Umatilla River Anadromous Fish Habitat Project

2023 Annual Report

(February 1, 2023 – January 31, 2024)

BPA Project Number 1987-100-01
Contract Numbers 73982 REL 150
April 4, 2024

PREPARED BY:

Jude Love, Rebecca Schwartz, & Christian Gonzalez

Confederated Tribes Umatilla Indian Reservation
Department Natural Resources Fish and Wildlife
Programs Nixyáawii Governance Center
46411 Timíne Way
Pendleton, Oregon 97801

Prepared for:
U.S. Department of Energy Bonneville Power Administration
Division of Fish and Wildlife
P.O. Box 3621
Portland, Oregon 97208-3621

Suggested Citation:
Love, Jude, Schwartz, Rebecca, & Gonzalez, Christian. 2023. The Umatilla Anadromous Fish Habitat Project: 2023 Annual Report. Confederated Tribes of the Umatilla Indian Reservation, report submitted to Bonneville Power Administration, Project No. 1987-100- 01.

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

ACRONYMS

BA	biological assessment
BDSS	beaver dam support structure
BIA	Bureau of Indian Affairs
BPA	Bonneville Power Administration
cfs	cubic feet per second
COR	Contracting Officer Representative
CREP	Conservation Reserve Enhancement Program
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CY	Cubic Yards
dbh	diameter at breast height
EPA	United States Environmental Protection Agency
ESA	Federal Endangered Species Act
ft	foot/feet
FY	fiscal year
in	inch/inches
JPA	Joint Permit Application
km	kilometer/kilometers
LWD	large woody debris
m	meters
mi	mile/miles
MOA	Memorandum of Agreement
NOAA	National Oceanic and Atmospheric Administration
NMFS	National Marine Fisheries Service
NPPC	Northwest Power Planning Council
NPCC	Northwest Power and Conservation Council
NRCS	Natural Resource Conservation Service
ODA	Oregon Department of Agriculture
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
ODSL	Oregon Department of State Lands
OWEB	Oregon Watershed Enhancement Board
OWRD	Oregon Water Resources Department
PCSRF	Pacific Coastal Salmon Recovery Fund
RM	river mile
SOW	Statement of Work
SE	Standard error
TMDL	total maximum daily load
UAFHP	Umatilla Anadromous Fisheries Habitat Project
UBNPME	Umatilla Basin Natural Production Monitoring and Evaluation Project
UBWC	Umatilla Basin Watershed Council
USACOE	United States Army Corps of Engineers
USDA-FS	United States Department of Agriculture Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UPRR	Union Pacific Railroad

TABLE OF CONTENTS

Contents

INTRODUCTION **1**
Project Area 4

COMPLETED WORK BY WORK ELEMENT **9**
Work Element A: 119. Manage and Administer Projects 9
Work Element B: 165. Produce Environmental Compliance Documentation 9
Work Element C: 114. Identify and Select Projects 10
Work Element D: 191. Watershed Coordination 10
Work Element E: 99. Outreach and Education 11
Work Element F: 122. Provide Technical Review and Recommendation 13
Work Element G: 172. Conduct Pre-Acquisition Activities 13
Work Element H: 186. Operate and Maintain Habitat/Passage/Structure 13
Work Element I: 186. Operate and Maintain Habitat/Passage/Structure 14
Work Element J: 198. Maintain Vegetation 14
Work Element K: 47. Plant Vegetation 15
Work Element L: 115. Produce Inventory or Assessment 16
Work Element M: 175. Produce Design and/or Specifications 16
Work Element N: 175. Produce Design and/or Specifications 17
Work Element O: Work Element T: 175. Produce Design and/or Specifications 17
Work Element P: 175. Produce Design and/or Specifications 17
Work Element Q: 132. Produce (Annual) Progress Report 17
Work Element R: 185. Produce Pisces Status Report 18
Discussion 18

OBSTACLES AND LESSONS LEARNED **18**

ADAPTIVE MANAGEMENT **21**

SUMMARY AND CONCLUSIONS **22**

LITERATURE CITED ..... Error! Bookmark not defined.

LIST OF FIGURES

Figure 1. Umatilla River Subbasin 6
Figure 2. Umatilla River Basin FY 2023 UAFHP Project Sites 7
Figure 3. CTUIR semi-annual report for the CTUIR UAFHP, July 1– December 31, 2023. 12

LIST OF TABLES

Table 1. Summary of Implementation work accomplished in 2023. 3
Table 2. Major designs and project planning completed in the 2023 calendar year. 4
Table 3. Habitat passage structures monitored and maintained by CTUIR to meet design specifications. 14
Table 4. Noxious weed treatments completed by location within the Umatilla River Basin, 2023 15
Table 5. The Umatilla Anadromous Fish Habitat Project objectives relative to the Umatilla River Vision touchstones (Jones et al. 2008), BPA 2008 Fish Accords primary limiting factors (Fish Accords 2008) and NOAA's ecological concerns (NMFS 2009). 20
Table 6. The CTUIR UAFHP restoration project descriptions by location, treated primary limiting factors (NMFS 2009) by CTUIR River Vision touchstones (Jones et al. 2008) and accomplishments; 2007-2023. 24

INTRODUCTION

The Confederated Tribes of the Umatilla Indian Reservation (CTUIR) retain aboriginal and treaty rights related to fishing, hunting, pasturing of livestock, and gathering of traditional plants within the Umatilla River subbasin. The CTUIR Department of Natural Resources (DNR) has developed and accepted a First Foods organization and approach to ecosystem management based on the cultural traditions and practices of the Longhouse. The organization follows the serving order of food and conceptually "Extends the Table" to manage for sustainability within the Umatilla River subbasin. The First Foods are considered the minimum ecological products necessary to sustain CTUIR culture (Quaempts et al. 2018). The order is watershed-based beginning with water at the first and lowest point and progresses up to salmon, deer, cous, and huckleberry. This creates clear links to treaty rights and resources and sets direction and goals that relate to the community culture. In addition the CTUIR DNR developed the Umatilla River Vision that provides a description of the processes and conditions needed to protect and provide for First Foods (Jones et al. 2008). The River Vision describes physical and biological processes in support of 5 touchstones; hydrology, geomorphology, connectivity, riparian vegetation, and aquatic biota. The work accomplished through this project is directly related to the First Foods of water and salmon and the 5 touchstones, which incorporates goals of restoring high water quality and healthy and sustainable salmonid fish populations.

CTUIR's right to fish in its historical fishing places was acknowledged in the Treaty of 1855 that stated: "the exclusive right of taking fish in the streams running through and bordering said reservation is hereby secured to said Indians, and at all other usual and accustomed stations…" (Treaty of 1855, Articles of Agreement, Article 1, page 3). Decreased salmonid abundance has significantly impacted the livelihood of the Tribal community and altered their way of life.

Overfishing, sweeping changes to rivers and streams, and policies that changed the landscape have endangered salmon and created a "salmon crisis" (Montgomery 2003). It is the challenging duty of the CTUIR Umatilla Anadromous Fisheries Habitat Project (UAFHP) to restore and sustain healthy conditions of local watersheds to both assist in salmon recovery and ensure they provide adequate quantities of sustainable natural resources to satisfy the CTUIR's needs and preserve opportunities for traditional ways of life.

As part of the Northwest Power Conservation Council's Columbia Basin Fish and Wildlife Program, this project is one of Bonneville Power Administration's (BPA) many efforts at off-site mitigation for damage to salmon and steelhead runs, their migration, and wildlife habitat caused by the construction and operation of FCRPS dams. The Umatilla Anadromous Fish Habitat Project (UAFHP; #1987-100-01) initiated by CTUIR in 1987 is an integral component of the Umatilla River Subbasin Salmon and Steelhead Production Plan (NPPC 1990), and project work is supported both locally and regionally by multiple planning documents: Umatilla/Willow Subbasin Plan (NPCC 2005), Umatilla River Basin TMDL and Water Quality Management Plan (2001), CTUIR TMDL (2005), Umatilla River Vision (Jones et al. 2008), Conservation and Recovery Plan for Oregon Steelhead Populations in the Middle Columbia River Steelhead Distinct Population Segment (NMFS 2009), Recovery Plan for the Coterminous United States Population of Bull Trout (*Salvelinus confluentus*) (USFWS 2015), Meacham Creek Watershed Analysis and Action Plan (Andrus and Middel 2003), Umatilla and Meacham Watershed Assessment (UNF 2001), and the Birch Creek Watershed Action Plan (CTUIR 2016).

The Final Umatilla/Willow Subbasin Plan (NPCC 2005; Subbasin Plan) provided a systematic vision of a healthy ecosystem with abundant, productive, viable, and diverse populations of aquatic and terrestrial species with goals, objectives, and management strategies necessary to reach the subbasin vision. The vision entails several broad goals for habitat: 1) Protect existing high quality fish and wildlife habitat and strongholds, 2) restore and enhance degraded and diminished fish and wildlife habitats to support population restoration goals and to mitigate impacts from the construction and operation of the Columbia basin hydropower system and other anthropogenic impacts, and 3) restore the health and function of ecosystems in the Umatilla subbasin to ensure continued viability of their natural

resources (Management Plan, page 5-3). Specific aquatic qualitative objectives and strategies were developed to support the subbasin vision and goals. Quantitative management objectives relative to the UAFHP work activities include 1) maintain and enhance natural production, productivity, abundance, life history characteristics and genetic diversity of fish and mussels throughout the Umatilla subbasin using habitat protection and improvement and 2) maintain and enhance passage of adult and juvenile steelhead and Chinook throughout the Umatilla subbasin with passage protection and restoration (Management Plan, page 5-5). The Umatilla Subbasin Plan (NPCC 2005) determined that the limiting factors could be addressed through habitat restoration and implementation ("Phase III") of the Umatilla Basin Project (pages 5-10). An identification and analysis of limiting factors/conditions and priority areas for action are fully described within the Subbasin Plan (Section 3.5) including passage barriers/entrainment, in-channel characteristics, habitat diversity (LWD), floodplain confinement, high water temperatures, high turbidity, inadequate flows, and poor riparian/floodplain vegetation. Priority management strategies are being conducted by the UAFHP in accordance with the Final Umatilla Willow Subbasin Plan (NPCC 2005; pages 5-8 & 5-9) to address limiting factors within the subbasin:

- Increase water conservation and irrigation efficiency
- Large wood/boulder structure placement
- Fence/plant riparian zones
- Modify channel floodplain function
- Construct pool/riffle habitat – In-stream modification
- Modify detrimental land use activities
- Restore upstream/headwater attributes to improve downstream conditions
- Increase fish passage efficiency

The UAFHP continues to protect, enhance, and restore functional floodplain, channel, and watershed processes to provide sustainable and healthy habitat for aquatic species in the Umatilla River subbasin. Habitat restoration efforts fit within a holistic watershed approach supporting capacity building and long-term progress towards 1) achievement of the CTUIR DNR River Vision and First Foods mission statements, 2) Endangered Species Act delisting of Columbia River bull trout and middle Columbia River steelhead, and 3) addresses water quality limiting factors per the Clean Water Act 303d list.

During the 33-year project history, the CTUIR has helped administer and implement a number of fisheries habitat enhancement projects in the Umatilla River subbasin. The CTUIR maintains partnership habitat enhancement projects along Meacham Creek, Isquúlktpe Creek, Birch Creek, Wildhorse Creek, East and West Birch Creek and the mainstem Umatilla River, among other sites. The CTUIR has developed effective interagency partnerships and is effectively working at the policy and project levels with various federal, state, and county agencies and private landowners.

The UAFHP is an integral component of the *Umatilla River Subbasin Salmon and Steelhead Production Plan* (1990) and is well integrated into the framework of the *Umatilla Subbasin Plan* (NPCC 2005) established by the NPCC to better coordinate habitat restoration work in the Umatilla River Basin. The CTUIR, ODFW, Natural Resource Conservation Service (NRCS), Umatilla National Forest, Umatilla Basin Watershed Council (UBWC), and other participating agencies and organizations have made significant progress towards restoring and protecting vital salmonid habitat in the basin.

The major project accomplishments during the 2023 contract periods are described in Table 1 below. This only includes the major implementation activities. The planning and design related activities for future implementation projects are contained in Table 2.

Project results are reported in various BPA formats including Pisces status reports, project completion reports, and annual reports. The CTUIR maintains a complete database on project planning, proposals, permitting, implementation, and results through the completion of required project deliverables. For a complete list of reports

submitted by the CTUIR's UAFHP since 1989, please consult the following website at URL: http://www.efw.bpa.gov/integratedfwp/reportcenter.aspx.

Table 1. Summary of Implementation work accomplished in 2023.

Work Element	Stream Name	Description
Conservation Agreements	Wildhorse, Birch, EFK Birch, WFK Birch, Cottonwood, & Umatilla River	Maintain current conservation agreement terms and conditions on 16 agreements, including maintaining fencing.
Conservation Easement	Umatilla River	Continue working on finalizing a Conservation Easement on the UmaBirch Property
Weed Treatment	Meacham, Umatilla River	Controlled noxious weeds on 415.5 acres of conservation agreements and previously implemented habitat projects using chemical and mechanical treatments. Biological control treatments are ongoing.
Planting	Meacham	2000 plants
Umabirch PA-4 Implementation	Birch Creek	Completed first phase of implementation with water quality BMPs, excavation of the new stream channel and wetland ponds. Work continues in the next contract period in 2024 to complete the floodplain work during winter/spring and move to the existing stream channel enhancement from July 1 – Sept 30.

Table 2. Major designs and project planning completed in the 2023 calendar year.

Project	Description
West Birch and Stanley Creek Fish Passage Project	Successfully completed the 100% Implementation Plan to remove passage barriers to increase steelhead survival and benefit channel morphology on West Birch Creek and Stanley Creek. Design was altered to account for cultural sites and changes due to past flood events.
Umatilla River Assessment	Received the 100% Final of the Assessment and Appendices and the Prioritization Tool. Working on the Action Plan in the 2024 contract period.
UmaBirch Conservation Easement	Collaborated with project partners to continue the progression of finalizing the UmaBirch conservation easement. Conservation Easement anticipated to be completed in summer of 2024.
UmaBirch Design	Completed 100% design for UmaBirch Project PA 1 and 60% designs for UmaBirch Project PA 2 and 3 including the Taylor Ln bridge. Completed the 60% design / Section 408 process for the Pendleton 2A Levee Setback as part of the PA 2 Floodplain Restoration Project
UmaBirch NEPA Compliance	The environmental assessment was completed in 2023.
Meacham Creek RM 10-11 Design	Finalized 100% design and implementation planned for 2024.
Imeques Reach Design	Completed HIP IV review on the 60% design with NMFS for floodplain restoration. Collaborated with Artificial Production staff and engineering firm to develop 15% design and supplementary screen intake report. Team of BPA, NOAA and CTUIR decided to maintain the diversion intake and use the floodplain restoration to enhance the facility intake to enhance the system's ability to maintain flows during the winter months. We are now working towards the 90% floodplain design in 2024.
Peterson Dam Fish Passage Design	Completed the 60% design for the dam removal. Work in the next contract period includes completing the design and environmental compliance during the first half of 2024 and implementing in summer/fall 2024.

Project Area

The UAFHP is defined by the boundaries of the Umatilla River subbasin, which is located in the northwest portion of the Blue Mountain Ecological Province in northeast Oregon. The Umatilla River subbasin comprises 1,465,600 acres of

the 6,400,000 acres of ceded CTUIR land (CTUIR 1995) as identified by the Treaty of 1855. Figure 1 illustrates the vicinity of the Umatilla River subbasin within the Blue Mountain Province (Project map: *http://www.cbfish.org/Project.mvc/Map/1987-100-01).* The Umatilla River drains an area of approximately 2,540 square miles (mi.^{2}) (6,579 square kilometers [km^2]) and flows approximately 89 mi. (143 km) from where it branches into the north and south forks of the Umatilla River to the mouth at the confluence with the Columbia River. Each fork adds another approximately 10 mi. (16 km) of length. The Umatilla River originates at elevations up to 4,228 feet (ft.; 1,289 m), and flows west and north to its confluence with the Columbia River (USFWS 2002) at an elevation of about 269 ft. (82 m).Other major tributaries include Meacham Creek, Birch Creek, McKay Creek, Butter Creek, and Wildhorse Creek.

The Umatilla River subbasin historically supported viable and harvestable populations of spring/summer and fall Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), sockeye salmon (*O. nerka*), summer steelhead (*O. mykiss*), Pacific lamprey (*Entosphenus tridentatus*), bull trout (*Salvelinus confluentus*), steelhead-rainbow trout (*O. mykiss sp*.), mountain whitefish (*Prosopium williamsoni*) and a variety of additional native species. Anthropomorphic alterations have negatively impacted the watershed and caused significant reductions of endemic salmonid populations. Beginning in the late 1800s, fish populations started to decline due to habitat degradation. In fact, Sockeye and Coho were extirpated by the early 1900s. Irrigation and agricultural development throughout the basin in the early 1900s is believed to be the primary cause of the decline of steelhead and the extinction of salmon. Since the signing of the Treaty of 1855, aquatic and riparian habitats have been degraded through irrigation diversions, water extractions, channelization, livestock grazing, logging, agriculture and urban development (NPCC 2004). Subsequently, the abundance of Chinook, steelhead, bull trout, and other fish species has also been dramatically reduced. The Umatilla River population of spring Chinook salmon was reported extinct in 1926 (Boyce 1986). With declining fish populations, Tribal governments, federal, state and international agencies were obligated to eliminate or significantly reduce subsistence and sport fisheries by the mid-1970s. The Federal government listed Middle Columbia River summer steelhead and Columbia River bull trout in the Umatilla subbasin as threatened species under the ESA in 2006 and 1999, respectively.

In the mid-1980s, a successful, hatchery-based salmonid reintroduction effort for the Umatilla River was instituted using neighboring strains of various salmonid species. Although hatchery programs currently support subsistence and restricted sport fishing opportunities for steelhead and Chinook and Coho salmon, there remains significant need to re- build viable, harvestable, and sustainable naturally-produced fish stocks throughout the basin. Our primary area of focus for restoration and monitoring work in FY 2023 was Meacham Creek, Wildhorse Creek, Birch Creek, and the mainstem Umatilla River (Figure 2).

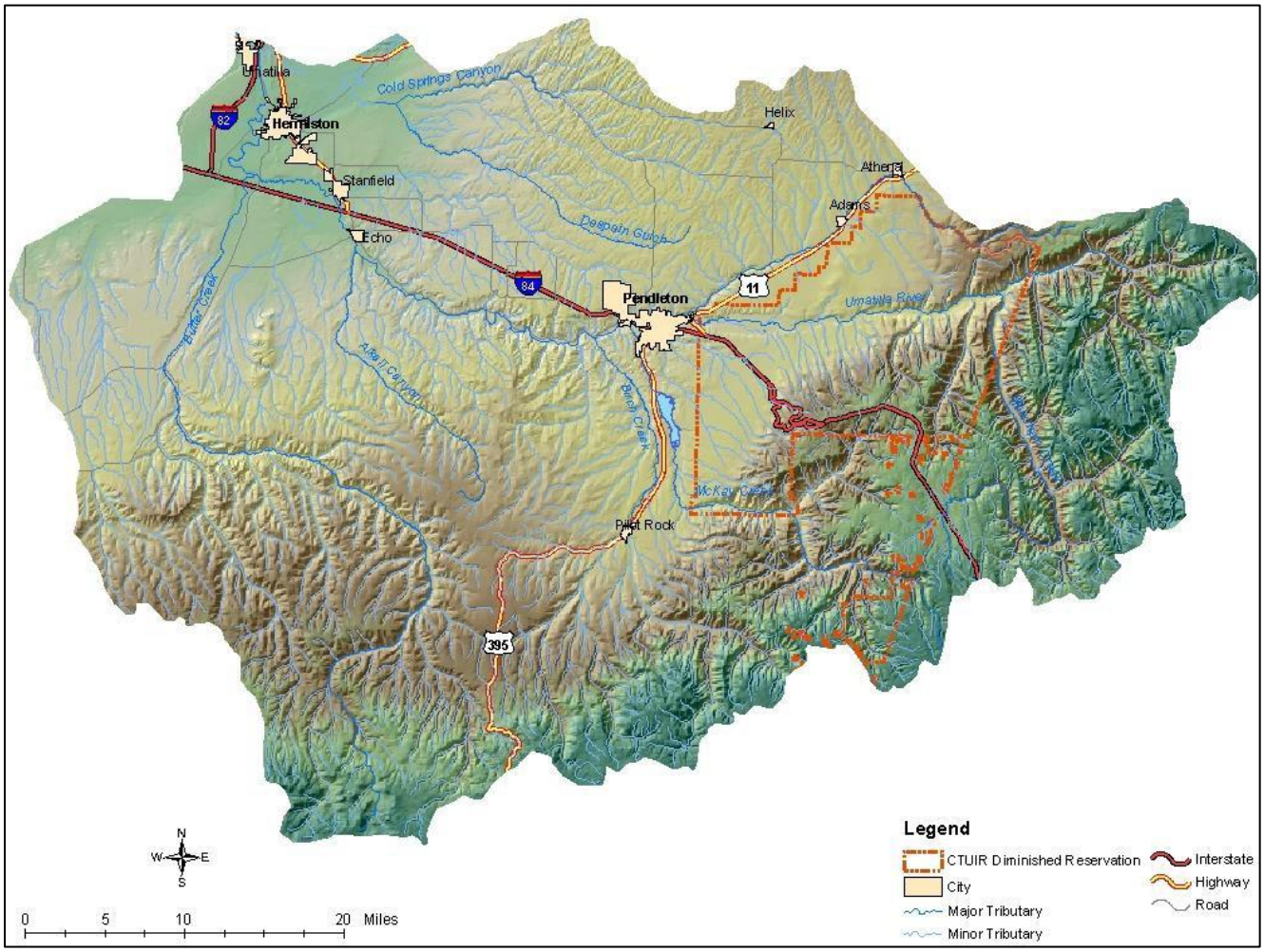


Figure 1. Umatilla River Subbasin

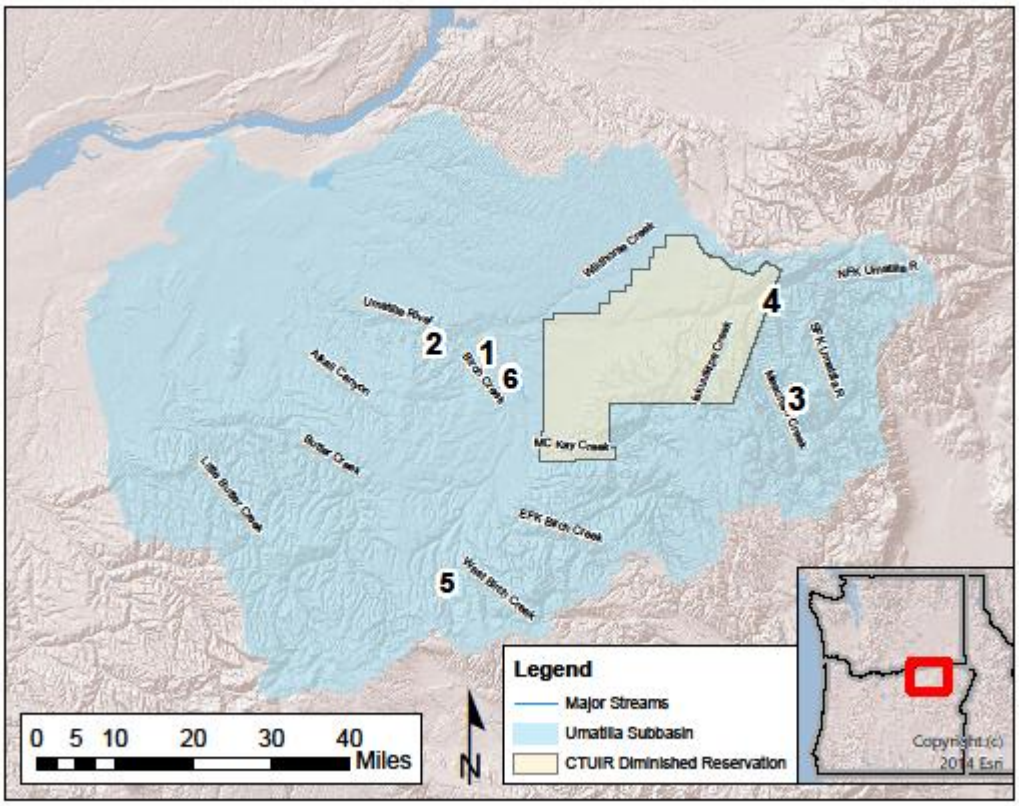


Figure 2. Umatilla River Basin FY 2023 UAFHP Project Sites

1: UmaBirch PA3 and 2 EC & Design UmaBirch CE/Design: Continued progress towards finalizing the conservation easement to protect over 225 acres of floodplain and 3.5 cfs of instream flow from surface water rights at the confluence of the Umatilla River and Birch Creek. Concurrently developing a restoration design. Developed 60% restoration design for both project areas. Drafting the final EA. Continued progress on the Sec. 408 application for the Pendleton 2A levee on PA2, developing a design to replace the Taylor Ln bridge on PA3, and working towards decommissioning the feedlot on PA3.	**2: Umatilla Basin Assessment**: Completed review and developed the Assessment document, technical appendices, spreadsheet tools, and geodatabases to 100%. Final was completed in January, 2024.	**3: Meacham Creek RM 10-11:** Worked collaboratively with USFS and landowner neighboring project to establish a landowner agreement. Completed 100%.
4: Imeques Reach Floodplain Enhancement Design: Worked with engineer to progress restoration design to 60% and expected to be completed in 2024. Facility design has been abandoned due to high cost and difficult feasibility.	**5**: **West Birch and Stanley Creek Barrier Removal:** Worked collaboratively with private landowners to complete restoration design development 100%. Implementation is currently planned for spring 2024.	**6: Peterson Dam:** Completed 60% design and currently working with engineering firm to complete the 80% design and 100% implementation plan in the following contract period.

COMPLETED WORK BY WORK ELEMENT

This section highlights and describes completed work elements in an outline similar to our statement of work on CBFish.org. Each work element with associated identifier code and milestone are listed, followed by a comprehensive summary of completed work under each work element. In addition to a description of completed work elements specific to restoration activities, we briefly highlight habitat inventory results specific to UAFHP efforts outlined for this contract period.

Contract 73982 REL 150 (CY 2023)

Work Element A: 119. Manage and Administer Projects

Work Element Title: Manage and Administer Project
Milestone Deliverable: Effective implementation management and timely contract administration

A. Evaluate current workload and monitor implementation progress.
B. Develop work plan consistent with expected budget availability and potential tasks or projects.
C. Integrate and manage the planning, permitting, environmental compliance, and coordinated implementation of contract actions.
D. Implement actions consistent with CTUIR River Vision. Complete CTUIR and BPA review of the funding package (SOW, Budget, and Property Inventory) for the upcoming contract period.
E. This contract year the UAFHP brought on a new Biologist. The Biologist I has worked alongside our technician I and II to help plant native vegetation, collect cuttings for future planting efforts, and taken photopoints for our project reports. In addition, the Biologist I has assisted the Assistant Project Lead Biologist II and Project Lead Fisheries Habitat Biologist III.

This work element includes general administration of the CTUIR Umatilla Anadromous Fish Habitat Project (UAFHP). CTUIR staff managed and administered project activities in accomplishing work elements and milestones with associated costs.

Work Element B:: 165. Produce Environmental Compliance Documentation

Work Element Title: Produce Environmental Compliance Documentation
Milestone Deliverable: Compliance Documentation and Assistance for Environmental and Cultural Resource Clearances

The following milestones were completed for FY 2023 projects:

CTUIR successfully submitted many applicable documents to the appropriate federal, tribal, state, county entities for select implementation projects in a timely manner required under work elements related to producing environmental compliance documentation in FY2023. Secondary environmental compliance accomplishments during the reporting period included coordination with various compliance personnel to prepare supplemental documentation and reporting for ongoing and planned management actions. Environmental compliance methods include development of appropriate documentation under various federal, Tribal, state and county laws and regulations governing federally funded project work. Methods involve coordination with various federal and state entities agencies and development and submittal of permit applications, cultural clearances, biological assessments, National Environmental Policy Act checklists, etc., as necessary. Part of the environmental compliance work element includes planning and developing site-specific proposals tailored to accomplish fisheries goals and meet compliance standards. The details concerning the implementation of treatments and preparations for putting efforts on the ground, including preparations for subcontracting, and specifics in regarding the safeguarding of ESA-Listed species during the implementation process are outlined in the proposals.

1) UAFHP Environmental Compliance Documentation
2) ESA consultation with NMFS for FY 2023 project activities was covered under the Terms and Conditions of the HIP III Programmatic Biological Opinion (HIP III BO). Project activities covered under the HIP III BO included:
    - Operate and Maintain Habitat/Passage/Structure (WE H: 186; WE I: 186): CTUIR monitored and maintained existing easements and habitat improvement sites. Maintenance included vegetation watering and installing bioengineering treatments to stabilize habitat features.
    - Maintain Vegetation (WE J: 198): Project activities included maintaining plants on NRCS CREP tracts and treating noxious weeds.
    - Plant Vegetation (WE K: 47): Project activities included planting in Meacham Creek Project Areas.

CTUIR submitted a letter and attachments with necessary project descriptions and geo-referenced maps for assisting BPA with Section 106 National Historic Protection Act consultations and environmental compliance. The following projects were submitted for compliance:

1) UmaBirch Floodplain Restoration and In-stream Enhancement PA 2 & 3
2) Additional surveys for UmaBirch PA-4 were completed to incorporate the well relocation APE

Cultural Resources protection and preservation compliance was ongoing during this contract period.

The CTUIR Cultural Resources Protection Program has completed the final report to complete SHPO Cultural for:

1. UmaBirch PA 1-3
2. West Birch and Stanley Creek barrier removal
3. Meacham RM 10-11 (Still in review as of Jan 31, 2024)
4. Imeques Reach (In initial process using previous year's surveys from land transfer from BPA to CTUIR).

Ongoing projects will all require Cultural Resource Protection and Preservation monitoring during construction in 2024. The UmaBirch Floodplain project and West Birch projects will be ongoing into the next CY.

Work Element C: 114. Identify and Select Projects

Work Element Title: CTUIR Umatilla Subbasin Restoration Coordination
Milestone Deliverable: Develop or update prioritized Habitat Project list

CTUIR UAFHP staff developed and annually updated habitat restoration and enhancement projects through coordination and planning with State, Federal and local partners, and private landowners consistent with the Umatilla Willow Subbasin Plan (NPCC 2005). This included participation with the UBWC and the Umatilla County SWCD. CTUIR completed a prioritized list of potential and final developed projects to be implemented contractually with BPA and other funding sources for the upcoming fiscal year and future year planning. Project development and planning were incorporated into this WE to assist in development of future funding packages. The CTUIR also continued to assist in completing the mainstem Umatilla River Assessment and Action Plan during this contract period. It is anticipated that this document will tier to all of the documents listed below and build on those to focus on the mainstem habitat actions, prioritized by reach and fish species.

Final Umatilla Willow Subbasin Plan (NPCC 2005),
Middle Columbia River Steelhead Recovery Plan (NMFS 2009),
Recovery Plan for the Coterminous United States Population of Bull Trout (*Salvelinus confluentus*) (USFWS 2015), Meacham Creek Watershed Analysis and Action Plan (Andrus & Middel, 2003), and
Birch Creek Watershed Action Plan (CTUIR 2016).

Work Element D: 191. Watershed Coordination

Work Element Title: Umatilla River Watershed Coordination Duties

Milestone Deliverable: Coordinate Watershed Association Activities

A. Coordinate with Umatilla Basin Watershed Council
B. Coordinate with NRCS and the Umatilla County Soil and Water Conservation District
C. Network with professionals in the field of habitat restoration
D. Coordinate with co-manager ODFW and other Federal agencies

CTUIR UAFHP staff participated and coordinated with multiple agencies and stakeholders in the Umatilla River subbasin through the Umatilla River Basin Restoration Team meetings, including ODFW, USDA-FS, NRCS, the Umatilla County SWCD, Umatilla Basin Watershed Council and local stakeholders to enhance natural resources, identify problems and solutions, coordinate efforts to prevent duplication, enhance communication and cooperation and identify funding and cost share opportunities within the Umatilla River subbasin. Staff further coordinated with other agencies (e.g. USFWS, NOAA, EPA, BPA and etc.) in planning and implementing partner habitat restoration and enhancement projects, ESA planning processes, and project prioritization and selection processes. CTUIR staff prepared agreements, if necessary, to assign duties and responsibilities to the appropriate entities. We also developed documents, press releases, web sites, and other communications to impart information to participating stakeholders and the public. This effort was made much more challenging because of the pandemic.

Work Element E: 99. Outreach and Education

Work Element Title: Public Outreach and Education
Milestone Deliverable: Complete Outreach and Education Activities

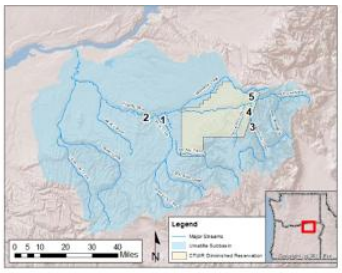
CTUIR UAFHP staff educated the public on natural resource protection and restoration principles, and communicated on project activities throughout the year whenever possible. Activities during 2023 included: providing presentation material for Watershed Field Days, communicated with local stakeholders and landowners during the outreach open house for the UmaBirch PA 1 and 2 EA, and participate at the CTUIR DNR open house. The staff attended River Restoration Northwest Annual Symposium in February 2023. Lastly, the 5 CTUIR Habitat Subbasins met in person in June for the annual team meeting in March to visit recently competed projects.

CTUIR UAFHP staff completed CTUIR semi-annual reports summarizing project objectives and outputs, expected outcomes, and resulting impacts of project restoration activities (Figure 3). These reports are used by the CTUIR Department of Natural Resources to inform CTUIR staff and government officials, other agencies and entities, and the public of project activities.

2023 CRITFC Salmon Camp education week – instruction for field day including stream ecology, floodplain restoration, riparian ecology, fish biology and planting exercise.

Figure 3. CTUIR semi-annual report for the CTUIR UAFHP, July 1-December 31, 2023.

Confederated Tribes of the Umatilla Indian Reservation
DNR Fisheries Program Project Semiannual Report
Project: Umatilla Subbasin Fish Habitat Restoration
Period: July 1– December 31, 2023



Project Statement/Goal: Protect, enhance, and restore functional floodplain, channel, and watershed processes to provide sustainable and healthy habitat for aquatic species of the First Food order.

Project Objectives: 1) Implement floodplain and passage restoration actions that meet defined quantitative biological, physical and social objectives defined by strategic restoration plans, recovery plans or subbasin planning and 2) Use adaptive management, available monitoring and recent literature to inform future restoration actions to maximize future project work to meet goals/objectives.

Outputs: (specific 6-mo task accomplishments)
- Hosted partner agencies at Tamastslikt in August to review and provide feedback on the preliminary final draft of the Umatilla River Assessment. Proceeding with Strategic Action Plan.
- Coordinated with project partners on the UmaBirch Conservation Easement. Outputs include: progression of restoration designs, water rights transfers, section 408 permitting for the Pendleton 2A levee with USACE, designs with Tetratech and finalization of the PA-2/3 Projects EA.
- Continued noxious weed management of 401 acres on mainstem Umatilla River, Birch Creek, Wildhorse Creek, and Meacham Creek project areas.
- Commenced construction on UmaBirch PA-4. Progress includes floodplain construction of the wetland ponds, excavation of the new primary channel, and hauling trees for LWD structures
- Coordinated with BPA and Artificial Production staff to determine a path forward to continue progression of the Imeques Floodplain Enhancement Project.
- Received $300,000 award from PCSRF for the Meacham Creek RM 10-11 Floodplain Restoration Project.
- Finalized the 100% design for Meacham Creek RM 10-11 Instream Design and Floodplain Restoration. Applied for $280,000 OWEB grant for RM 10-11 implementation.

Outcomes: (broader results/changes from cumulative accomplishments)
- Continue to utilize the Action Plans for prioritization and restoration of Birch Creek and Meacham Creek to develop projects.
- Continue to develop partnerships with agencies and landowners for new future projects.
- Added to the floodplain enhancement with vegetation planting and weed treatment as part of a larger Bonifer Reach project area restoration approximately 1 mile of Meacham Creek.
- Participated in multi-agency partnerships.

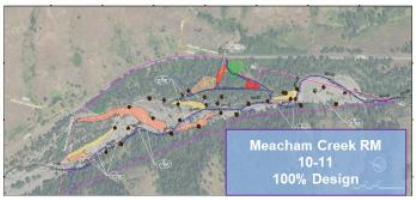
Impacts (work supports long-term progress towards):
- Contribute achievement of healthy watersheds (DNR River Vision) and increased traditional first food abundance and use opportunities.
- Contribute to achievement of Subbasin Plan and ESA Recovery Plan goals.
- Assist in recovery of Endangered Species Act subject species (spring/summer Chinook, summer steelhead, bull trout).
- Address water quality limiting factors as per Clean Water Act 303d list.

Project Inputs:	Funding	2023 Budget	Permanent Staff
	BPA 2023 BPA FY20 (PA-4) BPA Capital (UmaBirch) OWEB EPA FY22 PCSRF Total	$2,188,601 $1,967,917 $10,000,000 $351,090 $200,000 $302,490 $15,010,098	3 Biologists; 2 Technicians
	Staff: Jude Love-Bio III Project Lead, Rebecca Schwartz – Bio II Assistant Project Lead, Christian Gonzalez - Bio I, Larry Allen - Technician II, Austin Samuels - Tech I, Tech. 1 - Vacant		
	Collaborators: BPA, USFS, UBWC, ODFW, ODOT, OWEB, SWCD, NRCS, UPRR, EPA, USFWS, NOAA, Umatilla County, and private landowners.		









Work Element F: 122. Provide Technical Review and Recommendation

Work Element Title: Review and Provide Technical Input on Issues and Topics that Affect the Areas Natural Resources
Milestone Deliverable: Provide Technical Input and Summaries to Enhance or Protect Natural Resources in the Subbasin

A. Conduct review and provide input as necessary on natural resource preservation issues.
B. Review and provide technical input on issues that may adversely affect natural resources.

CTUIR UAFHP staff reviewed and provided technical input as applicable on plans and proposals by entities within the Umatilla River Basin that may adversely impact floodplain or riverine processes and biota productivity. Other projects that were reviewed included relevant public project planning, development and review of grant funding proposals, and proposed landowner projects. Project staff provided input to multiple CTUIR departments on annual activities relevant to work within the floodplain, rivers, and wetlands, US Army Corps of Engineers/Oregon Division of State Lands removal-fill permit applications, and CTUIR Stream Zone Alteration (SZA) Permit applications on work proposed within the floodplain on Reservation land.

Work Element G: 172. Conduct Pre-Acquisition Activities

Work Element Title: Conduct pre-acquisition activities for Birch Creek-Umatilla River confluence and East Birch Properties
Milestone Deliverable: Produce the necessary documents necessary to move forward with purchasing a conservation easement.

Significant coordination and planning efforts were accomplished in the 2023 contract year to advance the UmaBirch project towards execution of a conservation easement. The UAFHP has been working closely with the landowner, Blue Mountain Land Trust, Western Rivers Conservancy, and BPA to determine the scope and terms of the land and water conservation easement, conservation measures and value. Over the course of this contract year, all parties have met intently to coordinate all activities necessary for completion of the agreement. An appraisal was completed during this CY. The deliverable for the work element of producing documents and surveys necessary for the conservation easement has been met. CTUIR, landowner, and other partners will continue progress in 2024.

Additionally, CTUIR staff participated in assessment of a property on East Birch Creek for potential conservation easement including floodplain protection, restoration options and instream water rights transfer for increased instream flow.

Work Element H: 186. Operate and Maintain Habitat/Passage/Structure

Work Element Title: Inspect and Maintain Function of In-stream Improvement Structures
Milestone Deliverable: Maintain Proper Operation of In-stream Habitat Structures

A. Environmental compliance requirements complete.
B. The inspection, replacement and/or maintenance of passage and habitat structures.
C. Hire contractor to perform work.

CTUIR monitors 8 passage rectification projects to assure that treatments are effectively working and to insure that intrusive objects are not interfering with the designed function of the passage structures (Table 3). Routine quarterly scheduled site visits of individual projects are conducted either independently by the CTUIR or jointly with project partners such as ODFW. Site visits typically follow significant flow events or responses to landowner requests at project sites. Project maintenance included, but was not limited to, meeting specified conditional language in state and Federal permits, maintaining debris that is routinely captured or caught on in-stream structures, responses to landowner

requests and concerns, and completion of post-treatment surveys to monitor and quantify changes to physical and ecological responses.

Work Element I: 186. Operate and Maintain Habitat/Passage/Structure

Work Element Title: Maintenance of Habitat Features Associated with Project Conservation Agreements
Milestone Deliverable: Maintenance of Land or Structures Associated with Conservation Agreements

A. Environmental compliance requirements complete.
B. Adhere to details of existing easements and/or initiate additional agreements as feasible.

The purpose of these Conservation Agreements is to protect, enhance, and restore functional floodplain, channel, and watershed processes to provide sustainable and healthy habitat for aquatic species in the Umatilla River subbasin. The UAFHP have and will continue to maintain the individual projects to ensure that project structures and fencing are functioning and habitat recovery is progressing towards meeting projects goals and objectives. The CTUIR currently maintains 16 conservation agreements. Current agreements provide secured access and protection of resources for functional floodplain, channel watershed processes to provide sustainable and healthy habitat for aquatic specifies 26 miles of stream. CTUIR routinely conducts custodial maintenance on individual projects to ensure that project structures and fencing are functioning and habitat recovery is progressing towards meeting projects goals and objectives. Activities include, but are not limited to, installing and repairing riparian cattle exclusion fences, maintaining or installing water gaps, riparian and floodplain plantings and maintenance, noxious weed control, maintenance of fish habitat improvement structures, and landowner coordination and education.

Table 3. Habitat passage structures monitored and maintained by CTUIR to meet design specifications.

Year	Stream	Stream Location	Project Description
2007	Meacham Creek	RM 1.7	Passage rectified by removing large cabled boulders (improved adult passage)
2007	Meacham Creek	RM 20.2	Partial dam removed (juvenile and adult passage)
2007	Camp Creek	RM 0.3	Partial dam removal (juvenile and adult passage)
2007	Greasewood Creek	RM 0.4	Partial dam removal (juvenile and adult passage)
2007	West Birch Creek	RM 3.2	Roughened channel to restore proper gradient and reduce step height at road bridge crossing for adult passage
2008	West Birch Creek	RM 2.7	Hoeft Dam fish passage rectification (juvenile and adult passage)
2019	Umatilla River	RM 48.2	Partial dam removed (juvenile and adult passage)
2019	Wildhorse Creek	RM 18.8	Passage rectified by removing concrete grade control structure and replacing bridge (Juvenile and adult passage)

Work Element J: 198. Maintain Vegetation

Work Element Title: Maintain Vegetation and Control Noxious Weeds in Project Areas within the Umatilla River Subbasin
Milestone Deliverable: Maximize Survival of Native Vegetation in Enhancement Project Areas

A. Environmental compliance requirements complete.
B. Physical removal of non-preferred species of vegetative growth from project area.
C. Weed control in project areas by chemical means.
D. Water vegetation and reduce weed competition to improve survival at CTUIR project areas.
E. Till established weed areas as necessary for noxious weed control.

Project activities conducted in 2023 included the monitoring and maintenance of 16 conservation agreements on numerous individual landowner properties. Watering, weeding and maintenance methods for each Conservation Agreement and project area is important for enhanced native vegetation and project site but maintenance varies by site conditions. Strategies to address weeds are included in agreements that are either completed by the landowner, CTUIR, subcontractor, and/or through the County Weed Control Board. CTUIR staff provides assistance to landowners by coordinating and managing herbicide application, providing funding, and developing treatment strategies. Manual, biological and chemical treatment options are utilized by CTUIR and may be employed when consistent with existing standards. The project treated 402.43 acres of property within the Umatilla subbasin in 2020 (Table 4). Weed control is essential in establishing native grass and plant species. The UAFHP partnered with Umatilla County and the Forest service to spray/control noxious weeds on sites where chemical application is necessary. The team identified problem weeds, determined the appropriate herbicide and selected the most effective application methods and rates in accordance with the National Oceanic and Atmospheric Administration's (NOAA) Biological Opinion under BPA's Habitat Improvement Program. The UAFHP utilizes backpack spraying applications to treat perennial, annual and biennial weed species. All herbicide applications are consistent with Oregon Revised Statue (ORS).570.505 and Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) Regulations. CTUIR complies with BPA standards and supplies a report to BPA detailing the types and quantities of herbicides applied to specified locations.

Additionally, Habitat Department Staff assisted the Rangeland Management Department in monitoring invasive Japanese Knotweed at the Imeques Project and various locations along the Umatilla River. The Habitat Department also assisted Tri-County CWMA in Japanese knotweed control found in project and conservation agreement areas after the 2020 flood events. The department staff will be retaking the Pesticide Applicators exam in 2024 as well.

Table 4. Noxious weed treatments completed by location within the Umatilla River Basin, 2023

Agreement Name	Latitude	Longitude	Acres Treated	Method	Species Targeted
Meacham Creek	45.63673	-118.35686	21.44	Mechanical, Chemical	*Potentilla recta, Centaurea* spp., *Echium vulgare, Rubus spp.*
Wildhorse Creek	45.80863	-118.49055	35.5	Mechanical, Chemical	*Conium maculatum*
B&G Resources	45.66254	-118.99011	49	Mechanical, Chemical	*Lepidium* spp., *Centaurea* spp. *Chondrilla juncea*
Wujek	45.66254	-118.99011	15.8	Chemical	*Polygonum cuspidatum, Fallopia japonica*
Birch Creek PA-4			22.5	Mechanical, Chemical	*Conium maculatum Dipsacus fullonum, Onopordum acanthium, Salsola, Chondrilla juncea*
Total Acres Treated			**144.24**		

Work Element K: 47. Plant Vegetation

Work Element Title: Planting within Umatilla River Subbasin Project Areas
Milestone Deliverable: Complete Scheduled Tree and Shrub Plantings in Project Areas

A. Environmental compliance requirements complete.
B. Agreement with the Native Plant Nursery for Growing Plants and Developing Plant Protocol.
C. Establish Planting Locations in Existing Project Areas for Increased Recovery.

UAFHP staff annually plant vegetation and distribute native grass seed in areas we have implemented existing and new habitat enhancement projects or have identified a need in maintained riparian Conservation Agreement areas. In 2023, the UAFHP completed a fall planting effort within the previously implemented Meacham Creek Floodplain Restoration and In-stream Enhancement Projects. The fall planting effort included installing 1000 containerized, native plants in Meacham Creek.

Planting tasks include site planning and development of planting strategies, collection and preparation of materials (pruning and conditioning of live willow material), pre-order coordination with the CTUIR Tribal Native Plant Nursery, and installation. Planting techniques are customized for conditions within each project area. Planting location, species, age, form (cuttings, saplings, bare-roots, potted, plugs), and soil/substrate conditions were considered and addressed during the implementation planning phase. The CTUIR UAFHP staff work closely with the Tribal Native Plant Nursery to collect local seed and plant stock to provide native plants for particular project areas by elevation and planting zones.

In 2023, the UAFHP staff revegetation throughout the Meacham Bonifer Project Areas:

- 1000 ponderosa pine
- 2000 willow cuttings
- 500 cottonwood cuttings
- 300 potted willow saplings
- 700 potted riparian shrubs (delayed from fall of 2022).

Work Element L: 115. Produce Inventory or Assessment

Work Element Title: Produce Umatilla River Subbasin Assessment
Milestone Deliverable: Deliver Subbasin Assessment and Assessment Action Plan

The UAFHP awarded a contract for the Assessment and Action Plan to Tetra Tech Inc. in 2020. The CTUIR worked with Tetra Tech Inc. in identifying data gaps and collating the necessary data and identification of data gaps in 2021. The 100% final assessment document, appendices and Prioritization spreadsheet tools were delivered in January 2024. The Action Plan will be finalized in the next contract period in early 2024. The UAFHP worked closely with the CTUIR GIS department to transfer this data into new maps in the CTUIR repositories and in public databases as well as determining where critical data gaps still exist.

Work Element M: 175. Produce Design and/or Specifications

Work Element Title: West Birch Creek Fish Passage Project Design
Milestone Deliverable: Final Design

CTUIR collaborated with the ODFW and UBWC to design the replacement of two fish passage barriers with 1) an open-bottom arch bridge on Stanley Creek and 2) complete removal of another current abandoned irrigation diversion structure entirely on West Birch Creek. The UBWC have secured match funds to complete this work through an OWEB grant. An environmental engineering firm was solicited and contracted to complete topographic surveys, coordinating with the county and city by the UBWC. The UAFHP has worked with UBWC and engineering firm Tetra Tech Inc. and completed the 100% design .

Work Element N: 175. Produce Design and/or Specifications

Work Element Title: Meacham RM 10 Habitat Enhancement Project Design

Milestone Deliverable: Complete Meacham Creek RM 10 Habitat Enhancement Design

CTUIR continued to work collaboratively with the USDA USFS Walla Walla Ranger District to complete 100% design plan. Yellow Flag Iris was identified at the project location and is a known invasive species that needs to be addressed. The CTUIR/USFS agreement and financial plan for the project was completed and submitted for review by the USFS.

Work Element O: Work Element T: 175. Produce Design and/or Specifications

Work Element Title: Imeques Project Design

Milestone Deliverable: Imeques Reach habitat Enhancement Final Design

CTUIR developed a work plan and advertise for solicitation of engineering services for design. Kleinschmidt-R2 was selected for development of design. During this CY the 60% conceptual designs and draft basis for design report related to floodplain design have been delivered. Development of the feasibility assessment for the facility was completed to 15% and the decision was made to maintain the existing diversion and screen and use the floodplain restoration implementation to create the flow conditions to ensure the intake functions properly. The UAFHP staff are working closely with our Fisheries Program Artificial Production and Monitoring and Evaluation departments on design with intent to improve acclimation facility operations and maintenance, trap site and fish habitat improvements.

Work Element P: 175. Produce Design and/or Specifications

Work Element Title: UmaBirch Properties – Floodplain Restoration and Habitat Enhancement Design
Milestone Deliverable: 100% UmaBirch Floodplain Restoration and habitat Enhancement Design

In 2023, UAFHP staff continued towards finalizing the conservation easement for restoration work on the UmaBirch project established in 2017. Construction of PA 4 began in October 2023 through December 2023 and has resumed in the 2024 contract period and planned to be completed in 2024. Currently, the proposed wetland ponds have been successfully excavated and excavation of the new primary channel is still under way.

The design indicates a phased construction approach into four distinct project areas (PAs). The 60% Basis for Design Reports for PAs 2 and 3 were delivered during this review period, while PA 1 100% design has been completed. It was determined that a new bridge that separates PA 3 and 2 on Taylor Ln is needed due to erosion around the stream right abutment. Design for this bridge were delivered in 2023 with additional scope and funds added to the existing contract.

Work Element Q: 132. Produce (Annual) Progress Report

Work Element Title: Produce Annual Progress Report CY23 (Feb. 1, 2023, thru Jan. 31, 2024)
Milestone Deliverable: Completed annual progress report

A. Review progress report format requirements
B. Upload finalized RM&E technical report for BPA to publish
C. Distribute progress report for BPA review and comment
D. Upload non-technical progress report to Pisces
E. Review progress report format requirements
F. Draft CY2021 technical report

G. Interagency/tribal review
H. Confirm BPA posted received

The CY2023 BPA Annual Progress Report was completed and was uploaded to BPA through Pisces in February 2023.

Work Element R: 185. Produce Pisces Status Report

Work Element Title: Periodic Status Reports for BPA
Milestone Deliverable: Complete Periodic Pisces Status Reports

CTUIR reported to BPA periodically during the contract period on the status of each statement of work element, and milestones and deliverables using the computer program Pisces:
February-June (2/1/2023 - 6/30/2023)
July-September (7/1/2023 - 9/30/2023)
October-December (10/1/2023 - 12/31/2023)
Final January (1/1/2023 -1/31/2024)

The BPA Contracting Officer Representative (COR) reviewed the Pisces status reports, recommended changes as necessary and accepted them electronically upon approval. Additionally, upon completion of each deliverable milestone, we provided metrics and final project location (latitude and longitude) when required. These Pisces status reports provide a tool for the BPA COTR and administrative staff to track project progress in meeting contract requirements.

Discussion

The projects implemented in this reporting period were carefully designed in previous years to mitigate for the identified ecological concerns and align with local assessments. The CTUIR approaches restoration utilizing the Umatilla River Vision, previously described (Jones et al. 2008). The process-based philosophy of the River Vision encourages development of projects that address multiple River Vision Touchstones, limiting factors, and ecological concerns (Table 7).

Habitat protection and restoration actions, like those completed during this review period, were identified in numerous local assessments and planning documents. The Umatilla River Basin TMDL and WQMP (ODEQ and CTUIR 2001), Umatilla/Willow Subbasin Plan (NPCC 2005), Middle Columbia Steelhead DPS ESA Recovery Plan (2009), and the Recovery Plan for the Coterminous United States Population of Bull Trout (USFWS 2015) all identify one or more habitat restoration or protection actions implemented by the UAFHP in this reporting period as a way to address issues facing ESA-listed fish species and/or water quality concerns. In addition to the subbasin-scale planning documents, the restoration activities completed by the UAFHP in this reporting period are also supported by several smaller scale watershed assessments. The Meacham Creek Watershed Analysis and Action Plan (Andrus and Middel 2003) and the Birch Creek Watershed Action Plan (CTUIR 2016) both specifically support the restoration actions completed in those watersheds.

OBSTACLES AND LESSONS LEARNED

The largest obstacles to during the 2023 reporting period were staff changes, massive workload with five projects, 408 levee setback submission, $11 million in contracts and a Umatilla Rive assessment all at the same time. Additionally, we worked through design complications on all projects to reach an agreed upon resolution. Examples include 1) Discovering erosion on UmaBirch PA 3 near the Taylor Ln. Bridge and determining the best

way to proceeded to receive the best downstream delivery of the stream and floodplain connectivity; 2) Selecting an appropriate screen for the existing intake at the Imeques Reach Facility; and 3) Delaying implementation of UmaBirch PA4 due to deciding to relocate the existing well and irrigation infrastructure across Birch Creek. These obstacles created multiple challenges to communication, execute implementation to meet existing timelines, and staff daily activities. Throughout this period, project staff have adapted and strategized together to continue moving each project forward.

Overcoming these constraints as best as possible, the UAFHP completed work in areas with multiple jurisdictions, subcontracted several large design and construction contracts, and maintained complex partnerships with landowners and local action agencies. The wide variety of work presented a number of unique challenges. As a result of working through these challenges, the UAFHP has learned several lessons that will inform future project work.

Table 5. The Umatilla Anadromous Fish Habitat Project objectives relative to the Umatilla River Vision touchstones (Jones et al. 2008), BPA 2008 Fish Accords primary limiting factors (Fish Accords 2008) and NOAA's ecological concerns (NMFS 2009).

Umatilla Habitat Program Objectives	Umatilla River Vision 2008 Touchstones Addressed	BPA 2008 Fish Accords Primary Limiting Factor's Addressed	NOAA Ecological Concerns	NOAA Ecological Concerns Subcategories
Protect and conserve natural ecological processes that support the viability of fish populations and their primary life history strategies	Biota Connectivity Geomorphology Hydrology Riparian Vegetation	In-channel Characteristics Floodplain/Riparian Sediment	Multiple(Habitat Quantity, Injury and Mortality, Peripheral and Transitional Habitats, Channel Structure and Form, Sediment Conditions, Water Quality, Water Quantity, Population Level Effects)	Multiple
Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly function passage and connectivity	Geomorphology Connectivity	Passage/Entrainment	Habitat Quantity	Anthropogenic Barriers
Maintain and restore floodplain connectivity and function	Aquatic Biota, Connectivity, Riparian Vegetation, Geomorphology, Hydrology	Water Quality-Temperature Riparian/Floodplain	Food, Peripheral and Transitional habitats, Riparian Condition, Channel Structure and Form, Water Quantity	Altered Primary Productivity, Altered Prey Species Composition and Diversity, Riparian Condition, LWD Recruitment, Floodplain Condition, Bed and Channel Form, Instream Complexity, Decreased Water Quantity, Altered Flow Timing
Restore degraded and maintain properly function channel structure and complexity	Connectivity, Riparian Vegetation, Geomorphology	In-channel Characteristics	Riparian Condition, Peripheral and Transitional Habitats, Channel Structure and Form	Riparian Condition, LWD Recruitment, Side Channel Conditions, Floodplain Condition, Bed and Channel Form, Instream Structural Complexity
Restore riparian condition and LWD recruitment and maintain properly functioning conditions	Aquatic Biota, Riparian Vegetation, Hydrology	In-channel Characteristics Riparain/Floodplain	Food, Riparian Condition	Riparian Condition, LWD Recruitment, Altered Primary Productivity, Food-Competition, Altered Prey Species Composition and Diversity
Restore natural hydrograph to provide sufficient flow during critical periods	Connectivity, Aquatic Biota, Hydrology,	Floodplain/Riparian Water Quality-Temperature	Habitat Quantity, Water Quality, Water Quantity	HQ-Competition, Oxygen, Increased Water , Alter Flow Timing
Improve degraded water quality and maintain unimpaired water quality	Hydrology, Aquatic Biota	Floodplain/Riparian Water Quality-Temperature	Riparian Condition, Sediment Conditions, Water Quality	Riparian Condition, Decreased Sediment Quantity, Temperature, Oxygen Turbidity, Toxic Contaminants

ADAPTIVE MANAGEMENT

The UAFHP places a heavy weight on adaptive management, applying lessons learned in past years, and using research and action effectiveness monitoring data to support project decision making.

This contract year the UAFHP brought on a new Biologist. The Biologist I has worked alongside our technician I and II to help plant native vegetation, collect cuttings for future planting efforts, and taken photopoints for our project reports. In addition, the Biologist I has assisted the Assistant Project Lead Biologist II and Project Lead Fisheries Habitat Biologist III.

This CY include being adaptable to rapid changes in department staffing and learning how to adapt to multiple roles in order to ensure projects are completed and met on time. Additionally, reflecting on how to improve, plan, and coordinate planting will be critical when construction is completed at UmaBirch PA 4 in the next CY. The UAFHP continues to improve the species mix based on ecological suitability and enhancement of First Foods species. Methods for planting more efficiently, like hydro-seeding riparian species in addition to plugs has been researched to incorporate into the UmaBirch wetlands that will be constructed next CY.

Utilizing a River Vision (Jones et al 2008) approach, the staff have developed an implementation approach to allow the water to do as much work for us as possible. Not only does this align perfectly with a process-based approach, it also minimizes impacts to the resources in the short term. This approach, specific to constructing new side channels or main channels, relies on the premise that they are constructed in the fall and allowed to overwinter. These channels are roughly excavated, to allow the water to activate the newly constructed section at a designed flow elevation (e.g. typically about 1.2 year flow return interval). Channel dimensions are not constructed to exact widths or depths, as the water will be allowed to scour the channel to the appropriate dimensions. Also the project strives to only excavate the minimum amount necessary to reconnect relic channels. This accomplishes the following ecological/biological benefits:

- There is less excavation, as the water is allowed to more clearly define its own channel geomorphology, which reduces overall project costs;
- Allowing the water to define its own course more directly also likely contributes to longer term stability, as the water is creating its own channel;
- This allows the newly disturbed soil to gain weathering, which reduces the amount of turbidity produced;
- The newly disturbed soil is washed into place by hand. This turbid water is pumped into the floodplain and allowed to slowly re-infiltrate slowly, which further reduces future turbidity;
- When the turbidity is realized in the system, it is at a time of the year when there is substantially less stress to the fish that are present:
- Water temperatures are lower (i.e. there's less oxygen requirements on the fish);
- The turbidity presumably settles out along the length of newly reconnected channel prior to reaching areas occupied by fish;
- This occurs at a time of the year when there's more water, which allows fish more refugia areas to avoid any potential turbidity stressors; and,
- This approach minimizes the need for fish salvage, and thus, reduces the incidental take of listed and resident fish.

A gap in our current feedback loop stems from the simple truth that not many of these large-scale, full floodplain projects have been implemented and monitored in a manner that provides clear, concise answers. This is particularly true for certain project elements, like hyporheic exchange and long-term ecological improvements. Another flaw is the lack of resources available that allows project sponsors to clearly articulate finding of monitoring that is completed to colleagues.

SUMMARY AND CONCLUSIONS

The CTUIR Habitat Program utilizes a process based approach to restoration activities, following the CTUIR River Vision (Jones et al 2008), Upland Vision (Endress et al 2019) and First Foods policies (Quaempts et al 2018). These guiding documents provide the framework in which our program develops, designs, implements and monitors restoration activities and projects. Following this approach, project staff have developed a more holistic way to meet project objectives, provide the system with tools to place it on a recovery trajectory and allow the water to do some to the work for us.

In accordance with the 2006 NPCC solicitation outline, the CTUIR UAFHP has focused its restoration activities primarily on Meacham Creek, Birch Creek, and mainstem Umatilla River. However, project restoration activities occur in other areas of the basin where floodplain and riverine processes are treated with outcomes that are beneficial to ecological processes, water quality and fish production. The Meacham Creek Watershed has long been a primary focal point of the CTUIR effort to improve habitat conditions in the Umatilla Basin because of its location, size, historical significance, and recovery potential. Table 8 highlights the CTUIR Umatilla Anadromous Fish Habitat Project restoration accomplishments since 2007.

Proposed restoration actions have focused on protection, enhancement, and restoration of functional floodplain, channel and watershed processes at multiple scales using passive and active restoration techniques. Over the past decade, the CTUIR Department of Natural Resources and UAFHP have transitioned from restoration toward a fixed endpoint to address symptoms to a restoration of processes. Restoration of process is more likely to address causes of river ecosystem degradation, whereas restoration toward a fixed endpoint addresses only symptoms. Specific restoration actions proposed for completion by CTUIR include levee removal and or modification, floodplain and channel construction, in-stream and floodplain large wood additions, in-stream structure placement, wetland enhancement, floodplain and riparian plantings, noxious weed removal, riparian management through fencing, and removal of physical migration barriers. Threats from climate change, invasive non-native species, and chemical/fuel spills are becoming increasingly relevant within the Umatilla Watershed. The negative effects associated with these emerging dangers have the potential to severely compromise ongoing restoration efforts. The obvious and most direct potential threat to restoration efforts in the long-term is the increase in stream and river temperatures to an uninhabitable level for salmon and trout in the near future The UAFHP have and will continue to maintain project areas under secured conservation agreements, or conservation easements/land acquisition, on private properties for protection and enhancement of floodplain and riparian habitat investments. Completed project activities are described below in more detail in the context of the watershed with reference to annual progress reports.

During this reporting period, the UAFHP continued to implement habitat improvement projects. While implementation of UmaBirch PA4 had to be delayed, UAFHP staff completed maintenance of ongoing weed treatments, riparian vegetation plantings/enhancement and passage projects maintenance at properties where the CTUIR has pre-existing riparian conservation agreements like Athena Bridge.

The CTUIR UAFHP made progress as well as completion on several design documents that will serve to inform projects. The UAFHP began the design process for a floodplain reconnection and in- stream enhancement project on Imeques Reach of the Umatilla River, progressed design for UmaBirch PAs 1 to 100%, PA-2/3 to 60%, developing design for a replacement bridge to prevent continued upstream erosion, progressing on decommissioning the CAFO on PA 3, and working through the Sec. 408 application for the Pendleton 2A Levee setback to 60% and review process with the USACE and other project partners. While the Meacham Creek RM 10-11 design has been delayed to due additional planning needs, implementation is anticipated for 2024. The UAFHP made great strides on the Umatilla Basin Assessment and Action Plan by receiving the final draft submittal of the Assessment and reviewing the first draft of the Prioritization Tool.

A principal strength and focus of the CTUIR UAFHP project is the ability to work cooperatively with the various entities throughout the restoration process. Staff participated and cooperated with multiple agencies and stakeholders in the

Umatilla Basin Watershed including ODFW, USDA-FS, Natural Resource Conservation Service, Umatilla Basin Watershed Council, Umatilla County Soil and Water Conservation District, and local stakeholders to enhance or protect natural resources, identify problems and solutions, coordinate efforts to prevent duplication, enhance communication and cooperation and identify funding and cost share opportunities within the Umatilla River subbasin.

The UAFHP is an ongoing effort to protect, enhance and restore functional floodplain, channel and watershed processes to provide sustainable and healthy habitat for aquatic species in the Umatilla River subbasin, including ESA Threatened Middle Columbia River Steelhead. Project work further supports the CTUIR Department of Natural Resource River Vision and First Foods mission statements to sustain production. The River Vision principles have been successfully applied in effort to reestablish the salmonids to self-sustaining levels. We expect a substantial positive response of salmonid populations once habitat floodplain and channel function is addressed and improved. We believe a positive correlation between habitat improvement, salmonid density, and fitness levels will shift the status of ESA-Listed species towards a safer level of sustainability in the Umatilla River Basin.

Table 6. The CTUIR UAFHP restoration project descriptions by location, treated primary limiting factors (NMFS 2009) by CTUIR River Vision touchstones (Jones et al. 2008) and accomplishments; 2007-2023.

Subbasin, Stream and Years	Project Description	Species	CTUIR River Vision Touchstones/ Habitat Limiting Factors (PLF's shaded in yellow-NOAA BiOP)								Comment/ Accomplishments
			Biota-Connectivity	Geo-morphology	Connectivity		Hydrology			Riparian Vegetation	
			Passage Barriers/ Entrainment	In-channel Characteristics	Habitat Diversity (LWD)	Floodplain Confinement	High Temps	High Turbidity	Low Flows	Riparian/ Floodplain	
Meacham Creek and Camp Creek, Tributary of Meacham Creek (2007)	Fish passage rectifications, pool development with rock structures, and plantings	STS	**X**				**X**			**X**	Rectified two diversion dams and one in-stream structure providing unimpeded access to the entire watershed, development of pools with boulder cross vanes, 335 ft of streambank stabilization with added wood complexity, 0.3 miles livestock exclusion fence, and 500 riparian plantings.
West Birch Creek (2007-2008)	Fish passage rectification, riparian protection fencing and plantings	STS	**X**		**X**		**X**			**X**	Rectification of the Cunningham and Hoeft Dams providing 2.4 miles unimpeded habitat, 335 ft of streambank stabilization with added wood complexity, 0.3 miles livestock exclusion fence, and 5,000 riparian plants.

Mainstem Umatilla River (Initiated 2008-2012)	Treated and maintained 3.5 miles of floodplain and channel; riparian and uplands	CHS, CHF, STS, Coho			X		X	X	X	X	Conservation Agreement on B&G Property to maintain 355 (61 riparian and 294 upland acres; installation of 60.7 acres of CREP tract's), 2 off-channel water wells, 13,400 seedling trees planted, 1,335 lbs of native grass seed and noxious weed control; Installation of an access restriction fence (3 additional riparian acres protected).
Meacham Creek (2009)	Floodplain improvement with levee setback, initiation of off-channel rearing habitat, large wood placement, and riparian plantings	CHS, STS,BT, Pacific Lamprey	X	X	X	X	X		X	X	Restored 40 acres of floodplain connectivity over 1-mile of stream by removal or modification of 3 levees and 1 dike (3,200 linear ft, 24,000 cubic yards); distribution of large wood on floodplain; 15,000 planted hardwood and conifer seedlings (30acres).
Meacham Creek (Initiated 2008-2012)	Riparian protection fencing and plantings	CHS, STS,BT, Pacific Lamprey		X	X		X		X	X	Built 9.8 miles of livestock exclusion fence between RM 2.0-8.5 (~350 acres protected).
Birch Creek (2010-2016)	Bank stabilization and large wood habitat complexity and riparian plantings	STS		X	X	X	X	X		X	Restoration of 335 ft of streambank stabilization with large wood and boulders over 0.1 miles of stream, 2 large wood in-channel habitat structures, and planted 5,000 riparian plantings over the 1-mile property.

Meacham Creek Floodplain Restoration and In-Stream Enhancement Phase I Project RM 6-7.1 (2011-2012)	Floodplain and channel improvement with levee setback, large wood placement, side-channel connectivity, wetland enhancement, and riparian plantings.	STS, CHS, BT, Pacific Lamprey		X	X	X	X	X	X	X	Reconnected 67 acres of floodplain over 1-mile of stream by removing a 2,800 foot levee and modification of two spur dikes (600 ft removed), realigned historic channel with meanders in the floodplain, developed 3 secondary channels and 3,568 ft of off-channel habitat, 12 large pool structures, 10 major and 286 medium rock and log features, and installed 38,290 plantings.
Birch Creek (2012)	Fish passage rectification and habitat restoration project.	STS, Coho	X	X		X	X	X		X	Removed two abandoned irrigation diversions (Taylor Property-ODFW lead agency) providing unimpeded access to 2.7 river miles of stream. Included channel reshaping, setback of leveed road adjacent to the channel; and reshaping of the channel and banks, two j-hook rock structure placements and riparian plantings over 0.6 miles of stream.
West Birch Creek (2012)	Fish passage rectification and habitat	STS	X	X	X		X	X		X	Removed one abandoned irrigation diversion (Low Property-ODFW lead

	restoration project.										agency) providing unimpeded access to 5.0 river miles of stream, installation of rock and large wood structures, channel re-shaping and plantings over 1-mile of stream.
Dillon Diversion Dam Removal (2017)	Fish passage rectification	STS, CHS, CHF, Coho, BT, Pacific Lamprey	X	X							Removed a longstanding partial barrier to upstream migration and opened an additional 3.65 miles of river to unimpeded travel for anadromous salmonids.
Meacham Creek Bonifer Reach Floodplain Reconnection and In-stream Enhancement – Project Areas 3 & 4 (2017-2018)	Floodplain and channel improvement with levee removal, channel reconnection, large wood placement, and riparian plantings	STS, CHS, BT, Pacific Lamprey		X	X	X	X	X	X	X	Treated over 1.6 miles of Meacham Creek by removing 3,385 linear feet of levees and dikes, reconnecting 3,766 linear feet of primary and secondary channel habitat, and installing 69 engineered log jams with more than 537 logs with rootwads attached.
Basin-wide Agreements O&M (2008-2018)	Ongoing maintenance of 17 riparian conservation agreements including livestock exclusion fencing, tree planting and weed control	CHS, CHF, STS, Coho, BT, Pacific Lamprey	X	X	X	X	X	X	X	X	552 acres protected and maintained, 15.15 miles of riparian fence protection (184 ac.), 7,300 planted hardwood seedling trees.
Meacham Creek Bonifer Reach Floodplain Reconnection and In-stream Enhancement –	Floodplain and channel improvement with channel creation and reconnection,	STS, CHS, BT, Pacific Lamprey		X	X	X	X	X	X	X	Treated 0.95 miles of Meacham Creek by creating and reconnecting 7,656 feet of primary and secondary channel

Project Area 2 (2019)	large wood placement, and riparian plantings										habitat, and installing 14 engineered logjams, 45 individual log structures, and 130 boulders
Reith Dam Removal (2019)	Fish passage rectification	STS, CHS, CHF, Coho, BT, Pacific Lamprey	X	X							Removed a longstanding partial barrier to upstream migration and opened miles of river to unimpeded travel for anadromous salmonids.
Athena Bridge Fish Passage Project (2019)	Fish passage rectification	STS, BT, Pacific Lamprey	X	X						X	Removed fish passage barrier, replaced bridge, placed rock structures and planted native riparian vegetation.
Meacham Creek Bonifer Reach Floodplain Reconnection and In-stream Enhancement – Project Area 1 (2020)	Floodplain and channel improvement with channel creation and reconnection, large wood placement, and riparian plantings	STS, CHS, BT, Pacific Lamprey		X	X	X	X	X	X	X	Treated 0.8 miles of Meacham Creek by creating and reconnecting 7,656 feet of primary and secondary channel habitat, and installing 13 engineered logjams, and 22 additional log structures
Meacham Creek Punchlist – Bonifer Project (2021)	removing and modifying levees and spur dikes and adding LWM to improve habitat complexity	STS, CHS, BT		X	X	X	X	X	X	X	Treated 2 acres of habitat by full dike removal in the riparian zone and treated 0.55 acres of riparian non-wetland habitat
Meacham Creek Bonifer Reach Floodplain Reconnection and In-stream Enhancement – Project Area 1 (2023)	Floodplain and channel improvement; removing levees, adding LWM, planting, weed treatment habitat	STS, CHS, BT		X	X	X	X	X	X	X	Treated Meacham, Umabirch PA-4, Wujak, Wildhorse and mid-Umatilla River properties habitat with riparian planting and weed treatment. Maintained previous project areas

REFERENCES

Alt, D. and D.W. Hyndman 1995. *Northwest Exposures: A Geologic Story of the Northwest*. Mountain Press Publishing Company, Missoula, MT.

Andrus, C. & J. Middel 2003. Meacham Creek Watershed Analysis and Action Plan; Final Report. pp. 125, Prepared for the Confederated Tribes of the Umatilla Indian Reservation.

Arrigoni, A.S., Alicia S., Poole, G.C., Mertes, L.A.K., O'Daniel, S.J., Woessner, W.W., Thomas, S.A. 2008. Buffered, lagged, or cooled? Disentangling hyporheic influences on temperature cycles in stream channels. WATER RESOURCES RESEARCH, VOL. 44, W09418, 13 PP

Arscott, D. B., K. Tockner, and J. V. Ward. 2000. Aquatic habitat diversity along the corridor of an alpine floodplain river (the Fiume Tagliamento, Italy). Archiv Fur Hydrobiologie 149:679-704.

Arscott, D. B., K. Tockner, and J. V. Ward. 2001. Thermal heterogeneity along a braided floodplain river (Tagliamento River, northeastern Italy). Canadian Journal of Fisheries and Aquatic Sciences 58:2359-2373.

Baxter, C. V., and Hauer, F. R. 2000. Geomorphology, hyporheic exchange, and selection of spawning habitat by bull trout (Salvelinus confluentus): Canadian Journal of Fisheries and Aquatic Sciences 57:1470-1481.

Beechie, T., and Bolton, S., 1999. An approach to restoring salmonid habitat-forming processes in Pacific Northwest watersheds: Fisheries 24:6-15.

Beechie, T.J., G. R. Pess, P. Roni, G. Giannico. 2008. Setting river restoration priorities: a review of approaches and a general protocol for identifying and prioritizing actions. North American Journal of Fisheries Management 28:891-905.

Beechie, T.J., Sear, D.A., Olden, J.D., Pess, G.R., Buffington, J.M., Moir, H., Roni, P., and Pollock, M.M., 2010, Process- based principles for restoring river ecosystems: Bioscience, v. 60, p. 209-222.

Bencala, K.E., and Walters, R.A., 1983, Simulation of solute transport in a mountain pool-and-riffle stream: A transient storage model: Water Resources Research, v. 19, p. 718-724.

Bernhardt, E.S., Palmer, M.A., Allan, J.D., Alexander, G., Barnas, K., Brooks, S., Carr, J., Clayton, S., Dahm, C., Follstad-Shah, J., Galat, D., Gloss, S., Goodwin, P., Hart, D., Hassett, B., Jenkinson, R., Katz, S., Kondolf, G.M., Lake, P.S., Lave, R., Meyer, J.L., O'Donnell, T.K., Pagano, L., Powell, B., and Sudduth, E., 2005, Ecology - Synthesizing US river restoration efforts: Science, v. 308, p. 636-637.

Boulton, A.J., Datry, T., Kasahara, T., Mutz, M., and Stanford, J.A., 2010, Ecology and management of the hyporheic zone: stream-groundwater interactions of running waters and their floodplains: Journal of the North American Benthological Society, v. 29, p. 26-40.

BOR (Bureau of Reclamation). 1988. Umatilla Basin Project, Oregon. Planning report, final environmental impact statement. Boise, Idaho.

Boyce, R. R. 1986. *A comprehensive plan for rehabilitation of anadromous fish stocks in the Umatilla river basin*. Final report of the Oregon Department of Fish and Wildlife to Bonneville Power Administration, Portland, Oregon. Publication DOE/BP-18008-1.

Brown, A. G. 1997. Biogeomorphology and diversity in multiple-channel river systems. Global Ecology and Biogeography Letters 6:179-185.

Buchanan, D.V. and S.V. Gregory 1997. *Development of water temperature standards to protect and restore habitat for bull trout and other cold water species in Oregon*. *Proceedings of the Friends of the Bull Trout Conference*. Calgary, Alberta.

Buffington, J.M., and Tonina, D., 2009. Hyporheic exchange in mountain rivers II: Effects of channel morphology on mechanics, scales and rates of exchange: Geography Compass, 3(3): 1038–1062.

Burkholder, B. K., Grant, G. E., Haggerty, R., Khangaonkar, T., and Wampler, P. J., 2008. Influence of hyporheic flow and geomorphology on temperature of a large, gravel-bed river, Clackamas River, Oregon, USA: Hydrological Processes 22: 941-953.

CHaMP (Columbia Habitat Monitoring Program). 2011. CHaMP 2011 training version 1.1.

CHaMP (Columbia Habitat Monitoring Program). 2012. Scientific protocol for salmonid habitat surveys within the Columbia Habitat Monitoring Program. Prepared by the Integrated Status and Effectiveness Monitoring Program and published by Terraqua, Inc., Wacounda, WA.

Contor, C. R. Editor. 2012. *Umatilla Basin Natural Production Monitoring and Evaluation, 2011 Annual Progress Report*. Confederated Tribes of the Umatilla Indian Reservation, 46411 Ti'Mine Way, Pendleton, OR. Report submitted to Bonneville Power Administration, Project No. 1990-005-01

Contor, C. R. Editor. 2016. *Umatilla Basin Natural Production Monitoring and Evaluation, 2016 Annual Progress Report*. Confederated Tribes of the Umatilla Indian Reservation, 46411 Ti'Mine Way, Pendleton, OR. Report submitted to Bonneville Power Administration, Project No. 1990-005-01

Crispell, J.K., Endreny, T.A., 2009, Hyporheic exchange flow around constructed in-channel structures and implications for restoration design: Hydrologic Processes: 23(8), 1158–1168.

Christian, Richard L. 2015. *The Umatilla Anadromous Fish Habitat Project: 2015 Annual Report.* Confederated Tribes of the Umatilla Indian Reservation, report submitted to Bonneville Power Administration, Project No. 1987-100-01.

Christian, Richard L. and Ethan D. Green. 2017. *The Umatilla Anadromous Fish Habitat Project: 2016 Annual Report.* Confederated Tribes of the Umatilla Indian Reservation, report submitted to Bonneville Power Administration, Project No. 1987-100-01.

Christian, Richard L. and Ethan D. Green. 2018. *The Umatilla Anadromous Fish Habitat Project: 2017-18 Annual Report*. Confederated Tribes of the Umatilla Indian Reservation, report submitted to Bonneville Power Administration, Project No. 1987-100-01.

Christian, Richard L. 2019. *The Umatilla Anadromous Fish Habitat Project: 2018 Annual Report*. Confederated Tribes of the Umatilla Indian Reservation, report submitted to Bonneville Power Administration, Project No. 1987-100-01.

Christian, R. L. & M. Kelly. 2020. *The Umatilla Anadromous Fish Habitat Project: 2019 Annual Report*. Confederated Tribes of the Umatilla Indian Reservation, report submitted to Bonneville Power Administration, Project No. 1987-100-01.

Christian, R. L. & M. Kelly. 2021. The Umatilla Anadromous Fish Habitat Project: 2021 ISRP Proposal. Confederated Tribes of the Umatilla Indian Reservation, report submitted to Northwest Power and Conservation Council, BPA Project No. 1987-100- 01. Available online at link: Council-ISRP Geographic Review.

CTUIR 1994. *Umatilla Basin Natural Production Monitoring and Evaluation, Annual Progress Report 1992-1993*. Prepared by Confederated Tribes of the Umatilla Indian Reservation and submitted to Bonneville Power Administration, Project No. 90-005-01.

CTUIR 1995. *Umatilla Basin Natural Production Monitoring and Evaluation*, Annual Report, 1993-1994, Prepared by Confederated Tribes of the Umatilla Indian Reservation for U.S. Department of Energy, Bonneville Power Administration, Environment, Fish and Wildlife, Portland, OR, April 1995, Project No. 90-005-01.

CTUIR 2000. *Umatilla Basin Natural Production Monitoring and Evaluation Project, Annual Progress Report 1997-1998*. Confederated Tribes of the Umatilla Indian Reservation, BPA Project No. 1990-005-01.

CTUIR 2005. *Confederated Tribes of the Umatilla Indian Reservation Water Code.* Prepared by the Confederated Tribes of the Umatilla Indian Reservation, Department of Natural Resources, as amended through Resolution No. 05- 027 (March 7, 2005).

CTUIR 2005. *Confederated Tribes of the Umatilla Indian Reservation Total Maximum Daily Load for temperature and turbidity.* Prepared by the Confederated Tribes of the Umatilla Indian Reservation, Department of Natural Resources, Issued by the US Environmental Protection Agency, Region 10, July 2005. Available online at URL: http://yosemite.epa.gov/R10/WATER.NSF/TMDLs/Approved+TMDLs.

CTUIR 2007. *Biological Assessment, Birch Creek Salmonid Passage Improvements, Umatilla River Basin*. Prepared by the Confederated Tribes of the Umatilla Indian Reservation. July 2007.

CTUIR 2008. *Umatilla River Basin Anadromous Fish Habitat Enhancement Project*, *Annual Report, February 1, 2007 – January 31, 2008, Fiscal Year 2007,* Document ID# P109208, Contract # 32047. Confederated Tribes of the Umatilla Indian Reservation. Submitted to Bonneville Power Administration, January 2008. Available online as accessed January 22, 2009 at URL: http://pisces.bpa.gov/release/documents/documentviewer.aspx?doc=P109208.

CTUIR 2012. *Meacham Creek Floodplain Restoration and In-stream Enhancement Project Completion Report*. Published by Tetra Tech, Inc., Bothell, Washington. December 2012.

CTUIR 2012. *Umatilla Basin Natural Production Monitoring and Evaluation, 2011 Annual Progress Report*. Confederated Tribes of the Umatilla Indian Reservation, 46411 Ti'Mine Way, Pendleton, OR. Report submitted to Bonneville Power Administration, Project No. 1990-005-01

CTUIR 2016. *Birch Creek Watershed Action Plan*. Mission, Oregon. 115 pp.

CTUIR, ODEQ and UBWC. 2000. Umatilla River Basin Water Quality Analysis in Preparation for the Total Maximum Daily Load (TMDL). Umatilla Stakeholders and Technical Committee.

CTUIR, ODEQ and UBWC. 2000b. Public Comment Draft of the Umatilla River Basin Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WQMP).

CTUIR and ODFW 2006. *Five-Year Action Plan for the Development and Maintenance of Habitat Improvement Projects in the Umatilla Subbasin: 2006-2010,* Prepared for/Funded by: U.S. Department of Energy, Bonneville Power Administration, and Division of Fish and Wildlife, March 2006.

Downes, B.J., L.A. Barmuta, P.G. Fairweather, D.P. Faith, M.J. Keough, P.S. Lake, B.C. Mapstone, G.P. Quinn. 2002. Monitoring Ecological Impacts: Concepts and Practices in Flowing Waters. Cambridge University Press, Cambridge, UK.

Ebersole, J. L., Liss, W. J., and Frissell, C. A., 2001, Relationship between stream temperature, thermal refugia, and rainbow trout Oncorhynchus mykiss abundance in arid-land streams in the northwestern United States: Ecology of Freshwater Fishes 10:1-10.

Endress, B. A., Quaempts, E. J., and Steinmetz S., 2019. *First Foods Upland Vision*. Prepared for the Confederated Tribes of the Umatilla Indian Reservation. 32 pp.

Environmental Protection Agency (1986). Quality Criteria for Water. http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/upload/2009_01_13_criteria_goldbook.pdf

Evans, E. C., and Petts, G. E., 1997, Hyporheic temperature patterns within riffles: Hydrological Sciences Journal 42:199- 213.

Fernald, A. G., Landers, D. H., and Wigington, P. J., 2006, Water quality changes in hyporheic flow paths between a large gravel bed river and off-channel alcoves in Oregon, USA: River Research and Applications 22:1111-1124.

Fetter, C. W., Applied Hydrogeology, 3rd ed., 691 pp., Prentice-Hall, Englewood Cliffs, N. J., 1994. Geist, D. R. 2000. Hyporheic discharge of river water into fall Chinook salmon (Oncorhynchus tshawytscha) spawning areas in the Hanford Reach, Columbia River. Canadian Journal of Fisheries and Aquatic Sciences 57:1647-1656.

Freeze, A. R., and Cherry, J. A. (1979). *Groundwater*. Prentice Hall.

Geist, D. R., Hanrahna, T. P., Arntzen, E. V., McMichael, G. A., Murray, C. J., and Chien, Y., 2002, Physiochemical characteristics of the hyporheic zone affect redd site selection by chum salmon and fall Chinook salmon in the Columbia River: North American Journal of Fisheries Management, 22: 1107-1085.

Gooseff, M.N., Anderson, J.K., Wondzell, S., LaNier, J., and Haggerty, R., 2006, A modeling study of hyporheic exchange pattern and the sequence, size, and spacing of stream bedforms in mountain stream networks, Oregon, USA (Retraction of vol 19, pg 2915, 2005): Hydrological Processes, v. 20, p. 2441-+.

Haggerty, R., Wondzell, S.M., and Johnson, M.A., 2002, Power-law residence time distribution in the hyporheic zone of a 2nd-order mountain stream: Geophysical Research Letters, v. 29. Hanrahan, T. P., 2008, Effects of river discharge on hyporheic exchange flows in salmon spawning areas of a large gravel-bed river: Hydrological Processes 22:127-141.

Harbaugh, A.W., 2005, MODFLOW-2005, The U.S. Geological Survey modular ground-water model—the Ground-Water Flow Process: U.S. Geological Survey Techniques and Methods 6- A16

Harman, W., R. Starr, M. Carter, K. Tweedy, M. Clemmons, K. Suggs, C. Miller. 2012. A Function-Based Framework for Stream Assessment and Restoration Projects. US Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Washington, DC EPA 843-K-12-006.

Hester, E.T., and Gooseff, M.N., 2010, Moving Beyond the Banks: Hyporheic restoration is fundamental to restoring ecological services and functions of streams: Environmental Science and Technology: 44, 1521–1525.

Hester, E. T., Doyle, M. W., and Poole, G. C., 2009, The influence of in-stream structures on summer water temperature via induced hyporheic exchange: Limnology and Oceanography 51:355-367.

Hillman, T. W. 2003. Monitoring Strategy for the Upper Columbia Basin. BioAnalysts, Inc., Eagle, Idaho.

Hoehn, E., and Cirpka, O.A., 2006, Assessing residence times of hyporheic ground water in two alluvial flood plains of the Southern Alps using water temperature and tracers: Hydrology and Earth System Sciences, v. 10, p. 553-563.

Hoverson, Eric D. and Webster, James G. 2009. *CTUIR Umatilla Anadromous Fisheries Habitat Project Annual Report, Fiscal Year 2008*. Confederated Tribes of the Umatilla Indian Reservation, report submitted to Bonneville Power Administration, Project No. 1987-100-01.

Hubler, S. 2008. PREDATOR: Development and use of RIVPACS-type macroinvertebrate models to assess the biotic condition of wadeable Oregon streams. DEQ08-LAB-0048-TR.

Huff D.D., S.L. Hubler, Y. Pan, and D.L. Drake. 2006. Detecting Shifts in Macroinvertebrate Community Requirements: Implicating Causes of Impairment in Streams. Oregon Department of Environmental Quality. DEQ06-LAB-0068- TR.

Jones, K. L., G. C. Poole, E. J. Quaempts, S. O'Daniel, T. Beechie, 2008. *Umatilla River Vision.* Prepared for the Confederated Tribes of the Umatilla Indian Reservation, 31 pp.

Karr, J.R. and E.W. Chu. 1999. Restoring Life in Running Waters: Better Biological Monitoring. Island Press, Covelo, California.

Kasahara, T., Hill, A.R., 2006, Hyporheic exchange flows induced by constructed riffles and steps in lowland streams in southern Ontario, Canada: Hydrologic Processes: 20 (20), 4287–4305.

Kondolf, G.M., D.R. Montgomery, H. Piegay, and L. Schmitt. 2003. Geomorphic classification of rivers and streams, in Tools in Fluvial Geomorphology, edited by G.M. Kondolf and H. Piegay, pp. 171-204, John Wiley, Hoboken, NJ.

Lambert, Michael B. and Keith Karoglanian. 2012. The Umatilla Anadromous Fish Habitat Project: 2011 Annual Progress Report. Confederated Tribes of the Umatilla Indian Reservation, report submitted to Bonneville Power Administration, Project No. 1987-100-01.

Lambert, Michael B. 2015. *The Umatilla Anadromous Fish Habitat Project: 2013-2014 Biannual Progress Report.* Confederated Tribes of the Umatilla Indian Reservation, report submitted to Bonneville Power Administration, Project No. 1987-100-01.

Lambert, Michael B., James G. Webster, and Eric D. Hoverson. 2011. The Umatilla Anadromous Fish Habitat Project: 2009-2010 Annual Report. Confederated Tribes of the Umatilla Indian Reservation, report submitted to Bonneville Power Administration, Project No. 1987-100-01.

Lamontagne, S., and Cook, P.G., 2007, Estimation of hyporheic water residence time in situ using Rn-222 disequilibrium: Limnology and Oceanography-Methods, v. 5, p. 407-416.

Lucier, A., M. Palmer, H. Mooney, K. Nadelhoffer, D. Ojima, and F. Chavez. 2006. Ecosystems and Climate Change Research Priorities for the U.S. Climate Change Science Program, Special Series No. SS-92-06 of the University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, Ref. No. [UMCES] CBL 06-038. 50 pp.

Malcolm, I. A., Soulsby, C., Youngson, A. F., and Petry, J., 2003, Heterogeneity in ground water-surface water interactions in the hyporheic zone of a salmonid spawning stream: Hydrological Processes 17:601-617.

Merritt, R.W., K.W. Cummins, and M.B. Berg (eds.) 2008. An Introduction to the Aquatic Insects of North America, 4th edition. Kendall/Hunt Publishing Company, Dubuque, IA.

Miller, S.W., P. Budy, and J.C. Schmidt. 2010. Quantifying macroinvertebrate responses to in-stream habitat restoration: applications of meta-analysis to river restoration. Restoration Ecology 18: 8-19.

Montgomery, D.R., and J.M. Buffington, 1997. Channel-reach morphology in mountain drainage basins. Geological Society of America Bulletin 109(5):596-611.

Montgomery, David R. 2003. *King of Fish: The Thousand Year Run of Salmon*. Westview Press, Perseus Books Group, Boulder, Colorado.

Moore, Kelley M.S., Jones, Kim, K. Dambacher, Jeffrey M. 2002. *Methods for stream habitat surveys version 12.1: Oregon Department of Fish and Wildlife, Aquatic Inventory Project*. Corvallis, OR 97730.

Morrill JC, Bales RC, Conklin MH (2005) Estimating stream temperature from air temperature: implications for future water quality. J Environ Eng 131:139–145

Nagle, G. 1998. *Report on research project on environmental history of riparian areas in the Umatilla basin*. U.S. Forest Service, Pacific Northwest Research Station, Corvallis, Oregon.

NMFS 1996. *Making Endangered Species Act determinations of effect for individual or grouped actions at the watershed scale*. NMFS Environmental and Technical Services Division, Habitat Conservation Branch.

NMFS 2008. National Marine Fisheries Service Northwest Region. *Endangered Species Act – Section 7 Programmatic Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation.* Habitat Improvement Program, Oregon, Washington, and Idaho, CY2007-CY2012 (HIP II).

NMFS (National Marine Fisheries Service) Northwest Region. 2009. Middle Columbia Steelhead distinct Population Segment ESA Recovery Plan. Final Listing November 30, 2009. Available on the internet: http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Interior-Columbia/Mid-Columbia/upload/Mid-C-Plan.pdf

NPCC 1990. Northwest Power Planning Council. *Umatilla River Subbasin Salmon and Steelhead Production Plan*. Northwest Power Planning Council and the Agencies of the Indian Tribes of the Columbia Basin Fish and Wildlife Authority.

NPCC (Northwest Power Conservation Council). 2004. *Draft Willow/Umatilla Subbasin Plan*, Prepared by the Umatilla/Willow Subbasin Planning Team. Prepared for the Northwest Power and Conservation Council, May 28, 2004. Available online from the following URL as accessed November 19, 2008: http://www.nwcouncil.org/fw/subbasinplanning/umatilla/plan/.

NPCC (Northwest Power Conservation Council). 2005. *Final Umatilla Willow Subbasin Plan*. Prepared by the Umatilla/Willow Subbasin Planning Team, for the Northwest Power and Conservation Council, May, 2005.

NRC 1996. *Upstream. Salmon and society in the Pacific Northwest*. National Research Council, Washington D.C.

O'Daniel, S., J. 2005. Interactions between Regional-Scale Variation in Geomorphology and Potential for Hyporheic Exchange along the Umatilla River, Oregon. Geography. Santa Barbara, University of California.

O'Daniel, S.J., G.C. Poole and L.A.K. Mertes. 2003. Habitat diversity in alluvial rivers, Report to Bonneville Power Administration, #200100252, 39 pp.

ODEQ (Oregon Department of Environmental Quality) and Confederated Tribes of the Umatilla Indian Reservation. 2001. Umatilla River Basin Total Maximum Daily Load and Water Quality Management Plan. http://www.deq.state.or.us/wq/tmdls/docs/umatillabasin/umatilla/tmdl.pdf

ODFW/ODF (Oregon Department of Fish and Wildlife/Oregon Department of Forestry). 1995. A Guide to Placing Large Wood in Streams.

ODFW/ODF (Oregon Department of Fish and Wildlife/Oregon Department of Forestry). 1999. Oregon Aquatic Habitat Restoration and Enhancement Guide.

OWRD (Oregon Water Resource Department). 2006. Estimation of Peak Discharges for Rural, Unregulated Streams in Eastern Oregon. Salem, OR.

Peck, D.V., A.T. Herlihy, B.H. Hill, R.M. Hughes, P.R. Kaufmann, D.J. Klemm, J.M. Lazorchak, F.H. McCormick, S.A. Peterson, P.L. Ringold, T. Magee, and M.R. Cappaert. 2006. Environmental Monitoring and Assessment Program – Surface Waters; Western Pilot Study: Field Operations Manual for Wadeable Streams. U.S. Environmental Protection Agency 620/R-06/003. Office of Research and Development, U.S. Environmental Protection Agency, Washington D.C.

Phinney, W. 2017. *Tribes play big role in Dillon Dam removal*. Confederated Umatilla Journal. August 2017: 5A.

Print. Plaven, G. 2017 *Dam near gone*. East Oregonian. 22 July 2017: A1. Print

Pollock, D.W. 2008. User's guide for MODPATH/MODPATH-PLOT, version 3: a particle tracking post-processing package for MODFLOW, the U.S. Geological Survey finite-difference ground-water flow model. USGS Open-File Report 94-464.

Poole, G.C., O'Daniel, S.J., Jones, K.L., Woessner, W.W., Bernhardt, E.S., Helton, A.M., Stanford, J.A., Boer, B.R., and Beechie, T.J. 2008. Hydrologic spiraling: The role of multiple interactive flow paths in stream ecosystems: River Research and Applications, v. 24, p. 1018-1031.

Purser, Michael D. 1994. Non-point Sources of Water Pollution Assessment and Management Plan. Submitted by the Confederated Tribes of the Umatilla Indian Reservation to the U.S. Environmental Protection Agency.

Quaempts, E. J., K. L. Jones, S. J. O'Daniel, T. J. Beechie, and G. C. Poole. 2018. *Aligning environmental management with ecosystem resilience: a First Foods example from the Confederated Tribes of the Umatilla Indian Reservation, Oregon, USA.* Ecology and Society 23(2):29.

Rollins, P.A., Editor. 1935. *The Discovery of the Oregon Trail. Robert Stuart's Narratives of His Overland Trip Eastwards from Astoria in 1812-13*. University of Nebraska Press, Lincoln, Nebraska.

Roni, Phil, Beechie T. J., Bilby R. E., Leonetti F. E., Pollock M. M., and Pess G. R. 2002. "A review of stream restoration techniques and a hierarchical strategy for prioritizing restoration in Pacific Northwest watersheds." North American Journal of Fisheries Management.

Roni, Phil, Hanson K., and Beechie T. 2008. *Global review of the physical and biological effectiveness of stream habitat restoration rehabilitation techniques.* North American Journal of Fisheries Management.

Rosgen, D.L., 1994, A classification of natural rivers: Catena, v. 22, p. 169-199. Stanford, J. A., Ward, J. V., Liss, W. J., Frissell, C. A., Williams, R. N., Lichatowich, J. A., and Coutant, C. C., 1996, A general protocol for restoration of regulated rivers. Regulated Rivers: Research and Management 12:391-413.

Rosgen, D.L. (1996) *Applied River Morphology*. Wildland Hydrology, Pagosa Springs, CO.

Smith, E.P. 2002. BACI Design. pp. 141-148. In: A.H.E.-S.a.W.W. Piegorsc (ed.) *Encyclopedia of Environmetrics*, John Wiley & Sons, Ltd, Chichester, 2002.

Stanford, J. A., and Ward, J. V., 1993, An ecosystem perspective of alluvial rivers: connectivity and the hyporheic corridor: Journal of the North American Benthological Society 12:48-60.

Stonestrom, D. A. and Constantz, J. 2003. Heat as a tool for studying the movement of ground water near streams. U.S. Geological Survey Circular 1260, 96 p

Stillwater Sciences. 2011. Biological effectiveness monitoring and evaluation plan for fisheries habitat enhancement in CTUIR subbasins. Draft Report. Prepared by Stillwater Sciences, Portland, Oregon for Confederated Tribes of the Umatilla Indian Reservation, Pendleton, Oregon.

Taylor, George H. 1993. *Normal Annual Precipitation, State of Oregon, Period 1961-1990, Map.* Oregon Climate Service, 326 Strand Ag. Hall, Oregon State University, Corvallis, Oregon 97331-2209.

Tetra Tech 2010. *Final Biological Assessment Meacham Creek Floodplain Restoration and In-stream Enhancement Project River Mile 6 to 7*. Prepared for the Confederated Tribes of the Umatilla Indian Reservation, Pendleton, OR.

Tetra Tech 2012. *Meacham Creek Vegetation Monitoring Strategy and Survey Protocol*. Prepared for the Confederated Tribes of the Umatilla Indian Reservation, Pendleton, OR.

Tetra Tech 2013. Meacham Creek Floodplain Restoration and In-Stream Enhancement Design (Phase II) Implementation Plan (100 percent) Revision 1 Package.

Tetra Tech. 2013a. Meacham Creek Columbia Habitat Monitoring Program (CHaMP) Monitoring 2012 Baseline Report. Prepared for the Confederated Tribes of the Umatilla Indian Reservation. January 2013.

Tetra Tech. 2013b. Meacham Creek Floodplain Restoration and In-Stream Enhancement 2012 Monitoring Data. Prepared for the Confederated Tribes of the Umatilla Indian Reservation. January 2013.

Tetra Tech. 2020. Meacham Creek 2020 As-Built Survey Analysis. Prepared for CTUIR. Link

Thorp, J.H. and Covich, A.P. (eds.) 2010. Ecology and Classification of North American Freshwater Invertebrates, 3rd edition. Academic Press, Inc., San Diego, CA.

Three Treaty Tribes & FCRPS Action Agencies. 2008. *Columbia Basin Fish Accords, Memorandum of Agreement Among the Umatilla, Warm Springs and Yakama Tribes, Bonneville Power Adminstration, U.S. Army Corps of Engineers, and U.S. Bureau of Reclamation*. Prepared collectively "the Parties", May, 2008. Available online from the following URL as accessed January 28, 2013: www.salmonrecovery.gov/Files/BiologicalOpinions/MOA_ROD.pdf

Tonina, D., and Buffington, J.M., 2007, Hyporheic exchange in gravel bed rivers with pool-riffle morphology: Laboratory experiments and three-dimensional modeling: Water Resources Research, v. 43.

Tonina, D., and Buffington, J.M., 2009, Hyporheic exchange in mountain rivers I: mechanics and environmental effects: Geography Compass 3(3): 1063–1086.

Torgersen, C. E., D. M. Price, H. W. Li, and B. A. McIntosh. 1999. Multiscale thermal refugia and stream habitat associations of Chinook Salmon in northeastern Oregon. Ecological Applications 9:301-319.

Toth, J., 1963, A theoretical analysis of groundwater flow in small drainage basins: Journal of Geophysical Research, v. 68, p. 4795-4812.

Treaty of 1855. *Treaty with the Wallawalla, Cayuse, etc., 1855*, June 9, 1855, 12 Stats., 945, Ratified Mar. 8, 1859.

Umatilla National Forest. 2001. Umatilla and Meacham Ecosystem Analysis. https://scholarsbank.uoregon.edu/xmlui/bitstream/handle/1794/6779/Umatilla_Meacham_Vegetation_Analysi s.pdf?sequence=1

USFWS 2002. *Bull Trout* (*Salvelinus confluentus*) *Draft Recovery Plan*. U. S. Fish and Wildlife Service, Portland, Oregon. Paged by section. Available online from URL: http://ecos.fws.gov/docs/recovery_plans/2002/021129.pdf.

USFWS 2007. *Biological Opinion and Letter of Concurrence, USDA Forest Service, USDI Bureau of Land Management and the Coquille Indian Tribe for Programmatic Aquatic Habitat Restoration Activities in Oregon and Washington that Affect ESA-listed Fish, Wildlife, and Plant Species and their Critical Habitats.* US Fish and Wildlife Service, Lead Office: Oregon Fish and Wildlife Office, Portland, Oregon.

USFWS 2015. *Recovery plan for the coterminous United States population of bull trout (*Salvelinus confluentus*)*. U.S. Fish and Wildlife Service, Portland, Oregon. Avaialable online from: https://www.fws.gov/pacific/bulltrout/pdf/Final_Bull_Trout_Recovery_Plan_092915.pdf

USGS (U.S. Geological Survey). 2006. User's Manual for Program PeakFQ, Annual Flood-Frequency Analysis Using Bulletin 17B Guidelines.

USGS 2008. United States Geological Survey. "Columbia Plateau, Columbia River Basalt", as accessed November 19, 2008 from URL: http://vulcan.wr.usgs.gov/Volcanoes/ColumbiaPlateau/description_columbia_plateau.html.

Walker, George W. and Norman S. MacLeod. 1991. *Geologic Map of Oregon*, U.S. Geological Survey, U.S. Department of the Interior, U.S. Geological Survey Map Distribution, Box 25286, Federal Center, Denver, CO 80225.

Ward, J. V., 1989, The four-dimensional nature of lotic ecosystems: Journal of the North American Benthological Society 8:2-8.

White, D. S., Elzinga, C. H., and Hendricks, S. P., 1987, Temperature patterns within the hyporheic zone of a northern Michigan river: Journal of the North American Benthological Society 6:85-91.

White, T., Jewett, S., Hanson, J., Carmichael, R., 1989, Evaluation of juvenile salmonid outmigration and survival in the lower Umatilla River basin: Project No. 1989- 02401, 122 electronic pages, (BPA Report DOE/BP-00004340-3).

Whitney, L. 2007. Upper Grande Ronde Basin, Section 319, National Monitoring Program Project: Summary Report. Oregon Department of Environmental Quality Technical Report DEQ07-LAB-0058-TR. Oregon Department of Environmental Quality, Portland, Oregon.

Whittier, T.R. and J. Van Sickle. 2010. Macroinvertebrate tolerance values and an assemblage tolerance index (ATI) for western USA streams and rivers. Journal of the North American Benthhological Society 29: 852-866.

Wiggins, G.B. 2000. Larvae of the North American Caddisfly General (Trichoptera), 2nd edition. University of Toronto Press, Toronto.

Wilcock, Peter; John Pitlick; Yantao Cui. 2009. Sediment transport primer: estimating bed-material transport in gravel- bed rivers. Gen. Tech. Rep. RMRS-GTR-226. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 78 p.

Wohl, E., Angermeier, P.L., Bledsoe, B., Kondolf, G.M., MacDonnell, L., Merritt, D.M., Palmer, M.A., Poff, N.L., and Tarboton, D., 2005, River restoration: Water Resources Research, v. 41.

Wondzell, S.M., and Swanson, F.J., 1996, Seasonal and storm dynamics of the hyporheic zone of a 4th-order mountain stream .2. Nitrogen cycling: Journal of the North American Benthological Society, v. 15, p. 20-34.

Wondzell, S.M., LaNier, J., and Haggerty, R. 2009. Evaluation of alternative groundwater flow models for simulating hyporheic exchange in a small mountain stream. Journal of Hydrology, v. 364, p. 142-151.