August 2021
Chehalis Basin Strategy

Aquatic Species Restoration Plan Monitoring and Adaptive Management Plan

Prepared for
Office of Chehalis Basin

Prepared by
ASRP Steering Committee and Monitoring and Adaptive Management Team

TABLE OF CONTENTS

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

ASRP	Aquatic Species Restoration Plan
BDA	beaver dam analog
Board	Chehalis Basin Board
DOI	U.S. Department of Interior
EDT	Ecosystem Diagnosis & Treatment
EIM	Washington Environmental Information Management System
GSU	geospatial unit
HCP	Habitat Conservation Plan
M&AM	monitoring and adaptive management
NOAA	National Oceanic and Atmospheric Administration
PI	Principal Investigator
QAPP	quality assurance project plan
RM	river mile
SMART	specific, measurable, attainable, realistic, and time bound
SRT	Science and Technical Review Team
TAG	Technical Advisory Group
WDFW	Washington Department of Fish and Wildlife

EXECUTIVE SUMMARY

Background

The Chehalis Basin Strategy Aquatic Species Restoration Plan (ASRP) is a science-based plan collaboratively developed by the ASRP Steering Committee and regional partners to restore and protect native aquatic species habitat in the Chehalis Basin. By strategically improving habitat in locations where the greatest potential exists to provide substantial gains for aquatic species, the ASRP seeks to build a resilient future for the basin's aquatic species while honoring the social, economic, and cultural values of the region.

The ASRP will be implemented over multiple decades and represents a significant investment in the environmental resilience of the Chehalis Basin. It is critical that the ASRP be adaptively managed to ensure the activities are achieving stated program goals and to guide future investments in the program. The ASRP Phase 1 document (ASRPSC 2019) anticipated this need and called for the creation of a Monitoring and Adaptive Management (M&AM) Plan to "help the [ASRP] Steering Committee learn…and adapt to better direct, fund, and manage ongoing implementation." Between 2019 and 2021, the ASRP M&AM Team, a technical advisory group to the Steering Committee, identified essential questions to be answered and critical data to be gathered in order to support timely adaptive management decision cycles and prioritized and organized that information into the M&AM Plan.

Sampling Programs

The M&AM Plan is composed of the following three data sampling programs:

- **Status and Trends**, which evaluates changes in watershed conditions and abundance and distribution of target aquatic species over time
- **Project Effectiveness**, which examines the effectiveness of restoration activities and determines how well they improved habitat conditions at the project scale
- **Hypothesis Testing**, which conducts targeted studies to fill critical gaps in knowledge to inform restoration planning and to test the scientific assumptions used to create the ASRP

The M&AM Plan identifies the monitoring activities recommended for implementation in each sampling program as is currently envisioned for the 2021–2026 period. Monitoring plans for future 5-year periods starting with 2027–2031 will be developed near the end of the 2021–2026 period.

Feedback Loops

These three sampling programs will inform the Steering Committee, the Chehalis Basin Board (Board), and other decision-makers on the following two reporting cycles or "feedback loops": 1) an annual science feedback loop; and 2) an every-5-year policy feedback loop. The Steering Committee and Board

will use this information to exercise program oversight and make adaptive management decisions on future ASRP implementation actions.

The annual science feedback loop is intended to provide short-term learnings to decision-makers in order to act quickly on matters of interest as they are identified. The Technical Advisory Group (TAG) will receive annual reports for each monitoring activity that will summarize the year's monitoring progress and accomplishments. The TAG will use this information to develop any relevant adaptive management recommendations to the Steering Committee and Board. Each year, the Steering Committee and Board will receive a report authored by staff along with a briefing summarizing ASRP project progress, monitoring accomplishments, and short-term adaptive management recommendations for consideration.

The 5-year policy feedback loop will result in a formal evaluation of ASRP priorities and implementation, as informed by ongoing project implementation progress and monitoring results. The Steering Committee and Board will receive a Comprehensive M&AM Review report summarizing the previous four (or more) years of project progress and monitoring results, accompanied by a technical evaluation of those results compared to stated ASRP goals. This evaluation will result in programmatic adaptive management recommendations on ASRP priorities, sequencing, and implementation for the following 5-year cycle. The primary audience for this report will be the Steering Committee and the Board.

Using the M&AM Plan

The M&AM Plan lays out the operations of monitoring work to support structured adaptive management feedback loops and therefore provide the Steering Committee and Board the capability to properly oversee the ASRP program through time. Details of the M&AM Plan will support the actions of the ASRP TAG and the Principal Investigators of ASRP monitoring activities. The M&AM Plan is envisioned as being a living document along with the ASRP and should be updated as the program continues to be adapted to new information. Just as the ASRP will be updated by the Board and the Steering Committee with guidance from the annual and 5-year reporting cycles, so too will the M&AM Plan.

1 INTRODUCTION

The Aquatic Species Restoration Plan (ASRP) includes monitoring to evaluate the effects of actions that restore habitat and re-establish natural processes that form aquatic habitats through time (Appendix B, ASRPSC 2019). This is needed to ensure the ASRP is adaptively managed as new information becomes available and is producing the intended results. Specifically, the objective of the monitoring is to assess the outcomes of ASRP implementation at multiple scales and to provide relevant, timely feedback from which more informed management decisions can be made (Appendix B, ASRPSC 2019).

In 2019, the ASRP Steering Committee established a Monitoring and Adaptive Management (M&AM) Team as a technical advisory team to develop a monitoring program for the adaptive management of the ASRP. This document describes the M&AM Plan developed for the ASRP.

The M&AM Plan is envisioned as being a living document along with the ASRP. As described in Section 4, the M&AM Plan includes science and policy feedback loops that will result in annual reporting of monitoring activities along with a comprehensive analysis of ASRP priorities, sequencing, and monitoring every 5 years starting in 2026. The information produced via these summaries and syntheses will be used to adapt M&AM Plan elements throughout the ASRP implementation period.

The M&AM Plan is comprised of three sampling programs. The sampling programs evaluate population status and trends (**Status and Trends Program**), assess the effectiveness of specific restoration actions (**Project Effectiveness Program**), and inform knowledge gaps or assumptions of the ASRP (**Hypothesis Testing Program**). The M&AM Plan identifies the monitoring activities recommended for implementation in each sampling program as is currently envisioned for the 2021–2026 period. The 2021–2026 period was selected to allow sufficient time for enough restoration to be implemented and biological responses and physical changes to occur and be observed via the monitoring conducted under the three sampling programs. For the Hypothesis Testing Program, the M&AM Plan identifies specific, short-term data gaps that will be addressed in the 2021–2023 biennium; hypothesis testing priorities for the remainder of the 2021–2026 period will be developed during the 2021–2023 biennium.

The need for an M&AM Plan builds on the ASRP's Scientific Foundation (Appendix A, ASRPSC 2019). The Scientific Foundation identified several overarching assumptions that were incorporated into the ASRP that need to be confirmed. These assumptions apply to ecological processes that support and sustain productive habitats within the Chehalis Basin and the diverse populations of native aquatic and semi-aquatic species that depend on these habitats. Thus, the three sampling programs incorporated into the M&AM Plan address the need to both monitor restoration progress and responses through time and confirm key scientific assumptions that underpin the ASRP. The three sampling programs will allow physical changes in aquatic species habitats and biological responses to ASRP actions through time to be tracked. Note that the changes are in response both to ASRP actions and external factors that also

influence habitat and biological productivity. External factors include for example climate change and interannual variability in adult salmon returns to freshwater due to ocean conditions.

The M&AM Plan was developed by the M&AM Team, with guidance, contributions, and review by the Steering Committee and the Science and Technical Review Team (SRT); members of these groups are listed in Appendix A.

2 PLAN DEVELOPMENT

Phase I of the ASRP identified initial concepts of the types of monitoring studies needed and described key elements of monitoring programs (e.g., establishing data protocols and processes for quality assurance and data management) (Appendix B, ASRPSC 2019). Building from these initial concepts, the M&AM Team developed a framework for a comprehensive approach to monitor and adaptively managing the ASRP through time. In developing the M&AM Plan, the M&AM Team used the most up-to-date information developed on the ASRP. From stakeholder and public feedback on the ASRP Phase I document, there was substantial interest in improving the projected outcomes, particularly for spring- and fall-run Chinook salmon, and promoting ecosystem resiliency to climate change. Thus, in 2020, refinements to Scenario 3 of the ASRP were developed to further improve the projected outcomes and species performance. These refinements were informed by public comment suggestions on the ASRP Phase I document, new scientific data and monitoring outcomes, and outputs from two habitat models. For salmon and steelhead, this included updated information on trends in observed adult abundance on the spawning grounds, Ecosystem Diagnosis & Treatment (EDT) model outputs for potential changes in salmon and steelhead abundance relative to restoration actions, and National Oceanic and Atmospheric Administration (NOAA) life-cycle model information on the restoration potential associated with different types of restoration actions. For non-salmon aquatic species (amphibians, non-salmon fishes, and other aquatic wildlife such as American beaver), refinements were informed by review of unique data collected on these species, species distribution data, and available habitat occupancy modeling (Ferguson et al. 2020).

Second, using the updated Scenario 3, the SRT then developed a technical prioritization and sequencing approach for implementing the ASRP and meeting its objectives. The approach prioritized the types and locations of restoration actions and placed the actions into an implementation sequence (ASRPSRT 2021). This was done to prioritize where, how, and when to conduct restoration to best meet the ASRP objectives. The SRT organized ASRP activities into three 10-year time periods.

Beginning in 2020, the M&AM Team reinitiated work on developing an M&AM Plan using the most up-to-date information from the Scenario 3 refinement and the implementation approach for prioritizing and sequencing ASRP actions discussed previously. This was important because the prioritization and sequencing developed by the SRT is spatially and temporally explicit, and the monitoring identified under the M&AM Plan needed to be integrated with the prioritization and sequencing.

As a first step in the process, in March 2020 the M&AM Team convened a panel of monitoring experts from across Oregon and Washington working on similar large-scale restoration monitoring programs. Panel members included Joe Anderson (Washington Department of Fish and Wildlife [WDFW]), Kirk Krueger (WDFW), Bob Bilby (Weyerhaeuser Company), Bill Ehinger (Washington Department of Ecology), Kara Anlauf-Dunn (Oregon State University), Jamie Anthony (Oregon Department of Fish and

Wildlife), and Tony Olsen (U.S. Environmental Protection Agency). The panel provided key insights on programmatic monitoring approaches and scale of monitoring and overall lessons learned.

The M&AM Team also decided to organize the M&AM framework using objectives that are specific, measurable, attainable, realistic, and time bound (SMART) for each monitoring goal and organized those objectives into three sampling programs. The three sampling programs were based on the monitoring and adaptive framework presented in ASRPSC (2019). The M&AM Team then determined the actions needed for each sampling program and developed a suite of indicator species (Appendix B) and species of interest (Appendix C) to focus the biotic sampling conducted through the M&AM Plan.

Between M&AM Team meetings, state agency representatives met to further discuss implementation details, costs, and objectives for each potential study that were then communicated back to the entire M&AM Team at the next M&AM Team meeting. Through this iterative process, a final suite of studies was selected for each sampling program. As discussions proceeded, data gaps that needed to be filled were identified and documented as near-term actions under the Hypothesis Testing Program. The studies within each sampling program were then ranked in terms of their priority and estimated study costs were reviewed to evaluate how to increase the cost-effectiveness of the M&AM Plan. The M&AM Team used the final list of ranked monitoring efforts and estimated costs to finalize an M&AM Plan that achieves the M&AM objectives of the ASRP by implementing the highest-priority projects in each sampling program, balancing activities and costs among the three sampling programs, and filling important data gaps to inform ASRP actions.

3 NEED FOR ADAPTIVE MANAGEMENT

Monitoring and adaptive management are essential elements of large-scale habitat and environmental restoration programs such as the ASRP. This is because restoration science is evolving, responses to restoration can vary or not align with assumptions, some approaches are experimental, uncertainties need to be addressed, and data gaps need to be filled.

Adaptive management is a means to incorporate new scientific and programmatic information into the implementation of a program to ensure that the goals of the activity are being reached efficiently (CRS 2011). It is an approach to natural resource management decision-making that incorporates mechanisms to reduce uncertainty (Holling 1978; Walters and Hilborn 1978) and for improving resource management through partnerships between managers, scientists, and stakeholders who learn together how to create and maintain sustainable resource systems (Sexton et al. 1999).

For the ASRP, adaptive management provides feedback loops on the pace, science, and policy aspects of the ASRP that will be used to adjust the program through time to ensure its goals and objectives are met (as described in Section 4). In addition, M&AM activities are essential for measuring and documenting the success of a publicly funded program.

Examples of where adaptive management has been incorporated into large-scale ecosystem restoration efforts across the United States include the Everglades, Chesapeake Bay, and Lake Tahoe (CRS 2011). In the Pacific Northwest, Rieman et al. (2015) posit that a comprehensive approach to cost-effective habitat restoration in the Columbia River Basin includes the capacity for learning and adaptation. Rieman et al. (2015) also identify three additional elements needed for large-scale, cost-effective habitat restoration that have already been incorporated into the ASRP: a scientific foundation based on landscape ecology principles and the concept of resilience, broad public support, and means for collaboration and integration among involved parties.

One of the largest and most comprehensive adaptive management plans in the United States was developed as a part of the Washington State Habitat Conservation Plan (HCP). The HCP covers forest practices rules for more than 60,000 miles of streams running through 9.3 million acres of state and private forestland in the State of Washington, including the Chehalis Basin. It was developed to provide biologically sound and economically practical solutions to improve and protect riparian habitat on non-federal forest lands in the State of Washington, and most elements were incorporated into the Salmon Recovery Act of 1999 (Revised Code of Washington 77.85; sometimes called the “Forests and Fish Law”). The Forests and Fish Report (USFWS 1999) recognizes that an adaptive management program is necessary to monitor and assess implementation of forest practices rules and achieve the desired resource objectives and lays out a comprehensive adaptive management plan (Appendix L, USFWS 1999).

The U.S. Department of Interior (DOI) developed a technical guide to aid DOI managers and practitioners in determining when and how to apply adaptive management (Williams et al. 2009). The guide identifies three elements necessary for successful adaptive management: decisions must be recurrent to allow opportunities for learning to influence future decision-making, decisions must be based on predictions that incorporate structural uncertainty (often this will be represented by two or more alternative models or hypotheses about system functionality), and there must be an objective-driven monitoring program that provides information to inform decision-making.

In conclusion, M&AM is a critical element of large-scale habitat restoration programs, and the M&AM Plan for the ASRP includes all three elements identified by Williams et al. (2009) as being necessary for successful adaptive management of such programs. These include recurring decisions (i.e., the science and policy feedback loops described in Section 4), decisions based on modeled predictions (e.g., modeling conducted as part of ASRPSC [2019] and future model runs that will be conducted as monitoring information becomes available; results will be incorporated into the science and policy feedback loops), and an objective-driven monitoring program (see Appendices D, E, and F).

4 ADAPTIVE MANAGEMENT FEEDBACK LOOPS

The objective of the M&AM Plan is to provide the types of information necessary for decision-makers to adjust the ASRP through time to ensure it is producing the biological results intended in the most cost-effective and time-efficient manner possible. Decision-makers are defined as the Board, who, informed with recommendations from the Steering Committee, will decide on budgetary allocations and adjustments to the ASRP as part of the overall Chehalis Basin Strategy. Adjustments to the ASRP could include changing the type, location, scale, priority, and sequence of restoration and protection actions implemented under the ASRP. The adjustments will occur through two feedback loops: science and policy. These feedback loops provide for a structured exchange of information between the scientists conducting and reviewing the monitoring and decision-makers responsible for program oversight. Actions in all three sampling programs incorporated into the M&AM Plan (**Status and Trends**, **Project Effectiveness**, and **Hypothesis Testing**) are designed to inform both feedback loops. Note that a Technical Advisory Group (TAG) for the ASRP is being formed that will replace the SRT and M&AM Team. The SRT and M&AM Team focused on ASRP and monitoring program development, and the TAG will focus on ASRP adaptive management by reviewing restoration actions and monitoring studies conducted each year. The role of the TAG in each of the feedback loops is described in the following sections.

Science Feedback Loop: This annual feedback loop is intended to provide short-term learnings to decision-makers to act quickly on adaptive management decisions as they arise. Annual progress reports will be produced by each Principal Investigator (PI) responsible for individual monitoring activities and hypothesis testing studies implemented as part of the M&AM Plan and made publicly available via posting to an ASRP website. The annual progress reports will summarize the activities accomplished that year along with any preliminary findings and present monitoring and study plans for the upcoming year if applicable.

The information will be reviewed annually by the TAG. The annual progress reports will be compiled and made available to the TAG ahead of time, and the TAG will meet with the PIs conducting the activities to discuss the findings. Potential changes to sampling techniques and study designs and recommendations for improving the activities and studies implemented under the M&AM Plan will be discussed with the PIs. The primary focus of the annual reviews of ongoing monitoring is a science-based discussion and assessment of the monitoring activities and whether any changes in the study design or approach should be considered for project-level adaptive management. These discussions could include sampling designs, sample size and error estimates, and statistical processes used to analyze the data. The ultimate goal of these reviews is to assess how well the monitoring meets the study objectives and samples

target populations, and based on the results, identify any restoration project design modifications that need to be made to improve overall ASRP effectiveness.

The basis for making a change in a study design would likely require several years of data and annual reviews, though this could occur rapidly in the case of filling critical data gaps to inform restoration. In addition to routinely evaluating the study design and approach to monitoring, the science feedback loop will also identify recommendations to ASRP Program Managers on changes to restoration actions, priorities, and sequencing. This could include restoration project siting as new data is available from short-term studies ahead of the comprehensive reviews of monitoring that occur every 5 years (see the Policy Feedback Loop discussed below).

Annually, the Steering Committee will receive the compiled monitoring progress reports and a briefing on any technical recommendations to adjust actions at the project level. The Board will subsequently receive an annual report and briefing summarizing ASRP project progress, monitoring accomplishments, and short-term adaptive management recommendations to consider for the program.

Policy Feedback Loop: A formal evaluation of ASRP implementation progress and monitoring results will be the basis of the Policy Feedback Loop. Information from the monitoring activities implemented through the M&AM Plan will be summarized for policy-level review and used to inform and adjust priorities for ASRP restoration actions and locations, sequencing recommendations, the pace of implementation, biennial budget requests, and adjustments among ASRP elements within individual biennia.

It is recognized that effective feedback on the science and policy aspects of ASRP implementation will depend on the ability to synthesize the large quantity of data potentially generated by the M&AM sampling programs (**Status and Trends, Project Effectiveness, and Hypothesis Testing**) across multiple species and spatial scales. When appropriate, the data from the M&AM sampling programs and project implementation will need to be incorporated into the EDT and NOAA habitat and life-cycle model used in ASRP development. Model runs could then be conducted based on the new information and used to develop updated estimates of salmon and steelhead responses to ASRP actions and hypotheses, as well as compare implementation progress against original goals. Data generated via the M&AM sampling programs will also be used to update amphibian occupancy models and native fish distribution models.

To support the policy-level feedback on ASRP results to date, a Comprehensive M&AM Review report will be developed by ASRP staff supporting the TAG and Steering Committee that summarizes the previous 4 or more years of monitoring efforts. These comprehensive reports will be produced every 5 years starting in 2026. The template for the report has yet to be developed but will likely include the following:

- An assessment of the M&AM monitoring activities and project implementation progress to date

- When sufficient data are available, correlations between the physical responses of habitats to restoration actions and the biological responses of species to restoration via status and trends monitoring
- Results of any modeling conducted using the data collected
- Any recommended adjustment to activities within the sampling programs (**Status and Trends, Project Effectiveness, and Hypothesis Testing**)
- An evaluation of ASRP prioritization and sequencing to date based on the monitoring results
- Any formal adaptive management recommendations on restoration (the type, location, scale [project or reach], priority, and sequence of restoration actions)
- Any recommended adjustments to the species of interest (Appendix B) or indicator species (Appendix C) lists

Based on the TAG's review and discussions with PIs, additional analyses may be recommended and conducted. The draft report will be updated, and a draft final Comprehensive M&AM Review report will be provided to the Steering Committee for review along with a presentation and discussion. Additional analyses may be recommended by the Steering Committee, conducted, and incorporated into a final report. The final Comprehensive M&AM Review report will be provided to the Chehalis Board followed by a presentation to the Board by the Steering Committee of the information in the summary report and any adaptive management recommendations for ASRP adjustments.

It is also envisioned that decision-makers will have questions for the Steering Committee, TAG, and PIs that require clarifying a conclusion or recommendation, conducting additional analyses, or adjusting a monitoring activity. Thus, the Science Feedback Loop and Policy Feedback Loop are designed to support the communication of information in multiple directions (Figure 1).

Figure 1
Flow of Adaptive Management Feedback Loop Information Across ASRP Groups

5 ASRP M&AM SAMPLING PROGRAMS

The M&AM Plan is composed of three sampling programs and individual monitoring activities within each sampling program. The three sampling programs are distinct but are integrated into the M&AM Plan to address the essential needs of implementing the ASRP through time. These needs include the following:

- Monitoring changes in watershed conditions and aquatic species abundance and distribution (**Status and Trends Program**)
- Determining the success of restoration actions on physical habitat at the project scale (**Project Effectiveness Program**)
- Filling critical data gaps and testing key assumptions made during ASRP development (**Hypothesis Testing Program**)

A full listing of proposed **Status and Trends**, **Project Effectiveness**, and **Hypothesis Testing** monitoring activities for 2021–2026 can be found in Appendices D, E, and F, respectively. The sampling program appendices identify each monitoring activity in the sampling program, how each informs the science or policy feedback loops, the question(s) being addressed by the action, the implementation timeline needed to inform adaptive management via the feedback loops, the types of information being gathered via objectives that are SMART, and estimated cost per biennia.

The three sampling programs have been designed to deliver information at different spatial and temporal scales depending on the type of information needed to support adaptive management of the ASRP. Information developed through the M&AM Plan is also being delivered in a manner that meets both short-term and long-term needs. The authors acknowledge the natural complexity and blurred boundaries of terms utilized. Applicable definitions of spatial and temporal scale for each of the sampling programs are described in Tables 1 and 2.

Table 1
Monitoring and Adaptive Management Plan Spatial Scale Definition of Terms

TERM	DEFINITION OF SPATIAL SCALE	SPATIAL SCALE EXAMPLE	MONITORING ACTIVITY EXAMPLE
Restoration Project	Individual restoration action footprint	Sediment wedge installation project footprint	Evaluating how artificial sediment wedges alter sediment accrual within project footprint (Appendix E)
Restoration Reach	1 to 3 RMs or large segments of river[1]	Skookumchuck River Early Action Reach (RM 19 to 22)	Assessing whether reach-scale project implementation results in cooler stream temperatures throughout the reach (Appendix E)

TERM	DEFINITION OF SPATIAL SCALE	SPATIAL SCALE EXAMPLE	MONITORING ACTIVITY EXAMPLE
GSU	A river segment or collection of smaller river segments	Upper South Fork Chehalis River	Quantifying the distribution and physical characteristics of summertime thermal refugia in priority GSUs (Appendix F)
Subbasin	A tributary system within the Chehalis Basin	Newaukum River system	Conducting salmon and steelhead smolt trapping in the Newaukum River (Appendix D)
Basin	The Chehalis Basin and its tributaries	Chehalis Basin	Western toad surveys basin-wide (Appendix D)

Note:

1. Reaches can vary in size and include areas defined formally as an Early Action Reach (1 to 3 RMs)

Table 2

Monitoring and Adaptive Management Plan Temporal Scale Definition of Terms

TERM[1]	DEFINITION OF TEMPORAL SCALE[2,3]	MONITORING ACTIVITY EXAMPLE
Short-term	1 to 3 years	Identifying the distribution and physical characteristics of summertime thermal refugia in priority implementation areas (Appendix F)
Mid-term	3 to 7 years	Identifying if reach-scale project restoration actions promote increased habitat complexity (Appendix E)
Long-term	10 to 30 years	Conducting salmon and steelhead smolt trapping in the Newaukum River (Appendix D)

Notes:

1. Temporal scale terms for the M&AM Plan are defined differently than in the ASRP Prioritization and Sequencing Plan. The implementation timeline of the ASRP is consistently applied at 30 years.
2. Specific monitoring activities may deviate from the defined ranges to adequately answer the monitoring objective. These ranges are applied as averages within the M&AM Plan. The need for flexibility in establishing the appropriate monitoring period will vary with the monitoring objective and will be based on initial monitoring results. For example, long-term monitoring projects may require annual sampling or periodic sampling (e.g., every 5 years) to verify trends.
3. Monitoring requires consistent implementation to establish trends, which requires that consistent funding be available for monitoring. This is especially the case for long-term **Status and Trends** monitoring of salmon and steelhead and watershed health.

Each sampling program is summarized in the following sections as to its main purpose, the types of monitoring activities in the sampling program, the spatial and temporal scales of the identified monitoring activities, and the types of information developed for informing ASRP adaptive management.

The M&AM Team used the list of potential indicator species developed for Phase 1 of the ASRP (ASRPSC 2019) to develop two lists of species to focus monitoring efforts: indicator species (Appendix B) and species of interest (Appendix C). Indicator species are ones that, because of their habitat utilization patterns or life histories, represent larger species assemblages and demonstrate habitat conditions

important to those species (ASRPSC 2019). Species of interest are ones of special concern by the State of Washington or the federal government due to their status. Keys depicting the federal and state status of species are provided in Appendices B and C.

The species that will be targeted in the sampling programs vary depending on the purpose of the program. Indicator species will be targeted as part of biotic sampling conducted to assess status and trends and distribution. Tracking these species will provide direct insights on the connections between ASRP implementation actions and the realization of program goals. Information on additional species of interest will be collected if it is feasible and convenient during **Status and Trends** sampling (Appendix D). In contrast, data collected under **Hypothesis Testing** (Appendix F) to fill critical data gaps or evaluate ASRP assumptions could target indicator species or species of interest, depending on the specific purpose and location of the activity.

5.1 Status and Trends

Purpose: Establish the current status of a watershed (condition) and aquatic species population densities and distributions and repeat the sampling to monitor the changes in condition (i.e., the trend) through time.

The M&AM Plan describes **Status and Trends Monitoring** activities associated with the ASRP. However, it is recognized that other monitoring activities in the basin are ongoing that can add value to ASRP status and trends species tracking. This includes a salmon and steelhead smolt trap operated by WDFW in the mainstem Chehalis River near Independence Creek, a smolt trap in the upper Chehalis River operated by the Confederated Tribes of the Chehalis Reservation, and smolt and adult trapping on Bingham Creek in the Satsop River by WDFW. Independence and Bingham creeks sampling efforts are monitoring sites with long-term data that will also inform ASRP status and trends. In addition, the long-term spawning survey program conducted by the salmon co-managers in the basin provides important data on spawning escapements trends. These monitoring efforts are important for understanding the effects of external factors (ocean harvest, marine survival, and large-scale climate patterns) that will supplement the ASRP's focus on freshwater habitat within the basin.

Description: Status and trends monitoring of watershed conditions includes the physical, chemical, and selected biological conditions of aquatic and riparian habitats. Reliable information about changes in watershed condition requires consistent, long-term monitoring at multiple sites selected as reference locations in certain sub-basins that are repeatedly sampled to detect programmatic effects over the full term of ASRP implementation. Randomly selected sites will be defined by the specific monitoring activity. The physical habitat sampling methods for the basin-wide efforts will be conducted consistent with Project Effectiveness Monitoring activities where feasible to facilitate reliable comparisons between trends and effectiveness.

Biotic sampling plans are based on the distribution and habitat use of indicator species (Appendix B). Existing salmonid sampling in targeted sub-basins will be expanded to monitor fish in/fish out (i.e., adults returning and smolts produced) each year. Juvenile and adult abundance, distribution, biological diversity (size, age, origin, and run timing), and overall productivity (smolts per spawner and adult recruits per spawner) of the selected sub-basins will be monitored. Given the focus of the ASRP actions on affecting freshwater habitat productivity, it will be critical that the **Status and Tends Monitoring** activities document changes in this productivity.

The effectiveness of stream restoration activities for increasing the freshwater production of salmon and steelhead will be based on the fish in/out monitoring data. The actual methods and metrics for assessing change will be developed in the upcoming biennium and coordinated within the TAG. Multiple metrics and targets are available to discuss and use in the Chehalis Basin because of the extensive amount of work conducted on recovering salmon and steelhead in other regions that are listed under the Endangered Species Act. For example, these could include trends in abundance over a specific time period (e.g., increasing trend over a 5-year period) or more quantitative goals such as attaining a specific cohort replacement rate (a measure of population productivity), a specific coefficient of variation (a measure of variability in adult abundance), or reaching an effective population size (N_e) that reduces extinction risk (as described in Lindley et al. 2007).

For non-salmonid species, monitoring will be conducted to assess the presence and distribution of individuals through time. The monitoring will address how distribution changes through time relative to restoration, water availability, and climate change, and through relationships with other native and non-native species, vegetation types, and physical environmental characteristics.

Spatial scale: Subbasin and basin.

Temporal scale: Monitoring will be conducted annually or as required by the monitoring study design. The selected monitoring activities are designed to occur long term and over the course of ASRP implementation. Annual progress reports will be provided to the TAG for compilation, review, and synthesis of annual science-focused adaptive management recommendation reports. These interim reports will inform the 5-year policy feedback loop recommendation reports starting in 2026 or when trends are developed, whichever is first.

How the monitoring activities inform adaptive management:

- The information on habitat condition derived from the Watershed Health Survey Study will provide watershed-level and potentially ecological region- or basin-scale trends and watershed health information to help interpret and provide context for reach- and project-level results of restoration. Habitat conditions throughout the basin will improve resolution of EDT and life-cycle models helping to inform development restoration actions and locations in the basin. The habitat typing data used in EDT for the ASRP Phase 1 analyses for salmon and steelhead reflects

surveys done in the 1970s that have not been updated. As conditions change, due to climate or other environmental drivers, these data need to be collected and used to update habitat models to improve projections of restoration effectiveness and salmon and steelhead responses to restoration.

- Stream temperature is a master variable controlling biological processes in river ecosystems. The Chehalis Thermalscape Study will use a high-resolution stream temperature monitoring network to track current and future trends in stream temperature at the Chehalis Basin scale. Information from this effort will inform species distribution and abundance modeling and inform basin-scale restoration and protection strategies for current and future climate change conditions.
- Non-native species and climate change are among the few largest issues facing native aquatic species along with continued human activities in the basin. The Non-Native Fish Ecology Study will track the distribution, habitat use, and predation rates of non-native smallmouth bass, an indicator species, and other non-native fishes over time with respect to stream temperature (both current and modeled under climate change), landscape metrics, and restoration. Information from this study will inform strategies for minimizing ecological impacts of non-native fish species on native species in the Chehalis Basin.
- Stream-Associated Amphibians Surveys (e.g., coastal tailed frog), and surveys specific to Oregon Spotted Frog and Western Toad Surveys will track trends in presence, abundance, and distribution of the indicator species across different environments basin-wide. Information from this work will inform impacts of climate change on these sensitive indicator species and adaptive priorities for restoration projects.
- Salmon and Steelhead Smolt Trapping (Newaukum and Upper Chehalis rivers) will track out-migrating salmon and steelhead smolt populations by providing annual measurements of abundance with known precision and measuring characteristics of life history diversity (e.g., size, age, and run timing). Documenting trends and changes in abundance and productivity associated with restoration will allow the overall effectiveness of ASRP actions to be judged and the program adjusted if needed. How those adjustments will be made and what they might include has not been discussed but could include increasing or decreasing the intensity, spatial extent, and pace of restoration being implemented.
- Spawning Ground Surveys (Newaukum River) will estimate adult abundance in one focal sub-basin that will receive a large amount of restoration in the near term to evaluate stream restoration activities impact on resiliency in adult spawning populations facing climate change at the sub-basin scale.

5.2 Project Effectiveness

Purpose: These monitoring activities in this program will track only the physical response of habitats to restoration treatments. The results will be used to determine the success of restoration actions at the

project scale and whether specific actions are achieving their intended outcomes. This will include validating that actions to restore habitat are re-establishing natural processes that form aquatic habitats through time. Early monitoring activities are focused on more experimental restoration activities to better understand the potential effectiveness of such treatments at a larger scale in the basin.

Description: Typically, a restoration project includes several interacting treatments (e.g., the placement of large wood, channel reconfiguration, riparian vegetation restoration, levee removal, and floodplain reconnection). Project effectiveness monitoring is needed to inform the long-term function of the individual treatments (e.g., how are reconfigured channel sites changing and why?) and the collective treatments (e.g., is connectivity to the floodplain improved and maintained throughout the reach?). While restoration in early action reaches has been initiated, it is acknowledged that pre-treatment monitoring for these sites was limited, and it may require several years of pre- and post-treatment monitoring at reach scales of the reaches restored through the early ASRP actions.

The suite of monitoring activities included in the M&AM Plan are aimed at restoration treatments prioritized within the ASRP for early implementation that have greater uncertainty associated with intended physical benefits. While some restoration techniques such as large wood placements are well studied, the M&AM Plan focuses early monitoring activities on techniques where the effectiveness of the action needs to be established. This is to ensure the restoration is addressing a fundamental goal of the ASRP to restore habitat-forming processes and inform future project implementation, such as sediment wedges.

All project effectiveness monitoring activities will provide information for the first 5-year policy feedback loop. Three priority restoration actions were selected for project effectiveness monitoring in the first 5-year policy feedback loop period. These include beaver dam analogs (BDAs), sediment wedge treatments, and reach-scale restoration projects. Each major design objective of the identified restoration actions will be monitored to evaluate on-site effectiveness (Appendix E). The **Project Effectiveness Program** will be re-initiated with new projects and/or questions beginning in 2026.

Spatial scale: **Project Effectiveness** monitoring activities include both project-scale activities (e.g., sediment wedge treatments and BDAs) and large-scale activities that cover an entire restoration reach (*reach-scale projects*).

Temporal scale: Monitoring will be conducted annually and conclude between 3 and 4 years following construction, as identified by the project type. Annual progress reports will be provided to the TAG for compilation, review, and synthesis of annual science-focused adaptive management recommendation reports. These interim reports will inform 5-year policy feedback loop recommendation reports when applicable.

How the monitoring activities inform adaptive management:

- Climate change is a major driver of impacts to aquatic species in the Chehalis Basin, and the ASRP has prioritized multiple restoration actions to address climate change, including installing in-channel structures to increase habitat complexity and trap sediment, riparian plantings, and barrier removal. The ASRP also includes experimental treatments to reduce stream temperatures to combat those impacts more quickly than will occur through restoration of stream buffers through riparian plantings. Accordingly, sediment wedge treatments have been highlighted for project effectiveness monitoring to evaluate the effectiveness of sediment wedge installations on localized habitat conditions and the creation of thermal refugia. Monitoring focused on wedges are planned to evaluate this restoration technique in detail at two selected locations both pre- and post-project installation. Monitoring activities will evaluate the ability of these restoration actions to reduce stream temperature downstream of the installation and alter hyporheic exchange at the project location. The purpose of these studies is to inform future restoration designs and the application of sediment wedge treatments for basin-wide restoration.
- BDAs are a low-cost means of restoring stream habitat. Four monitoring questions related to BDA performance will be evaluated at three project sites both pre- and post-installation to assess how the structures increase fluvial habitat complexity, facilitate beaver colonization and dam building, increase hydrological connectivity with the floodplain, reduce downstream temperatures, and increase thermal habitat diversity. Results of the studies will inform the use of this restoration technique in the future, including information on project design and siting.
- Reach-scale projects are multi-treatment projects aimed at restoring ecosystem processes throughout a river reach (1 to 3 river miles [RMs]). The suite of monitoring activities on reach-scale project implementation are designed to inform future project design and siting. These activities include the following:
  - The length, duration, and area of floodplain inundation and off-channel habitat connectivity at different flows (post-construction)
  - Changes in the vertical hydraulic gradient and any resulting cooling of stream temperatures (pre- and post-construction)
  - Whether wood incorporated into reach-scale projects results in the expected changes in channel structure, remains in place, and continues to provide process-related benefits to habitat through time (pre- and post-construction)
  - Whether reach-scale project restoration actions promote increased habitat complexity (pre- and post-construction)
  - How the quality and quantity of spawning gravel and sediment and the level of bed scour in the reach changes following reach-scale restoration (pre- and post-construction)

5.3 Hypothesis Testing

Purpose: Hypothesis testing includes two types of studies: filling data gaps and the testing of assumptions made during ASRP development. The objective of filling data gaps is to inform and adjust restoration action types, designs, scale, and locations starting in the near-term implementation period. This will be accomplished through the Science Feedback Loop and Policy Feedback Loop described in Section 4. Testing key assumptions about biological restoration effectiveness will inform associated aquatic and semi-aquatic species response at the project scale. All hypothesis testing monitoring activities are designed to be short term in length and rapidly inform adaptive management needs predominantly through the Science Feedback Loop.

The studies listed in Appendix F are focused on filling urgent data gaps and information needs. Once preliminary information collected through the **Status and Trends** and **Project Effectiveness** monitoring programs is available, this information will inform the development of future hypothesis testing activities.

Description: The ASRP was developed knowing that data gaps exist and was based on multiple assumptions about the past, present, and future states of the Chehalis Basin and the performance of certain native aquatic species relative to those conditions (ASRPSC 2019). These assumptions shaped development of the ASRP and guided the selection and extent of restoration measures. An essential element of the M&AM Plan is to fill critical data gaps and test key assumptions to reduce uncertainty. The M&AM Team identified multiple hypotheses that either underpin the benefits of restoration that are assumed but need validation (i.e., uncertainty is relatively high) or represent fundamental questions where knowledge is needed. Studies are designed to ensure that factors limiting the productivity of native species in the Chehalis Basin are clearly identified and restoration actions can be designed to effectively address them.

The M&AM Team developed and prioritized a list of potential hypothesis testing projects to be carried out during the 2021–2023 biennium to fill urgent information needs that will be used to inform and, if needed, adjust future ASRP actions (Appendix F). The studies selected to fill data gaps focus on information needed relative to key indicator species. This list will be updated by the TAG over the lifetime of ASRP implementation. This includes updating studies that will be implemented starting with the 2023–2025 biennium during the 2021–2023 biennium. The new studies will focus on collecting data on factors that are poorly documented but need to be estimated and incorporated into performance models such as EDT to support the Policy Feedback Loop. An example is the need to collect information on the extent of bed scour and levels of fine sediment in the basin. The studies listed in Appendix F have a short duration of 1 to 2 years. Therefore, hypothesis testing studies that could be implemented starting with the 2023–2025 biennium will also be identified during the 2021–2023 biennium. These studies could include evaluating assumptions of how non-native predators will interact with large wood placed in the river and are affecting native fishes in off-channel habitats. These types of additional

studies could be developed once the Non-Native Fish Ecology Study being implemented under **Status and Trends** monitoring has enough data to develop a trendline. It focuses on the distribution and diet of non-native smallmouth bass and other non-native fishes over time with respect to stream temperature and landscape metrics. It is designed to assess the ecological impacts on native species as a result of restoration in the Chehalis Basin.

Spatial scale: The spatial scale of the data gap being filled, or the hypothesis being tested, varies depending on the study objective and could include project, reach, or basin-scale studies.

Temporal scale: Monitoring will be conducted annually or more frequently and conclude between 1 and 3 years as identified by the study design. Annual progress reports will be provided to the TAG for compilation, review, and synthesis of annual science-focused adaptive management recommendation reports. These interim reports will inform 5-year Policy Feedback Loop recommendation reports when applicable.

How the information on immediate critical data gaps informs adaptive management:
Collection of data to fill critical gaps in environmental data is needed to improve identification habitat limitations and projections of the effectiveness of restoration measures and to improve the accuracy of analyses of population responses to restoration using models (e.g., EDT, NOAA life-cycle, amphibian occupancy, and native fish species distributions). Activities identified include the following:

- A study of the distribution of adult Chinook salmon run timing genetics at the sub-basin scale to support future decisions to install BDAs to decrease the hybridization of Chinook salmon in the Chehalis River.
- Quantifying the abundance and relative proportion of homozygous spring- and fall-run Chinook salmon and the proportion of heterozygotes using fry and subyearling Chinook salmon traps at multiple locations in the Chehalis Basin to document the extent of hybridization.
- Quantifying the distribution and physical characteristics associated with thermal refugia to inform future design and project siting decisions and provide a baseline for additional hypotheses.
- Concluding the Native Fish Ecology Study in the 2021–2023 biennium to produce a multi-species occupancy model to understand native fish occupancy across the Chehalis Basin with respect to landscape metrics. Occupancy models estimate where species will occur across landscapes under different time scales and are used to explain the dynamics of occurrence patterns to better manage and conserve species. The model will inform future project design and siting to maximize benefit for native fishes. Additional discussion can inform potential future monitoring of these species through watershed health surveys conducted under the **Status and Trends Program**.
- A key data gap is our knowledge of freshwater mussel distribution. Completing the survey of freshwater mussel species, including the target species Western ridged mussel, will document

the extent of mussel species within the study area and the occurrence of die-offs. This information will be used to inform future restoration project design to benefit mussels and siting to not impact mussel beds during restoration construction.

- The Satsop Ponds Reconnection and Off-Channel Reconnection studies will evaluate how species respond to increasing the hydrological connection between off-channel habitats and the stream channel and inform future project design and siting.

6 DATA COLLECTION, ORGANIZATION, AND SHARING

Data for the proposed sampling programs will be collected, synthesized, stored, analyzed, and reported by the PI and agency responsible for each monitoring project and study in the M&AM Plan. Project sponsors will not be asked to collect, store, or analyze monitoring data funded through M&AM. Project sponsors will be expected to collect monitoring data required through permit conditions and provide the ASRP with template restoration project information to inform adaptive management discussions. Partnerships and efficiencies between agency and sponsor data collection should be leveraged as much as possible where feasible. The ASRP Steering Committee aims to organize and report data in a transparent manner using consistent methods and frequency. For example, as stated in Section 5, annual progress reports of monitoring developed by each PI for the Science Feedback Loop will be made publicly available via a posting to an ASRP website.

6.1 Data Collection

Data for approved monitoring activities funded by the ASRP will adhere to the following guidelines:

- Quality assurance project plans (QAPPs) will be created and adhered to for all M&AM activities. A QAPP is a document outlining the procedures a monitoring activity will use to ensure the collected, stored, and analyzed data meet ASRP requirements. QAPPs will be updated as necessary with modifications made to study designs or protocols based on decisions made through the adaptive management process. Template and programmatic QAPPs will be developed to leverage efficiencies when feasible.
- Restoration project site assessment templates will be used to document habitat restoration project information and existing on-site data as part of the project design process. Project sponsors will complete the site assessment template before design funding can be allocated toward their project, as it will be used to help evaluate project objectives with on-site baseline habitat conditions to ensure fit with ASRP goals. Site assessment templates will also be integrated as part of the planning process for future **Project Effectiveness Program** monitoring. Template information will help the TAG identify the best methods to measure achievement of quantifiable objectives and outcomes at the project scale. These site assessment templates will be developed collaboratively in 2021 between the TAG and local implementation teams. Ongoing template data collection and organization and sharing will be overseen by ASRP staff.
- Consistent sampling protocols and metrics will be utilized across studies and monitoring programs as feasible. This will allow information to be comparable among different aspects of the monitoring programs. Several of the sampling programs and studies are designed to interact and complement each other in terms of the methods used to collect data and the ability to

share data across sampling programs described in the M&AM Plan and other existing monitoring programs across the State of Washington. Adhering to this principle will provide an important overlap between the watershed **Status and Trends** and **Project Effectiveness** programs.

- Coordination with project sponsors is critical to successful data collection. Many project sites are on privately owned lands, and sponsors will be the main point of contact for landowners engaging in restoration projects. Monitoring leads will coordinate with sponsors and landowners to access sites and collect data at the project scale.

6.2 Data Organization and Data Sharing

Data for approved restoration project and monitoring activities funded by the ASRP will adhere to the following guidelines to ensure the transparent and timely organization and sharing of datasets:

- PIs, otherwise referenced as monitoring leads, will be responsible for the ongoing and timely organization of datasets. This will include annual progress report templates be completed and submitted to the TAG for review and input into annual monitoring summary reports. Progress report templates will be developed collaboratively by the TAG and PIs in 2021. Responsibilities will also include final study reports structured as templates and include all relevant design, methods, analysis, and results. Individual study reports will not include adaptive management recommendations but rather will be utilized to inform adaptive management recommendation development by the TAG for both feedback loops. The PIs will be available to answer questions and provide updates as necessary to internal and external partners. PIs will be state or tribal employees tasked with leading a respective monitoring effort on behalf of the ASRP M&AM effort. Several PIs may also serve on the TAG depending on expertise.
- Tracking of restoration implementation and monitoring locations is necessary to understand project- and watershed-level effects in the context of the multiple actions and efforts occurring in the basin, not just those associated with the ASRP. Template site assessment information about restoration projects will provide site specific data for ASRP actions, but there are several other entities and processes working on restoration in the Chehalis Basin through diverse funding mechanisms. The Salmon Recovery Portal is a comprehensive database to track all restoration and conservation efforts in the Chehalis Basin, including ASRP projects. Using the Salmon Recovery Portal, information from all entities including state, federal, private, city, county, port, and tribal organizations can be viewed to track where restoration and/or mitigation work is being conducted that is separate from, but may affect, the implementation of the ASRP. Metrics captured in the Salmon Recovery Portal include, but are not limited to, project location, description, cost, timeline, and monitoring metrics if applicable. ASRP program staff will be responsible for tracking ongoing project implementation in the Chehalis Basin and communicating that information to the TAG. The TAG will coordinate with implementation leads

on the ASRP and have routine access to tracking information on other ongoing restoration and monitoring work that could inform adaptive management recommendations for the ASRP.

- Availability of data is critical for large multifaceted monitoring efforts as many groups will need access to datasets for analysis and to use information for restoration and other types of work. There are several statewide environmental databases that could be solely or collectively utilized to share data publicly. For example, the Washington Environmental Information Management System (EIM) catalogues existing studies, information, and data statewide and is accessible to the public. During the 2021–2023 biennium, the TAG and program staff will evaluate the use of EIM and other environmental databases and web services as data sharing portals. This work will include a comprehensive analysis of needs, including but not limited to agency responsibility of datasets, quality assurance/quality control plans, and protocols for uploading and sharing continuous and raw datasets.

7 FUNDING

As noted in Section 3, M&AM are essential elements of large-scale habitat and environmental restoration programs such as the ASRP. This is because restoration science is evolving, responses to restoration can vary or not align with assumptions, some approaches are experimental, uncertainties need to be addressed, and data gaps need to be filled.

However, there can be a disconnect between the funding priorities as seen by decision-makers and scientists in large ecosystem restoration programs. Decision-maker priorities typically center on implementing restoration projects and deprioritize ongoing monitoring, while scientist priorities typically center on funding monitoring studies to learn from ongoing projects and reduce uncertainty. To bridge this gap, the M&AM Team has developed a scalable M&AM Plan that can be adjusted to funding levels each biennium. However, it is important to recognize that reduced funding among biennia will result in reduced monitoring information being collected, which could result in gaps developing in the time series data that will affect the ability to track trends in watershed health or species abundance through time. This in turn would lead to decreased ability to provide program oversight and communicate how the ASRP is meeting its goals.

The M&AM program is currently scoped to be 14% of the 2021–2023 ASRP budget. This level of funding strikes a balance between monitoring and restoration priorities. It reflects a conscious effort on the part of the M&AM Team to be thorough in terms of monitoring coverage and also efficient in terms of the cost of each project and each sampling program overall. The M&AM Team also strived to develop a M&AM program that was comparable to other large-scale efforts around the state and region.

The M&AM Team acknowledges that funding needs will not be static through time and will be scaled according to the overall ASRP budget and evolving information needs. However, monitoring has to occur to collect the types of information needed to adaptively manage the ASRP through time. The expected funding trajectories for each sampling program in general terms are summarized as follows; these trajectories do not account for external factors such as inflation:

- **Status and Trends**: Funding is expected to be somewhat constant throughout the proposed 30-year ASRP implementation timeline.
- **Project Effectiveness**: Funding is expected to decrease over the full 30-year timeline of ASRP implementation, but not reduce to zero. As projects are implemented, there should be targeted effectiveness questions tested to maximize positive outcomes of project installations. Future reductions in sampling program budget will reflect the gradual understanding of project types and expected outcomes. Early in the ASRP implementation period there are several experimental restoration techniques being tested and monitored for effectiveness. As the ASRP

matures and techniques are evaluated there will not be as large a need for this type of monitoring unless new experimental techniques are developed.

- **Hypothesis Testing**: Funding is expected to decrease over the full 30-year timeline of ASRP implementation, but not reduce to zero. Like the **Project Effectiveness Program**, the ASRP will fill priority data gaps and test critical hypotheses early in the ASRP implementation period that are expected to have a large impact on adaptive management through the feedback loops. As these studies are completed, more targeted questions could be developed and tested in the future. It is the expectation of the M&AM Team that while hypotheses and data gaps will reduce in number over time as the program gains a better understanding of baseline conditions and assumptions, there will continue to be a need to test specific hypothesis to inform adaptive management. The rate of change in sampling program budget may be different than **Project Effectiveness Program** over time.

The M&AM program is funded through the overall ASRP biennial budget. All studies will be approved by the ASRP Steering Committee and Office of Chehalis Basin on a biennial basis due to the program being funded through Washington State capitol budget. Ongoing studies should be refined to realize cost savings when feasible over time and reflected in future biennial budget requests. The TAG will be responsible for recommending to the Steering Committee the suite of studies to be funded within each biennial budget development cycle. Operationally, this will include the prioritization of any hypothesis testing studies each biennium, and at a 5-year interval, the project effectiveness studies. The TAG should continually review the status and trends studies for relevance and inclusion in the M&AM program, though these studies are intended to be long term datasets. As the ASRP committee structure shifts from M&AM and SRT committees focused on development to the TAG focused on adaptive management, the ASRP Steering Committee has recognized the importance of both new perspectives and retaining institutional knowledge from ASRP development.

Table 3 summarizes expected costs among the three M&AM Plan sampling programs for the 2021–2023 biennium, along with the proportion allocated to each program. Note that this funding level and the proportioning among the sampling programs represents the upcoming biennium only. Program allocations are not static and will be adjusted based on upcoming priorities, results of studies conducted during the biennium, and annual reviews by the TAG and Steering Committee.

Table 3
2021–2023 Biennium Funding for ASRP Monitoring and Adaptive Management Activities

SAMPLING PROGRAM	2021–2023	PERCENTAGE OF M&AM BUDGET
Status and Trends	$2.8M	62%
Project Effectiveness	$826,000	18%
Hypothesis Testing	$878,000	20%
Total	**$4.5M**	**100%**

8 NEXT STEPS

The ASRP is a "living" plan, meaning it is intended to be updated, refined, and adaptively managed through time along with the M&AM Plan. Implementation of the M&AM Plan will support the ongoing adjustments to ASRP priorities, sequencing of restoration projects, biennial budgetary needs, and many other topics. Further, information from monitoring and its use in adaptive management will help the Steering Committee communicate the impacts, successes, and learning from ASRP implementation to the Board, key constituents, and outside groups looking to set up similar processes for habitat restoration throughout the region.

The ASRP Steering Committee and TAG, along with monitoring PIs, will work to develop the necessary templates, data storage capabilities, and processes to fully implement the M&AM Plan starting in the 2021–2023 biennium. Collaboration will continue to be a cornerstone of ASRP development as experts from implementation, science, policy, and management backgrounds come together to track, monitor, learn from, and communicate ASRP outcomes through time.

9 REFERENCES

ASRPIPW (Aquatic Species Restoration Plan Implementation Planning Workgroup), 2020. Memorandum to: ASRP Steering Committee. Regarding: ASRP Implementation Planning Workgroup Summary and Recommendations. December 21, 2020.

ASRPSC (Aquatic Species Restoration Plan Steering Committee), 2019. *Chehalis Basin Strategy: Aquatic Species Restoration Plan – Phase I*. Office of Chehalis Basin. Publication #19-06-009. November 2019.

ASRPSRT (ASRP Science and Technical Review Team), 2021. Memorandum to: ASRP Steering Committee. Regarding: A Prioritization and Sequencing Plan to Guide Implementation of the ASRP. March 18, 2021.

CRS (Congressional Research Service), 2011. *Adaptive Management for Ecosystem Restoration: Analysis and Issues for Congress*. R41671. Available at: https://crsreports.congress.gov/product/pdf/R/R41671.

Ferguson, J., C. McConnaha, T. Beechie, M. Hayes, P. DeHaan, M. Mobbs, T. Abbe, and L. Lestelle, 2020. Memorandum to: Aquatic Species Restoration Plan Science and Technical Review Team. Regarding: ASRP Scenario 3 Refinement Methods and Results. December 29, 2020.

Holling, C.S., editor, 1978. *Adaptive Environmental Assessment and Management*. New Jersey: Wiley & Sons.

Liermann, M., and P. Roni, 2008. "More Sites or More Years? Optimal Study Design for Monitoring Fish Response to Watershed Restoration." *North American Journal of Fisheries Management* 28:935–943.

Lindley, S.T., R.S. Schick, E. Mora, P.B. Adams, J.J. Anderson, S. Greene, C. Hanson, B. May, D. McEwan, R.B. MacFarlane, C. Swanson, and J.G. Williams, 2007. "Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento-San Joaquin Basin." *San Francisco Estuary Watershed Science* 5(1):4. Available at: http://repositories.cdlib.org/jmie/sfews/vol5/iss1/art4.

Rieman, B., C. Smith, R. Naiman, G. Ruggerone, C. Wood, N. Huntly, E. Merrill, J. R. Alldredge, P. Bisson, J. Congleton, K. Fausch, C. Levings, W. Pearcy, D. Scarnecchia, and P. Smouse, 2015. "A Comprehensive Approach for Habitat Restoration in the Columbia Basin." *Fisheries* 40:3, 124–135. DOI: 10.1080/03632415.2015.1007205.

Sexton, W.T., A. Malk, R.C. Szaro, and N. Johnson, editors, 1999. *Ecological Stewardship: A Common Reference for Ecosystem Management, Volume 3: Values, Social Dimensions, Economic Dimensions, Information Tools*. Oxford, UK: Elsevier Science.

USFWS (U. S. Fish and Wildlife Service), 1999. *Forests and Fish Report*. US Fish and Wildlife Service and 11 other organizations. Washington Forest Protection Association, Olympia, WA. 1999.

Walters, C. J., and R. Hilborn, 1978. "Ecological Optimization and Adaptive Management." *Annual Review of Ecology and Systematics* 9:157–188.

Williams, B.K., R.C. Szaro, and C.D. Shapiro, 2009. *Adaptive Management: The U.S. Department of the Interior Technical Guide*. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC. 2009.

Appendix A
Aquatic Species Restoration Plan: Development Committees

STEERING COMMITTEE

Voting Members

- Dave Bingaman – Quinault Indian Nation
- Nicole Czarnomski – Washington Department of Fish and Wildlife
- Colleen Suter – Confederated Tribes of the Chehalis Reservation

Non-Voting Ex-Officio Members

- Tom Gorman – Washington Department of Natural Resources
- Kirsten Harma – Chehalis Basin Lead Entity
- Nat Kale – Washington Department of Ecology, Office of Chehalis Basin
- Mark Mobbs – Quinault Indian Nation
- Hope Rieden – Confederated Tribes of the Chehalis Reservation

Staff

- Emelie McKain – Washington Department of Fish and Wildlife

SCIENCE AND TECHNICAL REVIEW TEAM

The Science and Technical Review Team is composed of the following scientists, researchers, and technical experts that have specific expertise in the Chehalis Basin:

- Tim Abbe – Natural Systems Design
- Tim Beechie – National Oceanic and Atmospheric Administration, Fisheries
- Cinde Donoghue – Washington Department of Ecology
- John Ferguson – Anchor QEA, LLC
- Max Lambert – Washington Department of Fish and Wildlife
- Larry Lestelle – Biostream Environmental
- Marisa Litz – Washington Department of Fish and Wildlife
- Aimee Mcintyre - Washington Department of Fish and Wildlife
- Mark Mobbs – Quinault Indian Nation
- Chip McConnaha – ICF International
- Hope Rieden – Confederated Tribes of the Chehalis Reservation
- Mike Scharpf – Washington Department of Fish and Wildlife
- Colleen Suter – Confederated Tribes of the Chehalis Reservation
- Julie Tyson - Washington Department of Fish and Wildlife

MONITORING AND ADAPTIVE MANAGEMENT TEAM

The Monitoring and Adaptive Management Team is composed of the following scientists, researchers, and technical experts that have specific expertise in the Chehalis Basin:

- Scott Collyard – Washington Department of Ecology
- Cinde Donoghue – Washington Department of Natural Resources
- John Ferguson – Anchor QEA, LLC
- Max Lambert – Washington Department of Fish and Wildlife
- Marisa Litz – Washington Department of Fish and Wildlife
- Aimee Mcintyre – Washington Department of Fish and Wildlife
- Mark Mobbs – Quinault Indian Nation
- Miranda Plumb – U.S. Fish and Wildlife Service
- Hope Rieden – Confederated Tribes of the Chehalis Reservation
- Julie Tyson – Washington Department of Fish and Wildlife

Appendix B
Aquatic Species Restoration Plan: Indicator Species

The ASRP will answer monitoring questions relating to the indicator species listed. These species represent the suite of vital intersection between ASRP actions and achievement of goals.

STANDARD ENGLISH NAME (COMMON NAME)	SCIENTIFIC NAME	STATUS[1]	HABITAT INTEGRATOR[2]	HABITAT AND ASSESSMENT DETAILS
Native Animals				
Winter-run steelhead	*Oncorhynchus mykiss*	None	AOT	Abundant and recreationally important species; spawning takes place in the mainstem Chehalis, East and West Fork Chehalis rivers and in tributaries
Coho salmon	*Oncorhynchus kisutch*	None	AOT	Abundant with broad distribution; most spawning takes place in over 195 mainstem rivers and tributaries throughout the Chehalis basin; huge genetic diversity (portfolio effect)
Fall-run Chinook salmon	*Oncorhynchus tshawytscha*	None	AOT	Abundant and commercially important run of salmon; spawning occurs in all of the mainstem rivers and larger tributaries in the entirety of the Chehalis basin; adults enter the rivers in early September through October and spawn shortly thereafter
Spring-run Chinook salmon	*Oncorhynchus tshawytscha*	None	AOT	Not ESA-listed despite decreasing abundance; notable because of the extended freshwater summer holding period of adults prior to spawning; uncertainty about population abundance due to genetic introgression with fall Chinook salmon and inconsistency between carcass and otolith/genetic run-timing determinations
Chum salmon	*Oncorhynchus keta*	None	AOT	Spawn in lower river and Grays Harbor tributaries and notable for providing large inputs of marine-derived nutrients to aquatic watersheds

STANDARD ENGLISH NAME (COMMON NAME)	SCIENTIFIC NAME	STATUS[1]	HABITAT INTEGRATOR[2]	HABITAT AND ASSESSMENT DETAILS
Pacific lamprey	*Entosphenus tridentatus*	SGCN, FSC	AOT	Parasitic on Pacific salmon with widespread distribution throughout all sub basins of the Chehalis basin; extirpated above dams and other unpassable barriers along west coast; recommended best practices for management and conservation (USFWS 2010)
Olympic mudminnow	*Novumbra hubbsi*	SS, SGCN	AT	Endemic (found only) in Washington; one of five species worldwide in the family *Umbridae*; one of three native fishes designated as a sensitive species
Coastal tailed frog	*Ascaphus truei*	FFR	AT	Only amphibian representative in headwater streams (first through fourth order) of the five species of instream-breeding amphibians in Chehalis Basin; temperature sensitive
Western toad	*Anaxyrus boreas*	SGCN	AT	Only amphibian representative in medium river habitat (fifth through seventh order)
Northern red-legged frog	*Rana aurora*	None	AT	Only amphibian representative of the stillwater-breeding assemblage (seven native species) widespread enough in distribution to serve as a useful indicator
Oregon spotted frog	*Rana pretiosa*	SE, SGCN, FT	A	Only totally aquatic amphibian; cannot maintain populations in the face of exotics; only state and federally listed indicator species
North American beaver[3]	*Castor canadensis*	None	AT	Ecosystem engineer that creates and maintains habitat for diverse native amphibians and fishes
Western ridged mussel	*Gonidea angulata*	SGCN	AT	Only invertebrate considered for monitoring; larval (glochidial) life stage dependent on fishes; filter feeder that strongly influences water quality
Invasive Animals				
American bullfrog	*Rana catesbeiana*	None	AT	Widespread in lowland aquatic habitats in Chehalis Basin, most frequent in floodplain off-channel habitat and selected large river areas

STANDARD ENGLISH NAME (COMMON NAME)	SCIENTIFIC NAME	STATUS[1]	HABITAT INTEGRATOR[2]	HABITAT AND ASSESSMENT DETAILS
Smallmouth bass	*Micropterus dolomieu*	None	A	Probably the most frequent and widespread centrarchid in the stream network
Largemouth bass	*Micropterus salmoides*	None	A	Probably the most frequent and widespread centrarchid in the floodplain off-channel habitats

Notes:
1. Species Status Key:
    - None: No special status
    - SS: State Sensitive
    - SC: State Candidate
    - SE: State Endangered
    - SGCN: Species of Greatest Conservation Need (WDFW 2015)
    - FSC: Federal Species of Concern
    - FT: Federal Threatened
    - FFR: Forest and Fish Target Species
2. Habitat Integrator Key:
    - AOT: Aquatic-Ocean-Terrestrial
    - AT: Aquatic-Terrestrial
    - A: Aquatic
3. North American beaver is also a habitat engineer.

Appendix C
Aquatic Species Restoration Plan: Species of Interest

The ASRP will address monitoring questions related to Species of Interest as feasible. They are not indicator species but represent important connections between ASRP actions and goals.

STANDARD ENGLISH NAME (COMMON NAME)	SCIENTIFIC NAME	STATUS[1]	HABITAT INTEGRATOR[2]	HABITAT AND ASSESSMENT DETAILS
Native Animals				
Mountain whitefish	*Prosopium williamsoni*	None	AT	Strongly associated with spring-run Chinook salmon in terms of holding areas in summer
Eulachon	*Thaleichthys pacificus*	SC, SGCN, FT	AOT	Only federally listed native fish indicator species; eggs and larvae detected in lower Chehalis River
Speckled dace	*Rhinichthys osculus*	none	AT	Several populations listed, but not in the Chehalis Basin; poor information on life history diversity or habitat requirements
Largescale sucker	*Catostomus macrocheilus*	none	AT	Widespread and long lived (up to 15 years); occurs in slower-moving potions of rivers and streams
Riffle sculpin	*Cottus gulosus*	none	AT	Found in headwater streams occupying riffles or pools; closely associated with rainbow trout
Reticulate sculpin	*Cottus perplexus*	none	AT	Occurs in a variety of habitats, but mainly slower sections of coastal headwaters, creeks, and small rivers, ideally in old-growth forest; tolerant of variable temperatures and salinities
Van Dyke's salamander	*Plethodon vandykei*	SC, SGCN	AT	Only amphibian representative of riparian-breeding amphibian assemblage of species; associated with riparian areas in headwater streams; probably more sensitive to climate change than any other amphibian species
Great blue heron	*Ardea herodias*	SGCN	AOT	Significant dietary dependence on fishes in shallow (<1 meter depth) habitats in floodplain off-channel habitats and the stream network where shallow exist (more frequent in large river [eighth order] areas); breeding and roosting areas are well known and highly localized

STANDARD ENGLISH NAME (COMMON NAME)	SCIENTIFIC NAME	STATUS[1]	HABITAT INTEGRATOR[2]	HABITAT AND ASSESSMENT DETAILS
Barrow's goldeneye	*Bucephala islandica*	SGCN	AOT	Significant (at least seasonal) dietary dependence on freshwater, estuarine, and marine molluscs (mostly mussels); hole nester that has a close habitat tie to Northern flicker, which excavates cavities of a size usable by Barrow's goldeneye
Wood duck	*Aix sponsa*	SGCN	AT	Hole nester that has a close habitat tie to woodpeckers nesting in oaks and cottonwoods, which excavates cavities of a size usable by wood duck
Western pond turtle	*Actinemys marmorata*	SE, SGCN	AT	State endangered; only turtle species historically in the Chehalis Basin, historical distribution uncertain, possibility confined to Black River
Invasive Plants				
Brazilian waterweed	*Egeria densa*	none	A	Widespread submergent invasive that is easily confused with Canadian waterweed, which it frequently displaces. Its thick mats trap sediments, displaces native vegetation, and impedes anadromous fish migration. Its impacts reflect its fast growth, high rate of dispersal, ability to adapt to a broad range of light and nutrient availability, monopolizing the uptake of nutrients from the water column and the light-blocking effects of its submerged vegetation beds. Occurrence is thought to be widespread in the Chehalis Basin, but details are poorly understood.
Curly-leaved pondweed	*Potamogeton crispus*	none	A	Similar to Brazilian waterweed in that it monopolizes habitat and outcompetes native aquatic plants. It can reduce diversity largely because it provides less suitable habitat and food resources for native species. In the Chehalis Basin, widespread in floodplain off-channel habitats.

STANDARD ENGLISH NAME (COMMON NAME)	SCIENTIFIC NAME	STATUS[1]	HABITAT INTEGRATOR[2]	HABITAT AND ASSESSMENT DETAILS
Eurasian water milfoil	*Myriophyllum spicatum*	none	A	Similar to Brazilian waterweed and parrotfeather, Eurasian water milfoil crowds out native plants, reduces biodiversity, diminishes fish habitat, and negatively impacts wetland habitat quality. Eurasian water milfoil is locally common in off-channel aquatic habitat in the Chehalis River floodplain.
Parrotfeather	*Myriophyllum aquaticum*	none	A	Similar to Brazilian waterweed, parrotfeather produces dense mats that shade out other native aquatic plants and inhibit water flow. Thought to have negative effects on Olympic mudminnow, though the mechanism is poorly understood; action on food resources, habitat, or both are possible. Fairly widespread in aquatic habitat in the lower Chehalis floodplain.
Yellow iris (yellow flag)	*Iris pseudacorus*	none	AT	An invasive that favors marshy conditions, will produce dense monocultures that exclude native marsh plant species, sedges, rushes, and cattails. Typically results in negative effects on amphibian habitat, bird nesting habitat, and can limit water flow. Locally widespread in the Chehalis River floodplain.
Japanese knotweed	*Fallopia japonica*	none	AT	In the Chehalis Basin, the most pernicious of at least four species of introduced knotweed, largely because it can reproduce vegetatively and by fragmentation. Results in significant habitat loss because of the degree of heavy shading it produces along small streams and stillwater habitat margins. Also, it is attacked by very few grazers in the Pacific Northwest, so it has a particular advantage in establishment and spread over other species. It would rank as either the worst or equal to the worst of invasive exotics.

STANDARD ENGLISH NAME (COMMON NAME)	SCIENTIFIC NAME	STATUS[1]	HABITAT INTEGRATOR[2]	HABITAT AND ASSESSMENT DETAILS
Invasive Animals				
Bluegill	*Lepomis macrochirus*	none	A	Second most frequent and widespread centrarchid in floodplain off-channel habitat
Pumpkinseed	*Lepomis gibbosus*	none	A	Moderately frequent in floodplain off-channel; yet another centrarchid
Black crappie	*Pomoxis nigromaculatus*	none	A	Infrequent in floodplain off-channel habitat; yet another centrarchid
Rock bass	*Ambloplites rupestris*	none	A	Moderately frequent in floodplain off-channel habitat
Brown bulllhead	*Ameiurus nebulosus*	none	A	Moderately frequent in floodplain off-channel habitat
Common carp	*Cyprinus carpio*	none	A	Infrequent in floodplain off-channel habitat
Goldfish	*Carassius auratus*	none	A	Known from a single record in floodplain off-channel habitats
Yellow perch	*Perca flavescens*	none	A	Moderately frequent in floodplain off-channel habitat
Red-eared slider	*Trachemys scripta*	none	A	Infrequent in Chehalis Basin; two known instreams in Chehalis mainstem floodplain; scattered occupancy in glacial outwash lakes in Black River system

Notes:
1. Species Status Key:
   - SC: State Candidate
   - SE: State Endangered
   - SGCN: Species of Greatest Conservation Need (WDFW 2015)
   - FSC: Federal Species of Concern
   - FT: Federal Threatened
2. Habitat Integrator Key:
   - AOT: Aquatic-Ocean-Terrestrial
   - AT: Aquatic-Terrestrial
   - A: Aquatic

Appendix D
Status and Trends Sampling Program

A.M. APPLICATION	STUDY/MONITORING QUESTION	TIMELINE TO INFORM A.M.	INFORMATION TO SUPPORT ADAPTIVE MANAGEMENT (S.M.A.R.T. OBJECTIVES)	BIENNIAL COST
Status and Trends Sampling Program				
Policy and Science	Salmon and Steelhead Smolt Trapping (Newaukum and Upper Chehalis rivers)	Every 5 years, starting in 2026	• The Fish-In Fish-Out Study will provide annual abundance estimates for natural-origin juveniles in two focal sub-basins with plans for near-term ASRP implementation to test the effectiveness of stream restoration activities for increasing the freshwater production of salmon and steelhead. • Annual measurements will include juvenile abundance with known precision and life history diversity (size, age, and run timing).	$750,000
Policy and Science	Salmon and Steelhead Spawning Ground Surveys (Newaukum River)	Every 5 years, starting in 2026	• The Fish-In Fish-Out Study will provide annual estimates of adult abundance in one focal sub-basin with plans for near-term ASRP implementation to test the effectiveness of stream restoration activities for increasing resiliency in adult spawning populations facing climate change. • Annual measurements will include abundance, distribution, biological diversity (size, age, origin, and run timing), and overall productivity (smolts-per-spawner and recruits-per-spawner).	$750,000
Policy and Science	Non-Native Fish Ecology	Every 5 years, starting in 2026	• The Non-Native Fish Ecology Study will track distribution and diet of non-native smallmouth bass and other non-native fishes over time with respect to stream temperature and landscape metrics to assess the ecological impacts on native species as a result of restoration in the Chehalis Basin. • Information on non-native fish ecology will inform management strategies that minimize predation and competition impacts on salmon and other native fish in relation to ASRP restoration activities to maximize conservation success.	$500,000
Policy and Science	Stream-Associated Amphibians	Every 5 years, starting in 2026	• Stream-associated amphibians are sensitive indicators of aquatic conditions, and this study documents trends in the presence and distribution of multiple native stream-breeding amphibians across diverse environments basin-wide. • These data will describe the impacts of near-term restoration actions, climate change, and human activities on aquatic ecosystem health.	$250,000

A.M. APPLICATION	STUDY/MONITORING QUESTION	TIMELINE TO INFORM A.M.	INFORMATION TO SUPPORT ADAPTIVE MANAGEMENT (S.M.A.R.T. OBJECTIVES)	BIENNIAL COST
Policy and Science	Western Toad Surveys	Every 5 years, starting in 2026	• Toads are sensitive indicators of environment change, and toad surveys will track trends in presence, abundance, and distribution across different environments basin-wide. • These data will document impacts of near-term restoration actions and climate change.	$150,000
Policy and Science	Oregon Spotted Frog Surveys	Every 5 years, starting in 2026	• Oregon spotted frog is federally listed under the Endangered Species Act. This study will establish trends in abundance for Oregon spotted frogs at six sites that are a near-term focus of restoration in the Black River system. • Assess how Oregon spotted frog populations are impacted by restoration activities, water availability, and climate change, and relationships with native and non-native species, vegetation, and physical environmental characteristics.	$200,000
Policy and Science	Chehalis Thermalscape	Every 5 years, starting in 2026	• The Chehalis Thermalscape Study will provide a high-resolution stream temperature monitoring network to assess current and future stream temperatures across the Chehalis Basin. • Spatial stream network models (e.g., Chehalis Thermalscape) of current and future climate change scenarios will be available for use in other ASRP-related monitoring projects and analyses. • Results from the Chehalis Thermalscape Study will help guide restoration planning efforts and effectiveness monitoring at the basin scale.	$200,000
Policy and Science	Watershed Health	Every 5 years, starting in 2026	• Watershed health monitoring surveys will be performed at a basin-wide scale across all macro-ecological diversity regions identified by the ASRP within the Chehalis Basin to represent broad ecological, hydrological, and thermal environments. • Watershed surveys will include the physical, chemical, and biological conditions of aquatic and riparian habitats. This information will provide basin trends and context of watershed-scale condition and health to be used in interpreting reach- or site-level results.	TBD (starting in 2023)

Appendix E
Project Effectiveness Sampling Program

A.M. APPLICATION	STUDY/MONITORING QUESTION	TIMELINE TO INFORM A.M.	INFORMATION TO SUPPORT ADAPTIVE MANAGEMENT	BIENNIAL COST
Project Effectiveness Sampling Program				
Science	Do sediment wedge structures increase thermal habitat diversity?	5 years, 2026	• Evaluate how effective two sediment wedge installations are in increasing thermal refugia in project reaches. • Inform future design and application of sediment wedge treatments for basin-wide restoration.	$54,000
Science	How do artificial sediment wedges alter hyporheic exchange at project locations?	5 years, 2026	• Evaluate how effective two sediment wedge applications are in engaging hyporheic flow at each project location. • Inform future design and application of sediment wedge treatments for basin-wide restoration.	$110,000
Science	Does the sediment in pre-filled engineered sediment wedges remain stable over time? (for pre-filled structures) At what rates do engineered sediment wedges passively accrue sediment above the structure, and is sediment accrual stable over time? (for structures without pre-fill)	5 years, 2026	• Evaluate sediment wedge stability in two pre-filled wedges immediately post-installation and through time. • Evaluate the time it takes for non-pre-filled sediment wedges to passively accrue sediment above the structure through time. • Inform future design and siting of sediment wedge installations.	$28,000
Science	How do sediment wedge installations influence stream temperature downstream of structures?	5 years, 2026	• Evaluate how effective sediment wedge installations are at decreasing downstream temperatures at two project locations.	$110,000
Science	Does fish passage at engineered sediment wedges continue through time?	5 years, 2026	• Evaluate whether sediment wedge installation allows continued fish passage opportunities or constrictions at two project locations. • Inform future sediment wedge design to ensure post-implementation fish passage through time. .	$4,000
Science	Do beaver dam analog (BDA) structures increase fluvial habitat complexity at project locations?	5 years, 2026	• Evaluate whether BDAs at three project sites increase fluvial habitat complexity at project locations. • Inform future project design, guidance, and siting.	BDA total = $400,000

A.M. APPLICATION	STUDY/MONITORING QUESTION	TIMELINE TO INFORM A.M.	INFORMATION TO SUPPORT ADAPTIVE MANAGEMENT	BIENNIAL COST
Science	Do BDA structures facilitate beaver colonization and dam building?	5 years, 2026	• Evaluate whether BDAs at three project sites facilitate beaver colonization and natural dam building. • Inform future project design, guidance, and siting.	See above
Science	Do BDA structures increase hydrological connectivity with the floodplain?	5 years, 2026	• Evaluate whether BDAs at three project sites increase hydrological connectivity with the floodplain. • Inform future project design, guidance, and siting.	See above
Science	Do BDA structures reduce downstream temperatures and increase thermal habitat diversity?	5 years, 2026	• Evaluate whether BDAs at three project sites decrease downstream stream temperatures and increase thermal habitat diversity at project locations. • Inform future project design, guidance, and siting.	See above
Science	What is the length, duration, and area of floodplain inundation and off-channel habitat connectivity at different flows through reach-scale project implementation?	5 years, 2026	• Evaluate the effectiveness of reach-scale project at one project location to increase hydrological connectivity with the associated floodplain. Understand the length, duration, and area of floodplain inundation. • Inform future project design, guidance, and siting.	$60,000
Science	Has the vertical hydraulic gradient changed, resulting in cooler stream temperatures through reach-scale project implementation?	5 years, 2026	• Evaluate the effectiveness of reach scale project actions at one project location to increase hyporheic flow resulting in cooler water temperatures within the reach. • Inform future project design, guidance, and siting.	$35,000
Science	Does wood increase in reach-scale project reach and do installed structures remain in place?	5 years, 2026	• Evaluate the effectiveness of reach scale project actions at one project location to maintain and increase wood recruitment to reach. • Inform future project design, guidance, and siting.	$25,000 (includes habitat complexity, spawning gravel, fine sediment questions)
Science	Do reach-scale project restoration actions promote increased habitat complexity?	5 years, 2026	• Evaluate the effectiveness of reach-scale project actions at one project location to maintain and increase habitat complexity. • Inform future project design, guidance, and siting.	See above

A.M. APPLICATION	STUDY/MONITORING QUESTION	TIMELINE TO INFORM A.M.	INFORMATION TO SUPPORT ADAPTIVE MANAGEMENT	BIENNIAL COST
Science	Does spawning gravel quantity and quality increase within the reach-scale project footprint?	5 years, 2026	• Evaluate the effectiveness of reach-scale project actions at one project location to maintain and increase spawning gravel quantity and quality within the reach. • Inform future project design, guidance, and siting.	See above
Science	Does fine sediment storage increase within the reach-scale project footprint?	5 years, 2026	• Evaluate the effectiveness of reach-scale project actions at one project location to increase fine sediment storage within the reach. • Inform future project design, guidance, and siting.	See above

Appendix F
Hypothesis Testing Sampling Program

A.M. APPLICATION	STUDY/MONITORING QUESTION	TIMELINE TO INFORM A.M.	INFORMATION TO SUPPORT ADAPTIVE MANAGEMENT	BIENNIAL COST
Hypothesis Testing Sampling Program				
Policy and Science	What is the distribution of adult Chinook salmon run timing genetics at the sub-basin scale to assess efficacy of beaver dam analog (BDA) structures be used to spatially separate spring and fall-run Chinook salmon?	1 year, 2023	• The Adult Run-Timing Genetic Marker Study will assess genetic run-timing of adult Chinook carcasses located above and below BDA structures to assess the efficacy of BDAs as a tool for spatially isolating spring and fall populations. • Results of this study will inform the potential application of BDAs as a control method to decrease hybridization of spring- and fall-run Chinook salmon.	$4,100
Policy and Science	What is the extent of hybridization of spring- and fall-run Chinook salmon in the Chehalis Basin?	2 years, 2023	• The Juvenile Run-Timing Genetic Marker Study will quantify the abundance and relative proportion of spring-, fall-, and heterozygote-run types of natural-origin subyearling Chinook salmon over the duration of the outmigrating period at three trap locations in the Chehalis Basin (Newaukum, Upper Chehalis, and Chehalis rivers). • Information from this study has implications for action priorities, sequencing, pace of implementation, and will inform future design guidance and project siting aimed at preserving spring-run Chinook salmon.	$74,000
Policy and Science	What is the extent of hybridization of spring and fall-run Chinook salmon in the Chehalis Basin?	1 year, 2022	• Year 3 (final year) of Chehalis Fry Trap Study. The Quinault Indian Nation is currently operating a set of fry traps in the upper Chehalis Basin to investigate the extent of Chinook salmon hybridization at the fry life stage. Trapping locations are in the Skookumchuck, Newaukum, South Fork Chehalis, and Upper Chehalis rivers upstream of the South Fork Chehalis River. • Information from this study has implications for action priorities, sequencing, pace of implementation, and will inform future design guidance and project siting aimed at preserving spring-run Chinook salmon. It will be used in conjunction with the Juvenile Run-Timing Genetic Marker Study to get a comprehensive understanding of the hypothesis.	$220,000

A.M. APPLICATION	STUDY/MONITORING QUESTION	TIMELINE TO INFORM A.M.	INFORMATION TO SUPPORT ADAPTIVE MANAGEMENT	BIENNIAL COST
Science	Thermal refugia (pools, springs, seeps): What is the distribution and physical characteristics of summertime thermal refugia?	2 years, 2023	• The Thermal Refugia Study will identify areas of thermal refugia during the vulnerable summer period in 2022 and assess fish movement at the sub-basin scale (e.g., Newaukum River) in 2023. • This study will Inform future design and project siting and provide baseline information for additional hypotheses.	$230,000
Science	Native Fish Ecology	2 years, 2023	• The Native Fish Ecology Study will conclude in the 2021–2023 biennium with the development of a multi-species occupancy model. The study was designed to understand native fish occupancy across the Chehalis Basin with respect to landscape metrics though randomized eDNA and habitat monitoring. • This project will inform future project design and siting to maximize benefit for native fishes with potential for future monitoring coupled with watershed health surveys.	$240,000
Science	Freshwater Mussel Surveys	2 years, 2023	• Understand the presence and distribution of freshwater mussels basin-wide. • Document die-off occurrence and extent of Western ridged mussels within study area. • Inform future restoration project design and siting to benefit mussels.	$150,000
Science	Satsop Ponds Reconnection	2 years, 2023	• Evaluate how species respond to increasing the hydrological connection between off-channel habitats and the stream channel. • Inform future project design and siting.	$100,000
Science	Off Channel Reconnection	2 years, 2023	• Evaluate how species respond to increasing the hydrological connection between off-channel habitats and the stream channel. • Inform future project design and siting.	$80,000