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Chehalis Basin Strategy Aquatic Species Restoration Program

Chehalis Basin Freshwater Mussel Restoration Strategy

Prepared for
Office of Chehalis Basin

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ACRONYMS AND ABBREVIATIONS

ASRP	Aquatic Species Restoration Program
BMP	best management practices
MME	mass mortality event
USFWS	U.S. Fish and Wildlife Service
WDFW	Washington Department of Fish and Wildlife
WRM	western ridged mussel

1 INTRODUCTION

Figure 1
Western Pearlshell (*Margaritifera falcata*)



Note: Photograph taken April 2012 in Stillwater Creek by Roger Tabor of USFWS.

Freshwater mussels (order: *Unionida*) are vital bioindicators (e.g., Aquatic Species Restoration Program [ASRP] indicator species) and ecosystem engineers in the Chehalis Basin, contributing to water filtration, nutrient cycling, and habitat stability. Freshwater mussels, including western pearlshell (*Margaritifera falcata*), western ridged mussel (*Gonidea angulata*), and Oregon floater (*Brachyanodon oregonensis*; formerly *Anodonta oregonensis*), are critical to the Chehalis Basin's ecological health but face severe declines due to habitat degradation, disease, and climate stressors.

Range-wide, these species are also declining, and one species in particular, the western ridged mussel (hereafter, WRM), is being considered for listing under the federal Endangered Species

Act. Following a positive 90-day finding by the U.S. Fish and Wildlife Service (USFWS) and development of a draft Species Status Assessment, the species' listing decision is currently categorized under "Long-term Actions" (Endangered and Threatened Wildlife and Plants; Listing Determination and Critical Habitat Designation for Western Ridged Mussel, Spring 2025, 1018-BH80). Efforts by Chehalis Basin partners to survey, monitor, and study freshwater mussels between 2019 and 2025, as detailed in USFWS Final Report F19AC00507 (Blevins et al. 2025) have improved baseline knowledge around these sensitive species. Using this information and the collective expertise of partners, this restoration strategy seeks to outline a science-informed approach to restore mussel populations through targeted actions, partnerships, and adaptive management in the Chehalis Basin moving forward.

Figure 2
Western Ridged Mussel (*Gonidea angulata*)



Note: Photograph taken August 2016 in the Chehalis River by Roger Tabor of USFWS.

Table 1
Sentinel Monitoring Site Locations

These are sites where data on abundance and density over time has been collected. They are revisited every 3 to 6 years to track status and trends (Blevins et al. 2025).

SITE CODE	WATERBODY	LOCALITY	LATITUDE	LONGITUDE	STATUS
SKO	Skookumchuck River	Parkin Park	46.733044	-122.951721	Sampled 2022, 2023, 2024
LCM1	Chehalis River	Alexander Park	46.652419	-122.986030	Sampled 2017, 2022, 2023, 2024
MCM	Chehalis River	Near Meskill	46.635389	-123.182895	Sampled 2020, 2022, 2023, 2024
LCM2	Chehalis River	Sickman-Ford Bridge	46.829953	-123.258702	Sampled 2022, 2023
NEW	Newaukum River	Stan Hedwall Park	46.637452	-122.964914	Sampled 2022, 2023, 2024
UCM	Chehalis River	Rainbow Falls State Park	46.630700	-123.235120	No longer active; extirpated
WAKE	Chehalis River	Wakefield Bridge	46.981895	-123.413027	No longer active; not informative
NEW2	Newaukum River	Jackson Highway Bridge	46.605624	-122.871392	Sampled 2022
CSKO	Skookumchuck River	U.S. Geological Survey Gauging Station	46.769755	-122.926469	Sampled 2025
NorthForkNewaukum_1	North Fork Newaukum River	North Fork Road	46.608021	-122.8520550	Sampled 2025

Figure 3
Oregon floater (*Brachyanodon oregonensis*)



Note: Photograph taken August 2017 in Lake Quinault by Roger Tabor of USFWS.

2 ACKNOWLEDGING KEY PARTNERSHIPS

- **Chehalis Tribe:** Traditional ecological knowledge, monitoring, research, and habitat stewardship.
- **Washington Department of Fish and Wildlife (WDFW):** Permitting and monitoring support.
- **USFWS:** Monitoring support and habitat restoration.
- **Xerces Society:** Monitoring support and outreach.
- **University of Wisconsin - Madison:** Research and mussel health assessment support.
- **Local Non-governmental Organizations (NGOs):** Education and outreach, as well as pre-project surveys.
- **ASRP Project Sponsors/Reviewers:** Pre-project surveys and monitoring.
- **Local Landowners:** Riparian easements and conservation agreements.
- **Other Academic/Research Institutions:** Research on mussel-fish symbiosis and climate resilience.

3 ECOLOGICAL IMPORTANCE OF FRESHWATER MUSSELS

Freshwater mussels are important components of the Chehalis Basin's ecological community, and are especially noted for:

- **Water Quality Improvement:** Mussels filter particulates and algae, enhancing clarity and reducing nutrient loads.
- **Ecosystem Engineers and Biodiversity Support:** Mussel beds stabilize substrates, create microhabitats for aquatic invertebrates and fish, and cycle nutrients.
- **Cultural Significance:** Mussels are valued by Indigenous communities. Historically, freshwater mussels were utilized as a first food by the Chehalis Tribe but can no longer be consumed due to water quality concerns.
- **Indicator Species:** Mussel presence and health reflect watershed health through sensitivity to pollution and habitat changes.

4 THREATS AND STRESSORS

Table 2
Threats and Stressors

THREAT CATEGORY	SEVERITY	DESCRIPTION	FEASIBILITY/PROGNOSIS
Mass Mortality Events (MMEs)	High, acute impacts and critical timing considerations	MMEs are defined as the rapid, catastrophic die-off of organisms that punctuate background mortality rates (Fey et al. 2015). They are discrete events that are separate from, but can be simultaneous to, simple population decline. They include recent mussel bed extirpations (e.g., Newaukum River) with substantial impacts already observed, especially to WRM. See visual of extent of MME in Figure 4.	Poor to Uncertain. It is unknown currently what actions could help slow or halt the ongoing MME, so active monitoring and investigation into potential causes are scoped in Table 4 to help inform this. Research underway to clarify potential causes of MMEs (e.g., viral load/infections such as rhabdoviruses; Goldberg et al. 2023; Richard et al. 2023; USFWS 2026) is thus far inconclusive. Active monitoring at established sites in the basin have yielded key observations: • 99% decline in western pearlshell (2020–2024) at UCM site (see Table 1) linked to substrate scouring. • Macrophyte blooms and drying stream margins at MCM site (see Table 1) correlated with mussel mortality (2023–2024). • Near extirpation of multi-species mussel bed (2017–2024) at LCM1 site (see Table 1).

THREAT CATEGORY	SEVERITY	DESCRIPTION	FEASIBILITY/PROGNOSIS
Habitat Loss and Degradation (from Land Use and Development)	High	Development, run-off, sedimentation from logging/agriculture, bank erosion and armor, river channelization, in-water wood removal, and riparian degradation.	Low feasibility. Zoning and other factors resulting in development pressures. History of land use practices that adversely impact physical and ecological characteristics of habitat.
Pollution and Water Quality Decline	High, and variable; unknown for pesticides and microplastics; impaired for dissolved oxygen, temperature, and fecal coliform	Chronic exposure in some places to pesticides, heavy metals, microplastics, nutrient and coliform runoff, and/or low dissolved oxygen. Mussels can be highly sensitive to certain pollutants.	Poor. Total Maximum Daily Loads established for some. Nonpoint source and point source concerns, with few mechanisms available to address the range of water quality issues, including dissolved oxygen, temperature, and fecal coliform impairments.
Acute Impacts of in-Water Construction	High, acute impacts and critical timing considerations	De-watering, burial, scour, crushing.	Good. Reducing acute impacts of in-water construction is feasible (e.g., following best management practices [BMPs], see Table 4) and an area of active work. Restoration actions have the potential to help address existing loss and limit future losses.
Climate Change	Medium	Increased water temperature, altered flow regimes, drought, dewatering events (e.g., 2024 MCM monitoring site observations).	Poor. Severity expected to increase. Relocation may reduce impacts from dewatering events if implemented prior to losses.
Host Fish Population and Range Decline	Medium; with significant uncertainty	Mussels rely on declining native fish populations (e.g., salmonids and sculpin) for larval production and dispersal. Fish barriers also inhibit movement of host fish critical to freshwater mussel life stages.	Uncertain. There is evidence of non-native fish predation on host fish (e.g., Winkowski et al. 2025), but some host fish species are understudied. Selected research on host fish in the Columbia River Basin and Middle Fork John Day River included in "References and Additional Resources" section.
Genetic Vulnerability	Medium; considering variability across species and remaining areas of uncertainty	Small, isolated populations with low diversity. Known to affect WRM (high severity) more than other species (low severity).	Poor for WRM. Efforts underway to locate gravid WRMs to support a propagation feasibility assessment, intended to address both extirpation risk and genetic vulnerability.

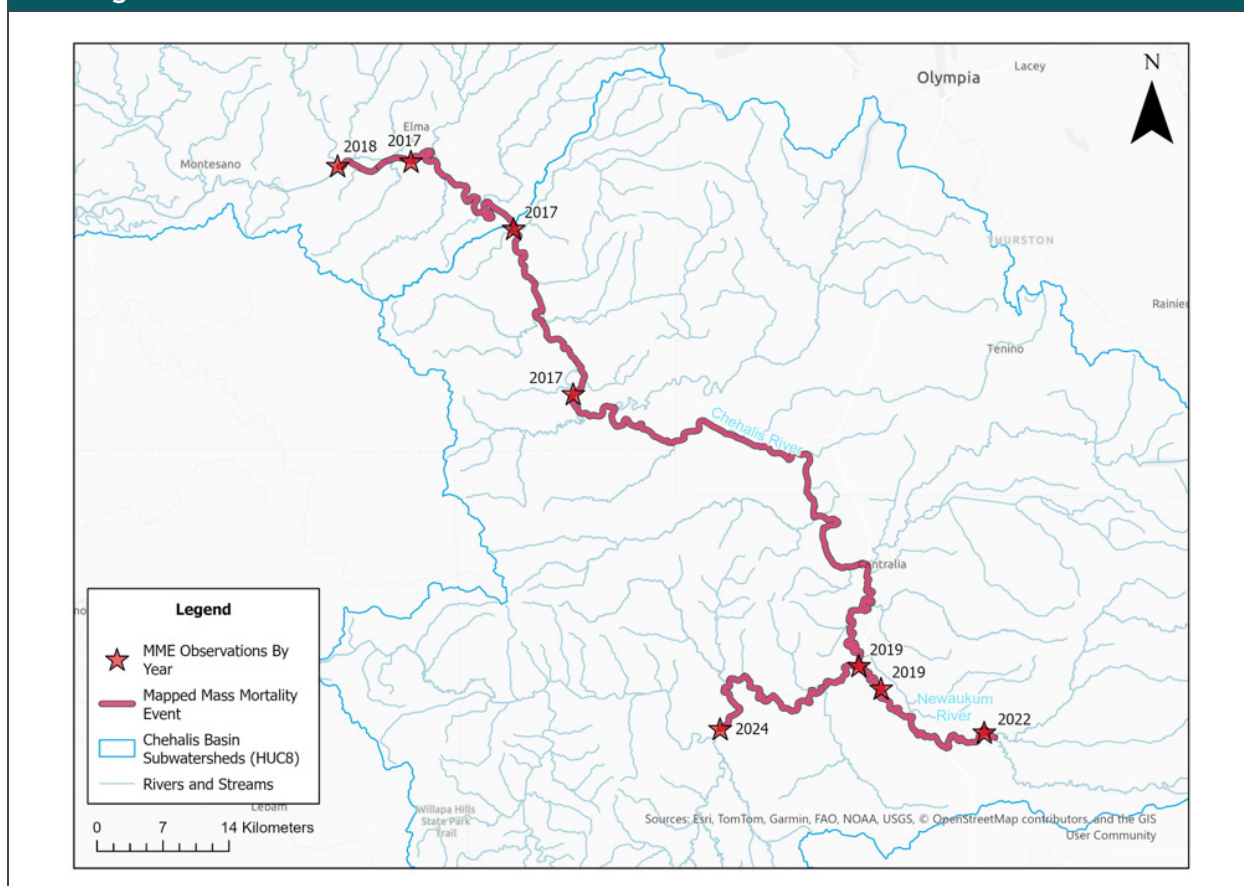
THREAT CATEGORY	SEVERITY	DESCRIPTION	FEASIBILITY/PROGNOSIS
Water Management Actions	Medium; with significant uncertainties	Human actions that alter hydrology directly or indirectly, such as water abstraction or changes to the natural flow regime, can impact freshwater mussel habitat.	Uncertain. Water management activities range widely across basin streams and are influenced by climate, all of which are generally in flux.
Non-native Species (animals)	Low	Competition from non-native clams (e.g., <i>Corbicula fluminea</i>) and predation of mussels and their host fish from non-native fish (e.g., <i>Micropterus dolomieu</i>).	Medium. Severity will increase, if unchecked. Some actions underway to address non-native fish. Some risk of introduction of non-native species at water access sites and associated with in-water construction. Efforts to prevent introductions as part of these activities are underway.
Invasive Vegetation	Low; with significant uncertainties	Degradation of riverbank or bottom habitats, including dissolved oxygen and other water quality concerns, as well as outcompeting native species for space and resources.	High-medium. Severity will increase, if unchecked. But actions underway to manage Japanese knotweed (<i>Polygonum cuspidatum</i>), Brazilian elodea (<i>Egeria densa</i>), and others. Some risk of introduction of invasive species at water access sites and associated with in-water construction. Efforts to prevent introductions as part of these activities are underway.

To address threat and stressor data gaps and uncertainties, the following surveys (including type and purpose) are recommended (Table 3).

Table 3
Recommended Surveys to Support Key Learning Needs

SURVEY/MONITORING TYPE	PURPOSE/OBJECTIVE	NOTES/DETAILS
Tracking distribution	Confirm continued presence/absence of mussels in different locations within the basin. Supports restoration/construction site pre-project surveys below.	Includes ground-truthing existing eDNA samples, as well as longitudinal surveys and site re-surveys, given the current flux of mussel occupancy in the basin.
MME extent tracking	Track the decline of mussel species to see how MME is spreading throughout the basin.	The upstream extent of the MME is documented as of 2024.
Monitoring of sentinel sites	Establish water quality baselines and track long-term trends in mussel status, health, water quality, reproduction, and threats	See Table 1. These sites are revisited every 3-6 years to track status and trends.
Restoration/construction site exploratory pre-project surveys	Check for mussel species before restoration activities occur with the goal of avoiding destruction of existing mussel beds.	Would benefit from close coordination with ASRP and WDFW habitat biologists.

Figure 4
Tracking MME Extent Over Time



Note: Locations of freshwater mussel beds (stars) where MMEs were observed (year noted) and the known extent of the MME (red line) as of 2024, based on surveys by Xerces, USFWS, WDFW, and Chehalis Tribe staff (Blevins et al. 2025).

5 GOALS, OBJECTIVES, AND ACTIONS

The previous sections summarize the current understanding of threats and stressors, their severity and the feasibility of addressing them, as well as known survey and learning needs. The following recommendations focus on the vision for freshwater mussels in the Chehalis Basin and goals, objectives, and actions to achieve that vision.

Vision: Recover resilient mussel populations that contribute to the ecological integrity of the Chehalis Basin by way of habitat protection, threat mitigation, and collaborative stewardship.

Figure 5
Collecting Mussels from Riffle



Note: Photograph by Lewis County Public Works.

Table 4
Goals, Objectives, and Prioritized Actions

GOAL	OBJECTIVE	ACTION	URGENCY
Address extirpation threats: MMEs, genetic vulnerability, and host fish decline.	Investigate potential causes of MME.	Continue longitudinal monitoring of MME extent to track the area of impact over time.	In progress
		Continue mussel health studies to identify causal agents of the MME and establish metrics for species' health assessments.	In progress
		Expand hemolymph sampling and testing using new tools and techniques developed by key partners (e.g., USFWS and University of Wisconsin - Madison). As part of this effort: collaborate with trusted laboratories to reduce risk of contamination (e.g., USFWS University of Wisconsin - Madison Co-Op Unit and LaCrosse Fish Health Lab) and test for synergies between viruses, pollution, and temperature (USFWS 2026).	In progress
		Initiate a study to deploy and assess growth and health factors of juvenile mussels using silo technology via partnership with USFWS/University of Wisconsin - Madison Co-Op Unit.	Mid-range planning (3-5 years)
	Investigate propagation feasibility to support mussel populations.	Survey mussel distribution in un-surveyed reaches and within MME/healthy bed reaches using eDNA, GIS, and field studies.	In progress
		Evaluate overlap and density of non-native fish with breeding populations of mussels and local host fish.	Secondary priority next step (1-2 years)
		Sample for host fish and mussel larvae in the basin to establish breeding phenology and gather evidence of reproductive activity. Use information to identify local host fish.	Secondary priority next step (1-2 years)
		Test propagation techniques for all species, including research regarding local host fish. Collaborate with trusted laboratories to reduce risk of contamination from basin-collected samples or specimens.	Mid-range planning (3-5 years)

GOAL	OBJECTIVE	ACTION	URGENCY
Address extirpation threats: MMEs, genetic vulnerability, and host fish decline.	Restore habitat for host fish where degraded and support healthy host fish populations.	Modify barriers to improve host fish passage (i.e., sculpin, lamprey and other native non-salmonid fish, as well as salmon; USFWS 2025)	In progress
		Initiate research assessing local host fish status and trends relative to mussel distributions.	Secondary priority next step (1-2 years)
	Support persistence of mussel populations throughout the Chehalis Basin.	Continue long-term population monitoring at established sites (Table 1) to track observations and refine understanding of potentially interrelated key threats/stressors.	In progress
		Explore feasibility of hatchery-based mussel rearing for re-introduction and supplementation, including identifying local host fish and mussel breeding phenology, potential source populations, and lab techniques.	Secondary priority next step (1-2 years)
		Manage non-native species populations, targeting species inordinately impacting mussels.	Mid-range planning (3-5 years)
	Support persistence of mussel populations throughout the Chehalis Basin (genetic vulnerability).	Conduct eDNA and visual surveys to confirm presence of WRM in the basin (e.g., only one live WRM observed in 2024). Identify remaining WRM individuals available for broodstock collection.	In progress
Address habitat loss/ degradation threat related to in-water construction and restoration.	Protect existing individuals, beds, and habitats from accidental destruction.	Conduct exploratory surveys throughout the basin to expand upon and disseminate information on mussel distribution and occupancy.	In progress
		Guide restoration projects to locations away from healthy mussel beds paired with mapping of high priority locations for mussels.	Immediate next step (< 1 year)
		Conduct and document voluntary pre-project exploratory mussel surveys at in-water restoration and construction sites throughout the Chehalis Basin.	In progress
		Develop/refine/communicate best practices for project sponsors (e.g., fish salvage protocols)	In progress
		Promote best practices for project sponsors (e.g., Xerces' mussel friendly restoration guide, Blevins et al. 2019; and BMP handbook, Blevins et al. 2018)	In progress

GOAL	OBJECTIVE	ACTION	URGENCY
Address habitat loss/ degradation threat related to in-water construction and restoration.	Protect existing individuals, beds, and habitats from accidental destruction.	Expand and enforce buffers near known beds during in-water construction.	Immediate next step (< 1 year)
		Conduct cost estimations to better understand the potential budget impact to projects of incorporating recommended protective actions into existing protocols and processes.	In progress
		Require ASRP-funded projects to conduct pre-project exploratory mussel surveys for projects with in-water work. Develop and provide ASRP guidance for this practice and provide funding and identify capacity to conduct this work. Create an ongoing process to coordinate surveys with restoration work and verify that project sponsors have incorporated survey information into project design.	In progress
Address water quality, water management actions, and climate change threats.	Implement best practices for soil and water conservation.	Establish or encourage BMPs for construction, retail, development, etc. within the Chehalis Basin.	Secondary priority next step (1-2 years)
		Expand on water quality sample collection, analysis, and monitoring to identify specific threats and stressors to mussels.	Secondary priority next step (1-2 years)
		Limit construction of impervious surfaces within the watershed, encourage native plantings and rain gardens.	Secondary priority next step (1-2 years)
		Reduce sediment and nutrient inputs via farmer BMPs.	Secondary priority next step (1-2 years)
		Protect and restore in-stream flow to mitigate low-flow impacts or dewatering	Secondary priority next step (1-2 years)
	Prioritize areas for protection and restoration with future hydrological resilience in the face of climate change.	Provide map of prioritized protection, restoration, and data gap reaches to project sponsors for their use in project planning. This should incorporate future resilience in the face of climate change.	Immediate next step (< 1 year)
Leverage science, collaboration, and outreach for conservation.	Collaborate across strategic partnerships to reach key audiences	Create/maintain community science opportunities (e.g., eDNA monitoring with Tribes and partner organizations).	Immediate next step (< 1 year)

GOAL	OBJECTIVE	ACTION	URGENCY
Leverage science, collaboration, and outreach for conservation.	Collaborate across strategic partnerships to reach key audiences.	Create/maintain a public-facing searchable library of outreach and education materials, including educational placards or signs to utilize at common access points.	Immediate next step (< 1 year)
		Partner with Chehalis Basin Collaborative for Salmon Habitat and local educational institutions and programs in the basin, as part of the ASRP community engagement planning effort, to support long-term stewardship.	Secondary priority next step (1-2 years)
		Provide periodic strategic updates at annual ASRP events, such as the progress and planning workshop.	Immediate next step (< 1 year)
Restore habitat for freshwater mussels.	Address key learning needs to inform future restoration actions: species-specific habitat requirements (e.g., substrate, temperature, and flow preferences).	Evaluate overlap and density of non-native competitors (e.g., <i>Corbicula fluminea</i>) with mussels.	Mid-range planning (3-5 years)
		Identify areas with potential for low flows or impacts from altered flow regimes.	Secondary priority next step (1-2 years)
		Identify key habitat requirements relevant to restoration designs in the basin.	Long-range planning (6+ years)
		Identify range of flow needs, and threats to maintaining beneficial flow regimes.	Mid-range planning (3-5 years)
		Map microhabitats using sentinel site data (e.g., substrate stability at UCM).	Mid-range planning (3-5 years)
		Overlay thermal data (Chehalis Thermalscape model) with mussel distribution. Evaluate threats from increasing temperatures in key reaches.	Secondary priority next step (1-2 years)
		Use collected observational, microhabitat, thermal, and host fish data to develop a habitat suitability model.	Mid-range planning (3-5 years)
	Plan and implement key early actions to restore mussel habitat.	Native riparian planting at priority sites (e.g., Newaukum confluence) for at least 10 priority reaches.	Secondary priority next step (1-2 years)
		Develop list of locations (e.g., geo-tagged photographs of example mussel habitat) and methods (engineering design elements) to conduct restoration to the benefit of mussels. Coordinate this with mapping of high priority locations for mussels and pairing with locations and methods important for lamprey as well.	Immediate next step (< 1 year)

GOAL	OBJECTIVE	ACTION	URGENCY
Restore habitat for freshwater mussels.	Plan and implement key early actions to restore mussel habitat.	Identify and recommend habitat restoration locations for freshwater mussels (e.g., Rainbow Falls) using information on key habitat suitability metrics (to be identified).	Immediate next step (< 1 year)
		Work with WDFW Engineering to develop potential design elements to recommend incorporating into restoration projects for the benefit of mussels.	Secondary priority next step (1-2 years)

6 NEXT STEPS: CHEHALIS FRESHWATER MUSSEL COORDINATION GROUP

- Seek grants/funding from:
 - Chehalis Basin ASRP
 - USFWS Fish and Aquatic Conservation Program
 - Washington State Salmon Recovery Funding Board
 - National Oceanic and Atmospheric Administration Community-Based Restoration Program
 - Washington State Department of Ecology Water Quality Combined Funding Program
- Continue coordination and regular meetings of strategic planning group.
- Identify new partners to contribute to adaptive management of this strategy and the recommended actions it contains.
- Implement Actions in Table 4 and track progress made toward goals, objectives, and actions.
- Develop success metrics for adaptive management, such as “increased mussel density and recruitment rates,” “increased stream miles surveyed,” or “improved water quality (e.g., reduced turbidity).”
 - Develop a process for tracking these metrics over time and responding to changes needed.
- Implement adaptive strategies (e.g., adjust strategies based on monitoring data and climate models).
- Chehalis Freshwater Mussel Coordination Group work products:
 - Develop a map-based work product to communicate:
 - Areas for priority protection (from potential adverse impacts)
 - Areas for priority restoration actions to enhance habitat for mussels
 - Reaches that contain priority knowledge gaps (for surveying or other data collection)
 - Work with engineers and other restoration practitioners to develop design elements that can be incorporated into restoration projects for mussel benefits.
 - Create or publicize agreed-upon restoration BMP one-pager for mussels and lamprey. In conjunction with the map tool, this could create a framework for improving mussel habitat within the basin.

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