Protect, Connect and Unlock the Natural Potential:

Technical Strategy for Salmonid Conservation and Recovery in the Green/Duwamish and Central Puget Sound Watersheds

(Water Resource Inventory Area 9 and Vashon/Maury Islands)
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Summary

The Water Resource Inventory Area (WRIA) 9 Technical Committee developed this technical strategy to help prioritize initial actions for salmonid conservation and recovery in the Green/Duwamish River watershed and nearshore areas of WRIA 9, including Vashon/Maury Islands. The strategy is based on the current state of knowledge, the ecological principles and habitat limiting factors described in the Habitat Limiting Factors and Reconnaissance Assessment Report (2000), the Viable Salmonid Population (VSP) guidance from NMFS (2000), and emerging information from the WRIA 9 Strategic Assessment. The technical strategy is designed to help focus future actions in the WRIA 9 watershed such as research and studies, habitat preservation, and restoration, rehabilitation and enhancement efforts. This document contains five sections: (1) principles to guide salmon recovery, (2) VSP in WRIA 9, (3) the technical strategy, (4) monitoring and adaptive management, and (5) use of the technical strategy in the WRIA 9 salmon conservation planning process. In addition, information on habitat factors of decline, and subwatershed actions and priorities is presented in the appendix.

The WRIA 9 technical strategy focuses on three high-priority watershed goals to address habitat issues in support of salmon conservation and recovery:

- **Protect currently functioning habitat and habitat forming processes from degradation,** primarily in the Middle Green River subwatershed and the nearshore areas of Vashon/Maury Islands. This will help maintain and support the abundance and productivity of salmonid populations.

- **Connect the Upper Green River subwatershed by restoring access for salmonids** to facilitate efficient and safe passage for adults and juveniles above and below the dams. This will increase the spatial distribution of salmonids and contribute to increased diversity and abundance.

- **Restore/Enhance habitat that contributes to adequate juvenile salmonid survival.** This will be the primary approach in the Lower Green River, Duwamish River and Nearshore subwatersheds to increase productivity and contribute to increased life history diversity.

The WRIA 9 technical strategy for salmon conservation and recovery will be used for three purposes: (1) to support development of the WRIA 9 Habitat Plan, (2) to evaluate and prioritize projects (e.g., for Salmon Recovery Funding Board and King Conservation District funding), and (3) to support development of a research agenda for the Strategic Assessment.

Principles to Guide Salmon Recovery

The National Marine Fisheries Service (NMFS), in its guidance for comprehensive salmon conservation and recovery habitat plans, identified five objectives as central to salmon conservation efforts (NMFS, 1996; Spence et al., 1996). The Factor of Decline Subcommittee and WRIA 9 Technical Committee used this guidance and other documents to develop a list of principles as a basis for developing the WRIA 9 technical strategy. These principles are:

- Protect and maintain existing physical, chemical, and biological processes and the habitats they form as well as restoring those that have been degraded or lost. This includes five sub-principles:
  - Protect and restore the natural ecosystem processes responsible for creating habitats required by salmonids;
  - Protect and restore those habitats that are necessary during all life stages of salmonid development;
  - Maintain quality habitats that function as refugia ("fish sanctuaries") from which salmonid populations may expand;
  - Maintain the corridors (connectivity) that link habitats and emphasize the (re)connection of freshwater, estuarine, and saltwater habitats and their associated zones as required by salmonids during all life stages; and
  - Adopt an ecological approach to maintaining, improving, and restoring freshwater, estuarine, and saltwater habitats and their associated zones.
- Emphasize self-sustaining runs of naturally-spawning salmon when developing protection and restoration strategies.
- Preserve protection and restoration/rehabilitation opportunities for important habitats.
- Apply scientifically rigorous adaptive management techniques to all elements of recovery activities for WRIA 9.

Viable Salmonid Populations (VSP) in WRIA 9

In May 2002, the WRIA 9 Steering Committee approved the use of the Viable Salmonid Population (VSP) guidance (NMFS, 2000) for carrying out the WRIA 9 Strategic Assessment. The VSP approach is intended to help establish delisting goals and Evolutionary Significant Unit (ESU)-specific delisting criteria. NOAA Fisheries will use this information to determine which and how many populations are necessary for a viable ESU. WRIA 9 technical work will help inform this determination.

The VSP document contains guidelines for each parameter that a salmonid population must demonstrate in order to be considered viable. At the heart of the VSP concept are four parameters that describe a viable salmonid population:

- Abundance: defined simply as population size or numbers of fish at all life stages
- Productivity: defined as how well the population is "performing" in its habitat, or the growth rate of the population
- Diversity: defined as differences within and among populations in genetic and behavioral traits (e.g., life-history trajectories)
- Spatial Structure: defined as both the geographic distribution of fish in a watershed and the physical processes that lead to that distribution.

In WRIA 9, information about these VSP parameters will be used to help guide our efforts with respect to the three high-priority watershed goals.

Abundance

Abundance refers to the number of fish in a population. Smaller populations have a greater risk of extinction than larger populations. To date, abundance has received the most attention in salmon recovery efforts. Abundance is measured by counting or estimating the total number of spawning salmon on redds, which is a measure of production or female spawners.

In order for the chinook population to be considered viable, it must be large enough to withstand the effects of natural environmental variation, such as changes in ocean conditions or stream channel impacts caused by landslides and earthquakes. It must also be large enough to achieve a population *density* that protects it against human-induced change. There must be enough fish to maintain healthy genetic diversity, and to maintain the ecosystem scale functions that salmon provide. For example, decaying carcasses provide important nutrients to the watershed, and adequate habitat is necessary to support sufficient numbers of fish to supply these nutrients.

The WRIA 9 Reconnaissance Assessment summarizes recent run data for the Green/Duwamish summer/fall chinook run. During the period 1968-1996, the estimated naturally produced run averaged 17,400 fish, with a range of 5,600 in 1973 to 41,000 in 1983. The estimated spawning escapement (or those fish that survive to spawn naturally) averaged 6,031 chinook with a range of 2,027 to 10,059. These figures include progeny of naturally spawning fish as well as hatchery fish that stray onto the spawning grounds. The proportion of hatchery-origin chinook that spawn naturally in the mainstem Green River and Newaukum Creek averages 50-56 percent (Cropp, unpublished data). The co-managers have begun mass-marking Soos Creek Hatchery salmon using adipose fin clips. In the future, this will improve information on the percent of hatchery-origin fish that spawn naturally. The co-managers consider the Green River population to be "healthy" based on trends in overall abundance (WDFW and WWTIT 1994). The goal for natural spawning escapement is 5,800 fish, which has been exceeded in most years since 1987. It is important to emphasize, however, that the number of natural spawners of wild origin alone is likely not enough to meet escapement goals. Thus, it will be necessary to address the issue of hatchery-origin versus wild-origin spawners in conservation and recovery efforts.

Productivity

Productivity provides information on how well a population is "performing" in the habitats it occupies during the life cycle. There are numerous ways to measure productivity or population growth rate, including spawners per spawners, recruits per spawner, or eggs per spawner. Changes in traits such as size and age of spawners are also indicators of a population's productivity. Estimates of productivity that indicate that a population is consistently failing to replace itself are indications of increased extinction risk no matter what the cause. To determine the total productivity of a watershed in terms of adults produced per adult spawner requires the reconstruction of age class cohorts and calculations of total run size. For a population of salmon to be viable it needs to produce enough offspring to meet or exceed their replacement need. This requires that either the spawner:spawner or cohort-replacement ratio must be 1.0 or better. The population also should be productive enough that when ocean conditions cause a decline in abundance, the remaining fish can exploit available habitat and perform better due to less competition amongst themselves. It is recommended that long time-series data be used to estimate productivity.

The VSP document notes that a viable salmon population that includes naturally spawning hatchery fish should exhibit sufficient productivity from naturally produced spawners (i.e., not hatchery origin) to maintain population abundance at or above viability thresholds in the absence of a hatchery subsidy. The population should not exhibit a trend of proportionally increasing contributions from naturally spawning hatchery fish.

Seiler et al. (2002) estimated egg-to-migrant survival for naturally-reared chinook salmon in the Green River above RM 34 (location of the WDFW screw trap) during the juvenile salmonid outmigration season in 2000. The estimated migration of 535,700 wild age 0+ chinook migrants divided by the estimated egg deposition above the trap site resulted in an egg-to-migrant survival of 7.3 percent. The estimated egg deposition was derived using an above-the-trap escapement estimate of 1,625 chinook females based on a redd count of 1,625 redds and an average fecundity of 4,500 eggs per female. It will be important to compare these estimates with those for 2001 and 2002 when they become available.

It will be important to determine the role of naturally spawning hatchery fish when examining productivity in WRIA 9. As noted above, the estimated average of naturally spawning chinook of hatchery origin is 50-56 percent (Cropp, unpublished data). An assessment of salmonid productivity in WRIA 9 is a key research need.

Diversity

Diversity refers to differences within and among populations in genetic and behavioral traits. Although some traits are dependent upon genetics, others vary as a result of a combination of genetic and environmental factors. Diversity relates to genetic diversity, adult return timing, and juvenile life history types. Diversity is important for three reasons: (1) it promotes spatial and temporal variability in habitat use, (2) it protects a species against short-term spatial and temporal changes in the environment, and (3) it provides the raw material for surviving long-term environmental changes.

The Green/Duwamish River chinook in WRIA 9 is considered to be an independent population because of their relative geographic isolation from neighboring streams (NMFS, 2001a). NMFS also noted that the historic connection between Lake Washington (via the Black River) and the White River with the Green/Duwamish River may have resulted in genetically related chinook in these three river basins. Prior to European settlement, the wild chinook likely exhibited a healthy, natural rate of genetic diversity. A major question related to the diversity of the current population is the effect of the hatchery fish on genetic diversity and other characteristics even though the hatchery fish are of Green River origin. NMFS (2001b) noted that hatchery salmonids are markedly different from their wild counterparts in behavioral and morphological characteristics, survival and reproductive ability.

In Newaukum Creek, data indicate that approximately 50 percent of the spawners are of hatchery origin (Cropp, unpublished data). Interestingly, about 39 percent of the spawners returning to the Soos Creek hatchery are the product of naturally spawning parents. These data are probably reliable because the sampling rate was 30 percent in Newaukum Creek and 98 percent at the hatchery (Cropp, pers. comm., 1999).

Kerwin and Nelson (2000) suggested that there is potential for at least four life-history trajectories in the Green/Duwamish watershed:

- Yearlings spend over a year in freshwater before migrating to the marine environment
- Fingerlings spend months in the freshwater and days in the estuary before migrating to the marine environment
- Fry/fingerlings spend days to months in the freshwater and months in the estuary before migrating to the marine environment
- Emergent fry spend only days in the freshwater before spending months in the estuary before migrating to the marine environment

Two examples of changes in behavioral diversity of WRIA 9 chinook over the past 150 years are the loss or dramatic reduction of the spring chinook run, and the loss or dramatic reduction in the yearling life-history trajectory. Spring chinook historically were present in the Green River, but today the fish may return in such low numbers that they are undetectable. It is possible that they were extirpated after the construction of the Tacoma Headworks Dam in 1911 or were re-routed from the basin with the diversion of the White River into the Puyallup River in 1906 (Kerwin and Nelson, 2000). The two primary life history trajectories that remain are the emergent fry migrants (which move downstream from late January to early April) and the fingerling migrants (which outmigrate from mid-May to mid-June) (Seiler et al., 2002)

Spatial Structure

Spatial structure refers to the geographic distribution of both adults and juveniles within the watershed. It helps protect the population from naturally occurring hazards as well as anthropogenic impacts. For instance, a major landslide that might smother redds in the mainstem

Green may not affect spawning habitat in Newaukum Creek. Therefore, maintaining the diversity of spawning areas is important to the long-term health of the population. While there is good information on spawner distribution within WRIA 9, there is limited data on the distribution of juveniles. Information on the distribution of juveniles and utilization of habitat is a key research need in WRIA 9.

Two major spawning aggregations of chinook salmon were identified by WDFW and WWTIT (1994) in the Duwamish and Green River system. These include chinook salmon that spawn from river mile 25-61 in the Green River, and an aggregation of similar fish that spawn in Neuwakum Creek, primarily in the lower four miles. Natural spawners in Neuwakum Creek are genetically similar to Green River Hatchery fish (Marshall et al. 1995), and the WDFW considers them the same genetic population.

In a draft analysis of spawning data from 1997-2000, Malcom (2002) found that on average about 20 percent of mainstem redds are in the Lower Green (from RM 25-33), 40 percent are between Soos Creek and the Old Flaming Geyser Bridge (RM 33-43), and 40 percent are between the bridge and the Tacoma Headworks Dam (RM 43-61). Within these large reaches, areas of dense spawning concentrations vary from year to year. In addition to the mainstem spawning, about 15 percent of natural spawning occurs in Newaukum Creek (Malcom, 2002).

The WRIA 9 Habitat Limiting Factors and Reconnaissance Report (Kerwin and Nelson, 2000) indicates that juvenile chinook rear in the mainstem Green River, Big Soos Creek, Newaukum Creek, Burns Creek, Mill Creek, Springbrook Creek, and Crisp Creek. Although juveniles may rear in creeks in which they were not born, the extent to which they do so is unknown. Within freshwater areas, juveniles tend to prefer areas of low to moderate velocity with adequate cover, food production, and connectivity to other edge habitats (Martin, 2002). These habitat conditions, including connected side channels and floodplain sloughs, have been greatly reduced by channelization and containment of flood flows, often resulting in juvenile salmonids being flushed downstream prematurely.

Juvenile salmonids also rear in estuarine and nearshore habitats in WRIA 9. However, very little is known about whether juvenile chinook preferentially use specific areas or habitats in the nearshore. Thus, this is another key research need.

The Technical Strategy – Protect, Connect and Unlock the Natural Potential

A component of any successful ecologically based restoration strategy is to protect and maintain watershed habitat forming processes that are functioning properly. In addition, NMFS (1996) states in its guidance for salmon conservation that "spawning and rearing areas that consistently yield the highest concentrations of fish should be identified as a high priority for protection." Following this guidance, one goal of the WRIA 9 technical strategy for salmon recovery is to protect currently functioning productive habitat and habitat forming processes, and areas with high concentrations of fish, primarily in the Middle Green River subwatershed and the nearshore areas of Vashon/Maury Islands. A second goal is to restore salmonid access to productive habitats, with a major focus on the Upper Green River subwatershed. Many migration barriers also exist on tributaries and access to historic mainstem side channels is also a concern.

A third important goal is to restore and enhance habitat that contributes to adequate juvenile salmonid survival in the Lower Green River, Duwamish River, and Nearshore subwatersheds. It is important that habitat in these subwatersheds provide the essential ecological functions necessary to support watershed-wide salmon conservation efforts. Since large data gaps regarding carrying capacity, habitat use and survival occur in these lower subwatersheds, scientific studies should be designed and carried out to fill these gaps and direct habitat conservation activities. Reasonable, scientifically defendable opportunities for increasing habitat in these lower reaches should be explored in concurrence with ongoing research. These three goals, described in greater detail below, are not prioritized but must work together and be adapted to specific situations and opportunities within the watershed. More information on specific subwatershed actions and priorities is presented in the appendix.

- **Protect currently functioning habitat and habitat forming processes from degradation** (primarily in the Middle Green River subwatershed and the nearshore areas of Vashon/Maury Islands). This will help maintain and support the abundance and productivity of salmonid populations.

This includes:

- ➢ Preserving physical habitat (e.g., spawning habitat, eelgrass beds), natural ecosystem processes (e.g., gravel and large woody debris recruitment, longshore transport of sediment), refuge and rearing areas (off-channel ponds, backwater sloughs), riparian vegetation, and nearshore areas with high salmonid use;
- ➢ Managing flows to maximize salmonid habitat in mainstem reaches of the Green River;
- ➢ Protecting water quality conditions that currently support salmonids, such as streams and groundwater inputs that provide cold, clean water;
- ➢ Protecting habitat connectivity that links freshwater, estuarine and saltwater habitats as required by salmonids during all life stages; and
- ➢ Managing landscape and watershed-wide land use changes to minimize adverse impacts on aquatic habitat.

Areas that are currently providing critical functions should be identified and targeted for protection. The Metzler-O'Grady reach (about RM 38 to 40) of the Middle Green River subwatershed is a good example of important habitat that is currently supporting naturally spawning chinook, steelhead, chum, some coho and a few sockeye and pink salmon.

- **Connect the Upper Green River subwatershed by restoring access for salmonids** to facilitate efficient and safe passage for adults and juveniles above and below the dams. This will increase the spatial distribution of salmonids and contribute to increased diversity and abundance.

This includes providing efficient and safe passage for adults and juveniles around the dams and operating the Howard Hanson Dam (HHD) to minimize impacts on salmonids. This could dramatically increase the number of naturally produced juvenile salmonids in the watershed. The two mainstem dams are complete barriers to the natural upstream migration of anadromous salmonids to the Upper Green River subwatershed. HHD is also nearly a complete barrier to downstream migration of juvenile salmonids. Efficient upstream and downstream passage will dramatically increase available spawning and rearing habitat, especially for chinook, coho, steelhead and cutthroat, and possibly result in an equal response in juvenile production.

Restoring salmonid access to the Upper Green River subwatershed (RM 64.5 to 93) may hold the greatest potential for increasing natural salmonid production in the freshwater portion of the watershed. Dams have blocked fish access to approximately 106 lineal stream miles and half of the Green-Duwamish River watershed acreage. The Upper Green subwatershed contains many reaches of suitable spawning and rearing habitat for salmonids, and has the potential to become important refugia if access is restored.

This reach has been adversely affected by logging, a dam, roads, a railroad, and reservoir flooding; however, because of the limited extent of land use practices and distance from population centers, many of the basic habitat forming processes such as sediment transport and flow regimes remain intact. This subwatershed is also large enough to provide salmonid refugia (Frissell, 1997) that can seed the degraded downstream habitat once efficient passage is provided around the dams. This is particularly important since the lower subwatersheds may no longer have the capacity to naturally rebound from disturbance events.

- **Restore/Enhance habitat that contributes to adequate juvenile salmonid survival.** This will be the primary approach in the Lower Green River, Duwamish River and Nearshore subwatersheds to increase productivity and contribute to increased life history diversity.

The severely degraded lower subwatersheds must provide essential ecological functions for salmonids to survive. This includes protecting existing functioning habitat, restoring and enhancing degraded habitat, and maintaining adequate water quality and flows. It will be critical to preserve opportunities for future habitat restoration in the Lower Green, Duwamish, and Nearshore subwatersheds. Success in realizing the potential of salmonid recovery in WRIA 9 will depend on the availability of adequate habitats downstream for rearing and migration. Juveniles from the Upper and Middle Green subwatersheds require the nurturing capacity of the Lower Green, Duwamish, and Nearshore subwatersheds to survive.

The downstream and nearshore areas of WRIA 9 are characterized by a high degree of habitat loss and damage and have been heavily altered by human activities. Among the most significant changes are the filling of 97 percent of the Duwamish River’s historic floodplain marshes and intertidal mudflats, and the extensive urban development of upland areas in this part of the watershed. The severely modified conditions of the Lower Green, Duwamish, and Nearshore subwatersheds will make restoration a challenge, but such restoration is important for the long-term viability of salmonids.

Juvenile rearing in these lower areas requires shallow water habitat as refuge from predators, and adequate nutrients from both aquatic and terrrestial insects and epibenthic invertebrates. Where rehabilitation is possible, projects that target these factors would be productive to pursue. In addition, it is thought that ample habitat in the critical Duwamish River transition zone where fresh and saltwater mix is important to juvenile salmon. Rehabilitation in the lower reaches should emphasize increasing habitat.

It will be necessary to direct rehabilitation efforts through modeling, scientific research, and properly designed monitoring and assessment methods. These areas will be costly to rehabilitate and it will take time to determine how well they respond, hence these projects should include a significant monitoring program. Nonetheless, actions are necessary to identify and improve important habitat functions (that provide for optimal migration, rearing, and osmoregulatory adjustment) for the survival of salmonids produced in upstream refugia and other areas, and for the production and survival of prey. In addition, water quality and flow regimes in these areas must be compatible with salmonid life-cycle needs.

There is a lack of detailed information concerning basic salmonid habitat utilization and survival requirements specific to the Lower Green, Duwamish, and Nearshore subwatersheds. Consequently, initial investigations should be directed at understanding and addressing the limitations these areas have on supporting salmonid juveniles, with specific focus on potential "bottlenecks" (i.e., areas that currently limit salmonid survival). Habitat restoration projects should be managed through scientific design, monitoring and making adaptive changes when necessary. Juvenile salmonid survival studies should be initiated in these subwatersheds to link production prospects with the rest of the watershed. Results of these studies will also help in the design of restoration efforts and reduce the risk that more fish produced upstream will encounter capacity bottlenecks downstream. These efforts will particularly benefit chinook and chum, whose life cycle needs rely heavily on estuarine and nearshore habitats.

Monitoring and Adaptive Management Strategy

The development and implementation of a monitoring and adaptive management program is fundamental to salmonid conservation and recovery efforts in WRIA 9. Monitoring allows us to measure and evaluate the success of actions aimed at protecting and restoring habitat. Adaptive management allows us to use monitoring information and results from past actions to continually improve future management actions. The adaptive management process is defined as "an approach to natural resource policy that embodies a simple imperative: policies are experiments; learn from them" (Lee, 1993).

The Independent Science Panel (ISP, 2000) recommended three different types of monitoring to support salmonid recovery efforts in Washington state, which have been adapted for application in WRIA 9:

- Implementation monitoring – monitoring to confirm that management actions (e.g., projects, programs, guidance) were implemented (Did proponents implement the project as proposed?)
- Effectiveness monitoring - monitors the status and trends of habitat characteristics on a project basis to assess whether desired performance objectives are being achieved (Did the management actions result in improved habitat conditions?)
- Validation monitoring – monitoring to confirm that management actions and restoration projects produced the desired change in population conditions and status (done as part of the

Puget Sound's regional recovery effort). (Do all actions taken together support the overall recovery of listed species?)

Adaptive management recognizes that uncertainty and unexpected changes are inherent in managing complex ecological systems. Adaptive management is a problem-solving approach to address this uncertainty that relies on six steps: assessment, design, implementation, monitoring, evaluation, and adjustment. The components of an effective adaptive management program include the following (adapted from ISP (2000) and Trinity River Restoration Program (2001)):

1. Define measurable goals, objectives, or questions that need to be addressed;
2. Document and evaluate baseline conditions with respect to these goals and objectives;
3. Develop testable hypotheses for achieving goals and objectives through management actions;
4. Evaluate and predict habitat or population response to management actions before implementing management actions;
5. Implement, monitor, and evaluate management actions.
6. Carry out monitoring using appropriate statistical designs with selected indicators and variables at appropriate geographical, temporal, and biological scales. Monitoring protocols should be standardized with necessary quality assurance and control (QA/QC).
7. Re-evaluate objectives, refine hypotheses, improve models, and target future management actions based on findings from monitoring;
8. Ensure that funding is stable and adequate to allow planning and implementation of sustained long-term efforts, and that there is an institutional commitment to complete the learning cycle required in adaptive management.

This guidance will serve as a foundation in our efforts to develop and implement a sound monitoring and adaptive management strategy as part of the WRIA 9 Habitat Plan.

Steps and Use of the Technical Strategy

The WRIA 9 technical strategy for salmon conservation and recovery will be used to support the following three purposes:

- Contribute technical information and provide a scientific foundation for the development of the WRIA 9 Habitat Plan
- Evaluate and prioritize projects for Salmon Recovery Funding Board and King Conservation District funding.
- Develop and guide the research agenda for the strategic assessment (to be carried out over the next two years) based on the data gaps identified and priorities listed in the initial technical strategy.

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Appendix

Habitat Factors of Decline

WRIA 9 currently produces chinook, steelhead, coho, chum, cutthroat and some sockeye and pink salmon. Habitat necessary to support these species must be protected, restored and enhanced in order to support healthy populations. Habitat has declined severely in the Lower Green, Duwamish, and Nearshore subwatersheds since the early 1900s. In the Upper and Middle Green subwatersheds, the dams have blocked upstream and downstream passage of salmonids, interrupted gravel transport, and altered flow regimes. Some of the primary habitat factors of decline for each subwatershed and the salmonid species present are listed below:

Upper Green River Subwatershed (above RM 64.5):

Factors of decline

The Howard Hanson Dam is a complete upstream barrier that prevents anadromous salmonids from migrating to and from the Upper Green River subwatershed. A key component to realizing the recovery potential of the watershed will be efficient passage at the dam for both adults and juveniles. Logging, revetments, roads with associated runoff and fish passage barriers, reservoir inundation, and water withdrawal also potentially affect salmonids in the Upper Green subwatershed.

Current salmonid use

Resident cutthroat, rainbow, and brook trout, as well as planted steelhead, chinook, and coho utilize the Upper Green subwatershed. Bull trout have not been documented.

Middle Green River Subwatershed (RM 64.5. to 32.0):

Mainstem factors of decline

The Howard Hanson and Tacoma diversion dams, revetments, and residential and agricultural land use have resulted in water withdrawals, changes in the natural flow regime, sediment starvation and scouring, loss of side channel and other off-channel habitats, disconnection of mainstem flows from the floodplain, and loss of riparian habitat functions.

Current mainstem salmonid use

Spawning and rearing of chinook, steelhead, coho, chum, as well as some pink and sockeye salmon. All species (including cutthroat and bull trout) use this subwatershed for migration and feeding.

Tributary factors of decline

Residential, agriculture and some urban development resulting in: (1) wetland and riparian function removal and increasing impervious surfaces leading to hydrologic disruption to stream flow, channel degradation, and degraded water quality; (2) rechanneling of streams and limiting their lateral migration to facilitate roads and protect property; (3) removal of in-channel woody debris; and (4) barriers to fish migration. There are also some tributaries where salmonid access is limited, or that are disconnected from the mainstem.

Current tributary salmonid use

Mostly coho and cutthroat, some chinook, steelhead, and chum, and a few sockeye.

Lower Green River Subwatershed (RM 32.0 to 11.0):

Mainstem factors of decline

Factors of decline include: (1) urbanization; (2) the historic diversion of the White and Cedar Rivers from the Green/Duwamish River; (3) dam flow manipulation, levees and revetments that have lowered the main channel elevation and disconnected numerous off-channel habitats such as sloughs, adjacent wetlands, and floodplains; (4) reduction of instream habitat complexity (wood), pools and riffles; (5) fish passage and hydraulic barriers caused by flood control gates; (6) degraded water quality conditions; and (7) severely reduced riparian functions.

Current mainstem salmonid use

Upstream and downstream migration and rearing for all species, some chinook salmon and steelhead spawning.

Tributary factors of decline

Urbanization and other human activities have resulted in: (1) loss of forest cover and increased impervious surfaces leading to unstable streambed channels and disruption of natural flow regimes; (2) roads with associated runoff and fish passage barriers; (3) water quality degradation; (4) loss of riparian functions; (5) stream channelization to facilitate efficient agriculture and urbanization; and (6) invasion by non-native plants and aquatic species. Some tributaries have difficult salmonid access or are disconnected from the mainstem.

Current tributary salmonid use

Many tributaries can no longer maintain self-sustaining runs, although some coho and cutthroat still use select tributaries. Some of the tributaries, especially near their confluence with the mainstem, may provide important rearing habitat for juvenile salmonids born in other areas of the watershed.

Duwamish Subwatershed (RM 11.0 to 0.0):

Mainstem factors of decline

Urbanization/industrialization has resulted in (1) dredging/channelization and filling of at least 97 percent of the estuarine mudflats, marshes, and forested riparian swamps; (2) elongation and simplification of remnant channels by dredging and shoreline armoring; and, (3) water quality degradation by industrial activities, and stormwater and wastewater discharges.

Current mainstem salmonid use

All species migrate, rear, and acclimate in this transitional area between river and marine waters. Salmonids born outside the watershed also use the Duwamish estuary for rearing.

Juvenile chinook, chum, and pink salmon are most dependent on the estuary. Some char sub-adults and adults have also been consistently documented in this reach.

Tributary factors of decline

Intensive development has made many tributaries inaccessible and inhospitable for salmonids. Most of the small patches of remaining marginal habitat are disconnected from the mainstem and heavily impacted by stormwater flows and degraded water quality. Functional riparian areas have been eliminated or fragmented to a few undeveloped areas.

Current tributary salmonid use

Some cutthroat and coho are observed in a few streams, but most are incapable of producing a self-sustaining run. The lower end of tributaries may provide important rearing habitat for juveniles born in other areas of the watershed.

Nearshore Subwatershed

Factors of decline

Much of the WRIA 9 marine shoreline has been filled, hardened, and/or replaced with bulkheads, and altered as a result of land use practices. Extensive areas in major waterways have been dredged to maintain navigation. The supply of beach sediment has been curtailed and water quality impacts stemming from upland areas may be affecting nearshore habitats. Riparian vegetation is lacking as a result of urbanization. Riparian functions that contribute to the nearshore ecosystem are greatly reduced. In short, shorelands and intertidal areas and the processes that maintain them have been significantly altered, thus reducing properly functioning conditions that support salmonids. Most nearshore tributary streams have been channelized, riparian zones degraded, hydrology dramatically modified, and outlets often have barriers to fish passage.

Current salmonid use

Many species of juvenile salmonids, such as chinook, chum, and pink salmon, are dependent on the nearshore for physiological transition, migration, and rearing prior to their rigorous ocean migration. The nearshore also produces important food items for all life stages of salmonids. Especially important are the forage fish for salmonids (e.g., sand lance, surf smelt, and herring), which require specific habitat conditions in this area for reproduction and rearing.

Subwatershed Actions and Priorities

Actions and priorities for each subwatershed vary because of the differences in the quality and quantity of existing habitats, the relative importance of the habitat functions provided, and the state of our knowledge and data gaps. The following set of conservation and recovery actions should not be considered a complete suite but instead emphasize the primary approaches for each area based on the Habitat Limiting Factors and Reconnaissance Assessment Report (2000). A more complete assessment of habitats and ecological processes will occur in the years ahead through the Strategic Assessment. This information will then be assembled to provide the technical and scientific basis for the WRIA 9 Habitat Plan.

Upper Green River Subwatershed:

- **Protect** functioning habitats and habitat forming processes responsible for the natural production of salmonids.
- **Connect -** restore safe and efficient downstream passage for juvenile and kelt (post-spawning adult) salmonids at the Howard Hanson Dam. Restore access from the Upper Green River mainstem to tributaries.
- **Rehabilitate/Enhance** habitat along the mainstem river and tributaries. Operate Howard Hanson Dam in such a manner as to reduce impacts of flow alterations on sediment transport, available habitat and water quality downstream. Rehabilitation efforts should be based on ecosystem principles and managed adaptively.
- **Fill data gaps** such as baseline habitat quantity and quality, outmigration of juvenile salmonids, including effects of reservoir storage and flow impacts on juvenile fish in the mainstem and North Fork Green River, and impacts of land use practices on habitat in the Upper Green River subwatershed.

Middle Green River Subwatershed:

- **Protect** functioning habitats and habitat forming processes responsible for the natural production of salmonids. Protect spawning and rearing areas that consistently yield the highest concentrations of salmonids on the mainstem and tributaries.
- **Connect** mainstem channel and flows with side-channels and floodplain habitat, and restore access to and within tributaries for salmonids. Restore safe and efficient upstream and downstream passage for adult and juvenile salmonids at the Tacoma diversion dam.
- **Rehabilitate/Enhance** interrupted processes including LWD input, flow regimes, and gravel transport. Enhance aquatic habitat within the mainstem and tributaries, including riparian vegetation to improve water quality conditions. Rehabilitation efforts should be based on ecosystem principles and managed adaptively.
- **Fill data gaps** such as how flow releases impact fish stranding, redd success, and downstream flushing of fry migrants, and salmonid survival studies focused on behavior, growth, survival rates and needs, and habitat carrying capacity. Evaluate options for gravel and LWD supplementation.

Lower Green River Subwatershed:

- **Protect** areas that currently provide functioning habitat or have reasonable potential for improvement to keep rehabilitation options open while data gaps are being addressed.
- **Connect** mainstem channel and flows with side-channels and floodplain habitat, and restore access to and within tributaries for adult and juvenile salmonids.
- **Rehabilitate/Enhance** aquatic habitat, riparian conditions, and water quality within the mainstem and tributaries. Rehabilitation efforts should be based on ecosystem principles and managed adaptively. Current understanding of lower river rearing areas suggest that rehabilitation efforts should focus on removing, setting back or resloping oversteepened, rock-lined levees and revetments and reintroducing large woody debris to create densely vegetated shallow water edge habitat, areas of reduced velocity and increasing riparian vegetation.

- **Fill data gaps** through salmonid survival studies of behavior, growth, survival rates and needs, and habitat carrying capacity. Study results should lead to improved rehabilitation designs, clearer priorities for protection and acquisition, and an understanding of the natural production capability of the watershed. Where possible, rehabilitation efforts should be based on ecosystem principles and managed adaptively. Where it is not possible to depend on natural processes, monitoring is needed to guide adaptive management approaches.

Duwamish River Subwatershed:

- **Protect** habitat that currently provides support for salmonids or has reasonable potential for enhancement to keep rehabilitation options open while data gaps are being addressed.
- **Connect** the mainstem channel and flows with side-channels and floodplain habitat, and restore access to and within tributaries for adult and juvenile salmonids.
- **Rehabilitate/Enhance -** Increase habitat area by removing, setting back or resloping oversteepened, rock-lined banks, and excavating filled areas to restore natural tidal circulation and productive habitat. Increase habitat quality by softening shoreline materials, increasing habitat complexity through the addition of LWD and overhanging vegetation, establishing conditions for deposition of sediment and organic matter, and increasing areas of marsh and riparian vegetation. Where possible, rehabilitation efforts should be based on ecosystem principles and managed adaptively. Where it is not possible to depend on natural processes, monitoring is needed to guide adaptive management approaches.
- **Fill data gaps** through salmonid survival studies of behavior, growth, survival rates and needs, and habitat carrying capacity. Study results should lead to better rehabilitation designs, clearer priorities for protection and acquisition and an understanding of the natural production capability of the watershed.

WRIA 9 Nearshore and Vashon/Maury Islands:

- **Protect** nearshore processes, structure and functions in riparian and aquatic areas that support salmonids. Unaltered areas are particularly important for protection and should be maintained, or enhanced, if appropriate, to provide nearshore functions and avoid future restoration actions.
- **Connect** upland areas to shorelines, shorelines to intertidal areas, and restore access to and within tributary streams.
- **Rehabilitate/Enhance** damaged processes, including sediment transport on a "process unit" basis (drift cells may be an appropriate surrogate in the nearshore environment). Restore linkages (connectivity) between high salmonid use areas (e.g., eelgrass beds, sub-estuaries) and other habitats utilized during the salmonid life cycle. Rehabilitation efforts should be based on ecosystem principles and managed adaptively. Where possible, rehabilitation efforts should be based on ecosystem principles and managed adaptively. Where it is not possible to depend on natural processes, monitoring is needed to guide adaptive management approaches.
- **Fill data gaps** through salmonid studies that evaluate salmonid habitat preferences and/or utilization of nearshore environments such as eelgrass beds, sub-estuaries, and other habitat types. Initial studies should focus on listed species (chinook, bull trout). Furthermore, studies should focus on identifying high salmonid use areas that play important roles in

support of salmonids and salmonid prey species. Evaluate how human activities and alterations (upland development, bulkheads/piers) modify salmonid habitat and affect utilization by salmonids. Study results should lead to improved rehabilitation designs, and clearer priorities for protection and acquisition. Rehabilitation efforts should be based on ecosystem principles and managed adaptively.