSI planning for pollutant reduction	Moderate - identifies pollutant loading trends, but limited temporal dynamics.	Water quality data, land use, soils, point/non-point sources
VELMA	General fish habitat (focus on water quality and flow)	Direct - simulates LID/GSI implementation and impacts	High - models climate, land use, and GSI effects over time.	Land use, soils, climate data, hydrology
BASINS	General fish habitat (water quality focus)	Supports evaluation of BMP and GSI implementation	Moderate - scenario analysis includes future BMP impacts.	Water quality data, land use, hydrology, BMP scenarios
WEPP	Indirect, sediment-sensitive species like salmonids	Supports erosion control planning and BMP effectiveness	Moderate - evaluates erosion trends under different land uses.	Soil data, climate, land use, topography

Table A-3 (continued). Fishery Habitat Model Comparison Summary.

Model Name	Outputs	Strengths	Limitations
NOAA HARP	Habitat condition reports, recovery priorities	Focused on actionable recovery planning, regulatory alignment	Requires detailed local data, less emphasis on GSI
HEC-RAS	Water surface profiles, flood extents, habitat connectivity	Accurate hydraulic modeling, supports restoration design	Requires hydraulic expertise, time-intensive setup
River2D	Habitat suitability maps, velocity, depth, substrate conditions	Detailed habitat analysis, flow-sensitive modeling	Limited to hydraulic conditions, no watershed-scale integration
CHAMP	Consistent habitat condition datasets	Standardized, field-based, supports long-term monitoring	Not a predictive model, limited spatial analysis, model support has been deprecated
Riparian Ecosystem Evaluation Tool (RipET)	Riparian health indices, restoration priorities	Useful for riparian planning, simple to apply	Limited to riparian zones, not integrated with full hydrology
WASP	Temperature, DO, nutrients, pollutant concentration trends	Detailed water quality modeling at the reach level	Not habitat-specific, focuses on water chemistry
NorWeST	Stream temperature maps, thermal refugia identification	Large-scale, detailed stream temperature data	Focuses solely on temperature, no direct habitat modeling
NetMap	Habitat quality, sediment sources, connectivity barriers, riparian condition	High-resolution spatial analysis, integrates with other GIS tools	Data intensive, limited dynamic climate integration, requires an annual subscription fee
SWAT	Flow patterns, sediment/nutrient loads, BMP scenario outputs	Robust hydrologic simulation, strong GSI application potential	Requires detailed calibration, limited reach-scale habitat detail
SPARROW	Nutrient and sediment delivery to streams	Strong pollutant tracking, good for large-scale planning	Less detailed at reach scale, limited habitat-specific outputs
VELMA	Hydrology, water quality, LID/GSI effectiveness	Strong for evaluating GSI and climate scenarios	Complex setup, may need extensive calibration
BASINS	Water quality trends, pollutant load reductions	Integrated tools for regulatory support and planning	Limited habitat detail, broader water quality focus
WEPP	Sediment yield, erosion rates, BMP impact	Strong erosion model, links sediment to habitat impacts	Does not model habitat directly, sediment-focused