Appendix F:

Monitoring and Adaptive Management Plan

ROGER TABOR

WRIA 9 Monitoring and Adaptive Management Plan

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King County

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WRIA 9 Monitoring and Adaptive Management Plan

Prepared for:

The WRIA 9 Watershed Ecosystem Forum

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EXECUTIVE SUMMARY

The WRIA 9 Monitoring and Adaptive Management Plan (MAMP) incorporates years of effort to create a monitoring plan that is both robust but simple to implement. The first version of this plan was drafted in 2013 by the WRIA 9 Implementation Technical Committee (ITC) but was purposefully left as a draft to allow time for regional efforts to create standardized monitoring processes. As part of the larger WRIA 9 Salmon Habitat Plan update, it was decided to finalize this MAMP, though not all of the regional monitoring efforts have been completed at this time. This plan focuses on tracking and evaluating large capital habitat restoration projects and does not address smaller routine habitat projects like basic revegetation, or noncapital projects like stewardship or education.

This MAMP breaks the broad topic of monitoring into three main components: implementation, effectiveness, and validation. The implementation monitoring section is focused on tracking large capital project implementation to see if the habitat plan goals and targets are being reached and if not, why and what can be changed to meet those targets.

The effectiveness section of the MAMP is broken into two broad categories, including project effectiveness and cumulative habitat conditions which is also known as status and trends monitoring. Additionally, the project effectiveness section is broken into two components: routine and enhanced project monitoring. Routine project effectiveness monitoring focuses on if the project is performing as we expected it to. It is expected that all project sponsors of large restoration projects receiving money through the WRIA will undertake the routine monitoring called for in the MAMP. The questions and metrics for routine monitoring focused on relatively simple and inexpensive physical metrics. The enhanced monitoring components address harder and more expensive to answer questions around if and how Chinook use restoration project sites. This type of monitoring should only be done on a limited number of projects and it is expected that the WRIA would use its funding resources to help implement this type of monitoring.

The second half of effectiveness monitoring, cumulative habitat conditions, looks beyond what habitat has been created and attempts to evaluate larger habitat trends throughout the five subwatersheds. This is where we see if the sum of all the activities are having a net gain or lift in habitat conditions, or if the improvements made in the name of salmon recovery are being offset by ongoing development or redevelopment. These cumulative habitat condition metrics are centered around the updated Salmon Habitat Plan recovery strategies and build off of the 2012 WRIA 9 Status and Trends report. Some of the data is being collected by other entities, but some of it will need to be collected and or funded by the WRIA. It is recommended that the WRIA spread out the effort to undertake a status and trends report by collecting and analyzing some metrics every year while reporting the findings once every five years.

Validation monitoring is composed of tracking Chinook Viable Salmonid Population parameters as well as validating assumptions or data and knowledge gaps in the Salmon Habitat Plan. The majority of the data used to evaluate Chinook salmon population metrics

is collected by the co-managers. One of the most important parts of evaluating the Chinook salmon numbers is the juvenile outmigrant trap, which has been in place for over twenty years. The WRIA has been contributing roughly a third of the funding for the trap, and given the data's importance to measuring salmon recovery efforts, the ITC recommended that the WRIA should continue to do so until a broader Puget Sound funding source for smolt traps can be secured. Additionally, the WRIA has used this category of monitoring to undertake applied research studies that will help validate assumptions that went into forming the Salmon Habitat Plan. These studies have greatly improved our knowledge of how Chinook use the system and have helped to elevate and prioritize additional actions for the WRIA to undertake. The ITC recommends that the WRIA continue to fund these types of studies into the future.

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1.0 BACKGROUND AND PURPOSE

Since the listing of Chinook salmon as a threatened species under the Endangered Species Act in 1999, local and regional entities have been working together to understand the reasons for their decline and take action to recover the species. The 2005 Green-Duwamish and Central Puget Sound Watershed Salmon Habitat Plan, "Making our Watershed Fit for a King" (hereafter called "Salmon Habitat Plan") calls for habitat protection, programs, and projects to benefit Chinook and other salmonids in Water Resource Inventory Area 9 (WRIA 9). Monitoring the implementation of the plan, the quality of habitat, and the status of salmonid populations is the only way to know whether we are moving towards the goal of recovery. The Salmon Habitat Plan cites monitoring as integral to implementation and identifies the need for a comprehensive monitoring strategy and sustained monitoring effort.

A monitoring and adaptive management plan is also called for in the Implementation Guidance for the WRIA 9 Salmon Habitat Plan (2006). When the National Oceanic and Atmospheric Administration (NOAA) approved the Puget Sound Salmon recovery plan, it required each watershed to develop a monitoring and adaptive management plan (Final Supplement to the Shared Strategy's Puget Sound Salmon Recovery Plan, National Marine Fisheries Service, Northwest Region, 2006). The WRIA 9 Implementation Technical Committee (ITC) began working on this Monitoring and Adaptive Management Plan (MAMP) in 2011. The work was put on hold while the Puget Sound-wide monitoring and adaptive management framework was being developed by the Puget Sound Recovery Implementation Technical Team (RITT) During that delay, the ITC researched and wrote the WRIA 9 Status and Trends Monitoring Report: 2005–2010 (February 2012). The Status and Trends report documented the progress made during the first five years of implementation of the WRIA 9 Salmon Habitat Plan, identified key monitoring gaps, and formed the foundation for this MAMP. A draft of the MAMP was completed in 2013 and approved by the WRIA 9 Watershed Ecosystem Forum, with the intent to finalize in a year or two once regional guidance was complete. Consistent regional guidance has taken longer than anticipated and the 2013 draft was updated in 2020 to coincide with a broader Salmon Habitat Plan update.

It should be noted that this MAMP focuses on monitoring the actions in the Salmon Habitat Plan recommended to improve habitat conditions. It does not address monitoring of other limiting factors such as hatchery, harvest, or ocean conditions. It is possible that even if the Salmon Habitat Plan is fully implemented, the other limiting factors could limit our ability to reach recovery.

The Monitoring and Adaptive Management Plan is intended to:

- Serve as a framework for prioritizing monitoring actions and funding by the WRIA 9 WEF;
- Provide guidance for adaptively managing implementation of the Salmon Habitat Plan;
- Promote collaboration among various entities collecting data in the basin; and
- Provide guidance for tracking net gains and losses in salmon habitat.

2.0 PLANNING PROCESS AND STRUCTURE

2.1 How This Plan Was Developed

This MAMP was developed in stages over seven years and represents multiple aspects of the salmon recovery planning effort. The 2013 draft MAMP focused on evaluating progress towards 2005 habitat goals and targets (implementation monitoring), if built projects are performing as expected (project effectiveness monitoring), and Tier one conservation hypotheses (validation monitoring) that are integrated throughout the Salmon Habitat Plan. If the plan is implemented as intended, projects are successful at improving habitat and we should eventually see an improvement in Chinook salmon Viable Salmonid Population (VSP) parameters of productivity, diversity, spatial structure, and abundance. The updated 2020 MAMP includes the same topic areas, but includes recently updated Salmon Habitat Plan targets.

The goals of the Salmon Habitat Plan were originally spelled out in the plan itself and in the Implementation Guidance for the Salmon Habitat Plan. The goals were updated in 2019 and are now found in Chapter 3, Table 2, and a shortened version in Table 1 below. The WRIA 9 ITC wrote a 5-year Status and Trends Report in 2012 with a focus on the highest priority (Tier 1) conservation hypotheses and interim plan goals. The Status and Trends report evaluated eleven of the eighteen conservation hypotheses and goals, for which monitoring data existed, and could be analyzed with existing or minimal resources. Gaps in ability to monitor plan progress were identified and resulted in 58 monitoring and adaptive management recommendations. Those recommendations are incorporated into this plan.

This monitoring and adaptive management plan was written by WRIA 9 staff with extensive input from the ITC in 2013 and 2020. It relies heavily on previous work, including, the 2012 Status and Trends report, (WRIA9 ITC 2012), and several white papers written for the 2020 plan update (King County 2017a, 2017b, 2017c, and 2018). Once the MAMP is approved by Watershed Ecosystem Forum (WEF), the recommendations of the MAMP will be implemented annually through the WRIA processes and funding decisions.

Table 1. Updated Habitat Plan Targets for 2028.

Habitat Indicator	Necessary Future Conditions	Current Condition	Recommended 10-year Target (by 2028)
Nearshore			
Shoreline Armor	65% of shoreline in natural condition	59 mi. of shoreline armored.	Remove 3,000 ft. (<1% improvement): achieve a net reduction
Marine Riparian Vegetation	65% characterized by riparian tree cover.	21.8 mi. is dense trees; 14.8 mi. is patchy trees]	Revegetate 60 ac. and/or 3.25 mi. (~3.5% gain) of shoreline
Shoreline Conservation	No condition stated	9.5 mi. of adjacent upland protected as natural lands	Protect 2 mi. of shoreline
Duwamish			
Shallow Water Habitat	173 ac. in the transition zone (RM 1-10)	5.8 ac. as of 2014 has been restored	Create 40 ac. of shallow water habitat between RM 1-10
Riparian Forest	65% of each bank of the river has > 165 ft. trees (586 ac. total)	69 ac. of 165 ft. buffer contains trees.	Revegetate 170 ac. (~29% of 165 ft. buffer) 9.8 mi. of streambank
Lower Green			
Off Channel Habitat	2.8 mi. side channels; 450 ac. wetlands; 5039 ac. floodplains	Not assessed in a way to accurately state.	Side Channels A: High flow (above bankfull) 550 ft. B: Low flow (below bankfull) 3740 ft. Floodplain Tributaries: 3080 ft. Backwater: 75 ac. Floodplain Wetland: 66 ac. Other 100-yr. Floodplain: 99 ac
Riparian Forest	75% of each bank of the river to >165 ft. wide (828 ac. total)	222 ac. of 165 ft. buffer has trees.	Revegetate 250 acres/8.52 mi. of high priority, unforested shoreline
Large Woody Debris	1705 pieces per mi. (21 key pieces)	2004: 54 pieces/mi. 2014: 48.5 pieces/mi.	Achieve 425 pieces/mi
Bank Armor	No new, decreasing amount	2014: 42 mi. are KC maintained facilities. The other 14.5 mi. are a combination of semi-armored roads acting like levees and natural banks	Set-back 1 mi. of levee

Habitat Indicator	Necessary Future Conditions	Current Condition	Recommended 10-year Target (by 2028)
Middle Green			
Floodplain Connectivity / Lateral Channel Migration	Floodplain subject to lateral channel migration represents 65% of historical conditions	2017: 1751 ac. or 55% of historic floodplain connected; 45 ac. restored (including riparian) from 2005-2014	Reconnect 200 ac of floodplain as measured by area subject to lateral channel migration
Riparian Forest	> 65% of Channel Migration Zone and up to 165 ft. wide where possible	2009: 50.5% of the Channel Migration Zone forested	Revegetate 175 acres (8% of CMZ)
Large Wood Debris	10 jams/mi.	2015: 3.8 jams/ mi.	Achieve 5 jams/mi.
Bank Armor	No new, decreasing amount	2004=25% 2009=24%	Set back 1 mi. of revetment/levee
Middle Green Tributaries			
Soos Creek Riparian Forest	65% revegetated to 165 ft.	2015: 150ft. riparian buffer is 4200 ac., 1626 ac. is forested	Revegetate 700 ac. or 11.7 mi. streambank
Newaukum Creek Riparian Forest	65% revegetated to 165 ft.	2015: the 150 ft. riparian area is 4088 acres, 960 acres of which is forested	Revegetate 900 ac. or 14.0 mi. streambank
Upper Green			
Fish Passage	Fish passage provided at Howard Hanson	Upstream passage facility complete. Downstream passage not complete	Provide downstream passage at HHD
Bank Armor	No new, decreasing	2009=15% armored	Remove/set back 0.5 miles

2.2 Types of Monitoring

Monitoring for this plan was broken into three types. Terminology may differ from other regional efforts to create salmon recovery adaptive management plans, but they have been agreed to by WRIA 9 for the purposes of this plan. The three are:

1. Implementation: Did we implement the plan's projects, programs and policies as intended?
2. Effectiveness: Did the projects perform as expected and have all the activities combined improved habitat conditions as expected?
3. Validation: What overall effects have habitat plan implementation actions had on the Green River Chinook salmon VSP parameters, and are the assumptions within the plan accurate?

We can adapt management strategies by learning the answers to the above questions and adjusting plan priorities and activities as needed.

This plan is organized by the type of monitoring, as described above, and as shown in Figure 1. For each type of monitoring (implementation, effectiveness, and validation), we identify what is being done, gaps, and propose activities or guidelines.

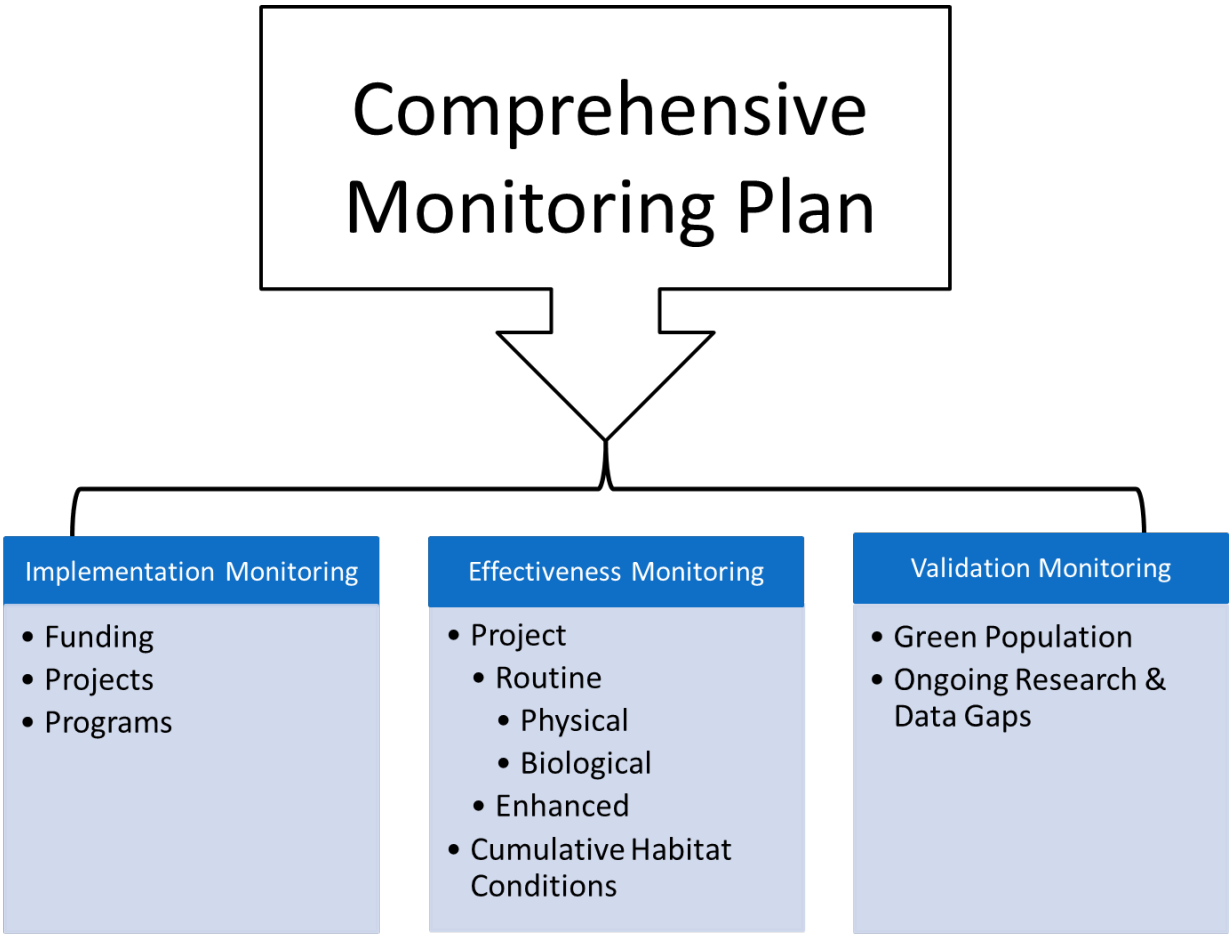

Figure 1. Three primary types of monitoring are used to evaluate management strategies and adapt them as necessary

This plan also prioritizes monitoring activities in order to develop a long-term funding strategy for WRIA 9 salmon recovery funds. The routine project effectiveness monitoring guidelines are intended to be implemented by project sponsors under existing funding of restoration projects, a combination of grant and jurisdiction funds. It is strongly recommended that these guidelines are followed for consistent and scientifically defensible measurement of the effectiveness of projects, both at meeting goals for the particular site, and overall habitat and VSP goals. The funding and projects components of implementation monitoring will be undertaken by both WRIA staff and project sponsors. Program implementation will need to be monitored periodically by WRIA staff.

3.0 IMPLEMENTATION MONITORING

3.1 Plan Implementation

Implementation of the 2005 Salmon Habitat Plan should influence Chinook salmon productivity and recovery in the watershed. While there are strategies in the Salmon Habitat Plan that describe programs and policies, and projects, this document does not directly address policies and programs. This section focuses on if the projects we are implementing are meeting habitat plan targets as described in Table 1. Knowing the status of the projects called for in the Salmon Habitat Plan, as well as the quantity and quality of habitat, will be important as the WRIA 9 stakeholders evaluate the effectiveness of recovery actions to date and update the Chinook recovery plan.

To adaptively manage plan implementation, the ITC will review the status of the goals in Table 1. The ITC will use the adaptive management decision framework (see Figure 2) to evaluate and prepare recommendations to the WRIA 9 Forum of Governments (Forum) of Salmon Habitat Plan projects, polices, or programs that need to be initiated or accelerated in order to get the implementation timeline back on schedule. The framework includes three primary steps or questions. Question one asks if the target been achieved or on target to be achieved? If no, question two asks does the strategic assessment or new research change our understanding of the current context? Question three asks if the metric we are using to evaluate progress is the correct metric or if we need to update the metric. These questions are evaluated against a set of factors limiting implementation, which would also provide guidance for potential changes in course to address the lack of progress. These limiting factors include habitat losses offset gains, insufficient funding, lack of opportunities or landowner willingness, insufficient funding or capacity, and information gaps. The type of limiting factor helps set context around the recommended adaptive management action.

The Forum will consider the ITC recommendations and make commitments of staff or other resources to take action to remedy obstacles to implementation.

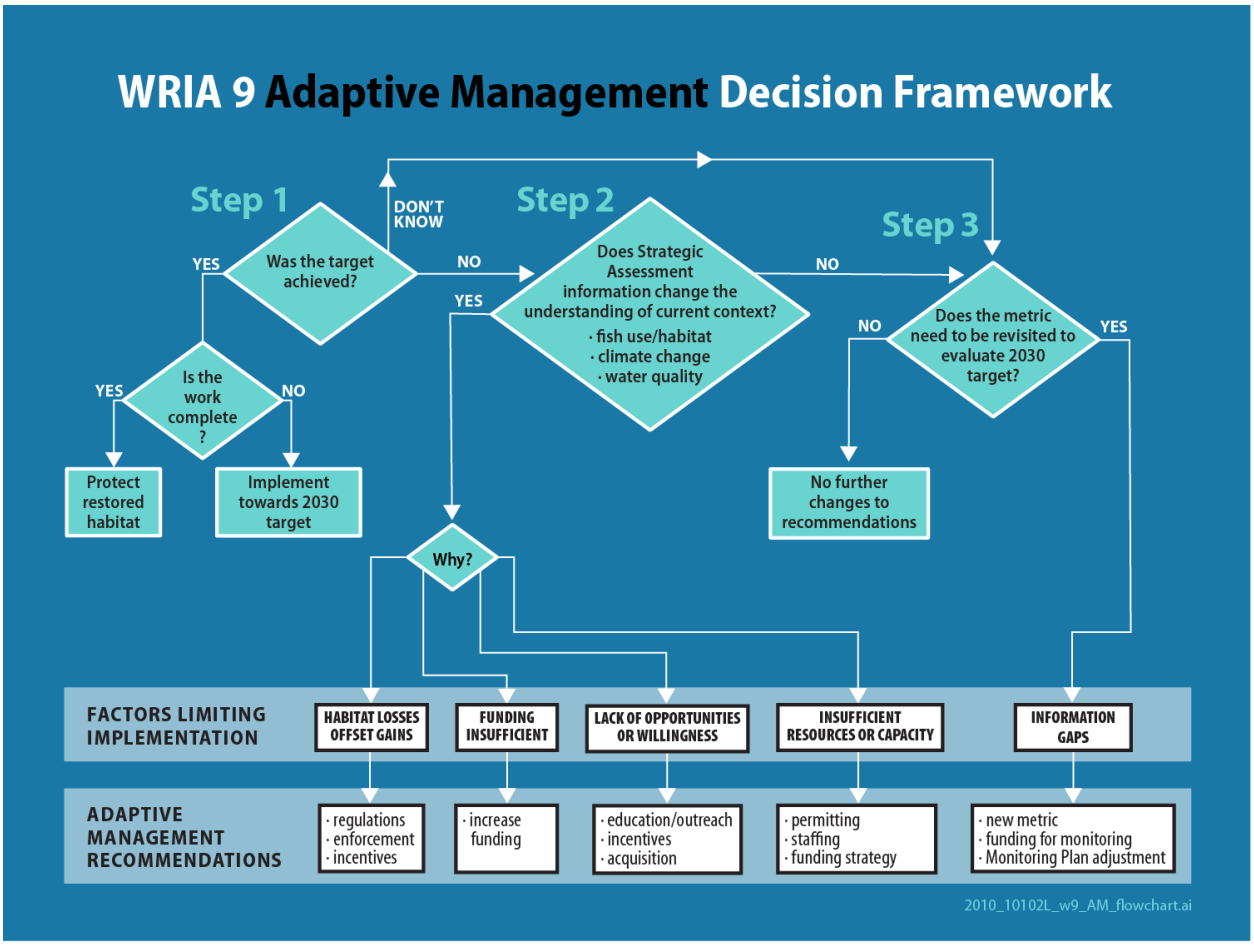

Figure 2. WRIA 9 Adapative Management Decision Framwork.

3.2 Project Implementation

Detailed information about how projects are constructed, including the amount and type of each habitat created and the cost is needed in order to assess overall plan implementation. Previous efforts to describe progress of plan implementation were very challenging because there were no consistent expectations or regular reporting requirements. As part of the 2020 Salmon Plan update there will be a standard project status reporting mechanism and schedule so that information is reported to the WRIA in a timely manner to better track implementation of plan goals. Within three months of project completion, project sponsors will be required to report on final project outcomes and future stewardship activities by filling in the Project Completion Close Out form, which will automatically get submitted to the WRIA 9 Habitat Project Coordinator. This data will be entered into the Habitat Work Schedule at http://hws.ekosystem.us/ to ensure the data is available to the public.

Adaptive Management Process for Project Implementation

An important component of project implementation is the comparison of the final design plans to the as-built completion plans created immediately after construction is complete. As-builts are project design drawings of the restoration project that are created shortly after construction and describe what was actually constructed versus what was on the design plans. An as-built can be created by modifying the existing design plans based on changes known to have occurred during construction or by undertaking a new site survey, which would be more costly, but is recommended if there has been a large amount of earth moving. The importance of having an as-built cannot be overstated. Without an as-built it is generally not possible to reliably track the physical changes occurring at any site. As-builts should be created as soon as possible, preferably before the upcoming flood season so the as-built conditions are not conflated with changes created by flood flows. Projects that get SRFB money for construction are now required to provide an as-built (see Appendix D-4: Construction Deliverables, RCO Manual 18, Salmon Recovery Grants).

As-built plans allow comparison to the project as approved by the ITC, WEF, and funding agencies, as well as documentation of the amount of different habitats that were built as part of the project in order to accurately track our progress towards the implementation goals and targets. The following are adaptive management roles and actions for project sponsors, the ITC, and the Forum.

Project Sponsor Action: Submit an as-built drawing to WRIA 9 Habitat Projects Coordinator. Compare final design to as-built drawings/designs. If the as-built does not represent the permitted final design, project sponsor should describe why in the Project Completion Close Out Form submitted post completion. The Habitat Project Coordinator will evaluate if the extent of changes needs to be reviewed by the ITC or the Project subgroup.

ITC actions: Review project sponsor analysis and make recommendations as needed. The ITC will respond based on type of issue, including the potential outcomes noted below:

1) Site condition different than anticipated (e.g. more contaminated soils, buried riprap, bedrock, etc.).
2) Recommend the project sponsor increase future project budgets to undertake more site reconnaissance in design/feasibility, and/or include a higher contingency.
3) Recommend that **ALL** sponsors of a specific project type or within a geographic area undertake a higher level of site reconnaissance than normal in design/feasibility. *(implicitly assumes that ITC will support higher project costs of this nature)*
4) Contractor error
    - Request the project sponsor work with contractor to have the contractor take corrective actions to address problems found.
    - Recommend project sponsor increase future project budgets to include more construction oversight.
5) Other-ITC respond as necessary.

Forum actions: The Forum will consider ITC recommendations and may assign or procure other resources to advance efforts to expand the current project or propose another project concept to enhance or address omitted project elements.

4.0 EFFECTIVENESS MONITORING[1]

4.1 Project Monitoring

Monitoring to determine project effectiveness has been somewhat inconsistent, and frequently includes only required permit conditions. Typically, most local and state permits only require monitoring plant survival over three to five years after the project has been implemented. For most WRIA 9 projects, this level of monitoring does not provide enough information to understand if the project has successfully created and maintained the type of habitat anticipated from the project. Additionally, much of the other monitoring in the basin has similarly been started after the restoration was done, without proper controls or reference sites making conclusions from the monitoring less reliable.

Monitoring plans should specifically address the goals and objectives of the particular project. The ITC encourages project proponents to start creating monitoring plans when they reach the 30% design phase. This would allow for pre-project monitoring to begin prior to implementing the project, if appropriate. Additionally, the ITC recommends when possible using a Before-After Control-Impact (BACI) monitoring design, as it provides a solid scientific basis for the results. The ITC can provide assistance in developing aspects of the monitoring plan if the sponsor needs assistance

The project effectiveness recommendations in the MAMP build on the Implementation Guidance Report (WRIA 9 Adaptive Management and Monitoring Workgroup and Anchor Environmental LLC 2006). That report provided general recommendations for the types of projects or issues that sponsors should monitor, but it did not provide detailed recommendations. This created variability in how project sponsors have monitored restoration projects, which has led to challenges in how to summarize effectiveness. The new recommendations are more detailed with the intent of promoting uniformity in how project success is described and reported back to the WRIA and other funding partners.

For this report, project effectiveness was broken into two types: routine and enhanced. It is expected that routine monitoring will be done on all projects as existing sponsor funds allow and should satisfy permit conditions as well as provide basic information about whether the project continues to function as intended. Routine monitoring includes very little biological monitoring, but rather relies mostly on physical habitat measurements to document performance and changes. For instance, routine monitoring of riparian vegetation should include evaluating the percentage of aerial cover that is occupied by non-native invasive plant species. Enhanced project effectiveness monitoring is more intensive and will be focused on projects with less certainty of success and higher expense. These are discussed in more detail in the next section below.

[1] This section pertains to high priority capital habitat restoration projects that the WRIA contributes funding to and does not include education, stewardship or revegetation only projects.

As of 2020, each restoration funding source treats monitoring requirements differently. The SRFB recently created a pathway where the Lead Entity could use up to 10% of its annual SRFB allocation for monitoring projects, though using these funds for monitoring is not generally encouraged. Instead, the SRFB funds its own monitoring program that monitors a subset of projects throughout Washington. There are generally several WRIA 9 projects being monitored by the SRFB each year. While the WRIA 9 recommended indicators and metrics do not perfectly match the SRFB's metrics, project sponsors should explore ways to collaborate with SRFB monitoring efforts when possible.

The United States Army Corps of Engineers (ACOE) through the Green River Ecosystem Restoration Projects (ERP) not only requires monitoring of their projects, they also provide up to a 65% match to undertake the monitoring. Currently, the ACOE roughly allocates $20,000 a year for three years of post-construction monitoring. However, this amount could be increased to closer to $100,000 a year if the local sponsor had the ability to provide the 35% match. The ability to leverage monitoring funds on ERP projects would likely make them ideal for enhanced monitoring (discussed below). Projects that receive funding through the Estuary and Salmon Restoration Program (ESRP) are able to fund monitoring of projects through the program. Furthermore, the ESRP is currently one of the few grant programs that funds "learning projects." This program could be a source of funding for enhanced monitoring efforts in the estuary and marine shoreline as well as for exploring research priorities that are included in the Validation Monitoring section of this report. Additionally, the WRIA directs some of its grant funding (e.g. Cooperative Watershed Management) towards monitoring and research needs.

4.1.1 Routine Monitoring

Routine monitoring helps determine if the project is performing the way it was intended. For example, if a backwater habitat is built to function as rearing habitat, the recommendations suggest monitoring the number of days the habitat is inundated during the Chinook juvenile outmigration (January through June) as well as if the amount of physical habitat available changes over time. The recommended indicators and metrics were specifically chosen to be generally affordable and straightforward to implement. The primary indicators and metrics are typically focused on physical attributes of the site versus biological. By giving simple and inexpensive recommendations, it is believed that project sponsors will be able to undertake the recommended monitoring. If project sponsors do not undertake the recommended monitoring voluntarily, it may be necessary to create minimum monitoring requirements as a condition for receiving funding through the WRIA.

It is expected that all projects will establish photo points and provide an as-built drawing. Photo-points are an extremely useful way of visually communicating the change that is (or isn't) occurring at a site. Without an as-built drawing it is generally not possible to reliably track the physical changes occurring at any site. Projects that get SRFB money for construction are now required to provide an as-built.

The monitoring recommendations for a particular project are in Table 2 below and broken into categories of project type and subtype, project objectives, and physical and biological monitoring questions with indicators and metrics for each The project type typically follows the nomenclature used by the SRFB monitoring program, while the project subtype more closely follows the terminology from the WRIA 9 Plan. The next column includes the primary project objective or objectives for that subtype. Defining the specific project objective helps clarify what the physical and biological questions should be. Generally, each project subtype has one primary objective. When there is more than one potential objective, each objective was noted by a bulleted letter that corresponds to bullets in following columns. The next two columns include the physical and biological questions along with the metrics and indicator that should be used to evaluate the specific question. In each of the two columns the questions are broken into primary and secondary questions. It is intended that the project sponsor's monitoring plan should at a minimum answer the primary questions. While the secondary questions would help refine how project success is described and reported, including is entirely up to the discretion of the project sponsor. Where the overall project includes more than one project subtype (e.g., planting combined with a levee setback), the project sponsor would answer the primary monitoring questions associated with each project subtype.

Table 2. Routine physical and biological monitoring recommendations by project type and subtype.

Project Type	Project Subtype	Project Objective	Physical monitoring questions and *Indicator/metric* (**Primary bolded**, Secondary regular font)	Biological monitoring questions and *Indicator/metric* (**Primary bolded**, Secondary regular font)
Planting	Revegetation of riparian area, including conifer under-planting	Establish vegetation (to provide multiple benefits i.e. shade, leaf litter input, food, bank stability)	N/A	1) **How much aerial coverage was created by end of year 5**? >50% aerial cover of native species after year 5 2) **What is the area of non-native, invasive plant coverage after 5 years compared to year 0?** <20% nonnative vegetation at end of year 3; <10% nonnative vegetative cover after year 5 If on a creek (not on Green River), has the project affected instream temperature during summer months? *Compare temperature upstream, within, and downstream of project area in years 0, 3, 5, 10*. If conifer underplanting, what is the aerial cover after 5 years? *>50% increase in aerial canopy cover of conifers after year 10.*

Project Type	Project Subtype	Project Objective	Physical monitoring questions and *Indicator/metric* (**Primary bolded**, Secondary regular font)	Biological monitoring questions and *Indicator/metric* (**Primary bolded**, Secondary regular font)
	Invasive control	To control non–native, invasive plant species and allow for native plants to naturally recruit or grow in their place. (This assumes no replanting is done at the same time and that eradication is not possible)	*N/A*	**What is the area of non-native, invasive plant coverage after 5 years compared to year 0?** <10% nonnative vegetative cover after year 3
Instream habitat enhancement	LWD installation	a) Bank protection b) Habitat/pool creation, (stream vs. river) c) Recruit LWD to jams d) Floodplain interaction-forcing channel to migrate, split, aggrade, etc.	**a) Has bank been protected from erosion/channel migration?** *% adverse eroding bank year 0 versus year 3/after high flows* **b) Have habitat conditions improved within project reach?** ***Stream**-change in mean residual pool depth between year 0 and year 3?* ***River**- Compare amount (ft^2) of edge habitat available before and in years 1, 3, and 5. Compare via GPS and velocity meter, mapping edge habitat as 1.5 ft/sec or less, using a modified Beechie et al 2005 for habitat types-bank edge (unarmored, bio-revetment, armored, bar edge, side channel edge, and backwater* **b) Is the wood structure providing cover?** *% of wood structure in contact with flow of 1200 cfs in years 0 versus year 3.*	b) Did fish use respond to LWD presence? *If evaluating for only 1 year: Higher relative abundance of target species in LWD/treatment habitat than in control habitat representative of pre-project conditions* *If using BACI: Increased difference between abundance of target species in LWD/treatment versus control habitat **after project** than between pre-project LWD/treatment location versus control habitat before project.*

Project Type	Project Subtype	Project Objective	Physical monitoring questions and *Indicator/metric* (**Primary bolded**, Secondary regular font)	Biological monitoring questions and *Indicator/metric* (**Primary bolded**, Secondary regular font)
			c) Has the number and/or size of jams increased over time? *Compare # LWD pieces in jams and ft^2 in years 0, 5, and 10* **d) Is channel more dynamic?** *Compare amount (ft^2) of edge habitat available before and in years 1, 3, and 5. Compare via GPS and velocity meter, mapping edge habitat as 1.5 ft/sec or less, using a modified Beechie et al 2005 for habitat types-bank edge (unarmored, bio-revetment, armored, bar edge, side channel edge, and backwater*	
Instream habitat enhancement	Spawning Gravel Supplementa-tion	Enhance/ increase spawning habitat or quality where modifications have limited natural gravel recruitment.	**Has gravel remained in or moved to the places intended for the time expected?** *1) Compare substrate size distribution (longitudinal trends in d16, d50 and d84) between years -1, 0, 3, 5* **Is placed gravel as stable as reference reach?** *Compare scour depth of placed gravel with reference reach of naturally recruited gravels under the same flow conditions.* Has gravel remained useable for spawning over time or has it become embedded with fines or moved into other reaches? *1) %embeddedness of spawning gravel years 0, 3, 5, 10*	Has redd spatial distribution changed with supplementation? *Compare redd distribution by river mile, in years 0, 3, 5 and 10.* ***NOTE: redd presence is not recommended as a metric because it is not a guarantee of redd success, and documenting redd success is risky to eggs and fry.***
Fish passage	Fish passage	Provide fish access to habitat that they currently do not	**Do target species and/or life history phase have access to new habitat?** *WDFW Fish passage and design criteria are met years 0, 3, and 5*	***NOTE: purposefully avoided using biological presence as a metric as absence of fish does not prove lack of access.***

Project Type	Project Subtype	Project Objective	Physical monitoring questions and *Indicator/metric* (**Primary bolded**, Secondary regular font)	Biological monitoring questions and *Indicator/metric* (**Primary bolded**, Secondary regular font)
		by removing artificial barriers.		
Shallow water/Edge Habitat	Pocket estuaries *AND* Duwamish Transition zone vegetated marsh and mudflat (marsh = +5.5 to +12 mean lower low water (MLLW), mudflat (-4 to +12 MLLW) habitat creation	Create or improve high quality rearing habitat in saline or partially saline habitats.	**1) Has the amount of intertidal habitat remained stable?** *Compare representative elevation profiles from as-built to years 3 and 5. Quantify ft^2 of intertidal habitat available in 2 ft. gradations from -4 to +12 MLLW.* **2) Has substrate type remained as intended?** *Compare as-built (year 0) to year 3, and 5 conditions*	1**) How much aerial coverage of vegetation was created by end of year 3 and 5 (minus mudflat areas)?** *> 50% aerial cover by end of year 3, >80% aerial cover by end of year 5* 2) Are juvenile Chinook using the habitat type? *Number and condition factor of juvenile fish compared to a reference site during the same season, or to the project site before the project was built*
Shallow water/Edge Habitat	Backwater habitat creation *AND* Green River side channel creation	Create high quality, but mostly static, rearing habitat by reconfiguring the stream channel to be more hydraulically complex.	**1) Is there access to the habitat when the target life stage is nearby**? *Use elevation of inlet/outlet compared to water levels in late winter/early spring, when juvenile Chinook need it or use time lapse cameras to describe number of "inundation" days, duration, frequency, and timing of connectivity* 2) **Has there been deposition or erosion of habitat? Has substrate type remained as intended?** *Compare as-built (year 0) to year 3 conditions*	1) Are juvenile Chinook preferentially using the habitat type? *If evaluating for only 1 year: Higher relative abundance of target species in treatment habitats than in control habitats representative of pre-project conditions* *If using BACI: Increase in difference between abundance of target species in treatment versus control habitat **after project** than between pre-project treatment location versus control habitat before project.*

Project Type	Project Subtype	Project Objective	Physical monitoring questions and *Indicator/metric* (**Primary bolded**, Secondary regular font)	Biological monitoring questions and *Indicator/metric* (**Primary bolded**, Secondary regular font)
Shallow water/Edge Habitat	Creek channel restoration or relocation	Reconfigure or restore the stream channel to be more hydraulically complex and have a more natural channel configuration	1) **Has habitat quality and quantity increased post project and been maintained over time**? *Between years 0, 3, and 5, changes in: mean residual pool depth, increased diversity in habitat types (e.g. pools, riffles), increased wetted area at a set flow, and increased sinuosity.* 2) Has the project affected instream temperature? *Compare temperature upstream, within, and downstream of project area in years 0, 3, 5, 10*.	1) Are juvenile Chinook preferentially using the habitat type? *If evaluating for only 1 year: Higher relative abundance of target species in treatment habitats than in control habitats representative of pre-project conditions* *If using BACI: Increase in difference between abundance of target species in treatment versus control habitat **after project** than between pre-project treatment location versus control habitat before project.*
Shallow water/Edge Habitat	Levee or revetment Setback or removal	Allow the river to migrate or gain access to a specific area of floodplain and create high quality edge/off channel habitat.	**1) Has the length of unarmored bank increased?** *Compare length of unarmored bank between years 0, 3, 5 and 10.* **2) How much slow water habitat is available at 1200 cfs?** (This flow level was chosen from Anderson and Topping 2018) *Compare amount(ft^2) of edge habitat available before and in years 1, 3, and 5. Compare via GPS and velocity meter, mapping edge habitat as 1.5 ft/sec or less, using a modified Beechie et al 2005 for habitat types-bank edge (unarmored, bio-revetment, armored, bar edge, side channel edge, and backwater* 3) How much slow water habitat is available at the 50^{th}, and 75^{th} percentile flow during the rearing	1) Are juvenile Chinook preferentially using the treated area? *If evaluating for only 1 year: Higher relative abundance of target species in treatment habitats than in control habitats representative of pre-project conditions* *If using BACI: Increase in difference between abundance of target species in treatment versus control habitat **after project** than between pre-project treatment location versus control habitat before project.*

Project Type	Project Subtype	Project Objective	Physical monitoring questions and *Indicator/metric* (**Primary bolded**, Secondary regular font)	Biological monitoring questions and *Indicator/metric* (**Primary bolded**, Secondary regular font)
			period (adds higher rearing flows than #2 if sponsor is able to undertake) *Compare amount(ft²) of edge habitat available before and in years 1, 3, and 5. Compare via GPS and velocity meter, mapping edge habitat as 1.5 ft/sec or less, using a modified Beechie et al 2005 for habitat types-bank edge (unarmored, bio-revetment, armored, bar edge, side channel edge, and backwater* **4) Has the rate of channel migration increased?** *Quantify migration rates before and after project using either aerial photos or GPS in field to measure bank locations and rate of migration.* 5) Has the number and/or size of jams increased over time? *Compare # LWD pieces in jams and ft² year 0 to years 3, 5 and 10* 6) How much high flow refuge habitat is available at 8800 cfs* *Compare amount of habitat available before and after project via topographic surveys*	
Shallow water/Edge Habitat	Armor removal-marine, at feeder bluff	Restore sediment delivery to beach and downdrift habitats.	**Has sediment delivery increased?** *% of treated shoreline with eroding banks in year 3, 5, 10* **Has the amount of forage fish spawning gravel/habitat increased?** *Compare area/amount of habitat in the same season for years 0, 3, 5 and 10* Is sediment transport moving material downdrift?	

Project Type	Project Subtype	Project Objective	Physical monitoring questions and *Indicator/metric* (**Primary bolded**, Secondary regular font)	Biological monitoring questions and *Indicator/metric* (**Primary bolded**, Secondary regular font)
			Beach profiles for site and downdrift year 0 and year 3, and 5.	
Shallow water/Edge Habitat	Armor removal marine, non-feeder bluff	Enhance habitat quality along the shoreline margins	**Have basic beach habitat conditions improved?** 1) *Compare amount of detritus (beach wrack, drift logs, etc.) between year 0 to year 3.* **Has the amount of forage fish spawning gravel/habitat increased?** *Compare area/amount of habitat in the same season for years 0, 3, 5 and 10* 2) Has beach sediment remained stable? *Beach cross section profiles at same time of year for year 0, 3, 5 and 10.*	
Shallow water/Edge Habitat	Soft shoreline armoring	Enhance habitat quality along the shoreline margin while still restricting the ability of the shoreline to erode.	1) Is the treated beach eroding? *Annual beach cross section profiles at same time each year for 3 years* 2) Have basic beach habitat conditions improved? *Compare amount of detritus (beach wrack, drift logs, etc.) between year 0 to year 3.*	Did the benthic community recovery from burial? *Has the benthic/epibenthic community shifted to a reference condition between year 0, 3, 5 and 10?*

*The inundated area at 8,800 cfs is an indicator of flood refuge habitat. It corresponds with the approximate flow level that is effective at causing measurable channel changes in the period after Howard Hanson Dam was installed (Konrad et al. 2011). The use of this metric assumes that inundated area at 8,800 cfs is positively related to the quantity of slow-velocity (<45 cm sec-1) flood refuge habitat. If so, maximizing area at 8,800 cfs could potentially give juvenile Chinook more opportunities to avoid displacement and injury during floods, and survive at a higher rate.

Adaptive Management Process for Routine Project Effectiveness Monitoring

Routine project effectiveness monitoring evaluates whether a project is functioning the way it was intended in the 3–10 years after the project is built. The timeframe for determining effectiveness will likely be longer for projects designed to restore processes, and shorter for projects designed to be static. The following are adaptive management roles and actions for project sponsors, the ITC, and the Forum.

Project sponsor action:

- Monitor project, report on progress to ITC in years 3 and 5 for static projects, and years 5 and 10 for process-based projects.

ITC action:

- Evaluate and review project sponsor analysis—if project has shortcomings, determine if it is a result of project design or unanticipated processes that will prevent project from being sustained, with or without planned maintenance.
- Evaluate options and recommend action as needed to project sponsor and/or the Forum (e.g., maintenance, modify the existing design, or initiating a new project to achieve the objective, and funding if needed).
- Summarize recommendations for making future projects of this type more effective and sustainable/successful.
- Recommend any additional monitoring needed to further evaluate site conditions to project sponsor. If recommended for enhanced project effectiveness, propose to Forum if approval for additional funding is needed.
- If the project is successful, encourage project sponsors to present widely to various audiences (e.g., WRIAs, newsletters, conferences, web sites). Recommend similar projects and highlight the successful elements and techniques to project sponsors of projects of similar type.

Forum action:

4. Consider ITC recommendations for enhanced monitoring for specific projects, or recommended actions for maintenance, modifications of the design or new projects. Consider approving actions and/or funding.

4.1.2 Project Monitoring-Enhanced

Enhanced monitoring is focused on understanding how fish are using a restoration project type. Unlike routine project monitoring, which asks whether a certain type of habitat was created and sustained, enhanced monitoring is meant to determine how fish use the habitat, and which restoration techniques work best. While we generally know enough about Chinook distribution and habitat preferences to design appropriate restoration projects, we do not have all the answers. For example, past studies have compared the relative abundance of juvenile Chinook between different control and treatment habitats, but have not looked at condition factors to determine if restoration projects are also contributing to higher growth rates (and thus survival) of juvenile Chinook. It should be noted that project types that are prioritized for enhanced monitoring should not be

avoided, but rather, should be done and carefully evaluated. It is not suggested that this level of monitoring be done by all project sponsors. It is intended that the WRIA should at least partially financially support these types of monitoring projects. Also, as noted above, several of the project subtypes are part of the ACOE ERP program. It would be strategic to undertake enhanced monitoring efforts on ERP projects due to the ability to leverage federal dollars for monitoring. Enhanced monitoring overlaps with the research framework described below in the validation monitoring section of this report.

Prioritization Framework

Unlike the routine monitoring, which was focused on creating detailed recommendations, this enhanced monitoring section focused on creating a prioritization framework to rank where the WRIA should focus funding in its annual grant round (Table 3). Project subtypes for enhanced monitoring are grouped based on the subwatershed. This was done because some project subtypes have different levels of benefit or certainty based on where within the watershed they are undertaken. For example, placement of spawning gravel within the Middle Green River subwatershed is more likely to benefit and be used by spawning Chinook than material that is placed in the Lower Green River subwatershed, which historically had little available spawning habitat. Four criteria were used to evaluate the priority of action by subbasin. Each criterion was scored from 1 to 5 and summed across the four criteria. The higher the sum of the scores, the more effort the WRIA should put in to understanding the benefits of that project type within that subwatershed.

Prioritization Criteria

1. What is the certainty of project benefit to Chinook? A score of 1 indicates high certainty, and a score of 5 indicates low certainty. Higher certainty indicates a strong scientific basis that the project type in that location will benefit Chinook. Where there is already a strong scientific basis, there is less need to verify the project's benefits.
2. Is the project subtype process-based? A score of 1 indicates projects that restore riverine processes (e.g., levee setbacks) and a score of 5 represents structural projects that add relatively static habitat features. The plan generally favors process-based restoration techniques because there is greater certainty that the project will provide habitat benefits over the long term. Structural fixes tend to be engineered and more likely to fail in the long term. Thus, it is a higher priority to verify the benefits of those types of actions.
3. How common is the project type? How many of this type are we likely to do in the next 10 to 20 years. A score of 1 indicates we are not planning many of the project type in this subwatershed, while a score of 5 indicates that many are planned. Before we make future investments in a particular type of project, we should make sure they function as expected.
4. How expensive is the project type? Projects with relatively low costs receive a score of 1, and expensive projects score 5. If a project type will require the investment of large financial resources, effectiveness should be verified before many of these project types are undertaken.

The project subtypes were scored by the ITC and are presented in Table 3. The scoring methodology creates a range of scores from the lowest possible score of 4 to a maximum score of 20. The actual summed scores ranged from 7 to 17, with 7 project subtypes scoring above 13 or greater points. The highest scoring project subtype was creating shallow water habitat in the Duwamish subwatershed. This is because while we have fairly high certainty of benefit, this project subtype is generally not processed based, expensive, and the WRIA expects to build many of them over time. When the factors are combined, the score indicates we should make certain our efforts in this location are having the benefits we want. The 21 project subtypes were binned into three tiers based on natural break points that created roughly equally populated tiers. Tier 1, or projects that warrant additional monitoring the most, included projects that scored 13 points or greater. Tier 2 included six projects that scored between 10 and 12 points. Tier 3 included seven projects that scored from 7 to 9 points.

Table 3. Enhanced project effectiveness monitoring priorities by project type and subwatershed. Higher scores are a higher priority for enhanced monitoring.

Subwatershed	Restoration project subtype (does **not** include acquisition, stewardship, fish passage, and education projects)	Certainty of Benefit to Chinook (1= High to 5=low certainty)	Process Based? (1=process to 5 = Creation)	Relevance to future projects (**number** likely to do in the next 10 yrs) 1-few to 5-many	Relevance to future projects (likely **cost** over next 10 years) Low=1, high=5	sum	Tier
Duwamish	*Shallow water habitat creation	3	5	4	5	17	
Middle Green	*Spawning Gravel Supplementation	3	4	4	4	15	
Lower Green	*Backwater (nonflow thru off-channel habitat) creation	3	5	2	4	14	
Lower Green	Spawning gravel supplementation	4	4	1	4	13	1
Marine	Pocket Estuary Enhancement	5	3	2	3	13	
Lower Green	*Side channel (flow thru off-channel habitat) creation	3	5	1	4	13	
Middle Green	LWD installation	3	4	3	3	13	
Marine	Soft-shoreline armoring	2	4	3	2	11	
Middle Green	*Setback of levee or revetment	2	2	2	4	10	
Duwamish	Revegetation	2	1	4	3	10	2
Middle Green	Revegetation	2	1	4	3	10	
Tributaries	*Revegetation	2	1	4	3	10	
Tributaries	*LWD installation	3	3	2	2	10	
Lower Green	*Setback or removal of levee or revetment	2	3	1	3	9	
Lower Green	*Revegetation	2	1	3	3	9	
Marine	Marine shoreline armoring removal-other shoreform	4	1	1	2	8	
Marine	Revegetation of riparian area	2	1	3	2	8	3
Middle Green	Removal of shoreline armoring	2	1	2	3	8	
Tributaries	*Creek channel creation or relocation	3	2	1	2	8	
Marine	Marine shoreline armoring removal-feeder bluffs	3	1	1	2	7	
Upper Basin	Enhanced level of monitoring is not suggested until fish passage is provided	N/A	N/A	N/A	N/A	N/A	
* denotes a project subtype that could be monitored through the ACOE Ecosystem Restoration Program							

Adaptive Management for Enhanced Project Effectiveness

Projects should be evaluated with a combination of BACI or reference/control sites research designs depending on site and circumstances. Adaptive management roles and actions for enhanced project effectiveness are similar to those described above for routine project effectiveness.

Project sponsor or evaluator action:

- Monitor fish use and report on progress to ITC in years 3 and 5.

ITC action:

- Evaluate and review project analysis – if project has shortcomings, determine if it is a result of the specific project design, geographic location, or if it is an issue with the project type more generally.
- Determine if additional fish use monitoring should occur beyond the initial phase and if additional information should be collected at the same time (e.g. water quality.
- Recommend any potential corrective actions as needed to project sponsor and/or the Forum (e.g., maintenance, redesign, or initiating a new project to achieve the objective, and funding if needed).
- Summarize recommendations for future projects of this project subtype to ensure we learn from additional examples of the project subtype.
- If the project is successful, make sure this information is widely shared with other project sponsors. Encourage project sponsors to present widely to various audiences (e.g., WRIAs, newsletters, conferences, web sites). Recommend similar projects and highlight the successful elements and techniques to project sponsors of projects of similar type.

Forum action:

- Consider ITC recommendations for enhanced monitoring for specific projects, or recommended actions for maintenance, redesign, or new projects. Consider approving actions and/or funding.

4.2 Cumulative Habitat Conditions

The Salmon Habitat Plan calls for a variety of actions to be taken by local jurisdictions. Some of those actions are specific restoration projects while others are regulatory or programmatic in nature, like protecting forest cover. The intent of all the actions called for in the plan is to improve the cumulative habitat conditions for fish over time. The effectiveness of all the actions is represented in the cumulative habitat conditions, which require that we know both the gains and losses to habitat parameters throughout the basin so that we can evaluate the net loss or gain of any particular habitat metric. It is recommended cumulative habitat conditions be reported on every 5 years.

The WRIA 9 Status and Trends Report 2005–2011 (ITC 2012), evaluated most Tier 1 and several Tier 2 Conservation Hypotheses. While it is recommended the WRIA continue to measure the same metrics into the future, the information has been reorganized around recovery strategies that are part of the larger Salmon Habitat Plan update. In addition to the tracking the same metrics as in 2012, it is recommended that two areas be added for future status and trends evaluation. Specifically, it is recommended tracking the amount of and change in intertidal fill along the marine shoreline. Baseline data for 2005 and 2015 have been created that allow for consistent tracking of this metric.

At the time the Salmon Habitat Plan was developed, the existing water quality data did not indicate a strong effect on Chinook salmon, thus all water quality parameters were considered a moderate priority. Since the Salmon Plan was developed, three different Temperature Total Maximum Daily Load (TMDL) studies indicated temperature is a serious concern in the mainstem Green River, as well as in Soos and Newaukum creeks. The 2012 Status and Trends report recommended tracking water temperature in the mainstem of the Green River in addition to the tracking water temperatures in Soos and Newaukum Creeks.

Information on how cumulative habitat conditions will be evaluated is based on work done for the Status and Trends report in 2012 and is summarized in Table 4. The table includes information on: the method to be used, who is expected to collect the data, who will likely pay for the data, how often and when the evaluation should be done, and a rough cost range for data collection, analysis, and reporting.

Unlike the 2012 effort where the ITC dedicated most of a single year to collect and analyze data for the report, it is the intent that some of the data and metrics in Table 4 will be collected and analyzed each year, rather than all the information being collected and analyzed at one time. This will spread the costs and time requirements across a five-year period, which will make the overall undertaking more manageable and affordable with limited resources. It is recommended that the ITC continue to annually coordinate with other entities conducting monitoring in the watershed and evaluate opportunities to leverage other monies and make recommendations to the WEF as to which opportunities to pursue. For example, the ACOE undertakes large wood survey of thirty miles of the Middle Green River every few years. This effort could be leveraged by paying the ACOE consultant to collect the same data in the Lower Green and Duwamish. Having the same data collection methods and same surveyors reduces startup costs and improves data consistency and the ability to reliably analyze trends throughout the river.

Table 4. Summary information on what, how, and when cumulative habitat conditions should be tracked.

Habitat Metric	Recovery Strategy	Evaluated in 2012?	Method	Who collects data: *who pays for data collection*	How often/when?	Cost to WRIA? Low>2k; med= 2k to 25k, high>25k
River, marine, and large stream riparian vegetation condition	Protect, Restore, and Enhance Riparian Corridors	yes	Photo interpretation of Middle Green CMZ, the banks of the Lower Green, Soos and Newaukum Creeks, and 200ft landward along the Nearshore (use nearshore field surveys supplement with aerial photos)	County or regionally consortium for photos. WRIA would pay for analysis.	Every 5 years dependent on availability of aerial photographs and staff (last done in 2009). County wide photos available every other year (odd years).	HIGH ~1.5 weeks per area, 5 areas to be analyzed (*Data for Soos and Newaukum needs to be redone, Nearshore might need to be adjusted)*
Habitat forming high flows	Protect, Restore & Enhance In-stream Flows & Cold Water	yes	Evaluation of # of days per water year that daily average flow exceeds 8829cfs	Available USGS data: *Not WRIA*	Every 5 years (last done in 2009). Analysis/write up in 2016.	LOW Several days of staff time
Riverbank and marine shoreline armoring	Protect, Restore, and Enhance Channel Complexity and Edge Habitat & Protect, Restore and Enhance Floodplain Connectivity	yes	Boat based surveys of banks	ITC or consultant; ***WRIA***	~ Every 5 years Marine banks last surveyed in 2018, on schedule to do in 2021. Lower Green last surveyed in 2014. Middle Green has not been comprehensively surveyed since 2004.	MED-Marine HIGH-Freshwater
Marine intertidal fill	Protect, Restore & Enhance Marine Shorelines	no	Aerial photo and LiDAR comparison. Baseline data for 2005 and 2015 completed. Map/define shoreline edge and compare and contrast to baseline to identify filled or restored areas waterward of OWHM	ITC: ***WRIA***	Every 5 years. Update could be done based on 2019 or 2021 aerial photos.	MED to LOW.
Feeder bluff condition by drift cell	Protect, Restore & Enhance Marine Shorelines	yes	Primary analysis relies on shoreline armor data to determine impact of changes in shoreline armoring on sediment processes	ITC or Consultant; ***WRIA***	~Every 5 years. Relies on data from All 6 being updated.	LOW Several days of staff time to evaluate and write up.
Shallow water habitat amount/condition in the Duwamish.	Protect, Restore and Enhance Estuarine Habitat	yes	Evaluate area of shallow water habitat created for net gain and linear feet of shoreline bank restored. Combine project reporting data with aerial photo analysis of losses and potential natural gains similar to analysis for nearshore fill.	ITC or consultant: ***WRIA***	Last evaluation of newly created habitat done in 2009. Limited baseline of shoreline condition established in 2004. No baseline of shallow water habitat amount exists.	HIGH
River aquatic habitat condition/complexity (wood and pools)	Integrate Agricultural Protection and Salmon Recovery Initiatives & Protect, Restore, and Enhance Channel Complexity and Edge Habitat	yes	Habitat data needs to be collected in the field. Metrics include pieces of large wood and number of wood jams per mile, pools per mile, pool % by length, avg residual pool depth, dominant pool forming factor, % pools formed by wood.	ITC, ACOE, TPU, consultant: ***WRIA*** *(Lower Green and Duwamish), ACOE (Middle Green), and TPU (Upper Green)*	Baseline data in Lower Green last collected in 2014. Baseline data for wood in the Middle Green last collected in 2019. Baseline data in Upper Green was last collected in 2019	HIGH
Benthic Invertebrate condition of streams throughout watershed	Protect, Restore, & Enhance Sediment & Water Quality	yes	General watershed health will be evaluated by analyzing trends in benthic index of biotic integrity scores.	King County and various jurisdictions independent of salmon recovery for lower basin. Upper basin: **WRIA**	Compile data every 5 years. Previous analysis only included subbasins flowing into the Mainstem Green River. Future analyses should include direct nearshore drainages (data is available for many) and possibly the upper Green River every other year.	MED—below HHD, 1 week of analysis-write up MED-Upper basin (no data currently, baseline would need established)

Habitat Metric	**Recovery Strategy**	**Evaluated in 2012?**	**Method**	**Who collects data: *who pays for data collection***	**How often/when?**	**Cost to WRIA? Low>2k; med= 2k to 25k, high>25k**
Forest and impervious cover throughout the basin	Protect, Restore, & Enhance Sediment & Water Quality	yes	Use Coastal Change Analysis Program (CCAP) land cover data to evaluate forested conditions. Use CCAP data modified for impervious surface conditions.	NOAA collects land cover data. WDOE has modeled impervious surface based on CCAP data.	CCAP data is collected every 5 years. 2016 was the last year data was collected	LOW. Several days of staff time.
Chinook Salmon passage up and downstream of Howard Hanson Dam.	Restore and Improve Fish Passage	no	This requires minimal tracking and no analysis. Once fish passage is provided there will be many opportunities to leverage required monitoring by TPU and ACOE	None	Once a year check in on status of downstream fish passage facility.	none
Number of days river, Soos and Newuakum Creeks violate State water temperature standards	Protect, Restore, & Enhance Sediment & Water Quality	no	Use continuous temperature data collected at mainstem sites located at the Koss and Upper Green River sites above the reservoir and two sites below the reservoir. Compare number of days the Green violated State standards	King County restarted collecting data in 2013 for two sites below reservoir. Tacoma collects data above the reservoir.	Compile and evaluate data every 5 years.	LOW 1 to several days to evaluate and write up data.

Adaptive Management for Cumulative Habitat Conditions

The ITC will prepare a summary of environmental indicator conditions in the watershed compared to the baseline conditions every five years. The summary will classify all environmental indicators investigated as improving, staying the same, or degrading. This information will be compared to the watershed-wide implementation monitoring to gain insight on whether activities to date address the environmental indicators. If so, but the environmental indicator conditions continue to decline, then it means that habitat is being lost faster than it is being gained.

The ITC will prepare recommendations of projects to conduct (or project timelines to accelerate) and policies, programs, and regulations that can be useful in stopping habitat loss and providing an overall improvement in habitat. These recommendations will include consideration of:

- Are there incomplete projects in the Salmon Habitat Plan that could improve habitat conditions in ways that would appear in environmental indicator monitoring?
- Does it appear that un-enforced regulations are contributing to the degradation and/or is there a need for additional regulations?
- Are there programs in the Salmon Habitat Plan that could improve conditions that are not being implemented, or is there a need for additional programs?

The Forum will consider the ITC recommendations and make commitments of staff or other resources to take action to implement more projects or programs, enforce regulations, or develop new policies, programs, or regulations to address the issue(s).

5.0 VALIDATION MONITORING

5.1 Population Status-Viable Salmonid Population Parameters

The central question when working towards salmon recovery is, what is happening with the Chinook? Specifically, we need to know the status (abundance, productivity, distribution/spatial structure, diversity) and long-term sustainability of the Green River Chinook population. These are described by NOAA as Viable Salmonid Population (VSP) parameters. These measures of population status tell us whether the cumulative actions of society and the Salmon Habitat Plan are resulting in improvements in population's overall resiliency. There are factors outside the scope of the Salmon Habitat Plan that affect adult population abundance—i.e., ocean conditions, harvest rates, hatchery management, other Puget sound stock abundance (WRIAs 7, 8, 9, and 10)—so it is important to focus on aspects of the population that are predominately affected by WRIA 9 habitat actions. Table 5 shows VSP parameters, what each is intended to represent, how they will be measured, and who is collecting data associated with them.

Table 5. Viable Salmonid Population parameters, and who and how they are being measured in WRIA 9.

VSP Parameter	What is it?	What does it mean?	How is it being measured?	Who is measuring?
Productivity	The performance of fish during each life stage	The natural-origin spawners will produce sufficient juveniles to grow the population over the long-term, withstand unproductive ocean cycles, and provide an abundance of returning adults without subsidies from the hatchery.	Spawner surveys and juvenile outmigrants moving downstream at RM 34, since 1999. (1) Egg-to-migrant survival; (2) Median short-term population growth rate of natural-origin spawners; and (3) Recruits per natural-origin spawner; (4) 5-year average of # of parr; (5) proportion of adults from fry life history type.	Green River Smolt Trap is operated by Washington Department of Fish and Wildlife (WDFW), and is jointly funded by ACOE, Tacoma Water, WRIA 9, and WDFW. WDFW and MIT count spawners. Otolith data for #5 would need to be paid for and collected separately from existing programs.
Abundance	The number of natural origin fish in a population	Sufficient numbers of Chinook exist to be resilient to disturbances and variation in the environment, allow for negative feedbacks to stabilize the population size, maintain genetic diversity, and provide ecosystem benefits such as marine-derived nutrients. When the population is too small, the population is vulnerable to crashes from positive feedbacks that reduce survival as abundance declines, and may suffer from inbreeding.	Number of natural origin spawners annually through spawner surveys	WDFW and (MIT) collect and report the data. Data is available via WDFW's SCORE database. NOAA's Salmon Population Summary Database includes a Puget Sound wide uniform escapement method to generate population numbers.
Spatial Structure	The configuration, quality, and dynamics of salmon habitats and salmon dispersal among habitats	The spatial structure is maintained by a net balance of habitat creation and destruction, natural rates of genetic exchange between populations, the presence of some room to explore (unused but suitable habitat), and by some highly productive subpopulations that can prop up less productive ones.	Broad redd distribution data by river reach is collected during spawning surveys, but a metric to track this parameter has not been developed due to the large reaches the co-managers use to summarize spawners.	WDFW and MIT have collected detailed redd locations in some years, but not consistently. Not currently evaluating this metric due to the coarse resolution of the data.
Diversity	Genetic, physical, and behavioral differences among and within populations	Natural patterns of run timing, age, size, egg production, body shape, behavior and genetic diversity still dominate the population. Fish may disperse unimpeded and gene flow continues with little alteration.	(1) Percent of total river-spawning adults that originated from a hatchery; (2) timing of fry and parr outmigration; and (3) proportion of older (5 and 6 years) spawners in natural-origin returns. (4) Median peak spawn timing (want to see it moving later in year and greater range)	Green River Smolt Trap (see above) and adult counts by WDFW and MIT (also in NOAA's Salmon Population Summary Database)

Gaps in VSP monitoring

Spatial structure is an important VSP parameter that influences the ability of a population to adapt to habitat complexity. Chinook spawning distribution data by reach has been collected by the co-managers for several decades. In several years, an effort was made to GPS each redd location during the spawning surveys, but this is not consistently done. It is recommended that the WRIA work with the co-Managers to facilitate the collection of detailed location information so that the WRIA can create a metric to measure and track spawning patches (i.e. finer scale redd distribution). This will become more important in the future when passage is provided at Howard Hanson Dam, and spawning distribution may shift due to a doubling of the spawning habitat.

Currently, smolt outmigration is measured just above the confluence with Soos Creek, at River Mile 34; there is no smolt trap lower on mainstem to determine productivity of lower river rearing habitats. While Muckleshoot Tribe maintain a smolt trap on Newaukum Creek the data for that trap is not available for analysis. The WRIA 9 Chinook Salmon Research Framework (Ruggerone and Weitkamp 2004) recommended an additional smolt trap at River Mile 18 after the fish passage facility is installed at the Howard Hanson dam. A smolt trap was installed at this location for a short period in 2003, but it was done for a specific research project and was not considered an ideal site for trapping (King County 2013). A new approach to tracking juveniles in the lower Green River will be undertaken in 2021 using Passive Integrated Transponders (PIT). Once the results from the PIT tagging study are complete, the ITC should evaluate if it is appropriate to fund the PIT tagging array in the long term to quantify habitat use and survival through the lower Green.

The smolt trap at River Mile 34 is a high priority. The smolt trap facilitates "fish in-fish out" monitoring. In combination with spawning abundance estimates, this trap is used to measure egg to migrant survival for each brood year and to collect data on aspects of life history diversity. It is the best available measure of salmon productivity in freshwater given the range of inter-annual variability with flood events and other factors. VSP monitoring needs to be done annually without breaks due to natural variability in populations. Over long time periods, data from the smolt trap can help detect changes in productivity and life history diversity which should result from the cumulative habitat restoration being undertaken. The smolt trap funding has been in doubt at various times. The current funding approach relies on contributions from four government entities and it is unclear how long this approach will be viable. A long-term regional funding plan is needed to ensure the trap continues operating.

5.2 Ongoing Research and Data Gaps

In 2004 the WRIA 9 Technical Committee created the WRIA 9 Chinook Salmon Research Framework to "provide guidance about which research efforts should be implemented in the Green/Duwamish and Central Puget Sound Watershed to inform recovery planning" (Ruggerone and Weitkamp 2004). Existing information was used to create a conceptual model of how Chinook salmon use the watershed to help organize and prioritize data and knowledge gaps for future research. Research topics were categorized into three tiers.

Topics in Tier 1 were developed in more detail within the report while Tier 2 and 3 topics were left undeveloped.

Since 2004 many data gaps have been addressed or at least partially addressed through various studies. However, as is typical with research, for every question answered many more new questions are created. We now know some items originally listed as lower priorities in 2004 should actually be considered higher priorities and our list of data or knowledge gaps has expanded. There have been many reports with recommendations for additional research. Two newer reports that that compiled and described many new research needs are the WRIA 9 Status and Trends Report (ITC 2012) and the plan update white paper on Chinook use, temperature, climate change, and contaminant (King County 2017a, 2017b, 2017c, 2018). Given the fluidity of our state of knowledge, it was not deemed appropriate to expend significant resources in updating or amending the research framework within the MAMP when it will be out of date shortly thereafter.

Instead, it is recommended that the ITC still use and refer back to the research framework as it has laid out many issues in need of additional study as well as possible methods and approaches to addressing the data gap while at the same time taking into account newer information generated since 2004. For example, there are several studies recommended to improve our understanding around how fry use the estuary, but these studies do not take into account our new understanding of how contaminated substrates may be driving the very low survival.

6.0 RECOMMENDATIONS

Adaptive management involves using monitoring results to make changes to the Salmon Habitat Plan and projects, and requires testing assumptions, and sharing what is learned with the people implementing the plan and projects. Implementing this monitoring and adaptive management plan will be the backbone of our ability to say if recovery actions are working. This plan has identified the monitoring needs for WRIA 9 as it nears the end of the first 15 years of the Salmon Habitat Plan implementation and enters the next phase of salmon recovery with the first major update to the Salmon Habitat Plan. Findings from the monitoring efforts will allow the WRIA 9 stakeholders to adaptively manage for salmon recovery with the latest information about the pace of project and program implementation, the effectiveness of projects, and their effects on the abundance, productivity, diversity, and spatial structure of Chinook salmon.

In recent years, the WEF has dedicated a proportion of its local resources to monitoring and research needs. It is recommended that the WRIA continue to do so given the need to describe if the Plans actions are leading to changes in the Chinook VSP parameters.

Specifically, it is recommended that the WRIA shift the current monitoring and research grant selection process into a more formal process than it has been. This will allow the WRIA 9 ITC to review and balance the various types of monitoring needs each year. It is expected the monitoring and research grant funding will predominately be directed at, cumulative habitat condition data collection and analyses, smolt trap funding, and some amount of enhanced monitoring and new research to address knowledge gaps.

Specific adaptive management actions and roles are described for each type of monitoring in the sections above and are summarized below.

Implementation Monitoring Priorities

In order to track how the Salmon Habitat Plan is being implemented, it is recommended that project sponsors report project funding and habitat accomplishments to the WRIA 9 Habitat Projects Coordinator within 3 months of project completion. Additionally, it is recommended that WRIA 9 staff report in writing on a biennial basis on the status of Salmon Habitat Plan implementation related the habitat targets for each subwatershed, as listed in the implementation monitoring section (chapter 3) of this plan.

Project Effectiveness Monitoring Priorities

The routine monitoring for projects suggested in this report were prioritized because they should be relatively easy and inexpensive to collect and frequently integrate with permit required monitoring. Routine monitoring for individual project effectiveness should be paid for by project sponsors or grants they receive for project construction, where monitoring costs are allowed. While not encouraged, project sponsors or other groups may also apply for WRIA directed grants for routine monitoring and maintenance, but a high bar should be placed by the ITC to justify why the normal expectations should be discounted. Some projects with more risk or uncertainty in outcomes should be monitored more

intensively with funding support by the WRIA under enhanced project monitoring. It is recommended that the WRIA 9 dedicate some funding each year to enhanced project effectiveness monitoring in order to learn more about if specific project types are having the desired benefits. Opportunities to partner with the Army Corps of Engineers on enhanced project effectiveness monitoring for projects in the ERP should also be pursued whenever possible in order to leverage WRIA dollars.

Cumulative Habitat Conditions

For cumulative habitat conditions, the strategy recommended is to whenever possible use data from existing monitoring efforts that are already occurring, and to leverage those with the agencies or groups doing the monitoring to expand the efforts to fill any gaps. Also, in some cases, WRIA 9 staff and partners, especially from the ITC, may be able to meet monitoring needs at no extra cost to WRIA 9. Data and evaluation of cumulative habitat conditions should be undertaken each year in order to spread out the tasks and make them manageable with limited staff resources. The sum of all those conditions should be reported on once every five years.

Validation Monitoring

A backbone of any monitoring effort is knowing how the fish are doing. The comanagers currently collect most necessary data on adults returning to the Green River. In 2013 when the smolt trap was likely to be funded only once every 10 years due to budget constraints, the ITC recommended that the WRIA contribute to its funding. This is because the smolt trap data is at the heart of our ability to say if the changes in habitat are resulting in changes in Chinook VSP parameters. The trap has been in place for over 20 years, and data compilation and analyses from that data recently provided many valuable insights into recovery efforts (Anderson and Topping 2018). Thus, the ITC strongly recommends continuing to work with basin partners to fund the smolt trap until a more appropriate regional funding source can be found.

It is suggested the ITC continue in its existing approach to ranking and funding priorities for research to fill data and knowledge gaps. Small investments in this type of work has provided useful information for the plan update, like the juvenile Chinook use of non-natal stream habitats in the Lower Green, which has raised the importance of restoring access to those habitats.

7.0 REFERENCES

Anderson and Topping, 2018. Juvenile life history diversity and freshwater productivity of Chinook salmon in the Green River, Washington. North American Journal of Fisheries Management, 38: 180-193.

Beechie, Timothy, Eric Buhle, Mary Ruckelshaus, Aimee Fullerton, Lisa Holsinger. 2006. Hydrologic regime and the conservation of salmon life history diversity, Biological Conservation, Volume 130, Issue 4, Pages 560–572, ISSN 0006-3207, 10.1016/j.biocon.2006.01.019. (http://www.sciencedirect.com/science/article/pii/S0006320706000450)

Coffin, C., S. Lee, and C. DeGasperi. 2011. Green River Temperature Total Maximum Daily Load Water Quality Improvement Report. Washington State Department of Ecology Publication No. 11- 10.046. http://www.ecy.wa.gov/biblio/1110046.html

Greene, Correigh M. and Timothy J. Beechie. 2004. Consequences of potential density-dependent mechanisms on recovery of ocean-type chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences, 61:590-602.

Green/Duwamish and Central Puget Sound Watershed Water Resource Inventory Area 9 Steering Committee. 2005. Salmon Habitat Plan: Making our Watershed Fit for a King. Prepared for the WRIA 9 Forum. King County Water and Land Resources Division, Seattle, WA.

King County. 2004. Auburn Narrows floodplain habitat restoration project: surface water Hydrology. Prepared by Kathryn Neal for King County Water and Land Resources Division, Seattle, WA.

King County. 2013. DRAFT. Juvenile Chinook migration, growth, and habitat use in the Lower Green River, Duwamish River, and nearshore of Elliott Bay, 2001–2003. King County Department of Natural Resources and Parks, Water and Land Resources Division, Seattle.

King County. 2017a. A synthesis of changes in our knowledge of Chinook salmon productivity and habitat uses in WRIA 9 (2004–2016). Prepared by Kollin Higgins of King County Water and Land Resources Division. Seattle, Washington for the WRIA 9 Watershed Ecosystem Forum.

King County. 2017b. Green River temperature and salmon. Prepared by Josh Kubo of King County Water and Land Resources Division. Seattle, Washington for the WRIA 9 Watershed Ecosystem Forum.

King County. 2017c. WRIA 9 Climate Change Impacts on Salmon. Prepared by Jessica Engel, Kollin Higgins, and Elissa Ostergaard of King County Water and Land Resources Division. Seattle, Washington for the WRIA 9 Watershed Ecosystem Forum.

King County. 2018. An evaluation of potential impacts of chemical contaminants to Chinook Salmon in the Green-Duwamish Watershed. Prepared by Jenee Colton, Water and Land Resources Division. Seattle Washington, for the WRIA 9 Watershed Ecosystem Forum.

Konrad, C., H.B. Berge, R.R. Fuerstenberg, K. Steff, T. Olsen, and J. Guyenet. 2011. Channel dynamics in the Middle Green River, Washington, from 1936 to 2002. Northwest Science 85: 1-14.

Latterell, Josh. 2008. Baseline Monitoring Study of Restoration Effectiveness in the Green River (Mile 32): Process and Habitats in the Channel and Floodplain. King County DNRP, Water and Land Resources Division, Seattle, WA. www.kingcounty.gov/environment/wlr/sections-programs/science-section/doing-science/green-river-restoration-study.aspx

Puget Sound Recovery Implementation Technical Team, R. Ponzio and K. Stiles. March 2013. Puget Sound Chinook Salmon Recovery: A Framework for the Development of Monitoring and Adaptive Management Plans. Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA.

Ruggerone, G.T. and D.E. Weitkamp. 2004. WRIA 9 Chinook Salmon Research Framework. Prepared for The WRIA 9 Steering Committee. Prepared by Natural Resource Consultants, Inc., and Parametrix, Inc. Seattle, WA.

WRIA 9 Adaptive Management and Monitoring Workgroup and Anchor Environmental LLC. 2006. Implementation Guidance for the WRIA 9 Salmon Habitat Plan. Prepared for the WRIA 9 Steering Committee, Seattle WA. pp101.

WRIA 9 Implementation Technical Committee. 2012. WRIA 9 Status and Trends Monitoring Report: 2005–2010. Prepared for the WRIA 9 Watershed Ecosystem Forum. King County Department of Natural Resources and Parks, Water and Land Resources Division, Seattle, WA.