A Proposed Framework for Willamette River Floodplain Implementation, Effectiveness and Status and Trends Monitoring

Report compilation by Bonneville Environmental Foundation, University of Oregon, City of Portland Bureau of Environmental Services

Questions about the technical content of report should be directed to:

Kathleen Guillozet (Bonneville Environmental Foundation) kguillozet@b-e-f.org
David Hulse (University of Oregon) dhulse@uoregon.edu
Melissa Brown (City of Portland, BES), Melissa.brown@portlandoregon.gov

Acknowledgments

We are grateful for funding from Meyer Memorial Trust and the USGS Cooperative Water Program and administrative oversight from City of Portland Bureau of Environmental Services. Rose Wallick (USGS) provided technical input and review, focusing on the effectiveness monitoring and status and trend monitoring portions of this report. Paula Gagnon provided background research and other support. Review and helpful input on the Monitoring Framework was provided by: Allison Hensey, Cristina Watson, Leslie Bach, Laura Brown, Stan Gregory, Andrew Dutterer, Ken Fetcho, Karl Weist, Steve Gagnon, Allan Branscomb and Chris Enright. Dan Bell established the plan for creating this report and led early phases of this study. We are especially appreciative of the dozens of stakeholders who attended the three monitoring workshops in 2018.

Table of Contents

List of Tables

List of Figures

executive summary

Key Takeaways

1

There is a pressing need for coordinated agency and philanthropic leadership and investment in floodplain conservation and restoration to protect previous gains, meet today's needs and seize tomorrow's opportunities for nature-based solutions. Floodplain conservation and restoration can address habitat goals and deliver co-benefits including flood risk reduction, drinking water provision, carbon sequestration, invasive species removal, recreation access and other important societal goals.

2

Given the:

1. diverse actions undertaken to conserve and restore habitats;
2. variable timescales under which responses may occur;
3. dynamic nature of systems;
4. partial and changing human understandings of complex systems; and
5. lack of program level monitoring funding,

this work is, at best, an imperfect science.

3

The absence of an organization or consortium that is accountable and has funding to conduct and communicate monitoring outcomes hinders monitoring.

4

A significant barrier to planning, implementing and sustaining program-level monitoring is the absence of predictable and sustained funding. This can bias programs towards adopting shorter term, more ad-hoc strategies and can undermine implementation, effectiveness and status and trends tracking.

5

Adaptive management is a strategy that restoration programs may adopt to provide structure within imperfect systems of knowledge, funding and capacity. It emphasizes learning by doing, with cycles of planning, implementation, evaluation, and adjustment, and is considered a contemporary best practice (Warren et al 2019).

Adaptively refining the goals and actions of Willamette River restoration programs will require a) establishing a long-term restoration program for the Willamette River because current programs are ending by 2021/2022, b) establishing process where restoration program goals and activities are adaptively refined utilizing research and monitoring findings, and c) creating an integrated implementation, effectiveness and status and trend monitoring program that can be efficiently incorporated into an adaptive management process. The Willamette River restoration programs have many of the foundational elements needed to address these requirements, but sustained funding and stewardship is required to integrate these puzzle pieces and create a meaningful adaptively managed restoration program.

Scope of This Report

This report seeks in part to address comments from the 2017 Independent Science Review Panel (ISRP) regarding Willamette habitat restoration investments. The ISRP reviews individual fish and wildlife projects funded by Bonneville Power Administration and makes recommendations following periodic reviews.

This report lays out considerations to inform the planning of future Willamette River floodplain implementation, effectiveness, and status and trends monitoring. It is intended to provide a common foundation for future monitoring efforts, including funders, scientists, practitioners, and agencies who may assist with different stages of planning, executing or utilizing the results from future monitoring.

Specific Objectives of This Report Include:

- Describe the diverse values underpinning monitoring and how different types of monitoring can be defined within the context of these values.
- Identify guiding principles to inform future monitoring—and how these guiding principles apply to implementation, effectiveness, and status and trends monitoring.
- Identify the monitoring infrastructure that supports monitoring programs and outline how this infrastructure varies across Willamette Basin implementation, effectiveness, and status and trends monitoring programs.
- Share a vision for monitoring based on core values and guiding principles, that could be employed in implementation, effectiveness, and status and trends monitoring programs.

The ISRP stated that:

> "The progress reports all reveal that adaptive management has not yet been implemented using the formal approach needed to more fully evaluate and improve restoration activities at a landscape scale...

Also, none of the reports describe the status and trends of habitat or fish populations at a landscape scale in a way that could be linked to habitat restoration activities.

The ISRP has identified several obstacles to evaluating progress through adaptive management. First, evaluation at a landscape scale requires quantitative objectives with explicit timelines that are expressed in terms of expected (hypothesized) improvements in habitat (outcomes) or Viable Salmonid Population (VSP) parameters. Second, evaluation at a landscape scale requires appropriate monitoring, access to monitoring data, and an explicit plan for evaluating and documenting outcomes.

Such a plan will likely include collaboration with other groups in charge of monitoring, but a specific entity or partnership needs to be accountable for the overall plan to make sure monitoring adequately addresses the needs of the umbrella restoration efforts."

("Review of Umbrella Habitat Restoration Projects" ISRP 2017-2, March 10, 2017).

Monitoring Framework Key Concepts

1 **Audiences that may consume monitoring information are diverse and may value and use information in different ways and on different timelines.**

2 **Programs may assess their readiness to use adaptive management strategies by determining whether or not they have specific monitoring infrastructure in place.**

Critical infrastructure we identify include: a clear statement of monitoring purpose, paired with:

A. restoration goals, objectives and actions, laid out in a Theory of Change or Results Chain,

B. monitoring indicators and metrics that relate to restoration objectives, and

C. reporting processes and timelines that support the monitoring purpose. The monitoring infrastructure concepts are described in Figure 2 and applied to current Willamette River floodplain restoration programs in Table 2.

Considerations for Implementation, Effectiveness and Status and Trends Monitoring

This report applies the key monitoring framework concepts (audience needs, monitoring infrastructure to three types of monitoring: implementation, effectiveness and status and trends. Key considerations include:

Implementation Monitoring

Implementation monitoring tracks progress toward restoration goals by collecting data on the implementation status of restoration projects and comparing this information against restoration targets. Key audiences are project and program sponsors and funders, desired audiences also include the broader restoration community, and policy makers. The WFIP Implementation program tracks OWEB-funded restoration accomplishments for three of eight restoration actions; data are summarized annually and reported biannually. In the Willamette River Basin where funding for implementation monitoring is likely to be very limited, the implementation reporting approach should be efficient to make it as easy as possible for practitioners to enter their accomplishments and for the reporting entity to synthesize and report this information.

Effectiveness Monitoring

Effectiveness monitoring supports learning, improving performance, and refinement of restoration program goals and activities in the future. It provides an opportunity to investigate specific assumptions in a results chain (or Theory of Change) that require affirmation or clarification (Figure 3). Effectiveness monitoring can also be used to improve best practices. As described in this report, effectiveness monitoring requires a results chain linking restoration program goals, ecological outcomes and restoration actions, so that effectiveness monitoring can be prioritized to address areas of greatest uncertainty. Effectiveness monitoring is program specific, and tailored to address the specific goals, objectives and actions of a particular restoration program.

The WFIP Effectiveness Monitoring Program plans to share results through published datasets, presentations and synthesis reports of two restoration actions (treatment of aquatic invasive plants, and restoration of gravel pits), but there is no current funding or plans for broader synthesis of overall findings.

Results Take Time

Results from effectiveness monitoring are available in varied timeframes. They may be used to refine future restoration projects or programs, but due to the long timescales required to plan, implement and monitor Willamette River restoration projects, findings may not directly inform actions in a short (1-5 year) timeframe.

Status and Trends Monitoring

Status and trends monitoring describes river conditions and net changes in river conditions over time. In the mainstem Willamette River, status and trends monitoring will hopefully continue in the future, building upon the framework established in SLICES where a small set of metrics describing floodplain conditions (channel complexity, floodplain forests, native fish communities) can be compared against the stakeholder-developed Conservation Scenario goals for 2050 (Hulse and others, 2002). The SLICES framework provides spatial framework for tracking system-wide changes in floodplain conditions, existing datasets from which to track detailed changes beginning from 2000 (and historical datasets from 1850 onward), and a website to share future findings. Future status and trend monitoring could continue this decadal monitoring, and also add annual reporting of flow, temperature and salmon/steelhead returns to the Willamette River basin. Stakeholders also identified the need for more story telling (at annual and decadal intervals) so that audiences could better understand floodplain conditions and have a common scientific foundation from which to understand the status and trends in habitats and salmon populations. At present, there is no funding or plans for long term status and trend monitoring, although fish sampling by OSU/USFS is continuing through 2022 and a pilot effort is underway by USGS to develop a proof-of-concept template for annual status and trend reporting.

Information Sharing and Adaptive Management

A critical step in adaptive management, especially involving numerous partners, is the setting aside of time to consider monitoring information, document decisions based on monitoring findings, and institute changes. Partners should understand their roles and responsibilities and point people should be responsible for leading conversations and ensuring they are documented and shared. There are a variety of forums, recurring meetings and existing processes where monitoring results could be shared and used to adaptively refine restoration program goals and actions (Figure 5, Table 9).

A critical step in adaptive management, especially involving numerous partners, is the setting aside of time to consider monitoring information, document decisions based on monitoring findings, and institute changes.

Vision for a Coordinated River-Wide Implementation, Effectiveness and Status and Trends Monitoring Program

The workshops, literature review and observations from experts including the ISRP highlight the need for a river-wide, coordinated implementation and status and trends monitoring program. Effectiveness monitoring is not included because this monitoring is typically focused on addressing key questions of a particular restoration program and should be tailored to future (currently unspecified) program-specific needs. This program could have the following elements:

1

River-wide implementation monitoring to track progress toward restoration goals and objectives. Ideally river-wide implementation monitoring would summarize accomplishments funded by different entities and through different restoration programs, because all of these projects contribute towards common goals for floodplain health. Findings could be summarized annually and shared in a brief, publicly available easy to understand biennial report (similar to WFIP Implementation reporting).

2

River-wide status and trends monitoring to report annual and decadal river system conditions. Annual reporting could entail summaries of flow, temperature, habitat, and fisheries data in a single place so that interested parties can better understand how these conditions vary throughout the year and from year-to-year and implications for salmon and steelhead. Decadal reporting could build on the SLICES framework to summarize spatial and temporal changes in channel complexity, native fish communities and floodplain forests and describe potential causal factors for observed changes.

3

Linkages among monitoring types can be made in a variety of ways. Implementation monitoring can illustrate the locations and acreages of floodplain forest planting efforts, to show how actions intersect with river-scale patterns of floodplain forest. Likewise, site-scale findings from effectiveness monitoring can be placed within broader context of reach or river conditions (from status and trend monitoring) so that the relative importance of individual or cumulative restoration actions can be assessed.

Looking Forward

This Framework serves as a starting point for further refinement that will rely upon on the collaboration, investment, and engagement of multiple partners and stakeholders.

Monitoring can provide information to assess the impacts of floodplain habitat enhancement actions and inform adaptive management and refinement of projects, programs, and system-wide conservation efforts. Altogether, this framework provides a foundation for tracking restoration progress in the Willamette River floodplain and assessing the river-scale context of site-level actions amid other processes that affect floodplain habitats. A multi-organizational monitoring effort could serve many purposes and inform many different restoration and conservation programs. Ultimately a multi-organizational monitoring effort that links implementation, effectiveness and status and trend monitoring is needed to establish a shared foundation that a variety of audiences may reference when making local and basin-scale decisions and building the case for continued restoration and conservation funding.

1. introduction

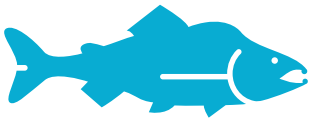
1.1 Background

The Willamette River and its floodplain are centerpieces of Oregon's identity and economy. It supports regional drinking water, cultural practices, agriculture, recreation, and wildlife. Home to 68 percent of the state's human population, the Willamette Basin is integral to the lives of rural and urban residents and visitors, as well as to the cultures of the indigenous peoples who have stewarded these lands and waters for millennia. The basin is poised to double in population in the coming decades, making this a critical time to support conservation and restoration actions that benefit clean water and healthy habitats. Working in the most populated part of the state provides an unparalleled opportunity to showcase work to diverse urban and rural residents, and makes the task of tracking, monitoring, and reporting outcomes more important than ever.

The Indian Removal Act of 1830 institutionalized the practice of removing Native Americans from their ancestral lands to make way for white settlement (Osife 2017).

This painful history and the resulting colonizer settlement of the Willamette Valley in the mid-19th century drove major losses in floodplain habitats through construction of upstream flood control dams, conversion of floodplain forests to other land uses, widespread bank stabilization efforts, and other alterations to the floodplain system. Declines in habitat quality and availability have harmed many culturally and ecologically significant species, such as Pacific lamprey *(Entosphenus tridentatus),* western pond turtle *(Actinemys marmorata),* spring Chinook salmon *(Oncorhynchus tshawytscha)* and winter steelhead trout *(O. mykiss;* NMFS, 2008). The river channel has been dredged to accommodate commercial shipping, and docks, piers, bulkheads (seawalls), and rock revetments (riprap) have replaced much of the natural bank habitat downstream of Willamette Falls. Pollution from industrial sources, especially in the river sediments, is a serious concern. A section of the lower reach, from RKM 5.6 to 15.3, was added to the U.S. Environmental Protection Agency (USEPA) "Superfund" list in December 2000.

In recent decades partners including public and private funders, Tribal Nations, non-governmental organizations, researchers, municipal, county, state and federal agencies, have aligned around a shared goal of improving the health of the river for human and aquatic life.[1] Clean water consistently ranks as a top priority in local, regional, and national polls, with recreation and access to nature as other key benefits people value. Examples of major, river-scale funding efforts to improve Willamette River floodplain habitats include the Willamette Mainstem Anchor Habitat Investments Funding Program which combines funding from Meyer Memorial Trust's Willamette River Initiative (WRI), Bonneville Power Administration's (BPA) Willamette Habitat Program and the Oregon Watershed Enhancement Board (OWEB), and the Willamette Wildlife Mitigation Program (WWMP) managed by Oregon Department of Fish and Wildlife (ODFW) and funded by BPA. In addition to these river-scale programs are local restoration projects and programs managed by tribes, Watershed Councils, municipalities, Soil and Water Conservation Districts, Land Trusts, agencies and other organizations. Collectively, these groups are investing in restoration and conservation actions to improve floodplain health. For example, more than $27 million will be



Declines in habitat quality and availability have harmed many culturally and ecologically significant species, such as

Pacific Lamprey
(Entosphenus tridentatus)

Western Pond Turtle
(Actinemys marmorata)

Spring Chinook Salmon
(Oncorhynchus tshawytscha) and

Winter Steelhead Trout
(O. mykiss; NMFS, 2008).

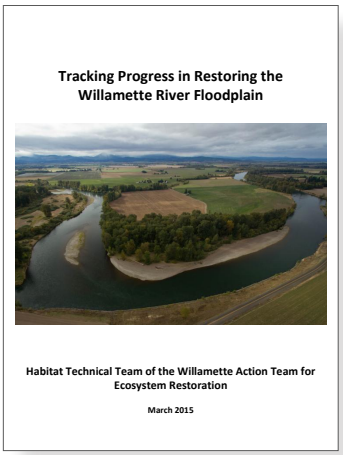
1 The terms "restoration", "rehabilitation" and "enhancement" are used interchangeably to describe on-the-ground actions to improve the health of the river and floodplain for people and nature.

invested in restoration projects through the Willamette Mainstem Anchor Habitats Investment Program (AHWG, 2015), and the City of Portland and U.S. Army Corps of Engineers are planning more than $30 million in future restoration projects along the lower Willamette River (BES, 2016).

1.2 The Case for an overarching Willamette Floodplain Monitoring Approach

The contributing partners to this report (City of Portland Bureau of Environmental Services (BES), University of Oregon, and Bonneville Environmental Foundation, or BEF) originally sought to develop: (1) a streamlined monitoring framework, and (2) a document that describes a collective vision for monitoring. These outcomes build upon the science and restoration foundation built over decades and has been identified in:

- The report *Tracking Progress in Restoring the Willamette River Floodplain* (Hudson et al, 2015), which called out the need for partners to draw on the scientific framework and lessons learned from previous floodplain monitoring efforts *"to develop a pragmatic approach for measuring the success of conservation and restoration activities along the Willamette River."*
- The 2017 recommendations from the Independent Science Review Panel (ISRP) which completed a review of the Willamette Bi-Op Habitat Restoration program (ISRP, 2017). The ISRP identified the need for a cohesive planning document, and the need to better track effectiveness of conservation efforts: *"The only major weakness is the lack of assessing Program progress. While it appears that some monitoring is occurring, a coherent description of the proposed and existing RM&E (research, monitoring and evaluation) efforts, including a plan for rolling out future activities, and how those data will be applied in assessing the Program progress, should be provided."*



Tracking Progress in Restoring the Willamette River Floodplain, 2015

Significant new information became available during preparation of this report to inform Willamette River restoration, monitoring and research programs, and shift our workplan, including:

- WFIP Implementation and Effectiveness Monitoring approaches were developed from 2016-2020, and provide a foundation for considering how monitoring can be efficiently carried out in the future. A number of components from these programs are reflected in this report.
- Several USGS studies conducted 2016-2020 for the USACE-funded Science of the Willamette Instream Flow Team (SWIFT process) described water temperature conditions and detailed patterns of rearing habitat availability for juvenile spring Chinook salmon and winter steelhead trout in the Willamette River. Findings from these studies led us to propose new indicators and metrics for tracking river and habitat attributes over time.
- The absence of future funding for all program level monitoring, and lack of bandwidth to pursue short term funding led us to divert away from developing a comprehensive plan and budget for potential future monitoring efforts. Once funding is identified, detailed plans to address ISRP comments could be developed.

1.2.1 Report Purpose and Objectives

This report aims to inform the planning of future implementation, effectiveness, and status and trends monitoring of the Willamette River floodplain. The monitoring considerations in this report are tailored specifically to monitoring efforts that would inform and support restoration and conservation planning on Willamette River, but could also be useful for other purposes. Concepts are intended to provide a common foundation for likely partners of future monitoring efforts, including: funders, scientists, practitioners, and agencies who may assist with different stages of planning, monitoring, communicating monitoring results or those who may assist in developing or refining or Willamette River floodplain monitoring programs.

Specific objectives of this report are to:

- Describe core values for monitoring and how different types of monitoring (implementation, effectiveness, and status and trends monitoring) can be defined within the context of these values.
- Identify a set of guiding principles to inform future monitoring—and how these guiding principles apply to implementation, effectiveness, and status and trends monitoring.
- Identify monitoring infrastructure that is needed to support monitoring programs and how infrastructure has varied for past Willamette Basin implementation, effectiveness, and status and trends monitoring programs.
- Develop a monitoring vision based on core values and guiding principles, that could be employed to establish future implementation, effectiveness, and status and trends monitoring programs.

1.3 Diverse Needs for Monitoring and Different Types of Monitoring

The term monitoring is derived from the Latin "monit" which means to warn, and while monitoring can serve to alert people to problems, it also serves additional roles. In 2018, we asked stakeholders why they valued monitoring and we received a range of answers that we organized under four themes (Figure 1):

While other reasons to monitor exist, the ideas shared by stakeholders provide a helpful introduction to the three types of monitoring outlined in this document, as well as the different values supported by each:

- **Implementation monitoring,** which tracks and rolls up information about actions taken by program partners, and progress toward program output targets. Primarily supports **communicating**, as well as **holding people accountable**.
- **Effectiveness monitoring,** which tests key questions about practices and outcomes associated with actions. Primarily supports **learning**, as well as **improving performance**.
- **Status and Trends monitoring,** which provides a long-term view of the overall system, using key system measures to track change over time. Primarily supports **holding people accountable**, **learning,** as well as **communicating.**
- **Adaptive management,** or the formal and informal information, knowledge and processes that support robust decision making in the face of uncertainty. Primarily supports **improving performance**, as well as **learning.**

Figure 1: Why Different People Value Monitoring
(summary responses from meetings with funder, implementer, research and agency stakeholders, 2018).

Learning	Communicating	Improving Performance	Holding People Accountable
Support learning in real time	Document cumulative achievements and show successes	Enhance coordination among groups	Keep grantees accountable, ensure funds are used for maximum benefit
Support collaborative decision-making	Build a central clearinghouse of accomplishments to demonstrate impact	Support momentum and morale	Comply with legal requirements or other formal obligations
Understand overall river health and trends	Communicate scope and scale of issues – to put in public consciousness	Calibrate expectations	Keep decision-makers, officials, funders, regulators, and the regulated accountable
Foster creativity and innovation	Build a case for funding or policy change	Reduce inefficiencies	Track progress towards goals
Demonstrate a proof (or negation) of concept			

1.4 Guiding Principles for the Monitoring Framework

This effort applies six guiding principles to develop the Monitoring Framework for the Willamette River and its floodplain.

A

Identify mandatory and desirable audiences for monitoring outputs;

B

Determine when audiences need information and clarify responsibilities;

C

Scale activities to budgets;

D

Build upon existing monitoring infrastructure, and leverage freely available data sets;

E

Allow partners who might contribute information, knowledge, or capacity to see how they can support the effort;

F

If information can't be reported effectively, don't track/monitor it (unless required to do so).

At minimum, monitoring should meet funding or other formal requirements. At best, it can support a multidimensional adaptive management process that generates meaningful and credible findings to inform decision-making, refine program goals and galvanize action across stakeholder groups. Ultimately, restoration programs and implementing organizations will benefit when funders can trust that investments create meaningful improvements in floodplain ecosystems and that continual learning will produce ongoing refinement of the restoration program goals and activities.

1.5 Geographic and Programmatic Focus

This report speaks to monitoring and adaptive management opportunities on the mainstem Willamette River and adjacent lands. The overarching Willamette River restoration program referenced in this report is the Willamette Anchor Habitat Investments Program, which spans 2008-2021 and combines funding from OWEB, BPA and MMT to implement restoration projects on the mainstem Willamette River and lower tributary regions. Restoration projects are concentrated in "anchor habitats"—"areas with opportunities to reconnect the river to its historic floodplain with limited social impact that were mapped as part of the Willamette Planning Atlas SLICES (Hulse et al. 2002) and by the Oregon Watershed Enhancement Board (OWEB 2014)" (USFWS 2017).

The Willamette River Anchor Habitat Investments Program includes following three initiatives:

- Willamette Anchor Habitats Focused Investment Partnership (funded by OWEB, and herein termed WFIP, spanning 2015-2021). From 2008-2015, the Willamette Special Investments Partnership (WSIP) existed which engaged the same funders.
- Willamette River Initiative (funded by Meyer Memorial Trust, herein termed WRI)
- Willamette Habitat Program (funded by BPA, herein termed WHP).

The monitoring concepts in this report are intended to complement and build upon program-scale Implementation and Effectiveness Monitoring programs that were established to support the WFIP restoration program. Although these monitoring programs were mainly funded by OWEB to evaluate restoration projects funded by the WFIP, they also serve the overall Willamette River Anchor Habitat Investment Program and can assist in evaluating accomplishment and outcomes that also result from restoration investments by BPA and MMT.

Complementary documents from the WFIP monitoring programs and SLICES status and trends monitoring include:

WFIP Implementation Monitoring Documents

- Implementation Reports describing restoration and outreach accomplishments for the WFIP are produced every two years; 2017-2019 accomplishments are summarized in the Willamette Anchor Habitat Working Group Progress Update (BEF, 2019). The key contact for the WFIP Implementation Monitoring effort is Kathleen Guillozet (BEF).

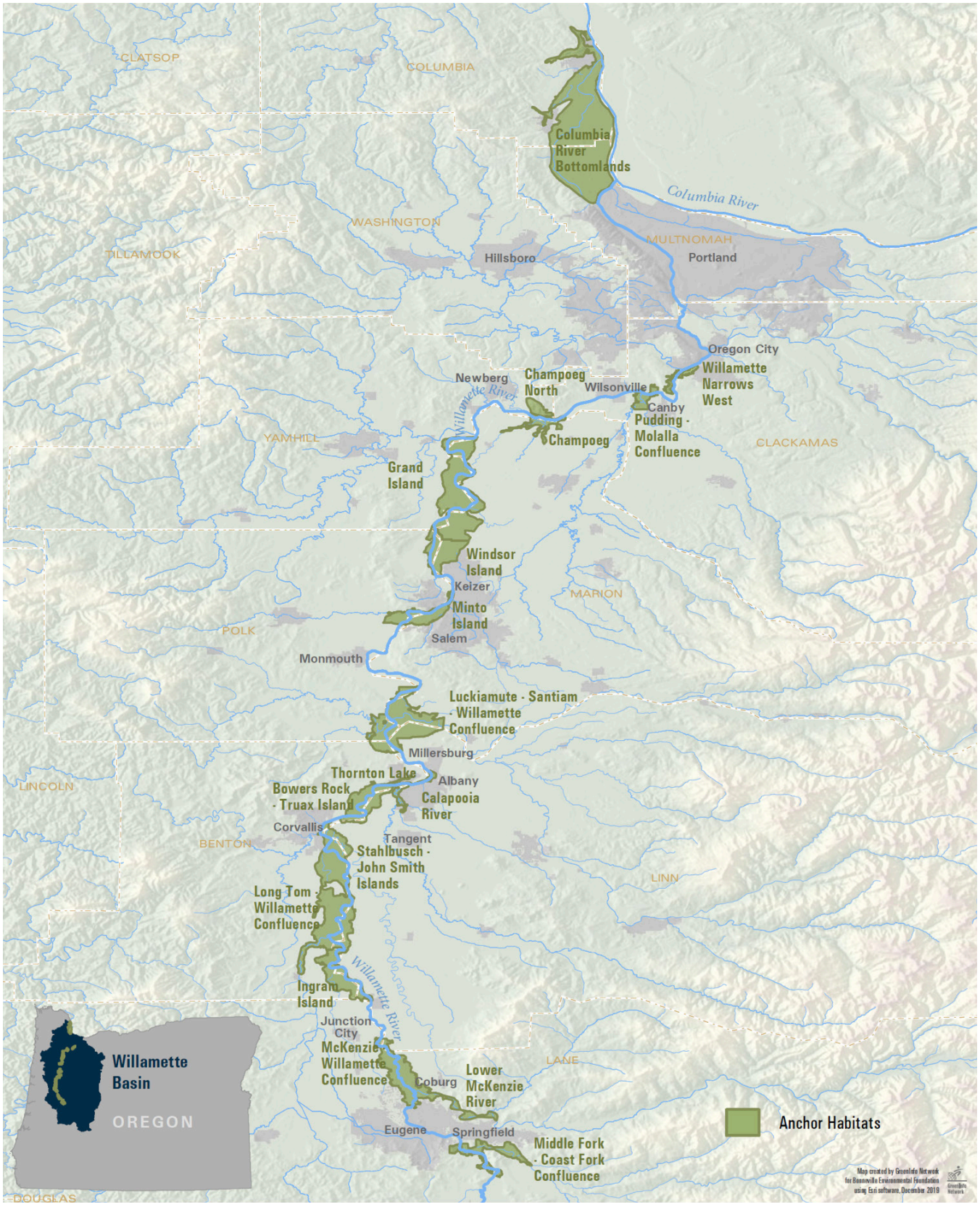
WFIP Effectiveness Monitoring Documents

- A Monitoring Plan for WFIP Effectiveness Monitoring Program describing the goals, objectives and preliminary plans for the effectiveness monitoring was developed by Wallick and others, 2019 and will be refined annually to reflect refinements to monitoring program goals and annual data collection activities.
- The "Monitoring Framework to Evaluate Effectiveness of Floodplain Restoration Activities for the Willamette Focused Investment Partnership, Willamette River, Oregon" (Keith and others, in press) links restoration program goals and restoration actions with monitoring indicators, metrics and approaches needed to evaluate effectiveness of restoration actions at improving and expanding native fish habitats.
- Key contact for the Effectiveness Monitoring Program is Rose Wallick (USGS and Technical Coordinator for WFIP Effectiveness Monitoring Program).

Status and Trends Monitoring Documents

- The SLICES website houses decadal, river-scale data on native fish communities, floodplain forest, channel complexity, and juvenile Chinook rearing habitat that form the foundation of a river-scale status and trends monitoring program for the Willamette River (https://ir.library.oregonstate.edu/collections/5425kh23p). The Willamette Basin Planning Atlas (Hulse and others, 2002) illustrates how status and trends information can be used to describe spatial and temporal patterns of river conditions, with implications for floodplain habitats and restoration.

Map 1: Mainstem Willamette and Lower Tributary Anchor Habitats.



2. monitoring framework elements and concepts

2.1 Approach and Findings for the Proposed Monitoring Framework

A four-step approach, described below, shaped this monitoring framework:

Step 1: Identify and describe other regional and national multi-organizational monitoring and adaptive management programs and plans for river ecosystems (Appendix B).

This includes document and website review and telephone conversations with key personnel. From this exercise, we concluded:

A. Monitoring programs are extremely varied in purpose, scope, scale, approach, and outcomes, thus it is challenging to directly compare programs or apply broad-scale findings from one program to inform another program;

B. Designing and using monitoring information to adaptively manage and learn from project implementation is still an evolving practice and is challenging to do effectively and efficiently; much learning and practical refinement still occurs through close observation and personal experience;

C. Crafting monitoring questions and data and analysis strategies that provide the information needed to support adaptive project or program management is challenging;

D. Monitoring plans do not often clearly articulate the process by which monitoring data and information are going to be used to adaptively manage efforts;

E. It is difficult to obtain budget and staffing information for multi-organizational monitoring programs. For example, personnel costs can vary widely among different organizations; staff from some organizations may be contributing in-kind services or equipment, and many different funding sources may be combined to fund the overall personnel and equipment costs. Hence, it is challenging to determine the true costs of a multi-organizational monitoring program and to directly compare program costs for different programs or develop expectations that can be scaled to actual program

Step 2: Identify the audience and requirements for a Willamette monitoring framework.

Several Willamette habitat restoration and land acquisition programs exist that have associated monitoring programs or expectations for monitoring (Table 1). We identified how the approach may or may not meet the needs and objectives of the Oregon Watershed Enhancement Board's Focused Investment Partnership (OWEB FIP), the Habitat Restoration Program for Bonneville Power Administration (BPA), and the Willamette River Initiative and Willamette River Network (WRI/WRN). The Willamette Wildlife Mitigation Program (WWMP) has its own comprehensive monitoring approach.

The varied drivers and audiences for monitoring, combined with limited resources to support it, means that programs must be selective in what they monitor, set aside resources to compile and report monitoring information, and ensure that information meets the needs of key audiences, both in terms of the timing of information releases and the type of monitoring conducted. Findings from the three stakeholder workshops held in 2018 (Appendix A) provided valuable information on various audiences that would utilize implementation, effectiveness and status and trends monitoring findings, and the requirements for various audiences.

Table 1: Audiences and Mandatory/Desirable Reporting Requirements for Existing Willamette River Restoration Programs

RESTORATION PROGRAM	REPORTING	IMPLEMENTATION	EFFECTIVENESS	STATUS AND TRENDS	ADAPTIVE MANAGEMENT
WFIP	Mandatory	End of grant reporting to OWEB (submitted to OWRI). For monitoring projects, applicants comply with OWEB data sharing requirements established in grant agreement.	Project-scale: effectiveness monitoring may be required at some sites as dictated by funders or regulatory community. Some level of program-scale effectiveness monitoring (data collection, syntheses) of select restoration activities is required for FIP programs to inform adaptive management.	The floodplain forest or channel length targets for the 2050 Conservation Scenario (reported in SLICES) are identified in grant applications for OWEB and technical reviewers.	Not formalized or no information available
	Desirable	Annual project reporting; biennial rollup of progress toward targets, qualitative highlights (AHWG Implementation reporting).	Targeted studies of certain restoration actions with high uncertainty is underway in WFIP monitoring. Interpretation and analyses of program-scale effectiveness monitoring at end of program to inform future programs is desirable but not funded.	Implementation information reported in context of net system conditions every 2-3 years.	Not formalized or no information available
BPA's Willamette Program	Mandatory	Project-scale: applicants submit implementation data to BPA database. Program-scale: As requested by ISRP (requires funding).	Project-scale: as requested by BPA in grant agreements. Program-scale: None	SLICES and floodplain forest or channel length targets identified in grant application.	As requested by ISRP.
	Desirable	Program-scale Implementation could be rolled up with biennial WFIP and WRI accomplishments.	Not formalized or no information available	TBD	
WRI/WRN	Mandatory	Applicants submit end-of-grant reports with implementation data according to grant agreements.	Not formalized or no information available	SLICES and floodplain forest or channel length targets identified in grant application.	Not formalized or no information available
	Desirable	Annual Program-scale implementation could be rolled up with biennial WFIP and BPA accomplishments.	Not formalized or no information available	Not formalized or no information available	Not formalized or no information available

FOOTNOTES:
OWRI – Oregon Watershed Restoration Inventory (OWRI) database for voluntary reporting of implantation and effectiveness monitoring data for OWEB-funded restoration and monitoring projects.

Step 3: Identify existing monitoring infrastructure (Figure 2) and link this to the three types of monitoring: implementation, effectiveness, and status and trends.

For this report, 'monitoring infrastructure' s includes the foundational information upon which floodplain restoration monitoring occurs, and includes: a clear monitoring purpose, and b) information that provides the basis against which monitoring information is compared and provides clear context. Examples include:

- **Documented restoration goals, objectives and actions** that provide a reference for monitoring changes that may result from restoration or conservation. For BPA-funded restoration programs in the Columbia River Basin, the Independent Scientific Review Panel (ISRP) has supported the use of SMART objectives; these quantitative objectives are specific, measurable, attainable, relevant and time-bound and based on explicit scientific rationale (Northwest Power and Conservation Council, 2014; Wayne State University, 2020). Monitoring may track changes in system conditions toward a desired status defined by specific stakeholders (such as the SLICES Conservation 2050 scenario). Ideally, hypothesized linkages between restoration goals, restoration actions and the anticipated outcomes for floodplain ecosystems are described in a Results Chain, or Theory of Change.
- **Identified monitoring indicators and metrics** that relate to objectives or targets and can be used to help determine whether objectives are being met. Monitoring metrics should be quantifiable, and spatially and temporally explicit to support direct comparisons with objectives.
- **Clearly articulated process and timelines** for reporting the findings of the monitoring effort that support the monitoring purpose.

Together, the three types of monitoring (implementation, effectiveness, status and trends) provide a holistic way to track restoration actions, progress toward restoration goals, and describe system trends over time. The core monitoring elements include critical information about restoration program goals, objectives and actions that form a necessary basis for comparison so people may determine if restoration programs are on track to meet goals. While additional monitoring infrastructure may already exist or could be added in the future, the monitoring purpose and corresponding monitoring elements comprise the fundamental basis upon which other implementation, effectiveness, and status and trends monitoring programs are built.

Figure 2: Monitoring Infrastructure includes Monitoring Purpose and Core Monitoring Elements, which must be clearly defined and in-place to support implementation, effectiveness and status and trends monitoring

MONITORING INFRASTRUCTURE	IMPLEMENTATION	EFFECTIVENESS	STATUS AND TRENDS
Monitoring purpose (What monitoring does)	Tracks progress toward goals and targets over time	Evaluates uncertainty in the results chain	Tracks status and changes in floodplain health
Core monitoring elements (Items that are required so that monitoring can meet stated purpose)	Spatially and temporally explicit goals and objectives for the restoration program Monitoring metrics to compare against restoration objectives (targets) Timelines and process for reporting	A results chain (or Theory of Change) linking restoration goals and actions with hypothesized benefits to floodplain habitats. Restoration goals Monitoring indicators Monitoring metrics Timelines and process for reporting	Desired floodplain status or conditions, represented in spatially and temporally explicit manner (objectives) Monitoring indicators Monitoring metrics Timeliness and process for reporting

We recognize that monitoring to support restoration and conservation can take other forms, have other purposes, and/or focus on other requirements and applications, however the concepts illustrated in Figure 2 build on existing Willamette monitoring programs and the stakeholder-defined values for those programs. To better coordinate Implementation, Effectiveness, and Status and Trends monitoring, and ensure the utility of these programs in the future, Figure 2 describes the essential building blocks (or monitoring infrastructure) for the Willamette mainstem monitoring effort.

We apply the monitoring infrastructure identified in Figure 2 to existing large-scale and multi-organizational habitat restoration and conservation funding programs in the Willamette Basin in Table 2 to identify critical gaps in our current monitoring infrastructure.

Table 2: Selected Willamette Multi-Organizational Habitat Restoration and Conservation Funding Programs and Summary of Programmatic Monitoring

	OWEB Willamette River Anchor Habitat Focused Investment Partnership (OWEB WFIP)	**BPA Willamette Habitat Program**	**Willamette River Initiative (WRI)*/ Willamette River Network (WRN)**	**Willamette Wildlife Mitigation Program (WWMP)**
ATTRIBUTES OF THE RESTORATION AND CONSERVATION PROGRAMS				
Years	2016-2022	2010-2023	2008-2019/2019-	2010-2025
Designated Monitoring Lead	FIP Effectiveness Monitoring team (Benton SWCD, BEF, PSU, USFS, USGS	HTT, OWEB (with technical support from FIP Monitoring Team)	Individual Grantees; BEF provides implementation rollup support	ODFW
Ecological Priorities	Seasonally important resources for native fish	Actions that support spring Chinook and winter steelhead	Floodplain health for all, capacity, project outreach and development	Acquisition of wildlife mitigation property to protect 26,537 acres by 2025
Geographic Focus	Specific project areas in mainstem anchor habitats	Anchor Habitats	Upstream of Willamette Falls (RKM 42)	Willamette Basin
MONITORING INFRASTRUCTURE				
Has restoration program goals?	Yes	Yes	Yes	Yes
Has restoration program objectives (targets)?	Yes	No	No	Yes
Has a results chain or theory of change?	Yes	No	No	N/A
Has system-wide indicators?	Yes	Yes	Yes	N/A
Has website for information sharing?	No	In development	Yes	N/A

**The WRI/WRN differs from other funders/programs listed in that it is a Foundation with diverse interests and a desire to flexibly support partner capacity. The WRI ended in March 2019 and the WRN,, now named Nesika Wilamut launched in 2020.*

Step 4: Describe proposed monitoring actions and identify processes for information sharing and ownership of key monitoring elements.

Change is underway in the Willamette as a result of ongoing funding opportunities through the OWEB FIP and MMT to develop a multi-organizational monitoring approach. Much of the work in development is still being vetted and improved by funders and partners, and we hope that this document helps clarify shared opportunities. The bulk of this document addresses step four.

3. considerations for streamlined implementation, effectiveness, and status and trends monitoring to support Willamette River floodplain restoration

Drawing upon input from three stakeholder workshops (Appendix A), as well as lessons learned from current and past Willamette River monitoring efforts (such as WFIP Implementation Monitoring, WFIP Effectiveness Monitoring, SLICES status and trends monitoring) this section describes current implementation, effectiveness and status and trends monitoring programs and considerations that could be used when developing future monitoring programs to support restoration and conservation efforts in the Willamette River floodplain.

3.1 Implementation Monitoring

Implementation monitoring tracks progress toward restoration goals and objectives by collecting data on implementation status of restoration projects and comparing this information against restoration objectives. Key and typically requisite audiences for implementation monitoring are project and program sponsors and funders. Desired audiences also include the broader restoration community, and policy makers.

3.1.1 Restoration Objectives used in Implementation Monitoring

Restoration objectives (also called targets) are set by restoration programs for defined periods of time and are intended to represent the specific actions that the restoration program aims to accomplish based on available resources or, more rarely, ecosystem needs. Restoration objectives provide the foundation from which Implementation monitoring data can be compared to determine the extent to which restoration actions are making progress toward stated targets.

EXAMPLE: The WFIP Implementation Monitoring Program tracks accomplishments for the WFIP restoration program (meaning, restoration specifically funded by OWEB) by quantifying the total acres directly restored by three types of restoration actions. The three restoration actions and corresponding implementation metrics are: acres of floodplain reconnected to the Willamette River; acres planted in native vegetation; and acres of waterbodies that were treated for aquatic invasive weeds. The overall restoration objective by 2022 is for restoration actions to impact 2,602 acres (AHWG, 2016). Lead personnel for individual restoration projects report acreage totals annually through a Smartsheets reporting system managed by the Bonneville Environmental Foundation. The WFIP Implementation Monitoring Program also tracks progress toward four outreach objectives. Information on restoration funded by MMT and BPA is also collected when offered, but is not a required component of the WFIP Implementation Monitoring Program.

The overall restoration objective by 2022 is to impact

2,602 acres

by restoration actions (AHWG, 2016)

3.1.2 Reporting timelines for Implementation Monitoring

Reporting timelines are established with the organizations who are reporting their implementation data, or as required by a funder or other oversight body.

EXAMPLE: The AHWG partners who receive OWEB funding through the WFIP program typically report implementation data for their respective organizations between December 1-31 of that same calendar year. Bonneville Environmental Foundation (BEF) synthesizes this information annually, and provides a summary report every two years to document restoration progress.

The December reporting interval for restoration organizations to report that year's restoration accomplishments was selected because:

- It is a clear, memorable timeline.
- Few field activities that might impact reporting information occur in December and so numbers have a higher likelihood of being accurate. Some reporting windows might unintentionally encourage partners to predict actions, which could later result in under or over-reporting.
- There are few other reporting and grant deadlines in December, reducing the likelihood of competing deadlines.
- Annual reporting timelines allow information to be aggregated on a regular basis, providing:
    - Quality assurance and control among implementers what can more easily find errors or misinterpretations of questions.
    - Feedback for funders and interested audiences on restoration accomplishments.

Challenges with this reporting timeline include:

- This presents yet another timeline under which organizations need to parse information. Other timelines that reporting entities may be beholden to include: funder fiscal years, organization fiscal years, grant timelines.
- For certain status and trends indicators that partners may want to present in conjunction with implementation updates, reporting timelines based strictly on the calendar year may not align with ecological processes occurring over different timeframes. For example, a status and trends indicator for winter steelhead (summarizing annual returns of adult steelhead) would span the period of December through May, whereas WFIP Implementation Monitoring summarizes restoration accomplishments occurring January-December. Hence, annual steelhead returns could be reported annually alongside restoration accomplishments, but the timeframes underlying each metric would need to be clearly described.

Table 3: Restoration Objectives and Monitoring Metrics in WFIP Implementation Monitoring Program

RESTORATION OBJECTIVE (OR TARGET)	IMPLEMENTATION MONITORING METRICS	2022 RESTORATION PROGRAM OBJECTIVE (OR TARGET)	REPORTING FREQUENCY
Ecological	Acres impacted by restoration actions	2,602	2,602
Outreach	Expert audiences reached through meetings, workshops, field tours	200	Annual
	Public attendees at meetings and tours	6,000	Annual
	Youth engaged in educational events	1,500	Annual
	Broader media reach	10,000	Annual

3.1.3 Reporting Process for Implementation Monitoring

There are a variety of approaches that can be used to solicit, organize and report implementation data, which will scale with program needs and funding availability. In the Willamette River Basin where funding for implementation monitoring is likely to be very limited, the implementation reporting approach should be efficient to make it as easy as possible for practitioners to enter their accomplishments and for the reporting entity to synthesize and report this information.

> **EXAMPLE:** Implementation data for the WFIP Implementation Monitoring Program are managed in a Smartsheets system created and managed by Bonneville Environmental Foundation (BEF) with funding from OWEB. Under current funding, BEF accepts implementation reporting from any partner who is implementing projects that align with AHWG actions and geographic area. Should an influx of reporting from non-OWEB funded partners occur in the future, additional funding may need to be secured to support this work.

Reports are released on an annual or biennial basis These may be integrated into a website if this can be launched by WFIP partners with current funding.

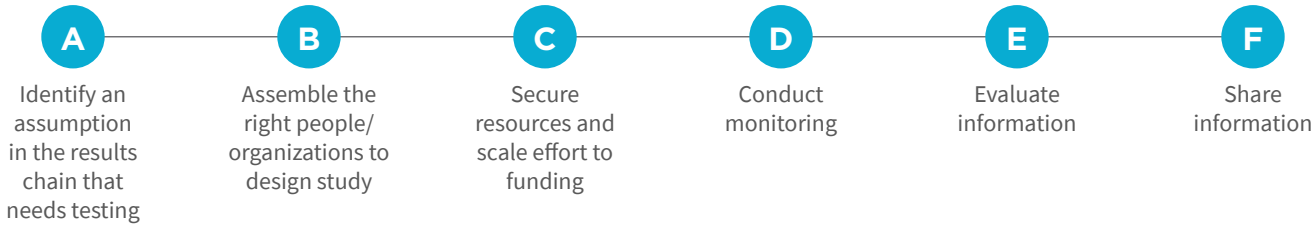
3.2 Effectiveness Monitoring

Effectiveness monitoring supports learning, improving performance, and refinement of restoration program goals and activities in the future. It provides an opportunity to investigate specific assumptions in a results chain (or Theory of Change) that require affirmation or clarification (Figure 3, Warren and others, 2019). Effectiveness monitoring can also be used to improve best practices. The approach proposed in this paper is tied closely to a results chain and assumes that a results chain linking restoration program goals, ecological outcomes and restoration actions to achieve those outcomes is already developed and has undergone appropriate scientific review (Figure 2). Once the results chain is developed, stakeholders can begin to plan effectiveness monitoring efforts with stakeholders determining what assumptions in the results chain most require verification or clarification. For example, the WFIP Results Chain was developed by BEF and OWEB based upon the Strategic Action Plan for Willamette Anchor Habitats Working Group (OWEB, 2019) and is the basis for the WFIP for prioritizing data collection for the WFIP Effectiveness Monitoring Program.

3.2.1 Background on Effectiveness Monitoring

Effectiveness monitoring studies can employ sampling designs that will generate estimates of statistical error and confidence, or, more typically, will use a comparative design that sheds light on key questions in a scientific case study approach. We define a scientific case study approach as one that uses vetted scientific protocols to test hypotheses, but do not have the study design required to make statistical inferences at the scale of the river system. Future Willamette River effectiveness monitoring efforts will likely consist of scientific case studies.

Figure 3: Steps in Effectiveness Monitoring.



3.2.2 Steps in Effectiveness Monitoring: Example from WFIP Effectiveness Monitoring

We provide an example from the WFIP Effectiveness Monitoring Program to illustrate how this study approach (Figure 3) was applied to evaluate effectiveness of invasive aquatic weed treatments at improving habitats used by native fish (also see Table 5). A similar process was also used by the WFIP Effectiveness Monitoring Program to develop an in-depth study to evaluate effectiveness of gravel pit restoration (Table 5):

A. Identify an assumption in the Results Chain or Theory of Change that needs testing: The hypotheses linking treatment of invasive aquatic plants with improvements in water quality and habitat conditions for native fishes was identified by the WFIP Effectiveness Monitoring team and other Willamette River experts as having substantial uncertainty relative to restoration investments being made. This hypothesis and the intermediate ecological outcome are labeled as 15 on the WFIP Results Chain (OWEB, 2019) and can be generalized as:

In response to treatment of aquatic invasive plants, habitat modification from invasive plants is reduced and improved water quality conditions will support native fish.

Technical experts and practitioners have identified this assumption as a priority for focused research and monitoring to ensure that learning is maximized and that the goals and actions of future invasive aquatic plant treatments can be realistic and strategically applied to places where the benefits to native fishes will be greatest. Some of the factors that confounded simple assessments of effectiveness of invasive plant treatments at improving fish habitats, and prompted the need for more in-depth effectiveness monitoring of aquatic plant treatments include: a) warm stream temperatures in off-channel features that exceed thermal tolerances for many native fishes where treatments are applied, b) low dissolved oxygen levels due to factors other than invasive aquatic plants, c) uncertainty regarding long-term efficacy of reducing the amount of invasive aquatic plants in off-channel features (due to upstream sources of invasive plants and geomorphic stability of areas prone to invasive plant colonization) and d) presence of non-native predatory fish in treatment sites that may limit habitat use by native fishes even if water quality conditions are improved.

B. Assemble organizations and people to design the study: USGS, in conjunction with BEF and Benton SWCD reached out to key technical experts at PSU (water quality) and USFS (fish) to create a study design. OWEB's Technical Review Team also provided thorough and helpful reviews that substantially strengthened the study design. Ultimately, it was determined that rather than collecting new field-based data to support effectiveness monitoring, a 'State of the Science Synthesis' was needed to understand multiple aspects of invasive aquatic plants in the Willamette River, their effect on fish habitats and implications for fish communities and treatment effectiveness.

C. Secure resources and scale effort to funding: USGS convened partners and BEF and Benton SWCD wrote relevant grant proposals with support from technical experts. Monitoring will be supported through a special one-time effectiveness monitoring grant from OWEB.

D. Conduct monitoring: Monitoring will roll out between 2020-2022, with scientists from different disciplines summarizing available information into a single report that will be co-led by BSWCD and PSU.

E. Evaluate information: BSWCD, PSU, USFS and the USGS.

F. Share information: Monitoring implementers will share findings in a publicly available, peer-reviewed report, with interim findings shared in presentations, and in-person meetings and discussions. The key datasets summarized in the synthesis report will be publicly available through report appendices and USGS data releases. These different approaches to information sharing will be scaled to balance the need for timely sharing of preliminary information with the AHWG, science community and funders while also waiting to share key findings with external audiences until results can be peer-reviewed and fully vetted.

Figure 4: Example of how information generated through Effectiveness Monitoring could be shared.

Table 4: Examples of Planned WFIP Effectiveness Monitoring Studies that will occur as part of the WFIP Effectiveness Monitoring Program

TYPE	THEORY IN THE RESULTS CHAIN THAT WILL BE EVALUATED	MONITORING APPROACH	REPORTING FREQUENCY
Ecological	If the spatial extent of invasive aquatic plants in an off-channel water body is reduced, then improved water quality conditions will improve and physical habitat for native fish will increase.	Synthesize available information on aquatic invasive plants in Willamette River, implications for physical habitat and water quality, fish communities, and treatment effectiveness.	Final publicly available PSU report when investigation is completed (approximately 2022).
	If former gravel pits are enhanced, reconnected or filled, then there will be an increase in seasonally important resources for native fish.	Synthesize available information on gravel pit restoration in the Willamette Basin and similar region and outcomes for fish habitats and fish communities. (Phase 4 of the WFIP Effectiveness monitoring program)	Interim presentations and updates to AHWG, OWEB and HTT (schedule TBD). Final publicly available USGS report when investigation is completed (approximately 2022).
	Riparian vegetation along sloughs and side channels is planted, then native riparian forest community is enhanced.	Avian indicator of vegetation health.	Updates to be shared starting in 2020, future work will be funding dependent.

3.2.3 Restoration Goals and Monitoring Metrics for Effectiveness Monitoring

The WFIP Effectiveness Monitoring Program is focused on generating program-level information that can inform the goals and actions of future restoration programs following the adaptive management approach described in OWEB (2019). Because it is not possible to systematically evaluate each of the restoration projects sites with available funding, the monitoring program utilizes a blend of low-cost, strategically planned field and desk-based data collection activities and syntheses of existing information. This information will ultimately be used to assess different categories of restoration actions. Linkages between restoration program goals, monitoring indicators and monitoring metrics are described in the WFIP Effectiveness Monitoring Framework (Keith and others, in press).

Table 5. Example of linkages among restoration goals, restoration activities, monitoring indicators and monitoring metrics used in the WFIP Effectiveness Monitoring Program

WFIP RESTORATION GOAL	EXAMPLE OF WFIP RESTORATION ACTIVITY	EXAMPLE EFFECTIVENESS MONITORING INDICATOR	EXAMPLE EFFECTIVENESS MONITORING METRIC
Increase and enhance habitats used by native fishes	Enhance gravel pits	Stream temperature Inundation	Number of days per year when pond temperatures are: lethal, sub-optimal, optimal, or safe but impact growth of juvenile Chinook. Number of days per year that pond is hydraulically connected to main channel.
	Expand floodplain forests	Canopy Cover Inundation	Percent of planted site with shrub or tree cover 3-5 years after planting. Number of days per year that planted site experiences inundation supportive for focal fish species.
	Treat aquatic weeds	Cover of aquatic plants Stream temperature	Percentage of treated waterbody covered with aquatic emergent plants 1-3 years after treatment. Number of days May to October that treated waterbody has lethal, sub-optimal or optimal temperatures for juvenile Chinook.

3.2.3 Reporting Processes and Timelines for Effectiveness Monitoring

Currently, the primary large-scale Effectiveness Monitoring program underway in the Willamette River floodplain is the WFIP Effectiveness Monitoring program, where reporting timelines and processes have been established to reflect the need for a) informal updates to funders and stakeholders and b) peer-reviewed documentation of data collection and findings. Our hope is that the less formal information sharing avenues outlined in Figure 4 will be used by researchers as time and funding allows. For the WFIP Effectiveness Monitoring program, regular meetings with the restoration community, HTT and OWEB are scheduled for the life of the program and organized in a Communication Plan (incorporated in the General Monitoring Plan, Wallick and others, 2019). This schedule establishes common expectations for all parties and was designed to support various audience needs. In addition to regular progress updates, published data and reports are anticipated beginning in 2021 (for datasets) and 2022 (reports). Willamette-focused scientists and researchers who are conducting relevant research will also be encouraged to share studies, observations, ideas and findings with practitioners. We hope that a website or other convening opportunities will help researchers understand how they can share their data with those who are working on the ground to improve habitats—however, there are currently no plans for a practitioner-focused website nor are there plans to convene future meetings for information sharing between practitioners and scientists (such as the State of the Willamette science conference held in Corvallis in 2020).

3.3 Status and Trends Monitoring

Status and trends monitoring describes river conditions, net changes in river conditions, and temporal and spatial trends. In the mainstem Willamette River, status and trends monitoring will hopefully continue in the future, building upon the framework established in SLICES where a small set of metrics describing floodplain conditions can be compared against the stakeholder-developed Conservation Scenario goals for 2050 (Hulse and others, 2002). Although there are currently no plans for such a program, future status and trends monitoring is likely to be most successful if focused on a small suite of indicators informed by those developed by Hulse and Gregory (2004) and shared in the SLICES website or similar platform. The original indicators of floodplain health described in the SLICES website were: channel complexity, floodplain forest and native fish communities, which are critical components of the floodplain corridor and indicative of geomorphic, hydrological, vegetation and biological processes that support the floodplain ecosystem (Hulse and others, 2002). As currently defined and quantified in the SLICES framework, channel complexity and floodplain forests provide an indication of habitat availability for native fishes and overall health of the floodplain ecosystem. Additional refinement of these indicators and associated metrics would be helpful for placing restoration projects within the context of seasonally-variable river conditions. Furthermore, the original SLICES datasets (floodplain forests, channel complexity, native fish communities) were intended to be reported at decadal intervals. However, as part of this project, the authors heard that other aspects of the river system that directly affect floodplain health (such as flow, temperature and annual salmon returns) should also be tracked, and that there is a need to provide more frequent updates on Willamette River conditions to maintain stakeholder engagement and support funder decisions. Hence, the status and trends monitoring considerations of this section reflect the science foundation established by SLICES as well as emerging needs of Willamette River status and trends monitoring.

3.3.1 Background on River-Scale Status and Trends Monitoring through SLICES and the Willamette River Report Card

The Willamette Basin Planning Atlas (Hulse and others, 2002) provides the science foundation for status and trends monitoring in the Willamette River Basin. The Planning Atlas established the spatial framework for tracking changes in river conditions through a series of 1-km wide floodplain kilometer transects (or SLICES), and it published spatially explicit maps of floodplain forests, channel complexity and native

fish communities for different time periods that show how these river attributes vary spatially and temporally along the length of the Willamette River. The Willamette Basin Planning Atlas (and many subsequent presentations and documents by the SLICES team) also illustrated how the SLICES framework and datasets can be used to aid in the planning and prioritization of restoration and conservation efforts.

SLICES uses a transect mapping approach to divide the river floodplain into 1- km long "slices" drawn perpendicular to the floodplain's center axis. SLICES enables users to track floodplain conditions using a variety of metrics describing channel complexity, floodplain forests and native fish communities; additional data such as cold water refuges, area of juvenile chinook habitat and inundated area during the 2-year recurrence interval flood are also reported for each SLICE. SLICES data and links to historical GIS layers created for the Willamette Basin Planning Atlas are stored on the Oregon Explorer website: https://oregonexplorer.info/places/basins/willamette?qt-basin_quicktab=1

The SLICES framework was a leap in innovation in several ways. First, it identified a key minimum set of indicators (and associated metrics) for the Willamette River that should be tracked: channel complexity, floodplain forest, native fish communities. Second, SLICES provided a spatial framework where historical river conditions could be compared with present-day (ca 2010) conditions, and different future conditions that might occur under different management scenarios; in particular, the establishment of the Conservation 2050 scenario that provided spatially and temporally explicit, quantifiable objectives for restoration efforts. Third, altogether, this framework drew the attention of funders and project implementers to the mainstem Willamette for the first time and helped people see where and how they could act to improve floodplain habitats for native fish and wildlife. Fourth, the native fish studies undertaken by Dr. Stan Gregory and colleagues provide a baseline understanding of a key limiting factor to native fish recovery: competition and predation from non-native fish, and helped the broader public to understand the linkages between river health and the overall community of native fish that reside year-round in the Willamette River.

The elegant simplicity of the SLICES framework may have also unintentionally led to misunderstandings about its potential use as a storage system for monitoring data. For example, while SLICES will undoubtedly provide a spatial reference system for the WFIP Implementation and Effectiveness Monitoring Programs, and also provide contextual data from which to compare site-level information, implementation and effectiveness monitoring data will not be physically incorporated into the SLICES framework or website. Instead, SLICES data will be used in a variety of ways to support the Effectiveness Monitoring Program, and data from the Effectiveness Monitoring Program will be stored in databases and websites that are specifically designed to store and display the distinct data collected from the WFIP monitoring programs.

If funding is not secured to continue tracking changes in channel complexity, channel length, and floodplain forest cover in SLICES beyond the last 2015 update, other opportunities will need to be explored to continue tracking Willamette River conditions. Continuity with data collected in previous decades will be need to be considered if such a program is developed by another entity; however, new remote sensing datasets and automated approaches for mapping tools are readily available, which creates opportunities to continue SLICES-like mapping efforts in the future, potentially at lower costs and generating higher-resolution datasets. SLICES has become a regionally familiar tool, with highly respected scientists leading this work for nearly two decades and provides an important science foundation for the Willamette River restoration community.

The Willamette River Report Card (WRI 2015), was an effort to communicate river health trends to a broad audience (WRI, 2015) and utilized three of the SLICES attributes (floodplain forests, channel complexity, native fish communities) along with other indicators to develop grades of river health (Table 6). While there are no plans to revisit the report card in future years, it was the first attempt to translate information on the status of river conditions in each of the three reaches in an easily understandable report card format.

Five broad categories of status and trends indicators for the Willamette River Report Card were identified by an advisory panel (Table 6):

Flow

Habitat

Water Quality

Fish and Wildlife

People and the River

Table 6: How monitoring metrics align with Willamette Report Card indicators (WRI 2015)

Categories of River Health used in 2015 Willamette River Report Card -	Flow	Flow	Habitat	Habitat	Water Quality	Water Quality	Water Quality	Fish and Wildlife	Fish and Wildlife	Fish and Wildlife	Fish and wildlife	People and the River	People and the River	People and the River	People and the River
Indicators used in 2015 Willamette River Report Card	Peak Flows	Flow Targets	Channel Complexity	Floodplain forest	Toxics	Water Quality Index	Temperature	Native Fish	Juvenile spring Chinook	Non-native Fish	Bald eagle	Harmful Algal Blooms	Tribal fisheries	Fecal Bacteria	Fish Consumption Advisories
Proposed metrics that could be part of a future status and trends monitoring program and their relation to Report Card indicators															
Floodplain Forest Area and Diversity															
Channel Features and Complexity															
Aquatic Habitat (Juvenile Chinook)															
Native Fish Community															
Salmon and Steelhead Returns															
Water Temperature															

While both the SLICES assessments and the WRI Report Card provided critical and scientifically sound information to inform a shared understanding of river health trends, there is currently no funding secured to repeat these analyses at ten-year intervals.

3.3.2 Reporting Status and Trends Monitoring at Annual and Decadal Intervals

For status and trends monitoring to be most meaningful, a plan for reporting and "story telling" should be a necessary component of future monitoring. This means that in addition to computing basic metrics of river conditions for specified locations and time periods, status and trends reporting should:

A. Describe river conditions in accessible language, datasets and graphics;

B. Describe spatial variation in key river conditions along the river corridor;

C. Describe temporal changes in key river attributes;

D. Describe potential explanatory causes for the observed spatial and temporal trends;

E. Describe potential implications of the observed conditions for critical habitats, restoration actions or other aspects of the floodplain system that the audience is most likely to care about;

F. Report river conditions at time scales that are relevant to intended audiences (in this case, stakeholders, funders and the general public);

G. Report river conditions at time scales that also accord with floodplain processes; some floodplain conditions (such as channel complexity) change gradually and changes may only be measurable at the decadal scale while other processes (streamflow, stream temperature) change daily, with year-to-year variation having greater significance for floodplain ecosystems.

The level of complexity and costs associated with these multiple reporting considerations vary with audience needs and funding, ranging from brief, inexpensive summaries of river conditions to more in-depth scientific investigations. Likewise, the frequency of reporting could scale with audience needs and data collection activities, ranging from simple, brief annual syntheses reported in a website to more in-depth reports produced at 5-10 year intervals describing changes in floodplain conditions and causal mechanisms for observed changes. While the reporting format and timeframes are scaleable, the status and conditions of the river corridor are important foundations underpinning the restoration efforts. Status and trend monitoring and associated reporting will help connect audiences with river conditions, identify conditions that are problematic or supportive for floodplain ecosystems, and ultimately provides necessary context for prioritizing and justifying continued restoration efforts.

Obtaining funding for status and trends monitoring is challenging, but a stratified approach that tracks a limited number of high-priority attributes of river conditions, reports these conditions at both annual and decadal time periods, leverages contributions by different organizations, and directly connects different audiences with iconic and important aspects of the river system may have the greatest likelihood of long-term success. Although such a program may be more likely to attain and sustain funding, the increased coordination and integration among multiple organizations would require non-trivial costs to ensure continuity and meaningful reporting.

Future Willamette River floodplain status and trend monitoring could also implement several steps so that the program is poised to take advantage of scientific advances or new publicly available data that could help achieve cost savings while still ensuring continuity and comparability with previous SLICES datasets. First, the monitoring indicators and metrics for channel complexity, floodplain forest and native fish communities for status and trends monitoring should be compatible with previous datasets, although additional refinement to these metrics may be warranted to address emerging questions. Secondly, the monitoring approaches used to generate the monitoring metrics will likely change over time reflecting new technologies and new remote sensing datasets available for mapping floodplain forest and channel complexity; however, the datasets themselves can be created and published in ways that will maximize comparability with previous datasets and each dataset should have metadata describing the methods, error and uncertainties with each dataset. Third, analyses and interpretations of datasets from different time periods can be carried out with awareness of the uncertainty and error introduced by individual datasets, and additional uncertainty or bias that may arise when comparing datasets from different time periods. Descriptions of the methods, analyses, interpretations and results should be incorporated into future reporting, providing a platform for describing monitoring results that may be indicative of actual changes in floodplain conditions versus detected changes that may reflect measurement uncertainty or differences in monitoring methods from two time periods. For example, improvements in image availability, remote sensing mapping techniques and computing speeds coupled with research advances provide opportunities to collect some indicators of river health (such as floodplain forest, channel complexity and rearing habitat availability) at lower costs and finer spatial resolution than would have been possible in previous decades.

Central to the concept of a 'stratified' approach to status and trends monitoring is the need to track key aspects of the floodplain at both annual and decadal intervals. The status of three indicators of floodplain health (floodplain forests, channel complexity and native fish communities) would be reported once a decade while four additional indicators of floodplain health (flow, stream temperature, habitat and salmon returns) would be reported annually. While the decadal indicators will require more intensive monitoring effort with new data collection (mapping and fish sampling along the entire river) the datasets needed for each of the annual monitoring indicators is currently collected by other organizations. Although the data for the annual synthesis is publicly available, there is currently no central repository where the information from these different topics, and different locations across the Willamette Basin is synthesized, described and publicly shared in an easy to understand format.

Key questions that could be readily addressed with annual reporting include:

- How many days was the floodplain inundated?
- How many days had mean daily stream temperatures that were lethal for juvenile spring Chinook salmon and other cold-water fishes?
- How much rearing habitat for juvenile spring Chinook salmon was available in critical periods for migration and rearing periods (spring, fall, winter)
- How many naturally produced adult spring Chinook salmon and winter steelhead trout returned to the Willamette Basin and key spawning reaches below USACE dams?

All of these questions could be efficiently addressed and reported using existing datasets that are already collected by the USGS, ODFW and US Army Corps of Engineers coupled with new research on Willamette River habitat availability. An annual synthesis of streamflow, stream temperature, habitat and salmon data could complement decadal-scale status and trends monitoring and assist people and organizations with understanding local river conditions and also illustrate basin-wide patterns of habitat availability, environmental conditions and numbers of salmon and steelhead returning to the Willamette Basin. The key to successfully implementing such a synthesis in an ongoing manner for future years is developing a process that is broadly useful, utilizes publicly available information and could be implemented at a minimal cost using standardized approaches. The USGS is currently developing a proof-of-concept for this annual synthesis with a goal of developing monitoring and reporting processes that could be efficiently implemented at a relatively low cost by other organizations in the future.

Status and trends monitoring is essential for tracking Willamette River conditions over time, but it faces many challenges including: a) uncertainty over future funding for decadal monitoring of floodplain forests, channel complexity and native fish communities in SLICES, b) demand for frequent reporting of river conditions, c) an increased awareness of the importance of flow, temperature and salmon returns as key indicators of floodplain health, d) increasing awareness of the need to synthesize annual and decadal status and trends information in an easy-to-understand format, and e) the emphasizing the need to incorporate emerging research and new monitoring approaches into status and trends monitoring. The stratified approach to status and trends monitoring described here (Table 7, Table 8) offers a plausible option to address these challenges and leverage existing monitoring efforts across the Willamette Basin -ultimately helping stakeholders, restoration funders, and the general public to better understand conditions in the Willamette Basin and context for restoration and conservation actions. This stratified approach described here could be tested and refined in coming years to best meet the needs of different audiences.

Benefits to a status and trends monitoring approach that utilizes annual and decadal metrics of floodplain health include:

- Select aquatic habitats metrics for annual reporting (Table 7) to help audiences understand flow, temperature, habitat, and salmon returns from the previous year and place these conditions within the context of recent decades. These metrics could be computed and reported annually based on publicly available information. The USGS and Benton SWCD are currently developing a proof-of-concept template for these annual metrics, report and website.
- Long-standing indicators and metrics of the Willamette River floodplain ecosystem (channel complexity, floodplain forest and native fish communities, Table 8) could still be measured and reported at decadal intervals (or more frequently as dictated by need and funding). Monitoring methods would be adapted to utilize new datasets and mapping techniques while still generating datasets that can be compared with previous datasets to permit tracking of system changes and progress toward the 2050 Conservation Scenario objectives identified in the Willamette Basin Planning Atlas.
- Reporting and storytelling of annual and decadal information would provide more timely and equitable access to critical information about Willamette River habitat and fisheries conditions and ultimately help diverse audiences have a common understanding of these conditions. An improved understanding of the status and trends of habitat and salmonid populations would help the restoration community to better leverage and coordinate existing partnerships, scientific insights, and restoration actions across the basin.

Constraints:

- A primary constraint is the absence of funding for any status and trends monitoring effort, let alone an expanded program that incorporates both annual and decadal metrics (Table 7, Table 8). Although an annual synthesis will be computed for the year 2020 (under the current pilot effort by USGS), there is no funding or plan for future annual syntheses or reporting. Likewise, we are not aware of funding to update the SLICES mapping datasets in 2020 (approximately 10 years since the 2010 channel complexity and floodplain forest maps were created). However, the datasets and approaches are available to efficiently support updated floodplain forest and channel complexity mapping (utilizing high resolution imagery from 2018 and the 2017 topographic-bathymetric LiDAR and new approaches such as those described by Overstreet, 2020).
- The annual synthesis of flow, temperature, habitat, and salmon return data depends upon timely dissemination of datasets provided by USGS, ODFW and USACE. Although these organizations are currently committed to producing these datasets at relevant intervals, the reporting circumstances may change in the future. Some additional datasets that would be useful in an annual synthesis are shared months or years following the events they are tracking, potentially rendering them irrelevant for the annual reporting envisioned for the Willamette Basin. Additional datasets that could be incorporated into an annual synthesis (with considerations for reporting frequency) include the following datasets on spring Chinook salmon and winter steelhead trout:
    - 2017 ODFW Annual Sport Fishing catch totals for Winter Steelhead were reported on April 25, 2019.
    - 2017 ODFW Annual Sport Fishing catch totals for fall Chinook were reported on April 25, 2019.
    - ODFW Falls Fishway Counts are posted monthly.
    - Review of 2018 Ocean Salmon Fisheries (Published February 2019 for the year 2018). Appendix B on page 217 of this document, TABLE B-12: Estimates of minimum in river run size, catch, and escapement in numbers of Columbia River adult spring Chinook destined for areas below Bonneville Dam. Columns on lower Willamette Sport Catch and Willamette Falls Escapement could be tracked to create a line graph showing change over time.
- While it may sound straightforward to compile the information that is already collected by other organizations for the annual synthesis (such as ODFW, USACE, USGS) it requires human resources to extract, aggregate, analyze, and report this information, especially when information is stored in a variety of formats (PDFs, text files) and may not be available on publicly accessible websites. Additional steps are required to display data visually, to explain what information means in the context of historical trends, natural and anthropogenic influences on flow, temperature and fish return data, and implications for floodplain health. The pilot effort by USGS will provide a template for future monitoring and reporting, but an organization needs to be identified that could carry out this synthesis in the future and ensure continuity in both the technical and reporting aspects of it. Even if funding is available, the annual reporting will be most successful if there is organizational capacity to carry out the monitoring and if there is continuity in how the monitoring is conducted and reported each year.
- For both the annual and decadal monitoring indicators and metrics, it is important to select straightforward indicators that allow diverse partners to understand important trends and set the stage for deeper conversations around adaptive management. The decadal indicators (floodplain forest, channel complexity, native fish communities) are well established, but annual indicators and metrics will need careful vetting during the pilot effort to ensure they are useful and applicable to adaptive management. Reporting at annual and decadal intervals should strive to explain the importance of the status and trends monitoring indicators and their significance to floodplain health.

Table 7: Examples of annual floodplain health indicators that could be part of a future river-scale status and trends monitoring program and reported every year

MONITORING CATEGORY	MONITORING INDICATOR	EXAMPLES OF MONITORING METRICS	EXAMPLE MONITORING APPROACH	DATA SOURCE(S)	ADDITIONAL CONSIDERATIONS
Physical habitat for salmon and steelhead	Water temperature	Number of days per year that bear lethal, sub-optimal and optimal temperature conditions for salmon and steelhead.	Temperature thresholds for fish survival, migration and behavior are applied to mean daily temperature data.	USGS continuous temperature data for Willamette River at Harrisburg, Albany, Keizer, Newberg, and Portland.	USGS is developing proof-of-concept metrics, reporting products and a website in a separate study titled "Willamette River Annual Synthesis." Estimated completion date is winter 2021/22. Thresholds for temperature, inundation, and rearing habitat availability are in development for separate USGS habitat studies (White and others, in progress).
	Streamflow and Inundation	Number of days per year that various inundation thresholds for habitat and flood control are met.	Inundation thresholds for different zones of the floodplain are applied to mean daily streamflow data.	USGS continuous streamflow data for Willamette River at Harrisburg, Albany, Salem, and Portland.	
	Rearing habitat	Number of days per year that different seasonally varying thresholds for rearing habitat availability are met.	Thresholds for rearing habitat availability are applied to mean daily streamflow data.	USGS continuous streamflow data for Willamette River at Harrisburg, Albany, Salem, and Portland.	
Number of returning adult spring Chinook and steelhead trout	Adult Chinook and steelhead	Number of adults passing Willamette Falls; Number of adults returning to tributaries. Timing, relation to flows and temperature.	Data from ODFW and USACE fish facilities are compiled, summarized, and reported annually.	ODFW and USACE fish facilities at Willamette Falls and major tributaries below USACE dams.	

Table 8. Examples of decadal floodplain health indicators that could be part of a future river-scale status and trends monitoring program

MONITORING CATEGORY	MONITORING INDICATOR	EXAMPLES OF MONITORING METRICS[2]	EXAMPLE MONITORING APPROACH	DATA SOURCE(S) FOR FUTURE MONITORING *(SLICES has 2010 data)*	ADDITIONAL CONSIDERATIONS
Floodplain forests	Floodplain forest extent and stand diversity	Area of floodplain forest cover in historical floodplain and 2yr recurrence-interval; summarized by reach, FPKM and bank of the river. Area of floodplain within different categories of landcover.	Automated mapping from available data using simple landcover and vegetation height categories that relate to vegetation community and seral stage.	Many publicly available sources for imagery. 2017 LiDAR and 2018 Oregon imagery could be used for ca. 2018 map.	Decadal synthesis could create GIS layers and a summary report describing spatial and temporal patterns of vegetation and channel change, along with possible causes for observed changes and implications for floodplain habitats. Future mapping should ensure comparability with past SLICES mapping so that temporal trends can be tracked over time.
Channel morphology	Channel complexity (as defined by channel features)	Area of gravel bars, and off-channel features. Metric of topographic complexity. Area, length of side channels. Other metrics TBD.	Once metric is established, could be decadal remote-sensing mapping approach repeated every 10 years or after a large flood.	Many publicly available sources for imagery. USGS mapping from 2016 could be utilized for 2020 effort. 2017 LiDAR and 2018 Oregon imagery could be used for ca.2018 map.	
Native fish communities	Native fish communities	Percent native species composition. Salmonid abundance.	Requires substantial field effort and ongoing maintenance of the Willamette fish database.	New field sampling required. OSU and USFS are conducting 2020 sampling upstream of Willamette Falls. City of Portland has ongoing monitoring below Willamette Falls.	Future sampling should consider past metrics and approaches as well as new methods (eDNA) to ensure comparability with past SLICES datasets.

4. information sharing and adaptive management

4.1 Reporting and Sharing Indicators and Key Monitoring Information

A critical step in adaptive management, especially involving numerous partners, is the setting aside of time to consider information, document decisions, and institute changes. Partners should understand their roles and responsibilities and point people should be responsible for leading conversations and ensuring they are documented and shared. Report authors, project team members and project or program leadership can communicate monitoring findings as feasible through local and regional information-sharing venues where Willamette floodplain restoration practitioners exchange best practices and emerging scientific information.

4.2 Venues and Meetings for Information Sharing and Adaptive Management

Forums and events offer key opportunities to use monitoring findings (and other pertinent scientific information, anecdotal reports, and experiential knowledge) to guide and inform decision-making and adaptive program management. We outline audiences, and relevant questions pertinent to adaptive management in Figure 5. Status and trends, effectiveness, and implementation monitoring outputs are updated at different intervals. Each key interest group can integrate monitoring information into annual discussions, as outlined in Table 9, into Annual Adaptive Management discussions (Annual AM) as information becomes available.

Venues include:

- Habitat Technical Team meetings (Table 9)
- WFIP Anchor Habitat Working Group meetings (Table 9)
- OWEB, BPA and MMT annual funder wrap-up meeting (Table 9)
- State of the Willamette meeting (Table 9)
- ISRP meetings and reviews (scheduled every few years – next review in 2021)
- Regional conservation partner gatherings (vary)
- Other state or regional science conferences (vary)

Table 9: Examples of recurring annual meetings for Willamette River restoration programs that were held 2016-2020 and could be a template for future meetings that support adaptive management (AM)

	HTT Meetings*	WFIP AHWG Meetings	Funder Meeting	State of the Willamette**
Jan				
Feb				
Mar		Annual AM		
Apr				
May				
Jun				
Jul				
Aug				
Sep				
Oct	Annual AM			
Nov				
Dec			Annual AM	
Convener	BPA	WFIP	OWEB	WFIP & agencies

*August meetings likely to be cancelled

** State of the Willamette was a meeting held in January 2020 to share science updates among practitioners, scientists, regulators and funders. This event could be repeated in future years.

Figure 5: Adaptive management cycle across monitoring types.

Status and Trends	• Plan: Funders, agencies and technical experts identify and commit to long term strategies • Design: Approaches are built upon existing and vetted technologies and approaches. • Monitor/Analyze: Data are analyzed	• Share and Evaluate: Date are made accessible and understandable • Adjust: A process exists whereby planners and others examine information, identify key take aways and institute changes to priorities and process. These are documented and shared.
Effectiveness	• Plan: Implementers and technical experts determine priority assumptions to test through effectiveness monitoring; assess available and potential budget • Design: Researchers write grants and refine approaches • Monitor: Studies are conducted	• Share and Evaluate: information is analyzed, reported, and discussed with practitioners, funders and agencies • Adjust: A process exists whereby content experts and others examine information, identify key take aways and institute changes. These are documented and shared.
Implementation	• Plan: Implementation experts determine what metrics they can track that can both be feasibly reported and say something meaningful about progress. • Design: A system is set up to collect and aggregate data • Monitor: People input their information	• Share and Evaluate: Reports are released that share information in meaningful ways • Adjust: Processes exist whereby implementers, content experts and funders examine information, identify key take aways and institute changes. These are documented and shared.

The next step is for parties to identify, if they have not already: 1) Who is responsible for leading, documenting, and disseminating adaptive management responses within each of three priority audiences, 2) what will communications about decisions look like, and 3) under what time interval and using what information will adaptive management conversations unfold?

The State of the Willamette is a new convening that took place in January 2020, and hopefully annually thereafter. Its stated purpose is to convene Willamette River restoration partners to share perspectives on the current state of restoration practice, science, and funding, and discuss ways to advance collective actions to improve restoration outcomes across local and regional scales.

Objectives of the convening are to:

- Build a broader understanding of emerging scientific findings and how they might inform future river ecosystem restoration priorities and practices;
- Promote evidence-informed adaptive management and decision making around Willamette River aquatic habitats;
- Connect those working at different scales (e.g., site specific aquatic restoration to basin-wide resource management) to help ensure restoration efforts are complimentary and efficiently applied; and
- Foster a culture of learning and open lines of communication among river ecosystem restoration practitioners, scientists, and funders, including those from Tribes.

In this and other convenings, key leaders can address questions such as those proposed in Table 9, and document findings to support adaptive management. Over time, the annual convening could become a form for priority audiences to hammer out clear next steps.

Table 10: Examples of Adaptive Management questions for different audiences.

	PRIORITY AUDIENCE(S)	ADAPTIVE MANAGEMENT QUESTIONS	POSSIBLE APPROACH
Implementation	• Funders and HTT • Restoration Community	• Are objectives (targets) per investment on track to/being met? If not, why not? • What project costs/actions have we overlooked; what did we do especially well? • Do our goals still make sense?	• OWEB, MMT and BPA discuss and document reflections in annual funder wrap up. • WFIP partners discuss and document at annual meeting.
Effectiveness	• Research and Restoration Community • ISRP and NWPCC	• Are actions leading to expected habitat responses across sampling sites and if not, why not? If so, how can we transfer successes to other sites? • What can we learn and do differently? • Are actions and investments addressing key limiting factors for fish?	• Institute regional gathering every year. • Determine how to best integrate into ISRP process.
Status And Trends	• ISRP and NWPCC • Funders and HTT	• Are actions and investments leading to desired habitat responses for listed native fish? • Are the right agencies and technical leads contributing to data collection and reporting? • Do we have enough data over a sufficient time period to draw inferences and make decisions? • Is there enough funding allocated to monitoring and are the right priorities being funded? • Is collected information being rolled up in ways that inform decision-making? • Is the scale of investment enough to move the dial, both at the locations where we are investing, and in the larger system context? If not, why not? If so, how can we transfer successes to other sites? • Do likely drivers of success/failure fall in the realm(s) of: project potential; investment size; administrative hurdles (e.g. permitting); relationships; external drivers; other? • Do our goals still make sense?	• Funders periodically review outputs and outcomes in the context of investments and realign, readjust or reaffirm investments. • Determine how to best integrate into ISRP process.

4.3 Website

WFIP partners are working to develop and share a website that will share a curated subset of monitoring information and key indicators of river health. Selected implementation, effectiveness, and status and trends data and reports could be posted and distributed would support technical experts, practitioners and others in accessing timely information. It could also encourage researchers and agency partners to support reporting efforts and eventually help provide structure for a multi-organizational monitoring collaborative.

The website, over time, could also highlight social and cultural dimensions of river health and connection that bring broader meaning and importance to the work partners are advancing.

5. vision for a coordinated river-wide implementation and status and trends monitoring program

5.1 Elements of a River-Wide Implementation and Status and Trends Monitoring Program

The workshops, literature review and lessons learned from existing Willamette River monitoring programs highlight the need for a river-wide, coordinated implementation and status and trends monitoring program. Effectiveness monitoring is not included here because this monitoring is typically focused on addressing key questions of a particular restoration program and should be tailored to program-specific needs. Implementation and status and trends monitoring could serve a much broader purpose of providing basic information about restoration accomplishments and river conditions, thereby informing many different restoration and river management programs. This program could draw upon previous sections of this report and would have the following elements:

River-wide implementation monitoring to report restoration and outreach accomplishments for the entire mainstem Willamette River

- **Audience:**
  - The audience would potentially include practitioners, funders, regulatory community, general public and broad spectrum of other conservation organizations and entities interested in Willamette River floodplain ecosystems. However, as stated previously in this report, the key and typically requisite audiences for implementation monitoring are project and program sponsors and funders. Desired audiences also include the broader restoration community, and policy makers.
- **Monitoring infrastructure for implementation monitoring:**
  - Monitoring Purpose: compile restoration accomplishments and outreach activities from a wide variety of funders so that the entire spectrum of Willamette River restoration activities could be summarized in one place.
  - Monitoring elements: Restoration objectives (or targets) and timelines (derived from restoration program goals and objectives) are needed and must be generalized to reflect the various funders and efforts along the Willamette River. Restoration objectives could also reflect existing river-wide conservation goals (such as those outlined in the Willamette Planning Atlas by Hulse and others, 2002) or could be specially developed to reflect stakeholder values.
- **Monitoring processes:**
  - Roles and responsibilities would need to be defined but could build upon lessons learned from the WFIP Implementation Monitoring Program where BEF is the coordinating entity and AHWG partners supply required information in systematic manner.
  - Information could be compiled annually and reported biannually, following the calendar year cycle of the WFIP Implementation Monitoring Program.
  - The biennial report could be publicly available, brief, and easy to understand, similar to the WFIP Implementation Report (AHWG, 2019). Datasets supporting the report (including a database of restoration activities and GIS layers describing locations of these activities) could also be publicly available in a single, unified database.
  - Many aspects of the monitoring infrastructure and processes developed for the WFIP Implementation Reporting could be readily adapted to support a broader, multi-funder river-wide implementation monitoring program.

River-wide status and trends monitoring to report annual and decadal river system conditions for the entire mainstem Willamette River

- Audience: practitioners, funders, regulatory community, general public and broad spectrum of other conservation organizations and entities interested in Willamette River floodplain ecosystems and the status of ESA-listed salmon and steelhead.
- Monitoring infrastructure:
  - » Purpose: Status and trends monitoring will convey information about annual conditions of Willamette River habitat attributes and adult returns of ESA-listed spring Chinook salmon and winter steelhead trout. We feel it is important to summarize flow, temperature, habitat, and fisheries data in a single place so that interested parties can better understand how these conditions vary throughout the year and from year-to-year. Annual metrics would be relatively straightforward to summarize, whereas floodplain attributes that change more gradually and are more expensive to monitor (floodplain forests, channel morphology, native fish communities) would be summarized at decadal intervals.
  - » Monitoring elements: Monitoring indicators and metrics must be defined and could include a blend of annual metrics that are readily summarized from existing, publicly available information (flow, temperature, rearing habitat, fish returns) as well as decadal metrics (floodplain forest, channel complexity, native fish) that require new data collection. See Table 6. Goals for floodplain conditions are needed to provide a basis for comparison with status and trend information, and identify areas where gains and losses in floodplain habitats affect progress toward goals. The Conservation Scenario 2050 goals (Hulse and others, 2002), provide logical starting point for developing refined goals for floodplain forests and channel complexity and native fish communities that could utilize new datasets and scientific understanding gained in the decades since the original goals were developed.
- **Monitoring processes:**
  - » Roles and responsibilities would need to be defined; ideally a single organization would lead the annual status and trends monitoring effort, with other organizations summarizing information from their respective agencies or providing information that others can summarize. The decadal monitoring effort would ideally be overseen by a single entity, with contributions by several different organizations according to expertise and availability.
  - » Annual status and trends conditions could be summarized each year and reported in a website using a series of plots that convey conditions for the previous year, and also summarize each year within a broader context of conditions over recent decades. Annual conditions should be compared against established thresholds (or goals) for fish habitat, health, or population recovery (as appropriate for each metric) to provide a basis for evaluating conditions in a particular year.
  - » Decadal reporting could vary from simple summaries to a more in-depth scientific report that describes temporal and spatial changes over time and explains causal factors for observed patterns. Decadal reporting should also compare status and trends of floodplain conditions with refined goals for floodplain conditions.
  - » Datasets generated from status and trends reporting would include flow, temperature and fish returns, along with GIS layers of floodplain forest, channel complexity and a fish database of fish sampling locations and findings. These datasets are the foundation of many other studies and provide necessary context to support restoration planning. These datasets must be publicly shared with metadata. Because they will likely be stored in different locations owing to different organizations that collect this information, a single website could point an audience to the locations of these data.

The Conservation Scenario

2050 goals

(Hulse and others, 2002), provide logical starting point for developing refined goals for floodplain forests and channel complexity and native fish communities that could utilize new datasets and scientific understanding gained in the decades since the original goals were developed.

Effectiveness Monitoring would be carried out in the future for individual restoration projects or programs according to the specific needs of those programs. Any future effectiveness monitoring could incorporate findings from this report (see section "3.2 Effectiveness Monitoring"). It may also be possible to develop an effectiveness monitoring program that could support several different restoration and environmental flow programs. However, as of 2021, all three of the current Willamette River restoration programs (WFIP, WRI and Willamette Habitat Program) have either ended or are in their final years of implementation, and there are no concrete plans for river-scale restoration programs to replace the programs currently underway. Hence, it is not practical at this time to make specific recommendations for effectiveness monitoring program(s) to inform restoration programs that do not currently exist, any future effectiveness monitoring program should include the following elements:

- Clearly established restoration goals, objectives and actions must be communicated by the restoration program to provide a basis for effectiveness monitoring. Ideally, SMART objectives would be developed for the restoration program (as recommended by ISRP).
- Hypothesized linkages between restoration goals, actions and hypothesized ecological responses should be communicated in a Results Chain or Theory of Change. Each hypothesized linkage in the Theory of Change could be classified in terms of uncertainty (or more ideally, in terms of risk to the floodplain ecosystem if the hypothesized outcomes are incorrect) to provide a basis for prioritizing effectiveness monitoring efforts.
- Established linkages among restoration goals, actions and the appropriate monitoring indicators, metrics and approaches for effectiveness monitoring.
- Annual data collection that proceeds in accordance with annual monitoring plans (grounded in a monitoring framework that reflect available monitoring resources, site conditions, priorities and other factors).
- Monitoring plans that support partners in selecting among the indicators, metrics and approaches of the monitoring framework.
- Diverse reporting fora that include informal and published datasets and written syntheses of findings. Interpretive reporting that describes monitoring approaches, findings and context of these findings amid other factors influencing floodplain habitats is essential for adaptively refining restoration program goals and activities. Datasets and reports will ideally undergo peer-review.

Linkages among implementation, effectiveness and status and trend monitoring:

- The findings from each type of monitoring (implementation, effectiveness, status and trends) will be most meaningful if the reporting connects audiences with information in a holistic way. For example, information describing restoration actions (from implementation monitoring) will be most impactful if audiences can visualize a) the spatial context of these actions, b) the extent to which restoration is addressing known gaps in floodplain habitats and c) the overall impact of restoration on floodplain conditions. While there are a variety of means to illustrate linkages among the implementation, status and trend, and effectiveness monitoring to tell a broader story about impact and context of restoration actions, Figure 6 illustrates a simple depiction of these linkages and could be adapted The specific plans for integrating

Information describing restoration actions (from implementation monitoring) will be most impactful if audiences can visualize:

A

The spatial context of actions

B

The extent to which restoration is addressing known gaps in floodplain habitat

C

The overall impact of restoration on floodplain conditions

implementation, effectiveness and status and trend monitoring into future reporting efforts will depend upon the goals and resources for future monitoring, but some examples could include:

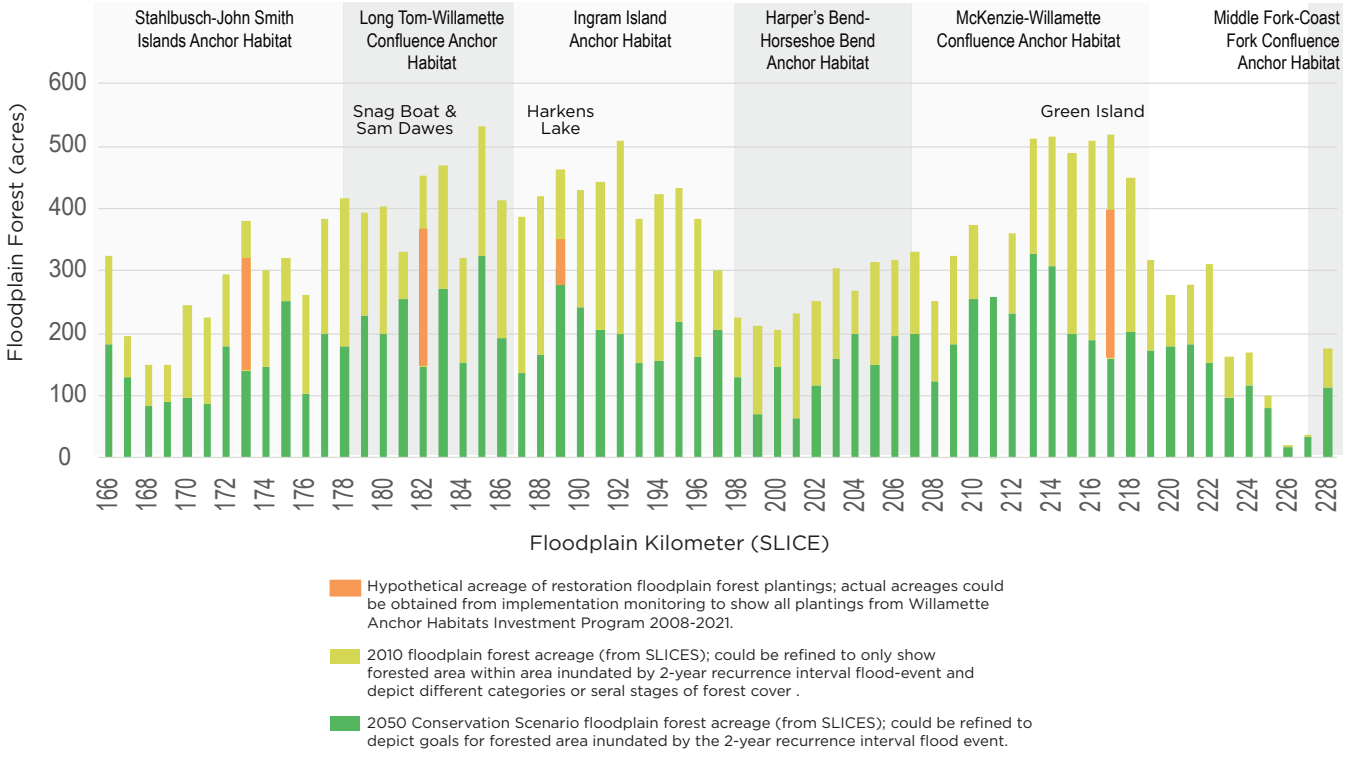
- As part of regular implementation reporting, river-scale graphs of floodplain conditions (derived from status and trend monitoring) could be presented to highlight the locations where restoration projects occurred and how those actions contribute to program goals (Figure 6).
- As part of effectiveness monitoring reporting, the effectiveness of restoration actions at increasing floodplain habitats could be described in terms of river or reach scale conditions and illustrated in plots such as Figure 6. Such information is needed to address questions such as: how does the area of newly planted floodplain forest (as part of restoration efforts) compare with the amount existing forest within the area inundated by the 2-year recurrence interval flood? Were floodplain forest planting efforts effective at addressing known gaps in floodplain forest?
- As part of status and trend monitoring, the relative impact of floodplain forest planting could be described within the context of river-scale conditions, and gains and losses due to other natural and anthropogenic influences. Questions to address could include: how does the area of new forest from restoration planting compare with area lost due to land development or area gained by natural vegetation recruitment?

To facilitate meaningful linkages among implementation, effectiveness and status and trends monitoring, each program will need to report information in timeframes and format that are relevant and comparable with the data from other programs. The following considerations would facilitate linkages between implementation, effectiveness and status and trend data.

- Implementation monitoring
  - A single database of Willamette River restoration actions could summarize restoration actions by many different funders. In addition to spreadsheet-based database, geo-referenced, standardized GIS datasets of restoration projects could be prepared with supporting metadata. This would require a data steward to collect, QAQC and standardize the GIS layers developed by individual restoration groups. This standardization and development of a single geodatabase of restoration actions is necessary to compare the many different site-level restoration actions with river-scale GIS datasets from status and trend monitoring. This data compilation could build upon the WFIP Implementation program, but will require more information and QAQC to permit scientific evaluation than may be needed solely for implementation reporting purposes. This database could be updated annually and shared with monitoring partners to facilitate effectiveness monitoring, although formal reporting may occur less frequently.
  - To extent feasible, implementation indicators and metrics could be comparable to those from effectiveness and status and trends monitoring.
- Effectiveness monitoring
  - A single database of effectiveness monitoring activities, including locations for data collection and types of data collection is needed to facilitate collaboration among entities involved in data collection. This database should include spreadsheets of monitoring activities and associated GIS layers describing the locations of those activities. Such a database could be updated annually when monitoring plans are developed.
- Status and trend monitoring
  - Refinement of channel complexity and floodplain forest databases and GIS layers are needed to facilitate detailed comparisons with implementation and effectiveness data and tell nuanced stories about Willamette River floodplain conditions. The SLICES datasets (including tabular data and GIS layers of each SLICE, attributed with area of floodplain forest and other information) provide a comprehensive foundation for status and trend reporting, but additional refinement of these datasets and databases is needed.

- For river-scale mapping datasets (channel complexity, floodplain forests), GIS layers of these maps must be published with supporting metadata to compare site-level conditions at restoration projects with reach and river-scale conditions. Mapped features could be attributed with contextual data to facilitate summaries relevant to restoration actions. For example, floodplain forest polygons could be attributed with information describing which side of the river they are located on, hydrogeomorphic zone, inundation frequency and seral stage (see legend text from Figure 6). Additionally, channel complexity is measured based on low-flow inundation (mapped from aerial photographs) and is not comparable with restoration actions that increase inundation at high flows. Indicators of high-flow inundation or habitat availability could be developed to facilitate comparisons between restoration actions and existing conditions.
- Tabular databases and reports could summarize this information to provide context for considering the relative impact of restoration projects. For example, in order to understand how floodplain forest plantings (from implementation monitoring) compare with the area of existing forest in the 2-year recurrence interval floodplain, such information must first be described in the status and trend monitoring database and GIS files. Some of this information is already in SLICES, but additional refinement to determine exact locations and types of existing floodplain forest.
- A database (tabular database and associated GIS layers) of Willamette River fish communities is essential for tracking changes in native fish communities and assessing the likely communities in the vicinity of restoration sites. The native fish database developed by Stan Gregory provides foundation for this effort, but funding is needed to ensure long-term maintenance and web hosting for this database (in addition to future data collection).

Figure 6. Example of graph showing floodplain forest acreage for the Upper Willamette River, including forest area from status and trend monitoring and hypothetical area of floodplain forest plantings (that could be obtained from implementation monitoring). With substantial refinement, such a plot could be part of effectiveness or status and trend monitoring (to illustrate cumulative effects of floodplain forest planting on overall system conditions) or it could be included in Implementation reporting to highlight areas of floodplain forest plantings and relationship with system-wide goals and conditions.



5.2 Potential Costs for River-wide Implementation and Status and Trends Monitoring

The proposed river-wide implementation and status and trends monitoring effort envisioned in this report would require funding to plan, execute, and share findings from these efforts. This funding would likely originate from a diverse network of partners including public and private funders; non-governmental organizations; university researchers; and municipal, county, state and federal agencies, all aligned around the common goal of improving the health of the river for people and floodplain ecosystems. We provide estimates of potential cost ranges for this effort to inform future discussions about river-scale monitoring. While estimates presented here are wide-ranging to reflect differences in the scope, approaches, and organizations that may carry out this work, the cost estimates are still helpful for framing potential funding needs and may help support decision-making and prioritization across audiences.

Table 11: Estimated cost ranges for past river-scale monitoring efforts in the Willamette Basin between 2008-2020.

WHAT	LEAD ORGANIZERS/ PREPARER(S) OF PAST OR CURRENT PROGRAMS	TIMING/ FREQUENCY OF MONITORING FOR CURRENT PROGRAMS	APPROXIMATE ANNUAL COSTS OF PAST EFFORTS[1]	CURRENTLY FUNDED?	CONSIDERATIONS FOR FUTURE COSTS
Implementation Reporting	BEF and OWEB FIP grantees	Annual	$2,000-10,000	Yes, through 2021.	Will depend upon the scope and scale of restoration efforts summarized.
Stratified Status and Trends	USGS (developing templates and initial report, in future could be others)	Annual	~$120,000	Yes, for 2020/21 to develop templates for future.	Future years may be cheaper once template is established. Will also require maintenance of website.
Effectiveness Monitoring, including publication of datasets and research reports	USGS, Benton SWCD, PSU, USFS	Annual, varies by study	$100,000-200,000	Yes, through 2022. Evaluation of findings not currently funded.	Future costs likely higher because WFIP Effectiveness Monitoring included substantial in-kind support from many organizations (USGS, USFS).
SLICES Floodplain forest, channel length and complexity	U of O	Every ten years	$20,000-150,000	No.	Future mapping costs may decrease if using automated approaches, but reporting and story telling will increase costs.
Fish Community Monitoring	USFS/OSU (continuation of OSU sampling)	Annual	50,000-100,000	Yes.	Future costs are likely much higher than past because OSU provided substantial in-kind support.
Program-scale Effectiveness Monitoring Summary Report	USGS, PSU, Benton SWCD	At the completion of program activities (2023-24)	TBD	No.	
Website	AHWG, BEF	Ongoing	TBD	No.	

[1] Cost ranges are for approximate costs of current monitoring programs, where in-kind salaries and other costs for multi-organizational monitoring programs were roughly estimated at 2019-2020 rates and added to costs directly provided by OWEB, BPA, and MMT.

5.3 A Basin-Wide Monitoring and Adaptive Management Partnership

Willamette River floodplain monitoring and adaptive management will evolve through time, hopefully expanding and becoming more robust as a funding collaborative takes shape, and with structured support to:

- Track progress toward programmatic objectives (or targets), refine the results chain (building from the framework described herein);
- Ensure that meetings and discussions around adaptive refinement of monitoring and evaluation occur and are informed by relevant monitoring information;
- Retain long-term data integrity and usability and continue to meet the needs of successive iterations of Willamette-wide action plans;
- House and manage web-based data storage and information sharing;
- Regularly track and make known to others the overall results of all three types of monitoring in the Willamette floodplain to inform adaptive responses; and
- Support partners in accessing information, as funding allows.

6. looking forward

This Framework serves as a starting point for further refinement that will rely upon on the collaboration, investment, and engagement of multiple partners and stakeholders.

When monitoring is linked to restoration goals and objectives and hypotheses linking restoration program goals, actions and anticipated outcomes for floodplain ecosystems are described in a results chain, monitoring can assess progress towards goals and refine uncertainties to increase restoration effectiveness and help restoration efforts to strategically address key habitat limitations. Overall, strategic implementation, effectiveness and status and trend monitoring can increase the impacts of floodplain habitat enhancement actions and inform adaptive management and refinement of projects, programs, and system-wide conservation efforts. A logical next step could be further distillation of these concepts to illustrate how implementation, effectiveness and status and trend monitoring could be developed and applied in an adaptive-management context for the Willamette River floodplain.

It is also important to acknowledge that restoration actions occur at a site scale within a large, complex river basin that is affected by several factors that are out of our control. We collect and assess observations at multiple scales to help us evaluate project level actions within the context of broader reach and river-scale processes over time. The monitoring framework incorporates multiple spatial and temporal scales so that we can determine the relative role of site-scale restoration actions amid other influences (like floods) that influence the entire river. Site-level observations for the implementation and effectiveness monitoring programs are targeted so that we can link specific actions to specific ecological processes or functions. Reach-scale observations for the status and trends monitoring are intended to inform reach-level planning and track the status of key metrics along the entire river corridor. However, connecting the dots between site-level conditions, river-scale conditions and the natural and anthropogenic processes that shape the river corridor requires data analyses, interpretation and story-telling, that must be considered as part of future monitoring efforts. Although stakeholders across the Willamette River Basin have expressed a desire to understand these broader stories, there is currently no funding or plans for this broader synthesis. Successfully telling these larger landscape stories and linking site, reach, and river-scale conditions with restoration efforts benefits not only rearing and migration of listed salmonids, but also native fish and riparian wildlife communities as well (ISAB 2011. Moreover, we believe that these efforts will inform and advance aspects of the Willamette River Network, as well as align with future efforts to engage the public and integrate social goals.

The literature offers many examples of monitoring approaches that, due to their complexity, large number of objectives, and intensity of sampling regimes could not be sustained over the timeframes required to track recovery of the system in question (Vaudor et al. 2015). To avoid that outcome, we have narrowed the restoration objectives (or targets) and associated metrics to be measured to the minimum 'backbone' set that we believe is affordable and scientifically defensible. There are many important ecological and physical phenomena that this report does not recommend measuring. We made difficult choices in an effort to propose an affordable and defensible approach to linking implementation, effectiveness, and status and trends monitoring of habitat in the Willamette River floodplain.

Through coordinating monitoring efforts, we will see gains made in working collaboratively in the Willamette Basin between restoration practitioners and the academic and scientific communities. By working together on project planning, prioritization, and monitoring, we strengthen the connection between science and implementation, allowing us to apply lessons learned from projects and informing restoration approaches and future priorities.

Our monitoring approach is ambitious, and we have endeavored to identify metrics for each action that are both feasible and meaningful. We have worked to identify ways to use the same data to shed light on multiple hypotheses and to leverage the work of many implementer and agency partners. We have identified a process in place to further hone this approach (pending funding), while still delivering meaningful monitoring and measures for tracking outputs and progress toward outcomes.

7. literature cited

Anchor Habitats Working Group, 2019, 2017-2018 Implementation Reporting, Willamette Anchor Habitat Working Group Progress Update. 4 pgs.

Anchor Habitat Working Group [AHWG], 2015, Upper and Middle Willamette Strategic Action Plan, Appendix C of the Application for Focused Investment Partnership Application, submitted to OWEB, October 2015, 142 p.

Cline, S.P., L.S. McAllister. 2012. Plant succession after hydrologic disturbance: inferences from contemporary vegetation on a chronosequence of bars, Willamette River, Oregon, USA. River Research and Applications. 28: 1519-1539.

EPA. 2002. Willamette Basin Alternative Futures Analysis. Office of Research and Development. Washington, D.C. Willamette Basin Alternative Futures Analysis

Gregory, S.V., F.J. Swanson, W.A. McKee, K. Cummins. 1991. An ecosystem perspective of riparian zones. Bioscience. Vol. 41, No. 8. 540-551.

Gregory, S., L. Ashkenas, P. Haggerty, D. Oetter, K. Wildman, D. Hulse, A. Branscomb, J. Van Sickle. 2002. Riparian Vegetation pp. 40-43 in Ch. 4 Willamette River Basin Planning Atlas: Trajectories of environmental and ecological change. Oregon State University Press, Corvallis, Oregon 97333. 180 pp ISBN 0-87071-542-9.

Hudson, W., K. Bierly, P. Burgess, K. Fetcho, S. Gregory, B. Graham-Hudson, D. Hulse, K. Moore, A. Mullan, R. Wallick, D. Welch, P. Wiley. 2015. Tracking Progress in Restoring the Willamette River Floodplain. A Report to the Habitat Technical Team of the Willamette Action Team for Ecosystem Restoration. 15 pp.

Hulse, D., S. Gregory, J. Baker. (Eds). 2002. Willamette River Basin Planning Atlas: Trajectories of environmental and ecological change. (2nd edition). Oregon State University Press, Corvallis, Oregon 97333. 180 p. ISBN 0-87071-542-9.

Hulse, D., A. Branscomb, S. Payne. 2004. Envisioning Alternatives: using citizen guidance to map future land and water use. Ecological Applications. v. 14, no. 2, pp. 325-341.

Hulse, D.H., and S.V. Gregory. 2004. Integrating resilience into floodplain restoration. Urban Ecosystems 7: 295–314.

ISAB (Independent Scientific Advisory Board). 2011. Using a comprehensive landscape approach for more effective conservation and restoration. ISAB-2011-4. Sept. 30, 2011.

ISRP (Independent Scientific Review Panel). 2017. Review of Umbrella Habitat Restoration Projects. ISRP 2017-2, March 10, 2017.

Keith, M., Wallick, J., Brown, L., Flitcroft, B., Kock, T., Hagar, J., Miller, R., Guillozet, K., and K. Jones. In press. Monitoring Framework to Evaluate Effectiveness of Aquatic and Floodplain Habitat Restoration activities for the Willamette Focused Investment Partnership, Willamette River Oregon., USGS Open File Report. 186 pgs plus figures, tables and appendices.

NMFS. 2005a. Endangered and threatened species; final listing determinations for 16 evolutionarily significant units of West Coast salmon, and final 4(d) protective regulations for threatened salmonid ESUs. Final rule. Federal Register 70:123(28 June 2005):37160-37204.

NMFS. 2005b. Endangered and threatened species; designation of critical habitat for 12 evolutionarily significant units of West Coast salmon and steelhead in Washington, Oregon, and Idaho. Final rule. Federal Register 70 (2 September): 52630.

NMFS. 2008. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation on the "Willamette River Basin Flood Control Project".

NOAA. 2008. Willamette Project Biological Opinion. https://www.fisheries.noaa.gov/west-coast/endangered-species-conservation/willamette-river-biological-opinion

Northwest Power and Conservation Council (NP&CC). 2014. Columbia River Basin Fish and Wildlife Program. Northwest Power and Conservation Council document 2014-12, October 2014.

ODFW and NMFS. 2011. Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead. August 5, 2011. Beamesderfer, R., L. Berg, M. Chilcote, J. Firman, E. Gilbert, K. Goodson, D. Jepsen, L. Kruzic, S. Knapp, B. McIntosh, J. Nicholas, J. Rodgers, T. Stahl, B. Taylor, R. Walton.

Oregon Department of Agriculture [ODA]. 2017. Agricultural Water Quality Management Program Monitoring Strategy December 2017 Prepared by Ellen Hammond Oregon Department of Agriculture Water Quality Program. Salem, OR.

Oregon Watershed Enhancement Board [OWEB], 2019, Progress Monitoring Framework for the Willamette Mainstem Anchor Habitat Working Group, Upper and Middle Willamette Mainstem Anchor Habitats: Oregon Watershed Enhancement Board, 8 p.

Overstreet, B.T., 2020, Mapping riverscapes using high spatial resolution remote sensing data: Laramie, Wyoming, University of Wyoming, Ph.D. dissertation, 168 p.

The Nature Conservancy (TNC). 2012. Willamette Basin Synthesis Project Map (created 2008, updated 2012).

U.S. Fish and Wildlife Service. 2017. Willamette Valley Conservation Study. Pacific Region, Portland, Oregon. 148 pp.

USFWS. 2008. Biological Opinion on the Continued Operation and Maintenance of the Willamette River Basin Project and Effects to Oregon Chub, Bull Trout, and Bull Trout Critical Habitat Designated Under the Endangered Species Act. As Proposed by: U.S. Army Corps of Engineers (Department of Army) Bonneville Power Administration (Department of Energy) and Bureau of Reclamation (Department of Interior).

Vaudor, L., N. Lamouroux, J-M Olivier, M. Forcellini. 2015. How sampling influences the statistical power to detect changes in abundances: an application to river restoration. Freshwater Biology 60: 1192-1207. DOI: 10.1111/fwb.12513

Wallick, J.R., Keith, M.K., Guillozet, K. and L. Brown, 2019. General Monitoring Plan for the Willamette FIP Effectiveness Monitoring Program. 24 p.

Wallick, J.R., K.L. Jones, J.E. O'Connor, M.K. Keith, D. Hulse, and S.V. Gregory. 2013. Geomorphic and vegetation processes of the Willamette River floodplain, Oregon—Current understanding and unanswered questions: U.S. Geological Survey Open-File Report 2013-1246., 70 p., http://dx.doi.org/10.3133/ofr20131246.

Warren, R., Moote, A., Arnold, J., and Mork, L., 2019, Adaptively Managing Restoration Initiatives, a guide prepared for Oregon Watershed Enhancement Board's Focused Investment Partnership. 31 p., accessed July 23, 2020 at https://www.oregon.gov/oweb/Documents/FIP-2019-Adaptively-Managing-Restoration-Initiatives.pdf

Wayne State University, 2020. S.M.A.R.T. Objectives - Wayne LEADS - Wayne State University. Accessed December 23, 2020 at https://hr.wayne.edu/leads/phase1/smart-objectives

appendices

Appendix A: Willamette Monitoring – Stakeholder Recommendations

Willamette Mainstem Shared Monitoring Framework Planning – Input from Stakeholder Workshops

The following is an informal summary of feedback provided by the approximately 90 individuals who attended workshops in Portland (June 21, 2018), Salem (May 14, 2018), and Eugene, OR (February 22, 2018).

Thoughts on why monitoring is needed and the values served by coordinated monitoring:

- Document cumulative achievements, build a central clearinghouse of accomplishments, and demonstrate progress toward program goals and objectives.
- Provide information for numerous stakeholders. Funders, ISRP, OWEB, decision makers, board members, environmental advocates, critics, neighbors/landowners, policy makers, program managers, legislators, regulators, public, media etc.
- Inform and guide funding. Understand what was implemented with requested funding, document value of investments, and demonstrate work is being done as proposed. Assist funders in assessing effectiveness of programs and respond/adjust at a programmatic level. Make the case for larger investments because need is demonstrated. Open opportunities to leverage more resources, align multiple funders in support of larger projects, and increase funding support from the private sector. Ascertain what kind of information is need for funding audiences.
- Facilitate adaptive management and decision-making. Test program hypotheses, demonstrate proof-of-concept, facilitate adaptation, calibrate expectations regarding time and level of intensity required to achieve goals, support project prioritization.
- Increase peer-to-peer learning and coordination. Foster creativity and innovation, support momentum and morale.
- Avoid duplication, non-standardization, and limited-use data. Currently, data are not standardized, are scattered across many organizations, and communication between important parties is not sufficient.
- Understand overall river health conditions, trends, trajectories, benefits and linkages. Track system level progress and cumulative effects (including climate, land use change, policy impacts).
- Provide ancillary benefits: facilitating permit compliance.

Key ideas shared:

- Establish a clear plan, lead entity, and coordination framework. A multi-consortium plan and a lead entity for coordinating a monitoring program are needed.
- Develop a strategic monitoring approach. “Measure and monitor what you can control. Focus on the most important questions and what can be reasonably tracked, what conclusions can be reasonably drawn. Measure at only a subset of representative fixed reference sites and track changes to those locations over time. Ensure metrics are scalable (from site to system). Consider costs, benefits, importance, and the need for pragmatism. Always pilot test monitoring approaches.”
- Focus on processes and structure. “Monitoring should measure complexity and connectivity, not species, temp, water quality, habitat, flow attenuation and vegetation. Move from single species monitoring to measures/metrics of broader sustained diversity.”

- Avoid unintended constraints. “Restoration actions should not be driven to achieve desired monitoring results at the expense of allowing natural ecosystem processes of change, disturbance and evolution.”
- Consider data collection and management challenges. Anticipate the expense of collecting data; expertise needed to collect data; data management and storage needs; difficulty of ensuring consistency across projects, personnel, and time; variability due to factors such as flow year, and site accessibility.
- Have multiple reporting venues and formats. Share results through a mix of meetings, publications, newsletters, etc. “Encourage reporting of failures too.”
- Use past or existing data where feasible. Capitalize on and coordinate with existing or past monitoring efforts (e.g., CREP, Stillwater, EQUIP, Columbia Basin etc.). If efforts are coordinated, costs are lower and monitoring becomes more feasible.
- Implementation monitoring timing and frequency: Monitor before action, annually during construction, immediately after construction, intermittently after construction (every 3-5 years), and immediately following large flood events.
- Effectiveness monitoring timing and frequency: Required frequency depends on the question, parameter, application, need. Measure pre- and post-project completion, and then collect and report intermittently for 10-15 years to track how projects mature over time and perform.
- Status and trends monitoring timing and frequency: Report on river health status and trends at least every 5 years (for human attention spans and decision-making time ranges) and every 10 years to be able to see changes for some indicators.

Additional thoughts and concerns:

- Double Counting. Multiple actions can occur at one site -- need to ensure monitoring does not double count impacts.
- Costs and Trade-Offs. Will monitoring costs detract from projects that could advance the biologic uplift? What are the benefits?
- Results interpretation. Ensure data being collected realistically reflects each project’s effectiveness. “Projects can be effective but measuring and understanding site level effectiveness and the relationship to landscape change or lack thereof is even harder.”
- Expectations. Need realistic expectations about the restoration impacts and monitoring program.
- Unintended, undocumented or uncomfortable results: What if results show little/no progress? What if what we’re doing isn’t working and we need to change course? What about positive or adverse effects that are not measured or are immeasurable?
- Effectiveness research. Difficult, and should be employed very strategically. What do you test? What data are easy to collect and cheap? How large does the sample size need to be? Does site variation become an issue? Are data being collected getting to the right questions? Are the right questions being asked? Is data collection rigorous enough to be able to stand up to scrutiny?

Appendix B: Review of Other Multi-Organizational Monitoring Programs

Table 10: Appendix B: Examples of Ecosystem Monitoring and Adaptive Management Program

GEOGRAPHIC SCOPE	PROGRAM PERIOD	MONITORING OBJECTIVES (S&T; EFFECTIVENESS; IMPLEMENTATION)	RESOURCES OR CONDITIONS MONITORED	LEAD ORG(S)
San Gabriel River Regional Monitoring Program http://108.163.237.35/sgrrmp/index.html				
CA - 1,236 miles of streams stretching from the San Gabriel Mountains to the Pacific Ocean	2005-2018	S&T: provide regional information specifically designed to answer the five key management questions: **1.** What is the condition of streams in the watershed? **2.** Are conditions at areas of unique interest getting better or worse? **3.** Are receiving waters near discharges meeting water quality objectives? **4.** Is it safe to swim? **5.** Are locally caught fish safe to eat? A specific monitoring design was established for each of these questions that included a set of parameters to be measured and an analysis approach to help managers answer these questions.	Macroinvertebrates; physical habitats; water quality and toxicity	Multiple stakeholders representing major permittees, regulatory and management agencies, and conservation groups
Sacramento River Monitoring and Assessment Project https://www.sacramentoriver.org/forum/index.php?id=sacmon; http://www.sacriver.org/aboutwatershed/reportcard				
CA - middle Sacramento River	2007ish - present	Evaluate ecosystem integrity and assess restoration success on the Middle Sacramento River; track riparian vegetation, channel, and floodplain forest riparian condition and recovery in response to natural variation and to various management actions.	Five key components: the Sacramento River riparian map, vegetation analysis, channel morphology and dynamics analysis, Sacramento River ecosystem scorecard and monitoring plan.	TNC, UC Davis, CSU Chico, UC Santa Cruz, and The Nature Conservancy
Salt River Restoration AM Plan* http://humboldtrcd.org/SaltRiverAMPFinal.pdf				
CA - Salt River (Humboldt County, CA)	2011-?	S&T, Effectiveness: evaluate impacts of restoration activities.	Erosion/sediment deposition; tidal exchange; bridges and culverts.	?
San Joaquin Flow Restoration Monitoring* http://www.restoresjr.net/monitoring-data/monitoring-and-analysis-plan/				
CA - San Joaquin River (CA)	2015-?	S&T, Effectiveness: inform adaptive management of the San Joaquin River Restoration Program (ESA driven).	Flow; conveyance; adult migration; entrainment; predation; rearing habitat.	San Joaquin River Restoration Program

GEOGRAPHIC SCOPE	PROGRAM PERIOD	MONITORING OBJECTIVES (S&T; EFFECTIVENESS; IMPLEMENTATION)	RESOURCES OR CONDITIONS MONITORED	LEAD ORG(S)
South Yuba River Citizen Monitoring Plan https://yubariver.org/our-work/river-monitoring/; State of the Yuba Report				
CA - South Yuba River, CA	2000-2018	S&T: use volunteers to collect information about biology and water quality of the Yuba River.	Water quality, sensitive and invasive species, contaminants.	South River Yuba
ODA Ag Water Quality Program https://www.oregon.gov/ODA/programs/Pesticides/Documents/PARCMaterials/May2017/Presentation.pdf				
OR - 9 pilot watersheds (?)	2016 to present	S&T, Effectiveness: survey to detect the presence of 100+ pesticides where pesticide loading is found, implement a water quality improvement program, retest for presence of pesticides.	100+ pesticides.	Oregon Department of Agriculture
Portland Area Watershed Monitoring and Assessment Program* https://www.portlandoregon.gov/bes/article/489038				
OR - greater Portland area	?-2018	S&T: measure the city's current and changing ecological resources. The program systematically measures changes in habitat, water quality and biological communities over time" and includes Willamette River; Johnson, Fanno, and Tryon Creeks, and Columbia Slough.	Instream and riparian habitat; water quality including temperature, oxygen, pathogens, and metals; macroinvertebrates; mish; riparian birds.	City of Portland
OWEB/ODFW Oregon Watershed Restoration Inventory https://www.dfw.state.or.us/wildlife/willamette_wmp/index.asp https://apps.wrd.state.or.us/apps/oweb/owrio/default.aspx				
OR – Oregon	1997-2018	Implementation and Effectiveness: collecting information on watershed restoration projects to track on-the-ground efforts to restore aquatic habitat and water quality conditions in Oregon.	See OWRI data dictionary available here: http://oregonexplorer.info/content/enhancing-watersheds-oregon?topic=56&ptopic=38#TheOWRIDatabaseandGISdata	OWEB
Oregon DEQ - Water Quality Monitoring Program https://www.oregon.gov/deq/wq/Pages/WQ-Monitoring.aspx https://www.oregon.gov/deq/wq/Pages/WQ-Assessment.aspx				
OR - Oregon-wide	? to present	S&T: Every two years, DEQ is required to assess water quality and report to the U.S. Environmental Protection Agency on the condition of Oregon's waters. DEQ prepares an Integrated Report that meets the requirements of the federal Clean Water Act for Sections 305(b) and 303(d).	Toxics in sediment, water column, tissue; (more to come....)	Oregon DEQ

GEOGRAPHIC SCOPE	PROGRAM PERIOD	MONITORING OBJECTIVES (S&T; EFFECTIVENESS; IMPLEMENTATION)	RESOURCES OR CONDITIONS MONITORED	LEAD ORG(S)
Sandy River Partnership https://www.thefreshwatertrust.org/case-study/sandy-river-basin-partnership/				
OR - Sandy River Basin	2005-??	Implementation and Effectiveness: Assess effectiveness of restoration actions.	Physical pre- and post-restoration monitoring has included cross-section and longitudinal (lengthwise) profile measurements of the stream channel, streambed pebble counts, stream habitat surveys, and photo point documentation; over 20 years of continuous smolt (young salmon or trout) out-migration monitoring and spawning surveys. Physical habitat surveys are repeated following construction and after events such as flooding.	Freshwater Trust
BEF Model Watershed Program http://www.longtom.org/science-projects/surveys-monitoring/ http://www.longtom.org/science-projects/surveys-monitoring/model-watershed-10-year-monitoring/				
OR - Six basins, including the Long Tom	2009-2018	S&T, Effectiveness: to learn how conditions are changing as well as to measure the effectiveness of restoration efforts.	1) Biological (e.g. fish density, macroinvertebrate presence and diversity) 2) Chemical (e.g. water temperature, bacteria, nutrients) 3) Physical (e.g. frequency of large wood, percent canopy cover, substrate quality, variation in stream depth).	BEF; Long Tom Watershed Council
Willamette Wildlife Mitigation Program Monitoring Plan https://www.nwcouncil.org/reports/review-of-draft-willamette-wildlife-monitoring-plan				
OR - Willamette	2016-2021	Implementation and Effectiveness: to track progress toward meeting WWMP acreage goals established through the 2010 Willamette River Basin Memorandum of Agreement Regarding Wildlife Habitat Protection and Enhancement between the State of Oregon and the Bonneville Power Administration (MOA); to ensure compliance with terms established in each site's conservation easement and management plan; to evaluate effectiveness at protecting or enhancing habitat conservation values on WWMP-protected lands; and to inform adaptive management and direction of the WWMP, including how WWMP implementation fits into broader landscape conservation efforts.		ODFW

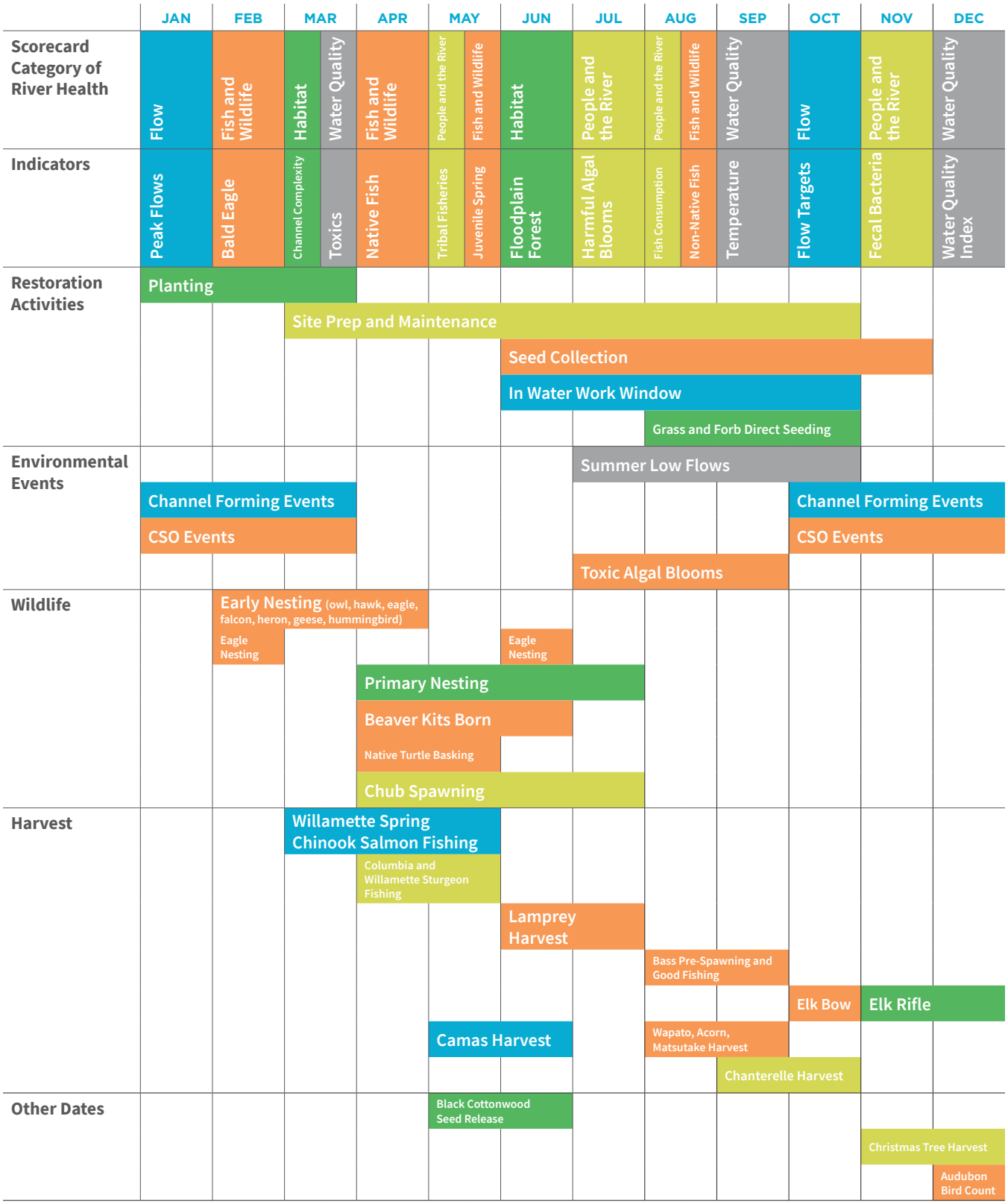
GEOGRAPHIC SCOPE	PROGRAM PERIOD	MONITORING OBJECTIVES (S&T; EFFECTIVENESS; IMPLEMENTATION)	RESOURCES OR CONDITIONS MONITORED	LEAD ORG(S)
Clackamas River Partnership https://www.clackamaspartnership.org/				
OR - Clackamas River Basin	2019-2025	Implementation and Effectiveness: track performance measures at project sites: https://www.clackamaspartnership.org/PerformanceMeasure/Index	Stream length, floodplain acres, number of restoration actions completed.	Clackamas River Basin Council
Lower Columbia Estuary Monitoring Plan* http://www.estuarypartnership.org/our-work/ecosystem-monitoring/ecosystem-condition-monitoring/				
OR/WA - Columbia River Estuary	2005-2018	S&T and Effectiveness: monitor long-term estuary habitat and toxic compound trends; assess effectiveness of restoration actions.	Habitat, toxics, juvenile fish use, vegetation, channel formation, water quality, sedimentation (monitoring of several key metrics at fixed and rotating sites throughout the lower river and estuary. Sites are systematically selected, based on specific river reaches defined in the Columbia River Estuarine Ecosystem Classification. Habitat monitoring has revealed key information about the Lower Columbia's tidally-influenced wetlands).	Lower Columbia River Estuary Partnership
Lower Columbia Habitat Status and Trends Monitoring https://www.pnamp.org/project/3132 https://www.pnamp.org/project/4585				
OR/WA - Lower Columbia Basin	? TBD - planning underway	S&T: habitats of mainstem and tributaries of the lower Columbia River up to White Salmon/Hood River; monitoring designed to support the recovery of salmonid species listed as threatened or endangered under the Endangered Species Act (Chinook, coho, chum, and steelhead), and addressing anticipated future monitoring requirements under municipal stormwater National Pollutant Discharge Elimination System (NPDES) permits for eight jurisdictions in southwest Washington.	Water temperature, conductivity, and stage (all continuously measured and recorded); sediment; metals; macroinvertebrates; bankfull width; bankfull depth; wetted width; and substrate size (all annually).	Pacific Northwest Aquatic Monitoring Partnership
Puget Sound Ecosystem Monitoring Program* http://www.psp.wa.gov/evaluating-PSEMP.php; http://www.psp.wa.gov/evaluating-vital-signs.php				
OR/WA - Puget Sound	2010(ish)? - present	S&T and Effectiveness: monitor ecosystem and human vital signs (tied to recovery goals); assess effectiveness of actions; "to evaluate progress toward ecosystem recovery and to serve as a foundation to continually improve the scientific basis for management actions in the Puget Sound."	Marine water quality, freshwater quality, nearshore systems, forage fish, food webs, salmon, birds, marine mammals, toxics, stormwater, modeling, terrestrial systems, and diseases.	Puget Sound Partnership

GEOGRAPHIC SCOPE	PROGRAM PERIOD	MONITORING OBJECTIVES (S&T; EFFECTIVENESS; IMPLEMENTATION)	RESOURCES OR CONDITIONS MONITORED	LEAD ORG(S)
Washington State Stream Habitat Monitoring https://ecology.wa.gov/Research-Data/Monitoring-assessment/River-stream-monitoring/Habitat-monitoring/Habitat-monitoring-methods				
OR/WA - throughout Washington	?-2018	S&T: track stream conditions across the state.	Biological data (fish, macroinvertebrates, and periphyton),habitat, water, and sediment chemistry; as well as multiple physical parameters.	Washington Department of Ecology
Chesapeake Bay Program* https://www.chesapeakebay.net/what/programs/monitoring; /				
US - Chesapeake Bay and Tributaries	1980 - present	S&T: detect changes that take place in the ecosystem, reveal trends over time that can provide valuable information to policy makers and improves our understanding of the natural world.	Freshwater inputs; nutrients and sediments; chemical contaminents; plankton; benthos; finfish and shellfish; temp; salinity; and DO -- "Nineteen physical, chemical and biological characteristics are monitored 20 times a year in the Bay's mainstem and many tributaries."	Chesapeake Bay Program (multi-agency partnership); Virginia DEQ
Everglades Ecosystem Assessment Program/ REMAP https://www.epa.gov/everglades/environmental-monitoring-everglades				
US - Everglades (FL) - 2000 mi2	1993 - current	S&T: measure current and changing conditions for water quality and ecological resources; evaluate effectiveness of water quality and habitat restoration and mercury control.	Water, sediment, fish, algal communities, and plants such as sawgrass and cattail.	EPA
Forest Ecosystem Monitoring Cooperative (formerly the Vermont Monitoring Cooperative) https://www.uvm.edu/femc/				
US - Forests throughout Vermont	?-2018	Track forest conditions across Vermont; clearinghouse for ecosystem research and monitoring information from a variety of cooperating agencies.	Forest ecosystems: air, forest, soil, water, wildlife.	Forest Ecosystem Monitoring Cooperative
Great Lakes Monitoring https://www.epa.gov/great-lakes-monitoring				
US - Great Lakes	?-2018	S&T: monitor atmospheric deposition, biology, fish, coastal wetlands; not clearly tied to an action plan.	Water, aquatic life, sediments,air, and amphibians.	EPA
Upper Mississippi River Restoration Program Long Term Resource Monitoring https://umesc.usgs.gov/ltrm-home.html				
US - Mississippi River above Missouri confluence?	1986 - present	S&T: to determine the status and trends of natural components of a large river.	Fish, invertebrates (e.g., insects, worms, and clams), aquatic plants, water quality, sedimentation, land use and land cover, and bathymetry .	Federal-state collaborative (USGS, USACE, USFWS, NRCS, MN/WI/IL DNRs)

GEOGRAPHIC SCOPE	PROGRAM PERIOD	MONITORING OBJECTIVES (S&T; EFFECTIVENESS; IMPLEMENTATION)	RESOURCES OR CONDITIONS MONITORED	LEAD ORG(S)
Missouri River http://moriverrecovery.usace.army.mil/mrrp/f?p=136:176:0::NO::: ; https://cdm16021.contentdm.oclc.org/digital/collection/p16021coll7/id/3100 ;				
US - Missouri River (2100 miles)	1986 - present	S&T: monitor habitat and populations of 3 listed species (least tern, piping plover, pallid sturgeon).	Emergent sandbars; least tern and piping plover adults and productivity; pallid sturgeon habitat and populations.	USACE
Snake River Watershed Monitoring http://mstrwd.org/wp-content/uploads/Snake-River-Monitoring-Plan.pdf				
US - Snake/ Red River (Minnesota)	2015-?	S&T and Effectiveness: track (1) performance of flood reduction and storage projects, (2) compliance to surface and groundwater quality standards, and (3) performance of restoration and protection projects to improve water quality.	Impoundment water levels; flow timing, frequency, magnitude, duration; water quality parameters.	Middle-Snake-Tamarac Watershed District

Appendix C: Social and Cultural Calendar

Table 12: Key ecological, social and cultural events linked to river health indicators



*Dates are approximations for communications purposes only and should be verified with proper oversight agency where permits or licenses are required for legal harvest.

Appendix D: Acronyms and Terms Used in This Report

Organizations involved with Willamette Restoration and Program-Scale Monitoring

AHWG: Anchor Habitats Working Group

BEF Bonneville Environmental Foundation

BES: City of Portland, Bureau of Environmental Services

BPA: Bonneville Power Administration

HTT: Habitat Technical Team (BPA)

MMT: Meyer Memorial Trust

NOAA: Also known as NOAA Fisheries or National Marine Fisheries Service, within the National Oceanic and Atmospheric Administration

OSU: Oregon State University

OWEB: Oregon Watershed Enhancement Board

PSU: Portland State University

UO: University of Oregon

USACE: United States Army Corps of Engineers

USGS: United States Geological Survey

USFS: United States Forest Service

Restoration Programs and Associated Terms

WILLAMETTE HABITAT PROGRAM (WHP): also referred to as the Willamette Program. The Willamette Habitat Protection and Restoration Program was developed by the federal Services, Action Agencies, and WATER, to carry out the restoration goals of the 2008 Biological Opinion for the U.S. Army Corps of Engineers Willamette Valley Project.

WFIP: The Focused Investment Partnership program is an OWEB initiative to invest in high-performing collaborative partnerships seeking to achieve strategic, ecological outcomes in specific project areas within the anchor habitats. The OWEB Board awarded the Willamette FIP funding in January 2016. The Willamette FIP replaced the agency's initial Willamette-based restoration and protection program, the Willamette SIP.

WRI: Willamette Restoration Initiative, restoration program funded by MMT.

Willamette River Monitoring Programs and Associated Terms

MONITORING INFRASTRUCTURE: For this report, monitoring infrastructure refers to the basic foundational requirements to support a monitoring effort. The infrastructure includes: monitoring purpose and monitoring elements (restoration objectives, monitoring metrics, processes and timelines for reporting). While additional features may exist or be added in the future, these are the fundamental elements upon which other implementation, effectiveness and status and trends monitoring programs are built.

OWRI: Oregon Watershed Restoration Inventory (OWRI) database for voluntary reporting of implantation and effectiveness monitoring data for OWEB-funded restoration and monitoring projects. https://www.oregon.gov/oweb/data-reporting/Pages/owri.aspx

SLICES: SLICES is a spatial framework for assessing changes in the Willamette River floodplain and a website that houses decadal, river-scale data on native fish communities, floodplain forest, channel complexity, and juvenile Chinook rearing habitat. Together the spatial framework (consisting of static floodplain transects), website and datasets of SLICES form the foundation of a river-scale status and trends monitoring program for the Willamette River (https://ir.library.oregonstate.edu/collections/5425kh23p).

WFIP IMPLEMENTATION MONITORING: program-scale, voluntary implementation monitoring to track OWEB-funded accomplishments for the Willamette Anchor Habitats Focused Investment Partnership Restoration program. Monitoring is led by Anchor Habitats Working Group and BEF.

WFIP EFFECTIVENESS MONITORING: program-scale effectiveness monitoring program for the Willamette Anchor Habitats Focused Investment Partnership Restoration program. This monitoring program is led by Benton Soil and Water Conservation District, USGS, BEF, USFS and PSU.

meyer MEMORIAL TRUST | WILLAMETTE RIVER INITIATIVE

This report and related products developed by University of Oregon, the USGS and the City of Portland Bureau of Environmental Services was made possible by a grant from the Meyer Memorial Trust through their Willamette River Initiative. MMT's investments in the Willamette drove transformative change that continues to evolve and serve people and the river through **Nesika Wilamut** (The Willamette River Network). The below documents provide additional information about the legacy of MMT's work:

The Model Watershed Partnership: 10 years of innovation and collaboration, 2021

Willamette River Initiative: An evaluation of Impact, 2020

bef watersheds program

watersheds@b-e-f.org