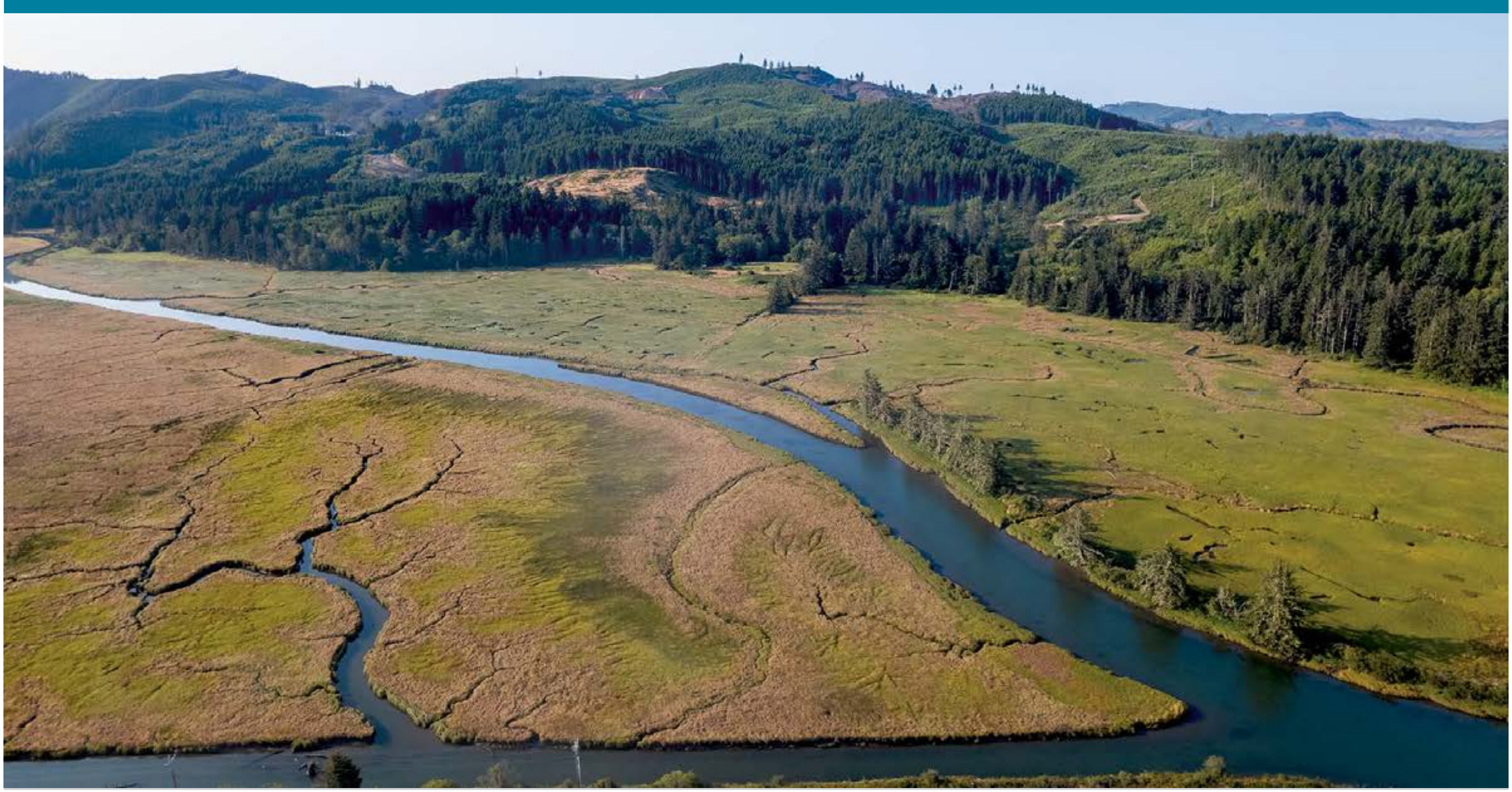
Strategic Action Plan for the Resilience of Coho Salmon Recovery

~ The Siletz River ~



Oregon Coast Coho juveniles: John McMillan. Cover photos: Paul Jeffrey and Holden Films. Back cover photo: Alamy

Contributors and Acknowledgments

The "Strategic Action Plan for the Resilience of Siletz Coho Salmon" was developed by the Siletz Coho Partnership, a team of dedicated resource managers and conservation professionals, representing the following agencies, organizations, and businesses:

- **Confederated Tribes of the Siletz Indians**
- **Manulife Investment Management (formerly Hancock Natural Resource Group)**
- **Lincoln Soil and Water Conservation District**
- **MidCoast Watersheds Council**
- **National Marine Fisheries Service**
- **Natural Resources Conservation Service**
- **Oregon Department of Environmental Quality**
- **Oregon Department of Fish and Wildlife**
- **Oregon Department of Forestry**
- **Oregon Water Resources Department**
- **Pacific States Marine Fisheries Commission**
- **The Wetlands Conservancy**
- **Trout Unlimited**
- **U.S. Fish and Wildlife Service, Oregon Coast National Wildlife Refuge Complex**
- **U.S. Forest Service**
- **Wild Salmon Center**
- **Weyerhaeuser**

The Siletz Partnership would like to thank the members of the Coast Coho Partnership (CCP), which includes the Oregon Watershed Enhancement Board (OWEB), Oregon Department of Fish and Wildlife (ODFW), National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service, NOAA Restoration Center, and Wild Salmon Center (WSC) for their facilitation and technical support of the planning process. We would also like to acknowledge the critical contributions of several project consultants, including: Steve Trask and Bio-Surveys for sharing 30 years of experience in coast Coho salmon population research and habitat restoration; Dr. Wayne Hoffman for sharing his detailed knowledge and vision of the Siletz watershed; TerrainWorks for generating the Netmap layers and conducting the initial spatial analyses; and Barbara Taylor and Fran Recht for their editorial support.

The Siletz Partnership would also like to thank the funders of both the planning effort – OWEB, NOAA Restoration Center, and Builders Initiative – and the first partners that stepped up to support this plan's implementation, including NOAA, WSC, U.S. Fish and Wildlife Service (USFWS), and OWEB.

Acronyms

AQI	Aquatic Inventories Project
BDA	Beaver Dam Analogue
CFS	Cubic Feet per Second
CMECS	Coastal and Marine Ecological Classification Standard
DEQ	Oregon Department of Environmental Quality
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FPA	Oregon Forest Practices Act
HUC	Hydrologic Unit Code
IP	Intrinsic Potential
KEA	Key Ecological Attribute
LSWCD	Lincoln Soil and Water Conservation District
MCWC	MidCoast Watersheds Council
MRT	McKenzie River Trust
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRCS	National Resources Conservation Service
NWFSC	Northwest Fisheries Science Center
OC	Oregon Coast
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
OFW	Oregon Fish and Wildlife
RM	River Mile
SAP	Strategic Action Plan
SWCD	Soil and Water Conservation District
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
WSC	Wild Salmon Center

Contents

List of Figures

List of Tables

Adult Coho salmon. Photo: Eiko Jones

Executive Summary

For millennia, Coho salmon (*Oncorhynchus kisutch*) have returned like clockwork to the Siletz River, spawning and rearing across the basin in its mainstem, tributaries, and estuaries. Through the years, these Coho evolved unique adaptations that have allowed them to survive and flourish in the Siletz River's ever-changing, diverse environment. Scientists estimate that one to two million adult Coho once returned to river systems along the Oregon Coast during favorable ocean conditions, often creating concentrations of several hundred spawners per mile in coastal rivers such as the Siletz (NMFS 2016).

The area's healthy ecosystems began to decline following the arrival of European settlers in the 1800s. The new settlers initiated over 150 years of resource extraction for fisheries, timber, agriculture, and minerals, substantially affecting watershed health and function. These practices impaired habitats and ecosystem processes throughout the Siletz, reducing habitat quantity and quality and, ultimately, the abundance and productivity of Coho and other salmonid populations. Factors in the watershed leading to salmonid declines include fish passage barriers, loss of stream complexity, degraded water quality, and conversion of estuary and wetlands into agricultural lands. In addition to reduced habitat quantity and quality, the combined effects of Coho hatchery production, high harvest rates, and poor ocean conditions contributed to the significant decline in salmon populations up and down the Oregon Coast in the mid-1900s. The widespread decline of Oregon Coast Coho led to its listing as "threatened" by the National Marine Fisheries Service (NMFS) in 1998 under the federal Endangered Species Act (ESA).

WHY RECOVER COHO?

- Opportunity to recover an ESA-listed species.
- Use the entire watershed and are an excellent indicator of ecosystem health.
- Recovering Coho habitats benefit human communities by providing clean water, groundwater recharge, flood mitigation, and recreation.
- Coho habitats support a wider variety of fish and wildlife.
- Are a "keystone species"—all life stages, from eggs to adult carcasses, play a vital role in the ecosystem food chain.

Since the ESA listing, collaborative efforts by state and federal agencies, tribes, local watershed groups, non-governmental organizations, and private landowners have helped turn the tide on the species' decline. Conservation plans developed at the state and federal levels guide these efforts for OC Coho recovery; the state of Oregon developed the Oregon Plan for Salmon and Watersheds in 1997, followed by the Oregon Coast Coho Conservation Plan in 2007. Then, in 2016, NMFS published the federal ESA Recovery Plan for Oregon Coast Coho Salmon. These plans aim to improve the viability of the species and ensure the long-term persistence of naturally self-sustaining Coho populations.

Habitat restoration priorities established under these plans are driven by one central goal: to protect and restore the freshwater and estuarine rearing habitats that support juvenile survival and overall productivity (NMFS 2016). This Strategic Action Plan (SAP) builds upon the broader federal and state plans to restore the Siletz Coho population.

The Siletz Coho SAP recognizes that the species' long-term recovery will depend on strategic partnerships where public and private stakeholders work together towards a shared vision. The effort must unite economic, ecological, and social goals and align limited financial capital to develop and implement solutions that protect and restore Coho habitats while sustaining and nurturing the long-term viability of working farms, forests, and communities.

The process of developing the Siletz Coho SAP began in 2018 when restoration practitioners and local fisheries managers agreed that a comprehensive, strategic plan for the Siletz Basin needed to: 1) determine specific locations where protection and restoration strategies would have the greatest positive impact toward increasing watershed function and habitat productivity over the long-term, 2) coordinate project implementation and leverage funding in the short term, and 3) formalize the commitment of a robust set of partners who have collaborated on Coho recovery and will continue to do so into the future. The Siletz Basin Coho Partnership (Siletz Partnership) convened this effort with the support of the Coast Coho Partnership, a team of public and private agencies and organizations working to accelerate Coho recovery throughout the Oregon Coast.

The Siletz Partnership approached the development of this SAP with the core belief that healthy ecological, economic, and social conditions will ensure a sustainable future for Siletz Coho. The Partnership strives to achieve watershed conditions that will support a full range of life histories for wild Coho in the Siletz River watershed. It recognizes that juvenile Coho follow a mix of life history "pathways" during their freshwater residency. These different pathways enable them to travel between varied habitats in the ever-changing coastal environment. It is hypothesized that individuals optimize habitat use to maximize fitness and survival in freshwater and estuarine environments and prepare for survival in the ocean. Sustaining various life history pathways is a core focus of the Siletz River Coho SAP. The expression of different life history pathways provides resilience at both the population and the ESU level, increasing the likelihood that local and meta populations will persist in the face of sudden or gradual variations in watershed function and the availability of high-quality habitats at various spatial scales.

As identified in the federal recovery plan and acknowledged by the local experience of the Siletz Partnership, Coho productivity and long-term viability in the Siletz Basin are primarily limited by the reduced quality, quantity, diversity, and connectivity of different freshwater and estuarine rearing habitats. Thus, a key measure of success for the Siletz River Coho SAP will be the protection, restoration, and connection of diverse, high-quality rearing habitats in mainstem, tributary, off-channel, and estuarine reaches.

The Siletz Partnership identified the following vision for native Coho in the Siletz River:

Our vision is to support an abundant and resilient wild Coho population through enhancing diverse habitats within the Siletz River Basin. In doing so, we will support fishing, economic, and aesthetic benefits for current and future generations.

Actions to achieve this vision aim to improve watershed processes that provide cool, clean water, large wood, and spawning gravel to the stream and to promote beaver throughout the watershed. Maintaining and restoring a connected system of diverse, healthy rearing habitats is needed to support the full expression of life history diversity in the basin. This diversity is especially critical given the expected changes in freshwater habitats due to climate change.

Through the implementation of this SAP, local partners hope to achieve several long-term goals.

LONG-TERM GOALS	
1	**Rebuild life history diversity.** By 2045, a restored network of connected and diverse habitats from freshwater into the estuary rebuilds and sustains the full portfolio of life history types of wild Coho present in the Siletz watershed.
2	**Increase abundance.** By 2045, the increased availability of high-quality habitats will generate an increase in the wild Siletz Coho population to annually stable returns that can sustain commercial, recreational, and traditional harvest needs.
3	**Provide economic benefits.** Ongoing investments in watershed restoration drive sustained job growth in commercial and recreational fishing and river-based recreation through 2045.

To achieve these goals, this SAP emphasizes the restoration of critical Coho habitats by repairing the watershed processes that generate and maintain them. This process-based approach focuses on a habitat strategy that seeks to identify, protect, and restore the stream and estuarine reaches most capable of supporting Coho across the full expression of life history types. The primary strategies presented in this plan seek to conserve and increase the quality and quantity of Coho habitats, including for life histories where Coho fry and parr move to non-natal habitats before outmigration. Access to lower tributary reaches, cold water refugia, and connected off-channel rearing and estuarine habitats is especially important because these areas support the variety of known life history strategies used by Coho in the Siletz watershed. The strategies aim to enhance riparian conditions to increase shade, stream stability, and future large-wood delivery to tributaries; actively install large-wood structures and support beaver activity to promote instream complexity and floodplain interaction in and around critical habitats; reconnect tidal wetlands, especially in confluence areas; and protect and enhance instream flows during critical periods.

Importantly, the Partnership aims to implement the strategies in ways that also promote economic recovery and a working landscape. The ultimate vision is a healthy watershed, connected from headwaters to the ocean, that supports a thriving fish population and a vital local economy.

Strategic Framework for the Siletz River Watershed:

The SAP's Strategic Framework prioritizes restoration strategies that will restore conditions to rebuild Coho life history diversity and viability in the Siletz River watershed. This framework identifies seven strategies that will achieve the desired outcomes by 2045.

Strategy 1: Restore instream complexity and stream-floodplain interaction in mainstem systems, tributaries, and sloughs through the installation of large wood.

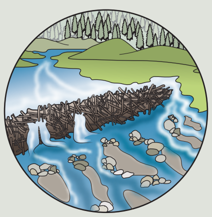
Outcome #1: Floodplain-channel interaction and instream complexity are increased through the addition of LWD in 78 miles of mainstem systems, tributaries, and sloughs. An additional 23 miles of instream assessments will be conducted to increase potential restoration mileage.

By 2045, the partnership will achieve the following Siletz Partnership restoration objectives.

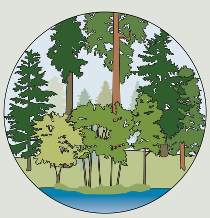
Instream Complexity
Add LWD in 78 miles of mainstem, tributaries, and sloughs.

Reconnection
Increase rearing opportunities in 1,123 acres of floodplains and wetlands.

Protection
Protect 847 acres of freshwater, tidal wetlands, and floodplains through voluntary acquisitions.



Beaver Persistence
Re-establish slow water and beaver habitats along 22 miles of tributary streams.



Riparian Enhancement
Enhance 40 miles of riparian areas in mainstem and tributaries.

Longitudinal Connectivity
Evaluate all crossings on Coho-bearing streams to restore longitudinal connectivity.

Large-Wood Delivery
Protect 8,689 acres of selected timber stands through policy and acquisitions for future LWD.

Artwork by Elizabeth Morales

Strategy 2: Restore and reconnect freshwater and tidal floodplains and wetlands instream complex.

Outcome #2: Rearing opportunities are increased in 1,123 acres of floodplains and wetlands through the restoration of hydrologic regimes, fish access, and ecologically appropriate native plant communities in freshwater and brackish systems.

Strategy 3: Ensure long-term protection of high-priority wetlands and floodplains.

Outcome #3: The long-term protection of 847 acres of freshwater and tidal wetlands and floodplains will be obtained through a series of voluntary acquisitions.

Strategy 4: Encourage beaver persistence in tributary and floodplain habitats.

Outcome #4: Slow water habitats and beaver-favored forage are re-established along 22 miles of tributary streams.

Strategy 5: Enhance riparian habitats along tributaries through native plantings and the management of invasive species.

Outcome #5: Riparian function is enhanced along 40 miles of the Siletz River and its tributaries, reducing stream temperatures and erosion and increasing macro-invertebrate abundance and long-term potential for large wood recruitment.

Habitat restoration on Drift Creek, a tidal estuary of the Siletz Bay. Photo: MidCoast Watersheds Council

Strategy 6: Increase longitudinal connectivity by addressing problematic stream crossings.

Outcome #6: All crossings on Coho-bearing streams will be evaluated and longitudinal connectivity will be restored in selected reaches with high-quality juvenile rearing habitat.

Strategy 7: Ensure future large-wood delivery by promoting update forest policy, landowner outreach, and acquisitions.

Outcome #7: Through policy, outreach, or acquisitions, the long-term potential for the conservation and restoration of watershed processes is improved through the protection of 8,689 acres of selected timber stands throughout the Siletz Basin.

The SAP includes a monitoring framework to evaluate both the rate that the actions are implemented and the degree that they produce the desired results at a meaningful scale. The monitoring framework also presents several critical data gaps, which, once filled, may redirect the team's priorities for implementation.

Finally, like all plans, this SAP has been generated with imperfect and evolving information. Most notably, considerable uncertainty exists regarding how global climate change predictions will challenge many assumptions made about future local watershed conditions and how aquatic systems may respond to restoration actions. Additionally, implementing the projects identified in the SAP relies on willing landowners. Thus, adaptive management is essential to the long-term success of this plan and the Partnership's ability to reach stated outcomes.

Chapter 1

Introduction: The Siletz Basin Coho Partnership and the Purpose of this Plan

Historically, the Siletz, like most coastal rivers from Cape Blanco, Oregon, north to the Columbia River, produced large runs of Coho salmon (*Oncorhynchus kisutch*). Scientists estimate that during periods of favorable ocean conditions prior to European settlement, Coho runs from river systems along the Oregon Coast may have ranged from one to two million fish or more and were far more abundant than Chinook salmon populations for the majority of the coastal watersheds (ODFW 2007).

Coho and other Pacific salmon runs have been central to the lives of people in the Siletz Tribe since time immemorial. The salmon are vital to a socioeconomic system that supports the Tribe, who, like other Indigenous peoples around the Pacific Rim, have practiced advanced systems of management involving cultural and spiritual beliefs and stewardship practices for generations (Atlas et al. 2021). These social-ecological systems were radically altered by European colonization, resulting in overharvest and habitat degradation as timber harvest and agricultural activities expanded. This pressure on the resources resulted in significant declines in salmon populations in the mid-1900s (Atlas et al. 2021).

After the decline of wild Coho populations in the mid-1900s, large-scale hatchery production was used to supplement commercial and recreational fisheries through the rest of the century. However, those supplementation efforts were largely unsuccessful. The total number of native Coho spawners along the Oregon Coast in 1983 was down to 14,600 and 26,200 (pre-harvest) in 1997 (ODFW 2016). This sharp decline led to the first petitioning of Oregon Coast (OC) Coho salmon for listing under the Endangered Species Act (ESA) in 1993 and the tightening of Coho harvest regulations (NMFS 1993). Continued declines eventually led to the designation of OC Coho as a threatened species under the ESA in 1998.

Adult Coho. Photo: Danita Delimont / Shutterstock

Restoration partners plant native trees on lower Drift Creek. Photo: MidCoast Watersheds Council

The Siletz Coho population is one of the 21 independent populations in the OC Coho salmon Evolutionarily Significant Unit (ESU). Scientists consider an independent population to have been historically self-sustaining, with sufficient historical habitat to have persisted through several hundred years of normal variations in marine and freshwater conditions (Lawson et al. 2007). The viability of the Siletz Coho population has mirrored that of the OC Coho salmon ESU since their listing. As described in the ESA, a threatened species is not presently in danger of extinction but is likely to become so in the foreseeable future.

While the ESU's 1998 listing under the ESA dramatically restricted Coho fisheries, impacting subsistence, recreational, and commercial harvest along the north coast of Oregon, population numbers continued to decrease. This downward slide prompted the state of Oregon and coastal communities to take action to stop the species' decline. The state of Oregon developed the Oregon Plan for Salmon and Watersheds in 1997, kicking off a substantial local recovery effort by state and federal agencies, local watershed groups, non-governmental organizations, and public and private landowners, who are collaborating to rebuild OC Coho population numbers and to increase their overall resilience.

A collaborative effort to restore OC Coho populations is vital to the species' long-term recovery along the rural, resource-dependent coast of Oregon. Watershed conservation and species recovery require establishing strategic partnerships where various public and private stakeholders work together toward a common vision. This vision must coalesce economic, ecological, and social goals and align the limited social and financial capital available in the region towards solutions that promote sustainable watershed and community health.

The Siletz Basin Coho Partnership (Siletz Partnership) convened to meet these needs. The Partnership developed this Strategic Action Plan (SAP) to engage local stakeholders in developing and implementing strategically aligned habitat protection and restoration actions to recover the Siletz Coho population while sustaining and nurturing the long-term viability of working farms, forests, and communities. The SAP describes a range of habitat restoration strategies that will further improve the quality and quantity of Siletz Coho habitats and restore natural processes to sustain the long-term viability of the Siletz Coho population.

Spawning Coho salmon. Photo: Jim Yuskavitch

1.1 The Vision for Healthy Native Coho in the Siletz River

The residents of the Siletz Basin value the native fish species that the watershed supports and recognize their responsibility to support the fish population's long-term viability. Therefore, the Siletz Partnership identified the following vision for native Coho in the Siletz River:

Our vision is to produce an abundant and resilient wild Coho salmon population in diverse habitats in the Siletz River watershed, supported by sustainable ecological processes, to provide for fishing and aesthetic benefits to current and future generations.

To attain this vision, the Siletz Partnership strives to achieve watershed conditions that will support a full range of life histories for wild Coho in the Siletz River watershed and boost Coho viability, productivity, and resilience. As identified in the state and federal recovery plans, and acknowledged by the local experience of the Siletz Partnership, Coho productivity and viability in the Siletz is primarily limited by the reduced quality, quantity, diversity, and connectivity of different freshwater and estuarine rearing habitats. Thus, a key measure of successful plan implementation will be the protection, restoration, and connection of diverse high-quality mainstem, tributary, off-channel, and estuarine rearing habitats to increase the Siletz population's viability, productivity, and resilience. Priority actions to achieve this vision will improve watershed processes that provide cool, clean water, large wood, and spawning gravel to the stream, reconnect various habitat areas, and promote beaver throughout the watershed.

1.2 Why Coho?

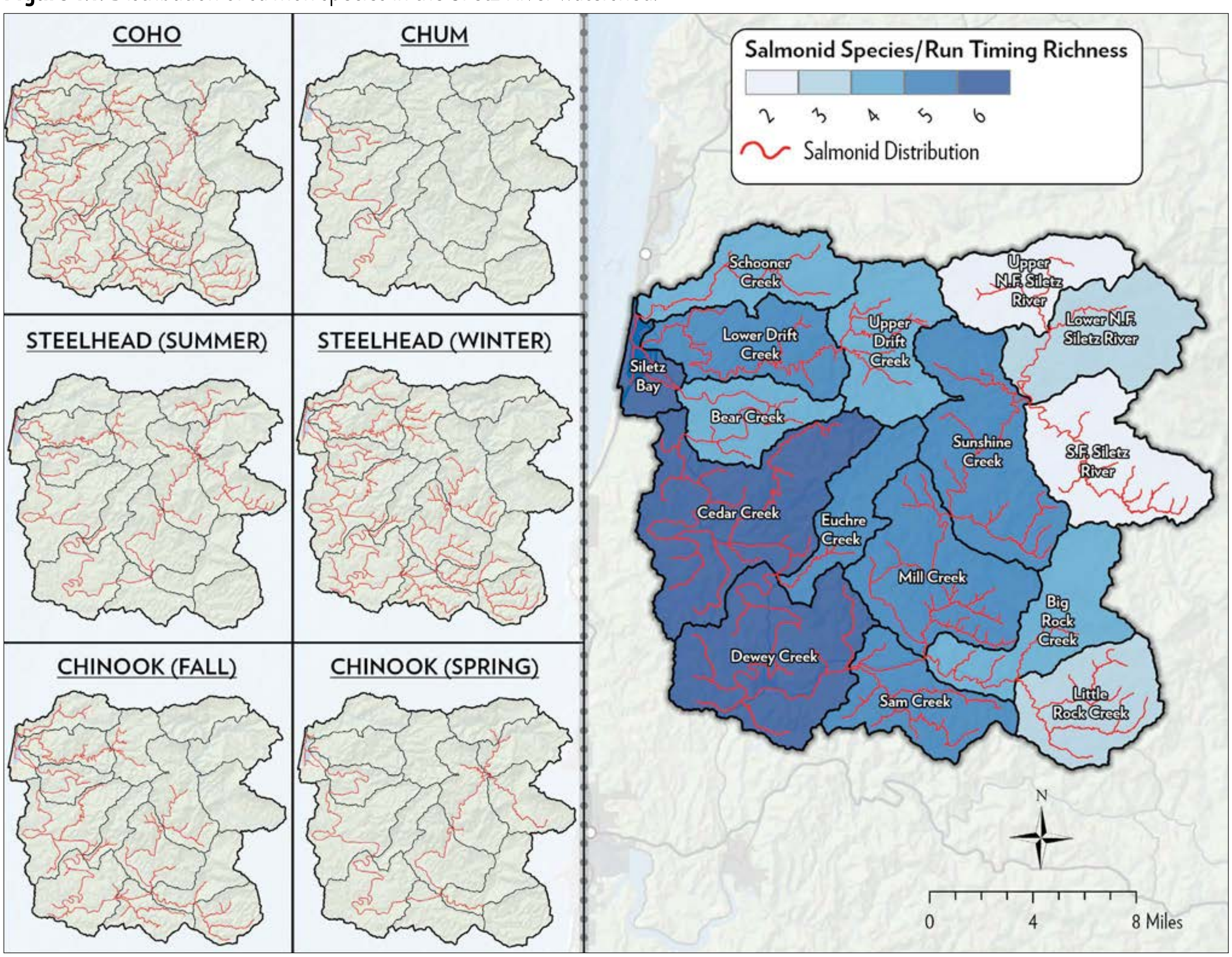
Besides the goal of recovering a listed species and promoting robust populations, Coho are the focus of this work for a number of reasons. Coho have a unique life cycle among Pacific salmon, with a long period of freshwater residency, making them an excellent indicator of watershed health. Adult Coho return to the Siletz from the ocean each fall to spawn in the basin's low-gradient tributaries. Their offspring emerge from the gravel the following spring, and most of the young Coho remain in freshwater habitats for an entire year before migrating to the ocean. This extended freshwater residency requires a watershed functioning sufficiently to maintain a variety of healthy habitat types throughout the year—habitats created by the interaction of complex watershed processes like hydrology, sediment delivery, and riparian (streamside) and floodplain interactions. For Coho, the network of off-channel habitats, such as beaver ponds, oxbows, and side channels, that these interacting watershed processes create is essential. Access to these off-channel areas allows juvenile Coho to find pockets of cool water for rearing when the mainstem of the Siletz heats up in the summer, and protected areas in the winter when peak flows threaten to sweep them downstream.

Protecting and restoring the natural processes that create diverse Coho habitats have broader benefits. Watersheds that generate and maintain enough complex instream and off-channel habitats to sustain viable Coho populations also produce services that human communities rely on, such as clean drinking water, flood control, groundwater recharge, and recreation. Further, Coho habitats also support a wider variety of fish and wildlife that rely on habitats in the Siletz watershed. Besides Coho Salmon, the basin supports fall and early-run fall Chinook (*Oncorhynchus tshawytscha*) and chum (*O. keta*) salmon, winter steelhead and a unique stock of summer steelhead (*O. mykiss*), resident and anadromous cutthroat trout (*O. clarkii clarkii*), white sturgeon (*Acipenser transmontanus*), and Pacific lamprey (*Lampetra tridentata*).

Coho are a "keystone species," helping to define entire ecosystems. They play a vital role in the health and functioning of both aquatic and terrestrial ecosystems, with over 130 other known species benefiting from them. All life stages of Coho (egg, fry, smolt, and adult) provide sustenance to aquatic and terrestrial organisms ranging from otter and black bear, which consume returning adults, to the smallest aquatic invertebrates that shred the carcasses of decaying fish after they have spawned.

Forest and plant communities also directly benefit from the decaying fish. Adult Coho return to the watershed after taking up phosphorus, nitrogen, and other nutrients from the ocean. After the salmon spawn, they decompose and release these critical marine-derived nutrients into the ecosystem, where they become available to grasses, shrubs, trees, and other plant life. While studies on marine-derived nutrients are lacking in the Siletz Basin, we know that, as found by Merz and Moyle (2006), "research over more than three decades has shown that the annual deposition of salmon-borne nutrients is important for the productivity of freshwater communities throughout the Pacific coastal region." Helfield and Naiman (2001) found that "trees and shrubs near spawning streams derive ~22-24 percent of their foliar nitrogen (N) from spawning salmon." Subsequent research by Naiman et al. (2002) suggests that even in highly modified watersheds in Northern California, "robust salmon runs continue to provide important ecological services with high economic value…. Loss of Pacific salmon can not only negatively affect stream and riparian ecosystem function, but can also affect local economies where agriculture and salmon streams coexist."

Figure 1.1. Distribution of salmon species in the Siletz River watershed.



Coho salmon carcass on the bank of Drift Creek. Photo: David Herasimtschuk

1.3 Scope of This Strategic Action Plan

The federal government and the state of Oregon have developed recovery plans for the OC Coho salmon ESU that encompass the Siletz population, including the Final ESA Recovery Plan for Oregon Coast Coho Salmon (NMFS 2016) and the Oregon Coast Coho Conservation Plan (ODFW 2007). These ESU-level plans identify population-scale limiting factors and recommend strategies to recover each population in the OC Coho ESU. Both plans also stress that recovery can only be achieved by implementing plans that are locally generated and include finer-scale, targeted conservation actions. Both recovery plans recognize that decisions on where and how these actions are implemented must be made in locally convened forums so input from the landowner community and other stakeholders can be fully integrated into both the long-term habitat restoration strategy and the selection of short-term projects.

This SAP seeks to meet the needs of communities within the Siletz River watershed. Chapter 5 presents a long-term "Strategic Framework" for Coho habitat protection and restoration. The framework describes the habitat restoration strategies that will have the highest potential to restore watershed function. It also identifies locations throughout the basin where these strategies can generate the greatest benefit. Chapter 6 presents a short-term work plan that maps the specific locations where the social, economic, and regulatory conditions exist to put projects on the ground that advance the long-term Strategic Framework.

It is important to note that the Siletz Partnership's ability to achieve the vision described in Section 1.1 is influenced by a variety of threats that cannot be fully addressed by this SAP, which focuses primarily on habitat restoration. Throughout this plan's development, participants considered many of the additional threats—predator management (sea lions, cormorants, etc.), the limitations of the state of Oregon's water quality rules, beaver harvest, and the management of fisheries, farms, and forests. Ultimately, the partners opted to limit the scope of this plan to priorities that the Siletz Partnership can influence, especially where, when, and how Coho habitats can and should be restored in the watershed. Reviewers of this plan are encouraged to consider the policies governing land use and species/habitat management in the Siletz Basin alongside this plan's habitat restoration goals and to use alternative venues to support policies aligned with the vision of Coho recovery described above.

Finally, the Siletz Partnership emphasizes that implementing this plan is entirely voluntary. The plan identifies high-quality habitats on both public and private lands to guide outreach to landowners, but the plan's implementation relies entirely on voluntary actions. No new actions will be required of public or private landowners. Consequently, while this plan's maps identify instream and upland habitats on some private lands as a high priority for restoration, the decision to implement actions on these lands is up to individual landowners. Likewise, this SAP does not propose any new regulations or modifications to existing regulations that would impact private landowners within the watershed.

1.4 SAP Implementation Timeline: Long-Term Goals and Outcomes

The Siletz Partnership expects that the implementation of this plan—including new projects identified through the adaptive management process—will occur through 2045. A long implementation horizon is necessary to achieve the plan's goals in part because of the time required for the system to respond to restoration treatments. For example, trees planted in a riparian zone may take a decade or more to begin providing sufficient shade to improve water temperatures and many more decades to be a potential source of instream habitat (via woody debris falling into the water). In addition, the Siletz Partnership recognizes that it will take many years for the implementation of a sufficient number of projects at a large enough scale to demonstrate an improvement in sub-watershed function.

The long-term goals developed by the Siletz Partnership represent the desired future condition of the ecological priorities for the Siletz River watershed and Coho population. They are as follows.

LONG-TERM GOALS	
1	**Life history diversity.** By 2045, a restored network of connected and diverse habitats from freshwater into the estuary rebuilds and sustains the full portfolio of life history types of wild Coho present in the Siletz watershed.
2	**Increased abundance.** By 2045, the increased availability of high-quality habitats will generate an increase in the wild Siletz Coho population to annually stable returns that can sustain commercial, recreational, and traditional harvest needs.
3	**Economic benefit of recovery.** By 2045, jobs supported by ongoing investments in watershed restoration, commercial and recreational fishing, and river recreation will increase.

We hope the implementation of the Siletz Coho SAP will produce the following outcomes by 2045.

2045 OUTCOMES	
1	Floodplain-channel interaction and instream complexity are increased through the addition of LWD in 78 miles of mainstem systems, tributaries, and sloughs. An additional 23 miles of instream assessments will be conducted to increase potential restoration mileage.
2	Rearing opportunities are increased in 1,123 acres of floodplains and wetlands through the restoration of hydrologic regimes, fish access, and ecologically appropriate native plant communities in freshwater and brackish systems.
3	The long-term protection of 847 acres of freshwater and tidal wetlands and floodplains will be obtained through a series of voluntary acquisitions.
4	Slow water habitats and beaver-favored forage are re-established along 22 miles of tributary streams.
5	Riparian function is enhanced along 40 miles of the Siletz River and its tributaries, reducing stream temperatures and erosion and increasing macro-invertebrate abundance and long-term potential for large wood recruitment.
6	All crossings on Coho-bearing streams will be evaluated and longitudinal connectivity will be restored in selected reaches with high-quality juvenile rearing habitat.
7	Through policy, outreach, or acquisitions, the long-term potential for the conservation and restoration of watershed processes is improved through the protection of 8,689 acres of selected old-growth timber stands throughout the Siletz Basin.

1.5 Implementing Partners

While the team of partners listed in the introduction to this chapter developed this SAP, a subset of agencies and organizations will lead its implementation on the ground. As the SAP is adaptively managed over time, the partnership may evolve and roles may shift among organizations. Table 1.1 lists these partners and the role each will play in implementing this SAP.

Table 1.1. Core Implementing Partners.

Core Implementing Partners		
Partner	*Experience*	*Anticipated Contributors*
MidCoast Watersheds Council	The MCWC draws on nearly 30 years of restoring watersheds and ecosystem processes on the Central Oregon Coast, including the Siletz Basin. MCWC has been a leader in working to restore life history diversity pathways for Coho through a whole watershed approach to restoration.	MCWC will be the lead entity for coordination of partners and implementation of the Siletz SAP.
Lincoln Soil and Water Conservation District	Since 1955 the SWCD has worked with local landowners and partners to enhance riparian habitat and implement best management practices on working lands to improve water quality. LSWCD provides invasive weed treatments and technical assistance to landowners to improve native habitats for salmonids, pollinators, and beyond.	LSWCD will provide project implementation and technical assistance to private and public landowners. Primary contributions also include riparian noxious weed control, agricultural best management practice implementation, and coordination of the Mid-Coast Water Planning Partnership to connect resources with partners.
US Fish and Wildlife Service Oregon Coast National Wildlife Refuge Complex	The Siletz Bay National Wildlife Refuge is owned and managed by the US Fish and Wildlife Service as part of the Oregon Coast National Wildlife Refuge Complex. Established in 1991, the 578-acre refuge encompasses a variety of habitats including salt marsh, mudflats, sloughs, and forested tidal wetlands that are utilized by Coho salmon. Refuge management has steadily transitioned diked pastureland to pristine habitat for fish and wildlife using tidal restoration techniques and is protected in perpetuity.	Active restoration of habitat on the refuge is ongoing. The US Fish and Wildlife Service will continue to collaborate with core implementing partners to improve habitat for fish and wildlife species, including Coho salmon. This includes the acquisition of properties with willing landowners for parcels that have potential estuary habitat in the Siletz Bay.
Oregon Department of Fish and Wildlife	ODFW has expertise in regional fisheries, aquatic and terrestrial habitat issues, and supporting and leading statewide partnerships. Local field staff in the MidCoast District have provided technical assistance to habitat restoration projects implemented in the Siletz since the development of the Oregon Plan.	ODFW staff will continue to provide technical support for locally led habitat restoration projects, and assist in data management, landowner outreach, public education, project development, and project implementation.
Confederated Tribes of the Siletz Indians	It is the mission of the Siletz Tribal Natural Resources Department to care for, protect, enhance, and provide for the wise use of all of the Tribe's natural resources in a manner which will ensure that all generations to come will benefit from these resources. This philosophy applies to all lands to which the Tribe is historically tied, including its ancient, aboriginal, ancestral lands, its Coast Reservation, and its current and future land holdings.	CTSI will implement habitat restoration projects in the Siletz watershed on CTSI-owned or managed lands. CTSI will also provide technical and cultural resources input on projects throughout the Siletz Basin.

Table 1.1. Core Implementing Partners.

Core Implementing Partners		
Partner	*Experience*	*Anticipated Contributors*
McKenzie River Trust	MRT was founded in 1989 to help people protect and care for lands and rivers they cherish in western Oregon. As of 2024, they have protected more than 10,000 acres across their service area and more than 2,000 of those acres are on the central coast of Oregon. In addition to land protection and stewardship, they work closely with tribes to return land to the original stewards who have been here since time immemorial and to co-manage properties together. MRT has completed very large-scale restoration projects on properties they've purchased, and works closely with partner organizations to assist in restoration work across their service area.	In the Siletz, MRT will help core partners identify properties for acquisition and assist in landowner engagement to result in successful acquisition of lands in fee title or through conservation easements to safeguard existing conservation values, and more importantly, to acquire lands in fee title to enable larger-scale restoration opportunities. In addition, MRT has capability to assist in targeted stakeholder engagement efforts as they have taken a lead in that role in the Siuslaw Coho Partnership, and they can assist with volunteer and events/outreach engagement as requested.
Natural Resources Conservation Service	The vision of NRCS is a world of clean and abundant water, healthy soils, resilient landscapes, and thriving agricultural communities through voluntary conservation. Their expertise includes conservation implementation on farms and forests, working with private landowners, and supporting agriculture.	Outreach to agricultural producers/small woodland owners; conservation project planning, design, and funding through Farm Bill programs.

Native trees planted post-restoration help provide shade to the creek and will eventually act as large woody debris when they mature and fall. Photo: MidCoast Watersheds Council

Chapter 2

The Siletz River Watershed

The Siletz River watershed covers approximately 373 square miles of the western central Oregon Coast. Starting deep within the Coast Range of Polk County, the Siletz gathers flow from the mountainous terrain along the west side of the Coast Range and meanders south and west before entering the Pacific Ocean at Siletz Bay south of Lincoln City. The basin borders the Salmon River watershed to the north, the Yaquina River watershed to the south, and the Pacific Ocean to the west. The Siletz River watershed supports an independent population of OC Coho salmon (NMFS 2008). This population relies on the watershed's 548 miles of Coho habitat and its habitat-forming processes for adult spawning, juvenile rearing, and migration to and from the ocean.

The mainstem Siletz River begins at the confluence of its north and south forks near Valsetz, Oregon, in Polk County and winds about 67 miles as it collects flow from its 235,531-acre drainage area (Lawson et al. 2007). Major tributaries to the Siletz River include the North and South Forks, Cedar Creek, Drift Creek, Euchre Creek, Gravel Creek, Rock Creek, Schooner Creek, and Sunshine Creek (Fig. 2.2).

2.1 Physical Geology and Geography

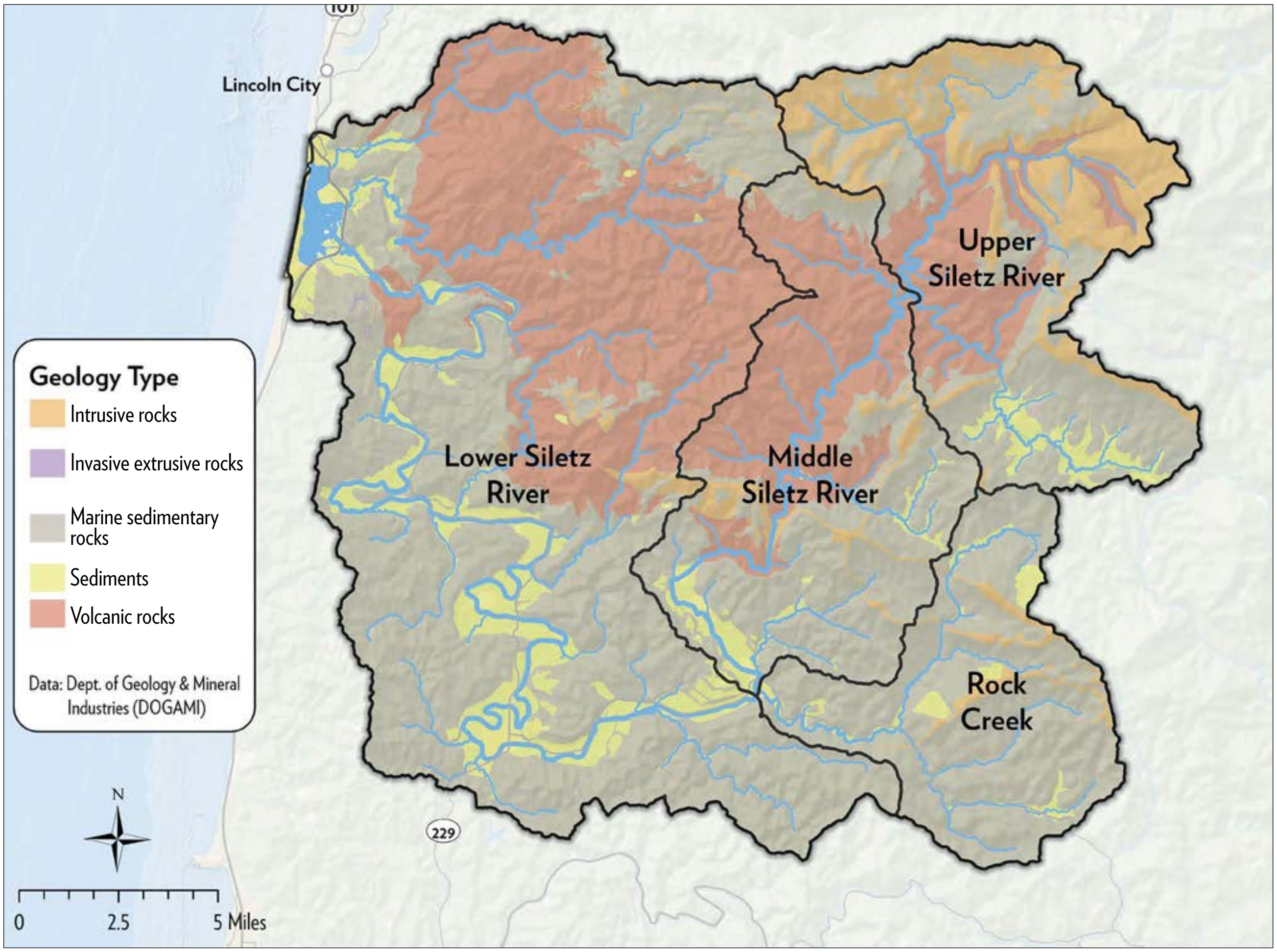
Geology

The Siletz Basin geology is more diverse than Oregon's other mid-coast basins. Over 142 square miles of the middle and upper watershed is composed of igneous (volcanic) geologic formations, making the Siletz the largest area of igneous formations in the mid-coast area.

The Siletz Volcanics form much of the upper watershed, part of a cluster of oceanic volcanic islands that existed during the Eocene, about 56 million to 33.9 million years ago. The generally basalt landscape created by the Siletz Volcanics produces rugged terrain with narrow gorges and canyons, higher-gradient streams, and numerous waterfalls. The basalts are often covered by thinly layered soils prone to landslide risk and erosion. The rugged terrain provides relatively little

Figure 2.1. Major sub-watersheds of the Siletz River.

Figure 2.2. Geology type within the Siletz River watershed.



Coho habitat, and waterfalls block Coho access to relatively large areas of the basin (upper Siletz, Big Rock Creek). Coho habitat in the Siletz Volcanics is mainly in Drift Creek and two tributaries in the Siletz Gorge—Sunshine Creek and Buck Creek, and to a lesser extent in Schooner Creek, Cedar Creek, and Euchre Creek. Importantly, while the volcanics provide little suitable Coho habitat, they deliver clean, cool water and abundant high-quality gravel to the sandstone areas downstream.

A large area of sedimentary formations—mainly sandstones, siltstones, and mudstones—covers about 192 square miles (MidCoast Sixth Field Watershed Assessment) and includes the Tyee Formation. The Tyee Formation displays thick layers of bedded sandstones and siltstones susceptible to mass movement, rapid erosion, flash flooding, and landslides. The lower gradient streams in this area generally have wide valleys but limited gravel. Tyee tributaries with good Coho habitat potential include Rock Creek, Sam Creek, Mill Creek, Upper Sunshine Creek, and Fourth of July Creek. Several west-side tributaries of the lower Siletz River have low-gradient streams with complex channels and embedded wetlands, which might appear at first glance like superior Coho spawning habitat, but the Tyee sandstone here is overlain by an even softer sedimentary rock that does not produce useful spawning gravel. While not providing high-quality spawning habitat, the conditions of this area do create good pre-smolt overwintering habitat.

Quaternary deposits cover a smaller area in the basin, primarily laid down by water and earth movement in river valleys, estuaries, beaches, and areas of ancient landslide activity. The deposits can be subject to erosion during high flows and tidal influence. Much of the mainstem Siletz River between Moonshine Park and the head of tide is deeply incised, with vertical banks of 30 feet or more. Several tributaries with otherwise suitable habitat for Coho are inaccessible because these incised vertical banks create waterfalls that block access at their confluences with the mainstem.

A small mountainside spring feeds into Smith Creek. Photo: David Herasimtschuk

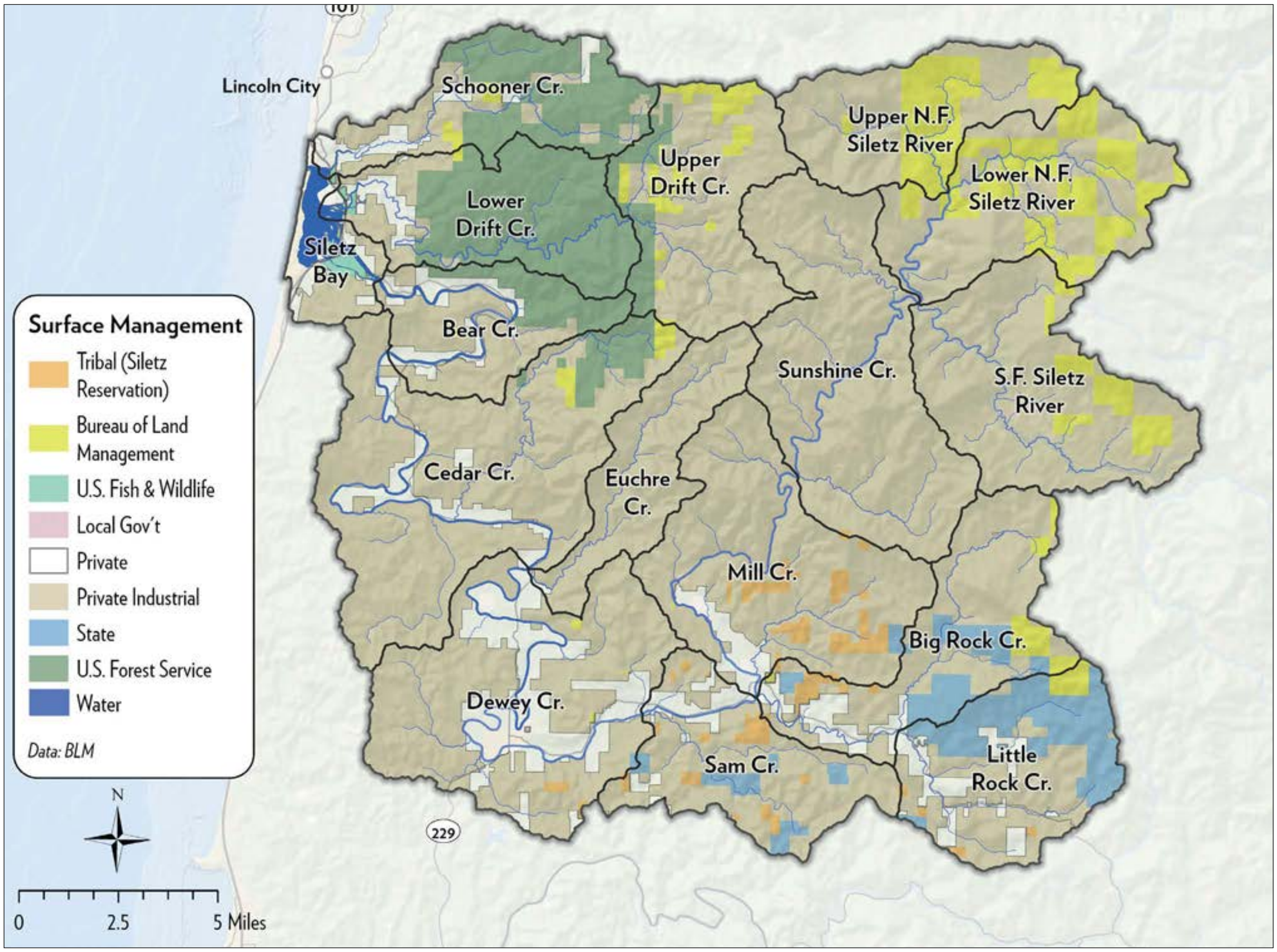
Geography

The Siletz watershed displays considerable physical variety, ranging from high, steep mountain slopes with lush forests to more moderate slopes and mid-elevation alluvial valleys to sand dunes, flat marine terraces, and extensive marshes near where the river joins the Pacific Ocean. The watershed is part of the Coast Range ecoregion, which extends along the entire Oregon coastline and east through coastal forests to the border of the Willamette Valley. The ecoregion is influenced by cool, moist air from the ocean and displays highly productive rain-drenched coniferous forests. Elevations in the basin range from sea level to 3,592 feet. Typical elevations near the crest of the Coast Range average around 1,500 feet in elevation.

Upland areas are generally moderately sloped terrain, becoming steep and rugged to the east, including along Fanno Ridge, Stott Mountain, Laurel Mountain, and Euchre Mountain. Ridges generally extend northwest to southwest. The lower basin displays rolling hills and flat, wide marine terraces that extend across the valley floor but are broken up by basalt headlands that stretch from the mountains to the sea. Tidal flow from the ocean reaches 22.5 miles inland, just below Jack Morgan State Park.

Historically, the Siletz River watershed's complex mosaic of habitat types supported a variety of functions for aquatic species and sustenance for Indigenous cultures before the arrival of European and American homesteaders and the subsequent rise of the commercial timber and agricultural industries. In the upper reaches, large wood (both standing and downed), beaver dams, and boulders promoted interaction between tributary and mainstem channels and their adjacent floodplains. High flows across this complex landscape generated well-connected side channels, oxbows, and ponds with cool, calm water ideal for Coho rearing. High flows also sorted river substrates, creating gravel and cobble riffles suitable for spawning salmon. In the lower reaches of the basin, the floodplain broadened into a connected network of sloughs, marshes, swamps, and other tidal habitats. Plentiful amounts of large wood contributed to the dynamic river as it migrated across the floodplain, creating side channels, alcoves, bars, and islands.

Figure 2.3. Land ownership in the Siletz River watershed.



Today, while 170 acres of tidal wetland habitats have been lost to diking, the Siletz Bay remains among the less-developed Oregon estuaries, with 420 acres of undiked tidal marsh, 20 acres of scrub-shrub tidal swamp, and 40 acres of forested tidal swamp. The Siletz estuary also retains more stranded large wood than other Oregon estuaries, though it has much less than it did historically. The bar is undredged and shallow, so tidal exchange is presumed to be similar to historical, pre-European settlement. Since 2003, the USFWS and partners have been working to restore much of this area (Brophy 2019). Additional restoration work has replaced undersized stream crossing structures with ones that can pass wood and sediment to improve the connectivity of habitats from forests to the estuary.

2.2 Water Resources

Water Quantity

The Siletz watershed follows a rain-dominated hydrologic regime, with most precipitation falling as rain. Snowmelt supplies only a small portion of the water in the basin. Rainfall in the basin varies greatly depending on elevation, with averages ranging from 60 inches annually in the lower watershed near Lincoln City to around 140 inches annually in the upper Drift Creek sub-watersheds. The average annual flow in the Siletz River is 1,526 cubic feet per second (cfs). However, being primarily fed by rainfall, streamflow varies considerably during the year, with flows peaking during winter storms, receding in the spring, and dropping to low levels during summer months. In winter, flows in the Siletz River average 3,211 cfs, while flows in summer average 283 cfs (United States Geological Survey 2001).

Additionally, the Siletz, like many other coastal watersheds, has a relatively shallow aquifer, causing a closer tracking of runoff to rainfall than in basins with more permeable bedrock and deeper aquifers (Leibowitz et al. 2014). As a result, streams in the basin are often flashy, with relatively fast rates of change. In the winter

Mainstem Siletz River. Photo: Holden Films

months, while the hydrograph generally follows a unimodal pattern, there are frequent peaks and valleys due to storm events. In the springtime, large rain events are less frequent and less intense, thus reducing streamflow at the beginning of the season and causing smaller rises throughout the season in response to short bursts of storm intensity. In the summertime, streamflow is primarily supported by groundwater inputs due to the lack of rainfall, with streamflow often declining steadily over the season. During the fall, rainfall recharges both the soil and groundwater, causing the hydrograph troughs to increase gradually throughout the wet season (Pazdral 2021).

The fluctuations in streamflow influence the distribution of Coho and other salmonids in the Siletz River watershed, which rely on specific aquatic conditions during both the wet and dry seasons for juvenile rearing and adult spawning. Increased flows during winter storms can flush juveniles out of rearing areas or scour redds. Extended summer dry conditions can further reduce already low flows and cause water temperatures to reach levels that stress fish. However, streams in the Siletz watershed that are dominated by volcanic bedrock are less likely to experience these large fluctuations in streamflow because the basalt channels are more permeable, allowing rainwater to infiltrate the soils and be stored, compared to streams with less permeable, sedimentary-type soils with limited storage (Pazdral 2021).

Flows in the Siletz watershed are also affected by multiple water diversions supporting other beneficial uses, including drinking water and industrial, agricultural, and municipal uses. Some of the largest water right holders in the basin include the City of Newport, City of Toledo, and Georgia Pacific lumber mill. While these withdrawals help meet critical human needs in the area, these large water rights are senior to the instream water rights for the river. Consequently, they can leave limited water instream and trigger curtailment of junior user diversions when supplies are short. This is becoming an increasingly common occurrence for the Siletz River. Currently, the most senior instream water right on the Siletz River is an allocation of 100 cfs, and summer flows are increasingly dipping below that level (Mid-Coast Water Planning Partnership 2022). Georgia Pacific, the Siletz's largest water user, works to maintain a minimum instream flow in the river by ceasing pumping when flows dip to 75 cfs at the streamgage.

Water Quality

Several streams in the Siletz watershed are listed as impaired in the Oregon Department of Environmental Quality's 2022 Integrated Report of impaired waters, approved by the U.S. Environmental Protection Agency in September 2022 (ODEQ 2022). The Oregon Mid-Coast Water Action Plan identifies 84.4 miles of water quality-limited streams in the Siletz River drainage area (Mid-Coast Water Planning Partnership 2022). Since summer flows are supported almost entirely by water stored in the subsurface, they often respond quickly to rising air temperatures, especially when flows are already at low levels. Given this, increased water temperature is the most common impairment in the watershed. The mainstem Siletz River is particularly vulnerable to summer warming below the town of Siletz because of domestic water withdrawals by the cities of Toledo, Newport, and Siletz.

Other water quality problems, such as elevated levels of E. coli and turbidity, the presence of biowaste, and decreased levels of dissolved oxygen, also impact watershed health. General causes of impairments are from changes in land use, lack of riparian vegetation, erosion, and nonpoint source pollution from agricultural practices and stormwater runoff (Mid-Coast Water Quality Management Area Plan 2019). Riparian zones alongside agricultural lands often lack adequate buffers on the mainstem Siletz River, Schooner Creek, Drift Creek, and Rock Creek and some of its tributaries. The Siletz River above the town of Siletz is 303(d)-listed for turbidity because of repeated winter events of excessive turbidity entering the Siletz municipal water intake. Flow from Rock Creek appears to be a major contributor to this problem. Still, the Lincoln Soil and Water Conservation District, landowners, and others have implemented numerous projects to improve water quality in the Siletz watershed. These projects include fencing to exclude livestock from streams, planting native riparian trees and shrubs to shade waterways and cool water temperatures, and adding large wood structures to increase stream complexity.

2.3 Biotic Systems

Vegetation in the Siletz watershed reflects the area's mild, stable temperate climate. Sitka spruce (*Picea sitchensis*) forests originally covered much of the fog-shrouded coastline, while a mosaic of western red cedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla*), Douglas fir (*Pseudotsuga menziesii*), and grand fir (*Abies grandis*) blanketed inland areas. Old-growth Douglas fir

Drift Creek. Photo: David Herasimtschuk

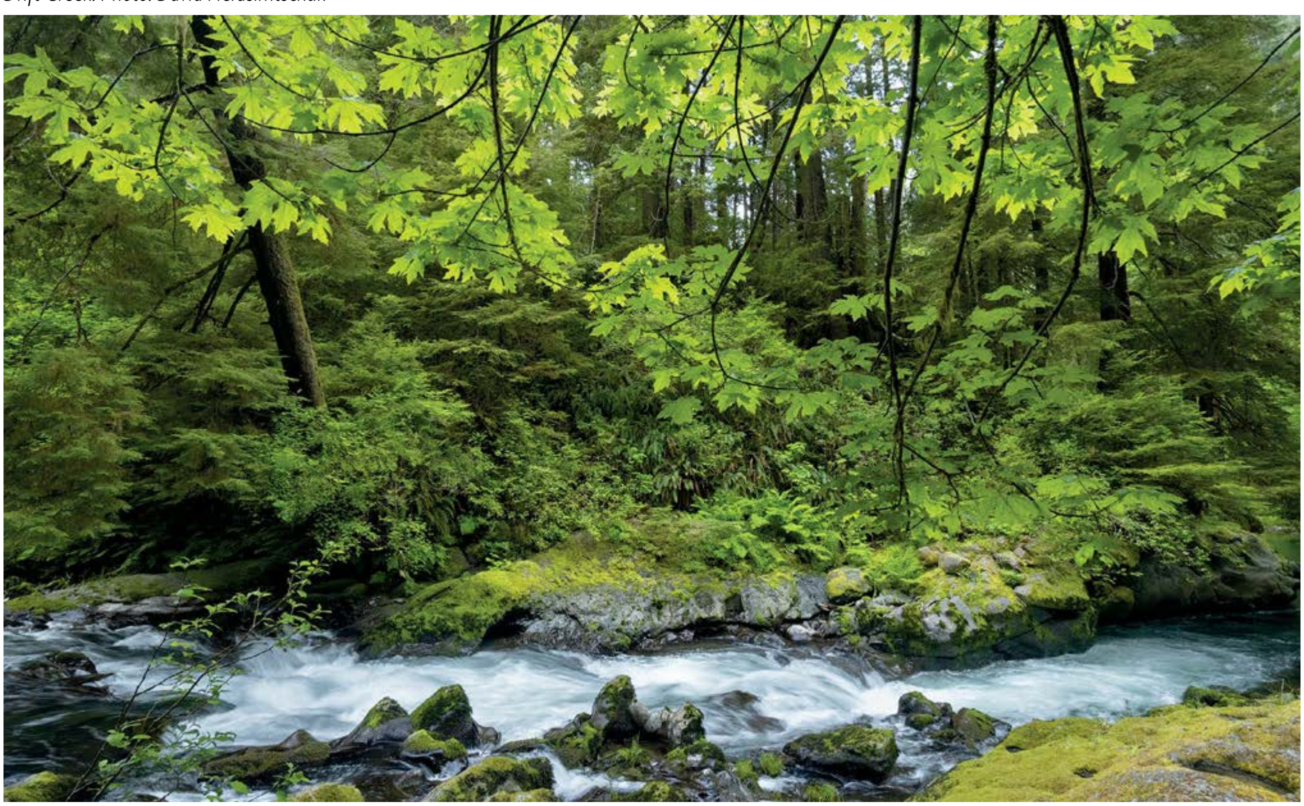
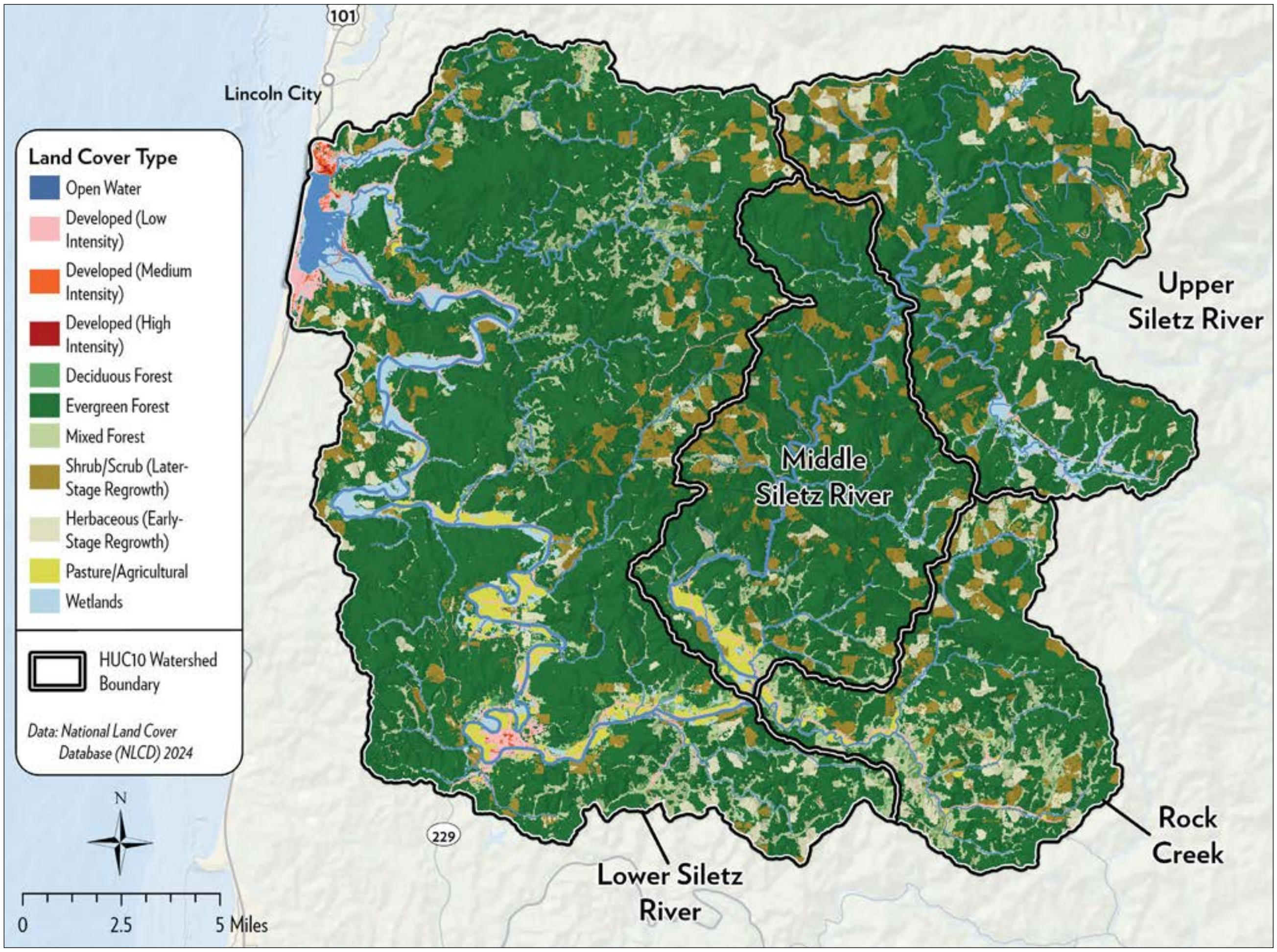


Figure 2.4. Land cover type in the Siletz River watershed.



forests were once a dominant feature in the inland landscape, with areas periodically disturbed by fires, both wildfires and fires regularly set by local Indian tribes to manage forestland and provide meadows for deer and elk grazing. Big leaf maple (*Acer macrophyllum*), vine maple (*Acer circinatum*), and red alder (*Alnus rubra*) are primary deciduous species in and near riparian areas. In the Siletz River estuary, habitats include mudflats, aquatic beds, emergent marsh, scrub-shrub, and forested wetlands.

Today, the old-growth forests have predominantly been replaced with younger, even-aged stands, primarily Douglas-fir plantations. However, older trees remain in some areas on lands owned or managed by the U.S. Forest Service (USFS), Bureau of Land Management (BLM), and Confederated Tribes of the Siletz Indians lands. Industrial forestlands dominate the rural land base in the Siletz River Watershed, with significant areas of National Forest in the north (including the Schooner Creek and Drift Creek drainages) and BLM land in the east. The industrial forest lands are managed as short-rotation tree plantations. Small woodlot owners, logging companies, and others also hold small private forest lands. The Oregon Department of Forestry (ODF) regulates these privately owned forests under the Oregon Forest Practices Act. Due to this combination of historic clearcutting, wildfire, and ongoing harvest (often 30- or 40-year rotations on private lands), most forest stands in the watershed are younger than 70 years. Lower in the basin, floodplains and wetlands have been modified to support farming, especially on valley floors along major streams. This land use is prominent in the valley near the town of Siletz. Reaches along the estuary and many coastal wetlands have also been modified to support this agricultural production using dikes and levees, drainage ditches, and tide gates. Developments for municipal uses and other purposes also changed stream habitats in the area, as has grazing on upland meadows in timber areas. These past and current land management practices have simplified stream habitats within parts of the Siletz watershed.

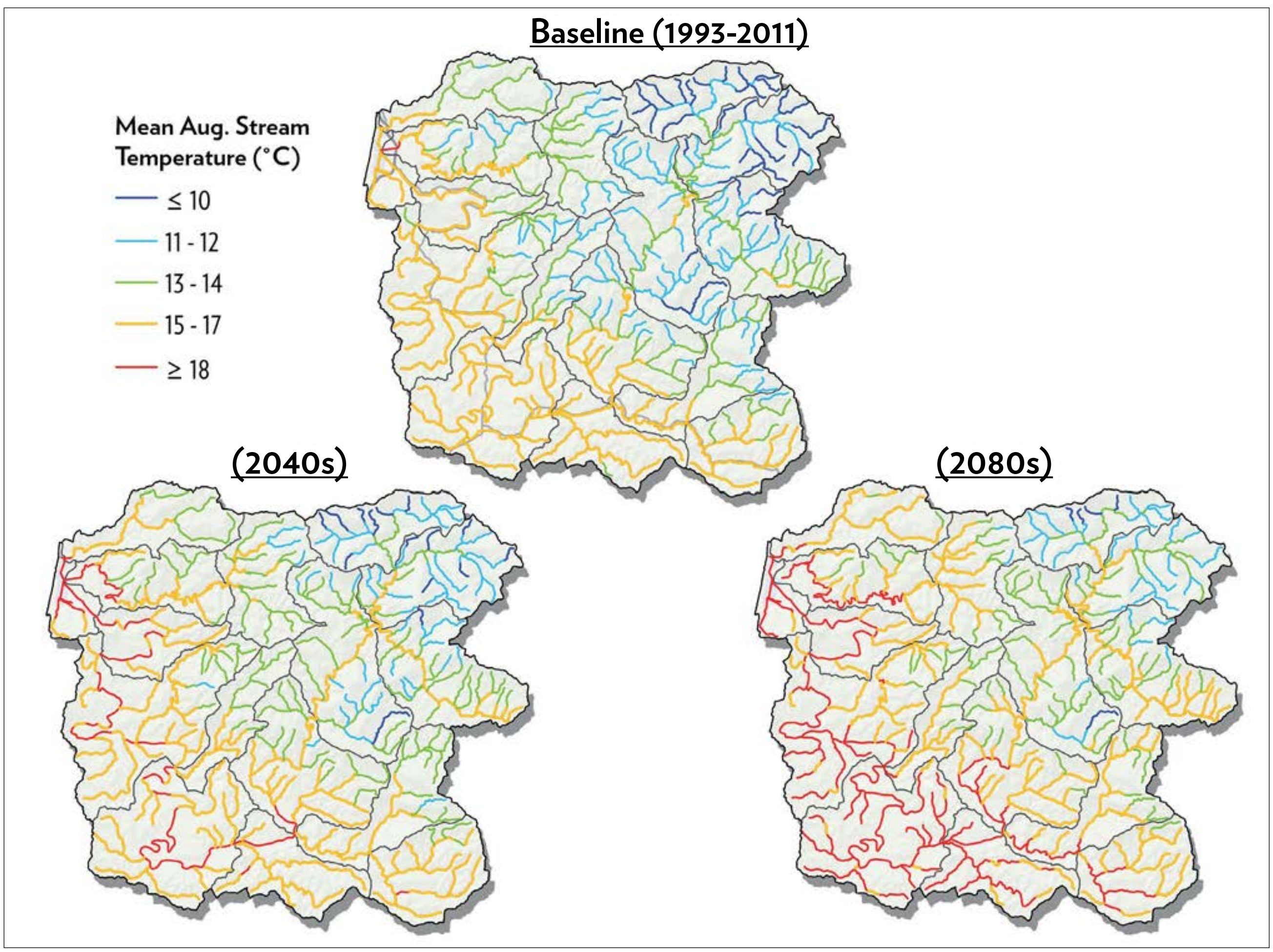
2.4 Changing Climate and Ocean Conditions

It is well established that the global climate system is changing (IPCC 2014). Since the 1950s, ocean warming and acidification have occurred at an unprecedented rate (IPCC 2014). Overwhelming scientific evidence indicates that this warming will continue through the 21st century and that the magnitude and rate of change will be influenced substantially by the amount of greenhouse gas emissions released into our atmosphere (IPCC 2014). Ocean acidification is also expected to continue through the end of the century under most greenhouse gas emission scenarios and could accelerate as the ocean's buffering capacity diminishes (Jiang et al. 2019).

Increases in global air temperature, ocean temperature, and ocean acidification will continue to drive changes in climate and ocean conditions in the Pacific Northwest. If greenhouse gas emissions continue at current levels, the average annual air temperature in Oregon is projected to increase by 5°F (2.8°C) by the 2050s and 8.2°F (4.6°C) by the 2080s, with the largest seasonal increases occurring in summer (Dalton and Fleishman 2021, Fleishman 2023). Seasonal changes in precipitation patterns and increased drought frequency are also expected, causing significant impacts on stream flow volume and timing (Dalton and Fleishman 2021, Fleishman 2023). Late fall and winter flows will likely increase in the coastal rivers, while spring, summer, and early fall flows will decline throughout the 21st century.

Without counteracting management actions to improve degraded habitats, summer stream temperatures are expected to rise due to increasing air temperatures and decreasing base flows (Figures 2.6 and 2.7). These changes could affect Coho growth and survival through numerous pathways during their life cycle (Wainwright and Weitkamp 2013). High stream temperatures have been linked to reduced Coho parr abundance

Figure 2.5. Projected change in stream temperatures in the Siletz River watershed.



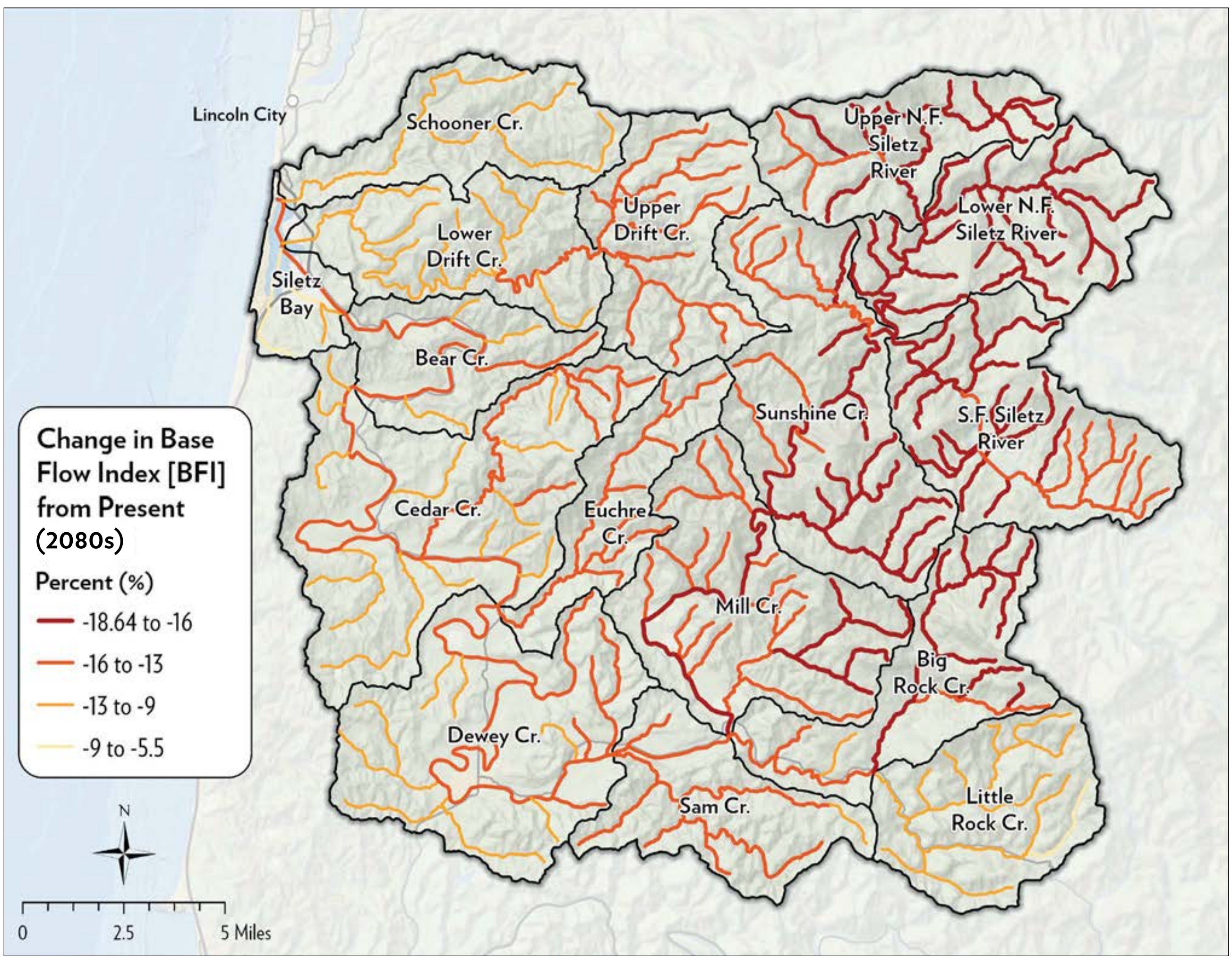
(Ebersole et al. 2009), higher susceptibility to disease (Cairns et al. 2005), and lower freshwater production (Lawson et al. 2004) in the OC Coho salmon ESU. This can be particularly detrimental to Coho juveniles that predominately rear lower in the basin and in the mainstem river.

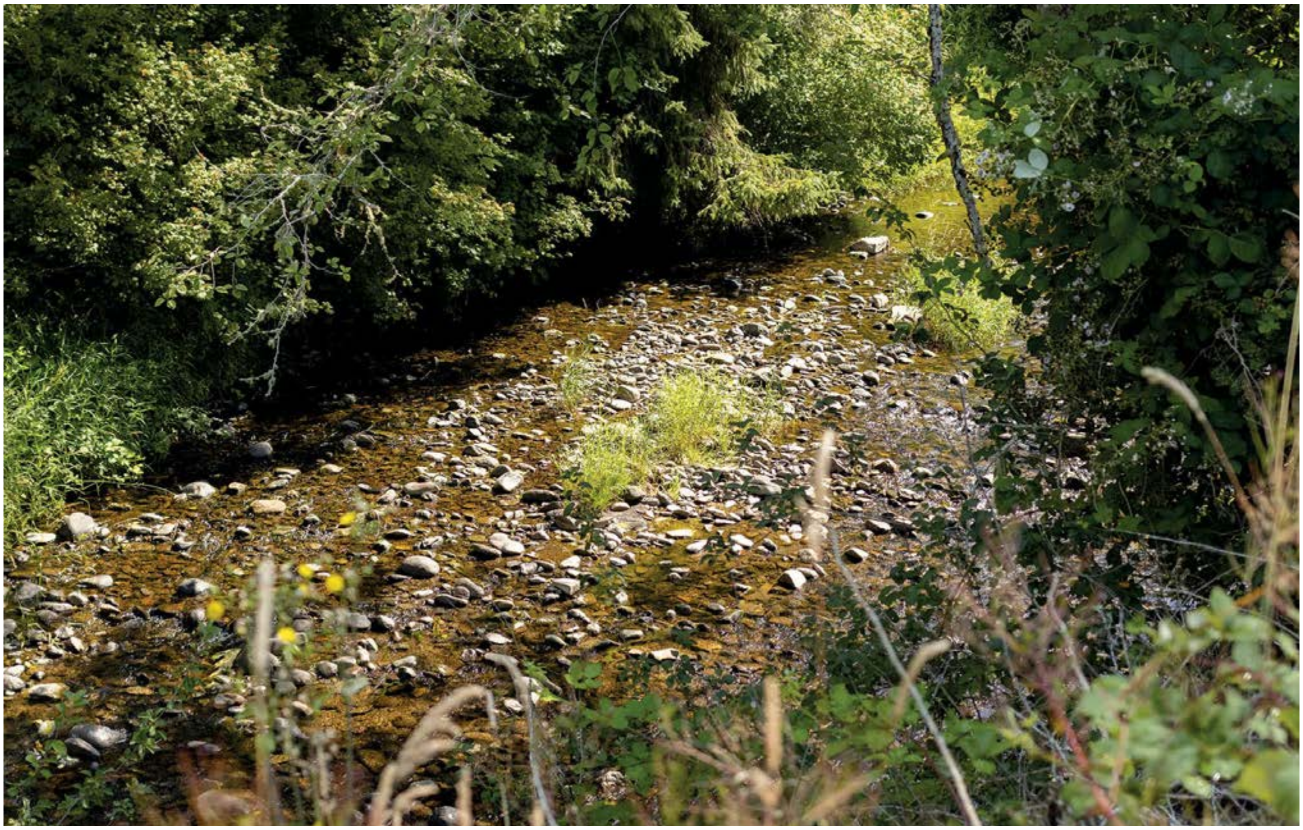
The impacts brought on by the changing climate will exacerbate the factors limiting the recovery of this species. Poor water quality is currently a secondary limiting factor for most OC Coho populations, including the Siletz population. If increases in summer stream temperatures outpace actions that increase shade and reduce water temperatures, water quality may become a primary limiting factor (ODFW 2019). Therefore, there is a need to continue work to restore stream complexity while also implementing actions to mitigate expected changes in summer temperature and flow.

In most OC Coho populations, low overwinter survival of Coho parr due to a lack of stream complexity will continue to limit smolt production in the near-term. However, increasing water temperatures and decreasing base flows could eventually lead to an even more severe reduction in productive summer habitat (ODFW 2019). Additionally, thermally stressful summer rearing conditions could reduce subsequent overwinter survival (Ebersole et al. 2006), worsening the winter bottleneck that may also be exacerbated by increased flows.

The effects of increasing summer water temperature on juvenile Coho abundance and smolt production will depend on many factors, including temperature heterogeneity and the presence of thermal refuges within stream reaches, food resource availability to support increased metabolic needs, and the quality and quantity of overwinter habitat available to juvenile fish that survive the summer period (ODFW 2019). Since local climate, geomorphology, and riparian conditions differ across the ESU, the ecological consequences of climate change for Coho populations will vary

Figure 2.6. Projected change in base flows in the Siletz River watershed.





Summer low water at Euchre Creek. Photo: Holden Films

based on their vulnerability. Still, no Coho population will be unaffected.

A population's vulnerability to climate change is a function of the following three components: 1) Exposure: the physical, chemical, biological, and other changes occurring in a selected geography due to broader shifts in climate; 2) Sensitivity: the unique characteristics of habitats and species that determine the impacts of exposure; and 3) Adaptive Capacity: the ability to adapt to rapidly changing environmental conditions (IPCC 2007, Crozier et al. 2019). The more vulnerable a species or system is to climate change, the greater the impact. A vulnerability assessment of ESA-listed Pacific salmon and steelhead ESUs completed by Crozier et al. (2019) concluded that OC Coho are highly vulnerable to climate change due to increased sensitivity and exposure. Further, since most young Coho spend a full year in freshwater before entering the ocean, the juvenile freshwater stage is considered highly vulnerable. OC Coho also scored high in sensitivity at the marine stage due to expected changes from ocean acidification. The assessment concluded that the OC Coho ESU had a moderate adaptive capacity, meaning that life history diversity may offset some of the negative effects of exposure and sensitivity to climate change. These results are consistent with the Wainwright and Weitkamp (2013) climate change assessment. They highlight the importance of implementing actions to increase ecosystem resilience for these populations.

2.5 Human Settlement and Demographics

Native Residents

The Siletz Band of the Tillamook Tribe, the southern-most Salish-speaking people in the world, lived in a number of villages in the Siletz watershed, likely numbering 15,000 individuals, before EuroAmerican settlement. The watershed's abundant natural resources supported the Tribes throughout the year, providing food, shelter, clothing, and medicine. These early residents built homes from cedar planks and beams, and wove floor mats, baskets, and other needed items. The river system's plentiful runs of fish, including salmonids and lampreys, provided their main food. This was supplemented by camas root, berries, shellfish, and wild game. Tobacco was the only plant cultivated.

Siletz Tribal Farm Property, which grows food for the local community and is the site of ongoing beaver habitat restoration. Photo: Holden Films

The tribal population dropped significantly after European explorers and trappers arrived with new diseases that the Indigenous people had not experienced before and had no immunities against. After the 1782-83 great smallpox epidemic, which swept the entire region, the Tribal population declined by about a third. The Tribal people were hit again in 1823-25 by fevers and measles that wiped out several tribal populations in their entirety. By 1850, the Tribes had declined to only about 6,000 individuals (Oregon Explorer Natural Resources Library).

In the mid-1800s, the tribes of western Oregon signed eight treaties with the United States Government, ceding parts of their land. The people of the Siletz Band of the Tillamook Tribe lived in the Siletz Basin for thousands of years before signing the Coast Treaty in 1855. The following year and many years after, the federal government forced people from many tribes and bands to move to a portion of the Oregon Coast known as the Siletz Reservation. The Confederated Tribes of Siletz Indians was formed from the diverse combination of those tribes and bands, speaking ten different languages, whose ancestors came to the Siletz Reservation after signing the Coast Treaty.

The Siletz Reservation originally extended about 100 miles along the coast and encompassed 1.1 million acres, but the reservation was repeatedly reduced by a series of actions that violated the treaties and did not provide compensation. By the early 1950s, only 3,200 acres of Tribal land remained, a loss of over 99 percent of the land base since the establishment of the reservation one hundred years earlier. Moreover, most of the allotted land parcels assigned to individual tribal members had also been revoked as a result of non-payment of taxes, mortgages, and forced fee sales of inherited allotments to non-Indians. In 1954, Congress passed the Western Oregon Termination Act, in which the federal government terminated recognition of the Siletz as an Indian tribe and liquidated what little remained of their reservation. In 1977, after many years of effort, the Tribe regained federal recognition, re-establishing ownership of more than 3,600 acres of land in Lincoln County. By 2021 the Tribe had regained ownership of nearly 16,000 acres, mostly in the Siletz, Yaquina, and Alsea watersheds.

EuroAmerican Settlement and Development

The earliest European visitors to the basin were likely fur trappers, traders, and explorers drawn to the flooded woodlands of the lower Siletz River Valley that produced abundant beaver pelts for the fur trading industry. Settlement of the area continued into the 1900s as the commercial fishing industry grew and settlers moved inland to harvest the basin's productive forests. Forestry became a primary industry in the basin as the transportation corridor expanded.

Many watershed conditions changed with the settlement and development of the basin. The new residents built levees along the lower river for flood protection and agricultural production, disconnecting the river from its historic floodplain and straightening and deepening the mainstem. They also drained marshes and swamps to support agricultural use. Past logging activities included using splash dams and log drives to float cut logs down the mainstem and tributaries to lumber mills, scouring entire reaches of critical spawning substrates. The log drive and "river cleaning" to support boating led to the clearing of habitat-forming large woody debris. Timber harvest and land clearing for agricultural and housing development further stripped riparian areas of large wood.

The historically prolific runs of salmon shaped the development of the basin. As a key food source for the Siletz peoples, they established villages at prime fishing locations. Later settlements of EuroAmerican fishing communities followed suit, even establishing canneries on the lower river in response to the abundance of salmon. More rural developments sprang up on the mainstem Siletz and other tributaries as small independent sawmills. While these areas were important for fish production, there was little concern or understanding about how impacts to salmon habitats would eventually impact abundance. Complaints of sawdust and refuse-laden water from the sawmills flowing into those creeks went unresolved. Eventually, the runs began to noticeably decline in the mid-1900s, primarily due to overharvest by commercial fisheries and watershed habitat degradation as timber harvest and agricultural activities expanded. While wild Coho numbers continued to decline, communities became more reliant on the production of hatchery fish to support tribal, commercial, and recreational fisheries through most of the century.

Loggers survey a large log pond in Toledo. Photo: Lincoln County Historical Society

Sheep at Euchre Creek Farm. Photo: Holden Films

Siletz Communities Today

Today, the area remains a hub for fishing, shellfishing, forest products, and transportation. Forestry continues to be the primary industry in the interior portion of the basin, with private industrial forests covering 75% of the watershed. Farming continues mainly in valleys along major streams, with agricultural lands concentrated in the Siletz Valley. Tourism is a growing industry in the area, with people drawn to the ocean beaches, fishing, and other recreational opportunities. The largest community in the basin, Lincoln City, has been growing steadily in recent years. Research by Portland State University (2024) indicated Lincoln City had a population estimated at 10,067 in July 2021. While there have been huge advances in the sustainability of land use activities since the mid-late 1900s, stakeholders still have to balance the growing pressure on coastal resources with preserving a healthy watershed. Chapter 5 will delve into more detail on watershed stressors.

Chapter 3

Siletz Basin Coho and Habitats

3.1 Coho Salmon Life Cycle and Habitat Needs

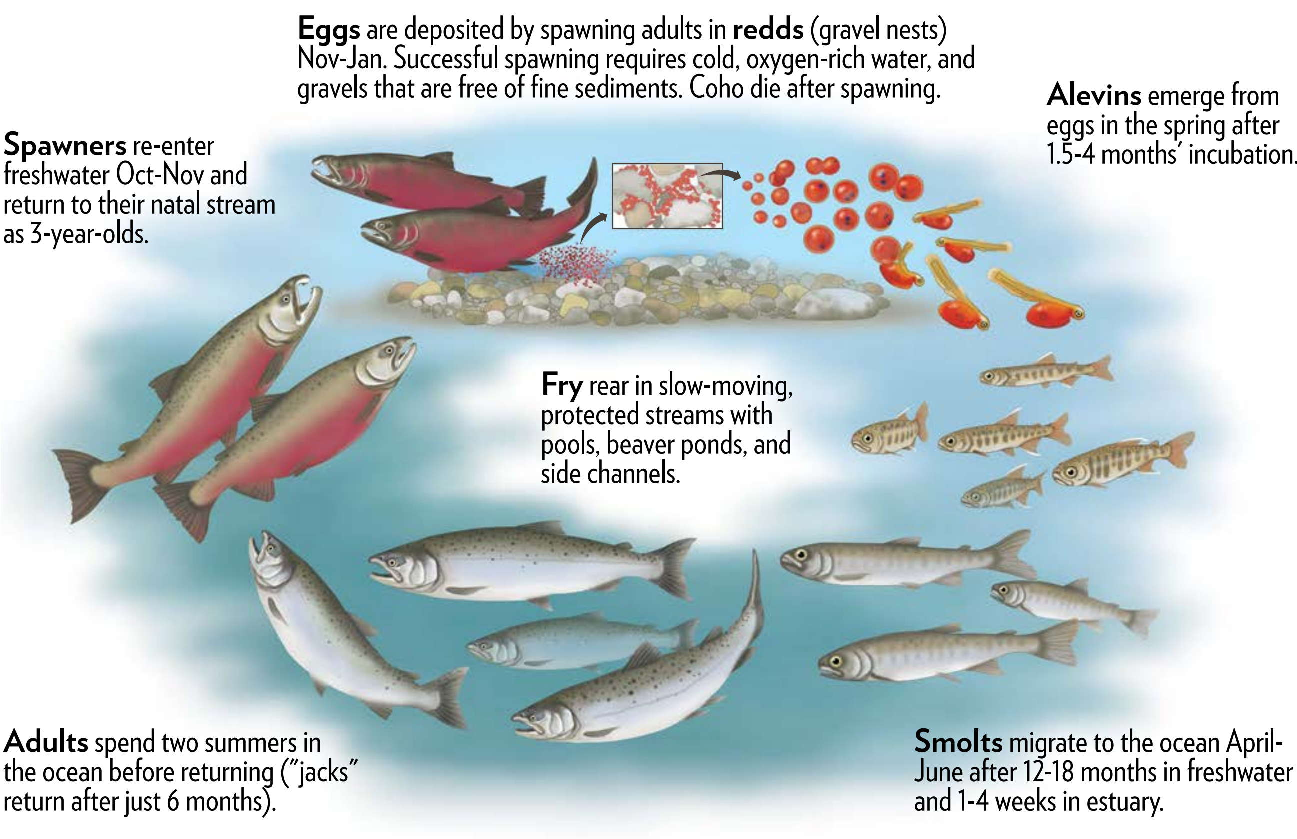
Coho typically return to the Siletz River from the ocean as three-year-olds and migrate to their natal streams from September through December, spawning between November and January. Coho spawners generally seek out low-to-moderate-gradient tributary stream reaches, but some spawn in mainstem sections of rivers and headwater reaches (Kavanaugh et al. 2005, 2006). Successful spawning requires appropriate mixes of gravel substrate in riffles and pool tailouts. Female Coho build redds (gravel nests) and deposit their eggs, which one or more males then fertilize. Adult Coho typically die within two weeks after spawning. Figure 3.1 depicts the standard Coho life cycle.

In the spring, a new generation of Coho emerges from the eggs as alevin—juveniles that rely on an attached yolk sac for nourishment while they remain in the gravels. The Coho alevin, like eggs, require a steady flow of clean, oxygen-rich water for survival. They also need gravels free from fine sediments that can smother eggs and young fish. As the young fish grow, they search out protected, slow-moving streams and quiet areas, such as beaver ponds and side channels, where they can feed and shelter before migrating toward the ocean.

Juvenile Life History Strategies

Coho in the Siletz Basin, as in other Oregon coastal watersheds, follow a mix of juvenile life history strategies during their freshwater residency. These strategies or "pathways" typically reflect a unique suite of life history traits that include developmental transitions, growth rates, habitat use, and the timing and patterns of movements between habitats before ocean entry (Dunne et al. 2025, Bourret et al. 2016, Clemens & Schreck 2021). This movement allows them to travel between varied habitats in the ever-changing coastal environment to take advantage of seasonal opportunities for growth and prepare for survival in the ocean.

Figure 3.1. Life cycle of Coho salmon. Artwork by Elizabeth Morales.



Juvenile Coho salmon. Photo: Eiko Jones Photography

Many Coho in the Siletz River are believed to follow a "standard" life history strategy, where Coho fry rear near their natal stream for about a year before migrating to the estuary in the spring as smolts. During smoltification, juvenile salmon undergo physiological changes to adapt from the freshwater to saltwater environment (Sandercock 1991, Nickelson 1998). During their outmigration, the smolts often feed and grow in lower mainstem and estuarine habitats for days or weeks before entering the nearshore ocean environment. This lag time before entry into the ocean provides further opportunity to adapt to the saltwater environment.

Other Coho in the Siletz River watershed follow alternative life history strategies, moving within and between freshwater and estuarine habitats during their first year, often shortly after emergence. Habitats used by juvenile Coho over a range of temporal scales include natal and non-natal tributary streams, intermittent streams, mainstem rivers, lakes, freshwater off-channel wetlands, and brackish estuaries. A primary driver of life history diversity is hypothesized to be the effect of proximate cues (e.g., environmental or ecological conditions experienced by the individual) on key life history decisions, such as dispersal and migration. Movement of Coho fry was reported as early as the 1960s, and it was originally believed that fry migrants did not survive to contribute to adult returns (Chapman 1962). Subsequent research has demonstrated that fry migrants represent viable alternative life history strategies when downstream habitats are suitable for growth and rearing (Bottom et al. 2005, Koski 2009, NMFS 2016). Indeed, this life history makes up a significant proportion of overall adult returns in coastal Oregon watersheds (Jones et al. 2021). Coho parr also show varied movements between complementary headwater, mainstem, and estuarine habitats (Miller and Sadro 2003). The expression of different life history pathways, defined by these diverse seasonal movements and patterns of habitat use, provides resilience at the population level, increasing the likelihood that local and meta populations will persist in the face of sudden or gradual variations in watershed function and the availability of high-quality habitats at various spatial scales.

NMFS's Biological Review Team reported at least three discrete life history strategies involving Coho fry and parr migrations into lower river habitats: late fall migration into side-channel habitats connected to lower mainstem reaches from mainstem summer rearing habitats; lower mainstem and estuarine summer rearing followed by upstream migration for over-wintering; and lower mainstem and estuarine rearing followed by subyearling outmigration to the ocean (Stout et al. 2012). These differ slightly from the life history strategies observed in the Siletz by biologists from the Confederated Tribes of the Siletz Indians, ODFW, and other natural resource partners.

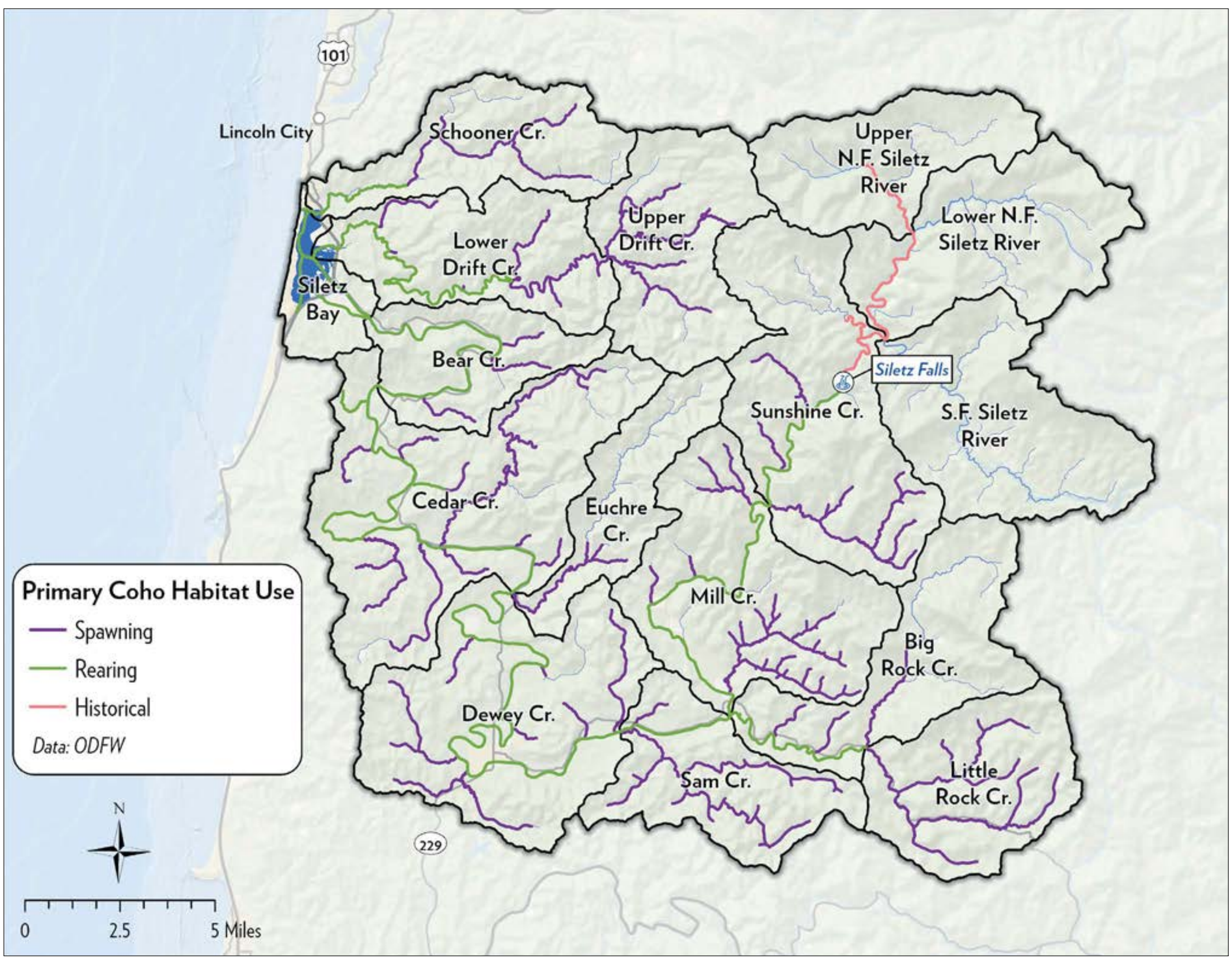
There is a lack of data on the diversity of current and historical life history pathways that the Siletz Coho population exhibits; however, local professional judgment and a synthesis of available information (Dunne et al. 2025) support the recognition of four main Coho life history strategies:

1. Natal site rearing, yearling smolt. Traditionally considered the "standard" life history type. Juvenile Coho following this pathway rear in their natal stream for a full year before migrating to the estuary in the spring (March through June) as smolts. They may feed and grow in lower mainstem, off-channel, and estuarine habitats for days or even weeks before entering the nearshore ocean, but the majority of freshwater growth occurs during natal stream rearing.

2. Spring fry migrant, mainstem-rearing, yearling smolt. Coho following this pathway emigrate from the natal stream in spring but continue rearing in other freshwater habitats, including mainstem edges, backwater and off-channel areas, beaver wetlands, non-natal tributaries, pockets of cold water refugia and other slow-water areas. To reach these areas, the juveniles migrate either upstream and downstream from their natal sites. These migrants move to the estuary in the spring at age one and enter the ocean soon after.

3. Spring fry migrant, estuary-rearing, yearling smolt. Here, the fry emigrate from the natal

Figure 3.2. Coho distribution by primary habitat use.



Decaying adult Coho. Photo: Josh Havelind

stream in spring, moving downstream into larger-order streams. By midsummer, they reach tidally influenced estuarine habitats and rear over the summer, optimizing rearing locations in the estuary based on conditions such as temperature, flow, prey availability, and salinity. Estuarine residence continues through the winter and smolting occurs in the spring at age one, with ocean entry as an age-one smolt (~18 months) (Hoem Neher et al. 2013, Jones et al. 2021, Miller and Sadro 2003, Wallace et al. 2015a). This life history type is associated with higher growth rates and generally larger individuals compared to natal stream-reared counterparts, but their movements may expose these fish to greater predation risk and lower freshwater survival (Hoem Neher et al. 2013, Koski 2009).

4. Fall/winter parr migrant, freshwater-rearing, yearling smolt. Juvenile Coho fry following this pathway rear in natal streams from early spring through the summer. In fall or early winter, often associated with decreasing temperatures and increasing flows, the Coho parr migrate to overwinter in downstream off-channel habitats (e.g., wetted floodplain, adjacent pond or freshwater tidally influenced wetland). Outmigration occurs in the subsequent spring, including a short time spent in the estuary (one to four weeks) before entering the ocean as an age-one smolt. There is a survival cost associated with freshwater movement; however, fish rearing in off-channel sites have been associated with higher growth rates and increased size at outmigration relative to natal stream-rearing counterparts (Craig et al. 2014, Gallagher et al. 2012, Solazzi et al. 2000).

The Siletz SAP focuses on these four Coho life history types, and also recognizes that there are variations within these general life history categories (see below). Juvenile Siletz Coho migration and residency patterns are often fluid—with Coho expressing considerable variation in their migratory pathways and rearing environments depending on how habitat conditions meet their individual needs—several other life history strategies may also be expressed within the population. While the percentage of the Siletz Coho population expressing alternative life history strategies is unknown at this time, the contribution of alternative life histories to the total watershed production of Coho smolts can be substantial and may be important in repopulating both natal and non-natal streams.

The sustainability of the population is tied to its long-term adaptive potential and ability to migrate between habitats under changing environmental conditions. The SAP recognizes the lack of understanding regarding Coho use of different life history pathways in the Siletz Basin as a primary data gap. Section 7.2 discusses why this information is critical and identifies research needs to learn more about the population's life history strategies. Further, the actions in the SAP promote this vital life history diversity within the Siletz Basin by restoring habitats that will support the different life history types and provide population resilience as the watershed undergoes further climate and environmental changes.

Restoration priorities focus on addressing the variety of life history pathways expressed by juveniles. However, adult Coho can have life history variability as well. Adult Coho generally spend 16 to 20 months in the ocean before returning to their natal streams to spawn as three-year-old adults. However, a proportion of male Coho reach early sexual maturity and return to freshwater as two-year-old "jacks" after only six months in the ocean or nearshore environment. The jacks represent another life history variation within Coho populations that provides resilience.

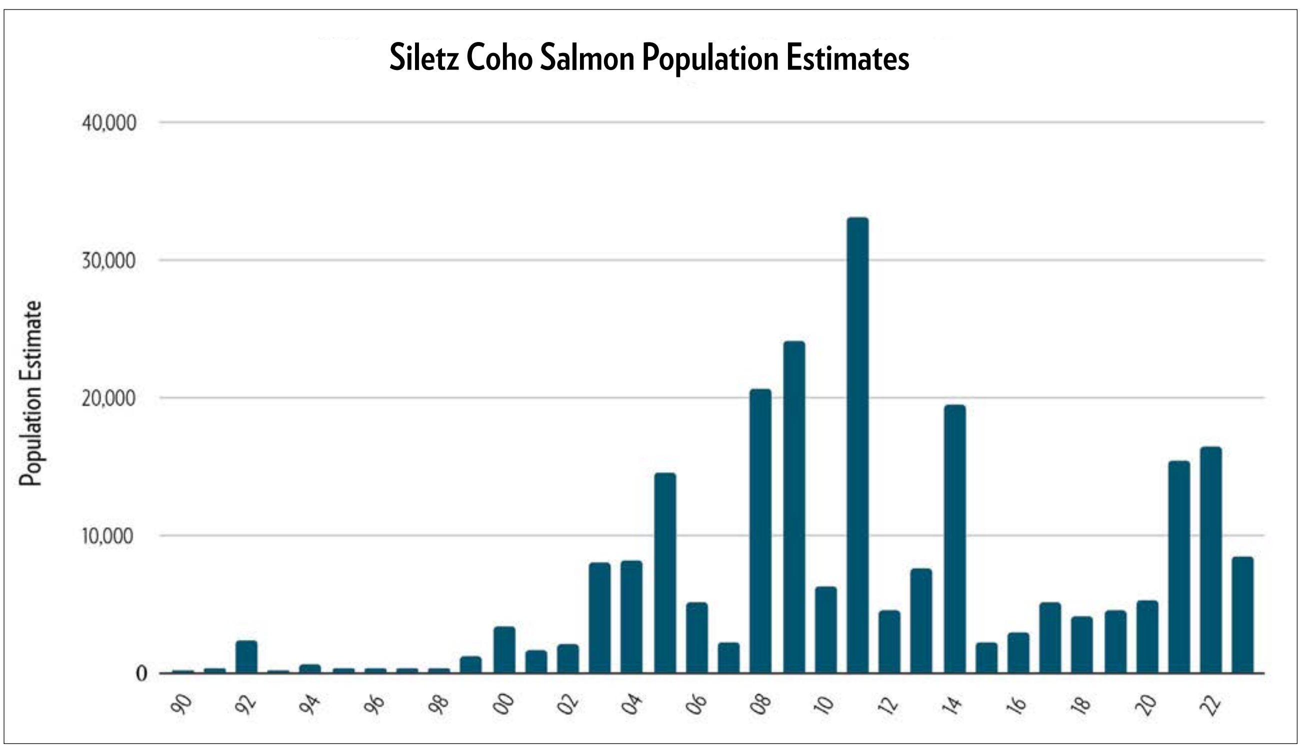
3.2 Coho Salmon Population Abundance

Indicators of historical Coho runs to the Siletz include an average catch in commercial fisheries of about 17,000 fish annually from 1923 to 1940 (Mullen 1981). This catch equates to an estimated total return of at least 50,000 adults. The indicators of historical population size point toward a progressive decline until the population of Siletz River Coho reached its most depressed state in the late 1990s. More recently, since the late 1990s, improvements due to freshwater habitat restoration, reduced hatchery fish releases, increased marine survival, and responsive harvest closures resulted in a rapid increase in adult returns (Fig. 3.3).

3.3 Hatchery Production

Early 20th-century declines in salmon population abundance and the growth of commercial fishing in the Siletz River spurred the development of hatcheries in the Siletz and other coastal basins. Initially, Coho were produced at the Rock Creek Hatchery, a tributary to the Siletz River. Releases averaged ~800,000 smolts until 1996,

Figure 3.3. Siletz Coho population estimates (1990–2022) (ODFW 2024).



when hatchery managers reduced the releases to ~50,000 smolts, with the remaining production for Siletz Tribal cultural needs (Figure 3.3). When the Salmon River Hatchery opened in 1978, Coho production for the Siletz Basin shifted to the new facility. Approximately half of the smolts were released at the Rock Creek Hatchery, and the other half were released in or near Euchre Creek on the lower mainstem Siletz River. Hatchery Coho releases were discontinued in 2006. Since the hatchery closure on the Oregon Coast, the viability and abundance of wild Coho populations have seen an increase (Jones et al. 2018).

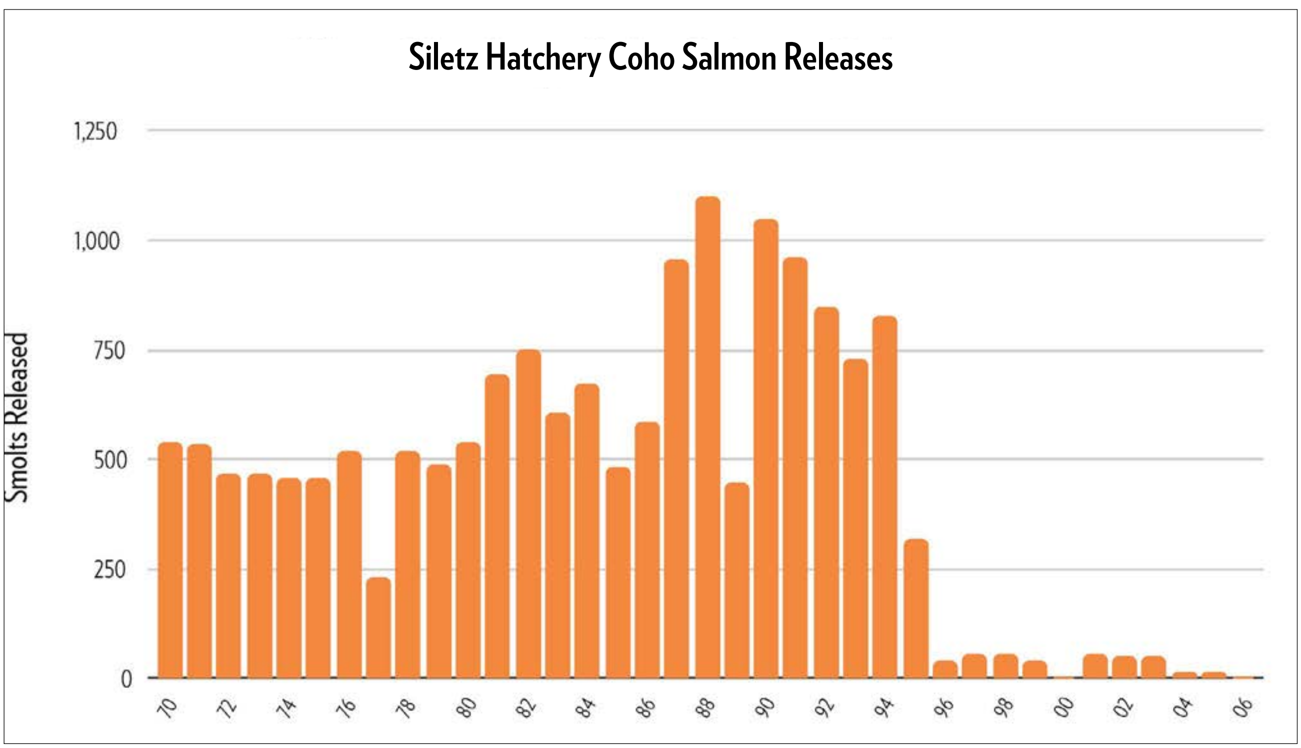
3.4 Overview of Habitat Needs and Watershed Components

As described previously, Coho may use different habitat types during their various life stages, and spatial and temporal use of these habitats varies according to an individual's life history strategy. Coho populations require diverse, complex, and highly connected habitats in freshwater and estuarine ecosystems to express a diverse range of life history strategies. During their freshwater residency, juvenile Coho rely on slow-moving water (ideally velocities around 3-6 cm/s) with complex instream and riparian structures capable of generating and maintaining pools, off-channel rearing areas, and channel-floodplain interaction. Among other attributes important to Coho, these conditions generate food, shelter from predators, refuge from high water temperatures in summer, and low-velocity resting areas during fall/winter high flows.

The specific habitats that Coho require are generated and maintained within a complex, interconnected system of watershed "components" that are essential to support the freshwater portion of the Coho life cycle. The "Common Framework for Coho Recovery Planning," which the Coast Coho Partnership developed in 2015, standardizes how Coho coastal habitats are defined, classified, and evaluated. The Siletz Partnership used this common framework to develop this SAP. This approach helps link federal, state, and local planning efforts by consistently describing the habitats that Coho rely on and the ecosystem processes that generate and maintain these habitats. The following watershed components are used throughout this SAP:

- **Mainstem river** includes portions of rivers above the head of tide (Coastal and Marine Ecological Classification Standard [CMECS] definition); these are typically 5th order, downstream of Coho spawning distribution, and "non-wadeable." The mainstem river component includes associated riparian and floodplain habitats. Mainstem areas support

Figure 3.4. Hatchery Coho releases in the Siletz River (1970–2005) (ODFW 2024).




Mainstem Siletz River. Photo: Holden Films

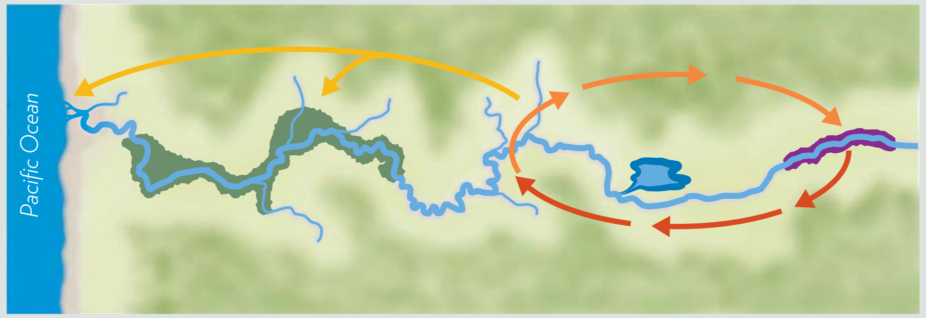
upstream migration for adults, downstream and upstream migration for juveniles, summer rearing for juveniles, and limited spawning.

- **Freshwater non-tidal wetlands** include areas inundated or saturated by surface flow or groundwater at a frequency and duration sufficient to support—and under normal circumstances do support—a prevalence of vegetation typically adapted for life in saturated soil conditions. Habitats include depressions, flat depositional areas subject to flooding, broad flat areas that lack drainage outlets, sloping terrain associated with seeps, springs, and drainage areas, bogs, and open water bodies (with floating vegetation mats or submerged beds). This component is restricted to those wetlands that are hydrologically connected to Coho streams. Estuarine-associated wetlands are addressed in the estuary section. Wetlands are essential for capturing sediment and other contaminants before they enter tributaries and mainstem rivers, and for maintaining and regulating cold water flows. In addition, non-tidal wetlands historically provided thermal refugia for the Coho life histories originating in headwater wadeable streams.
- **Off-channel areas** include locations other than the main or primary channel of mainstem or tributary habitats that provide velocity and/or temperature refuge for Coho. Off-channel habitats include alcoves, side channels, oxbows, and other habitats connected to the mainstem or tributary. These off-channel habitats are essential to the survival of juvenile Coho, providing refuge from high flows in winter and high water temperatures in summer.
- **Beaver ponds** slow stream flow and increase the growth of off-channel and edge habitats. These conditions support Coho by offering refuge from flood flows in winter and high water temperatures during summer. They also provide cover from predators and abundant food, which requires substantially less energy to find than in higher velocity tributary habitats. Further, beaver ponds drive watershed processes. They recruit and retain spawning gravels and forest nutrients, increase hyporheic flow, elevate local water tables, and generate lateral connectivity between the stream channel and floodplain. Beaver ponds are specific features within other watershed components, such as tributaries, off-channel areas, freshwater wetlands, and estuaries.

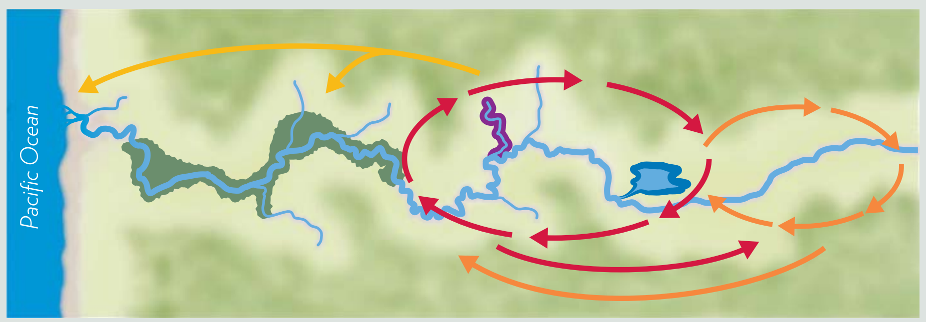
Beaver dam in the Alsea watershed. Photo: Bureau of Land Management

- **Estuaries** include areas in tidally influenced lower reaches of rivers that extend upstream to the head of tide and seaward to the mouth of the estuary. Head of tide is the inland or upstream limit of water affected by a tide of at least 0.2 feet amplitude (CMECS). This includes tidally influenced portions of rivers that are considered to be freshwater (salinity <0.5 parts per thousand). Estuaries are considered to extend laterally to the uppermost extent of wetland vegetation (mapped by CMECS). Estuarine habitats include salt marsh, emergent marsh, open water, subtidal, intertidal, backwater areas, spruce, scrub shrub and other tidal swamps, and deep channels. They include the ecotone between salt and freshwater and the riparian zone. Estuary areas have been historically available for feeding, rearing, and smolting Coho. They have also provided summer and winter habitat used by Coho dropping out of headwater reaches as emergent fry.
- **Uplands** include all lands at higher elevations than adjacent water bodies and alluvial plains. They include all lands from where the floodplain or riparian zones terminate, and the terrain begins to slope upward, forming a hillside, mountainside, cliff face, or another non-floodplain surface. Uplands provide most of the wood and gravel resources required to maintain natural processes in a properly functioning ecosystem.

Mouth of the Siletz River under Highway 101. Photo: Holden Films



Natal site rearing, yearling smolt: Juveniles spend first year in their natal stream, then migrate to the estuary in the spring as smolts.



Spring fry migrant, mainstem-rearing, yearling smolt: Fry migrate either upstream or downstream of natal site in spring to rear in freshwater habitats along the mainstem and non-natal tributaries. Juveniles move to the estuary in the spring at age one.

Spring fry migrant, estuary-rearing, yearling smolt: Fry emigrate in the spring and by midsummer, they reach estuarine habitats where they reside through the winter. Smolting occurs in the spring and ocean entry as an age-one smolt (~18 months).

Fall/winter parr migrant, freshwater-rearing, yearling smolt: Fry rear in natal streams through the summer, then migrate downstream in fall or early winter, where they rear in freshwateror brackish wetlands before entering the ocean as an age-one smolt.

Figure 3.5. Representation of four life history pathways for Coho juveniles recognized on the Oregon coast.

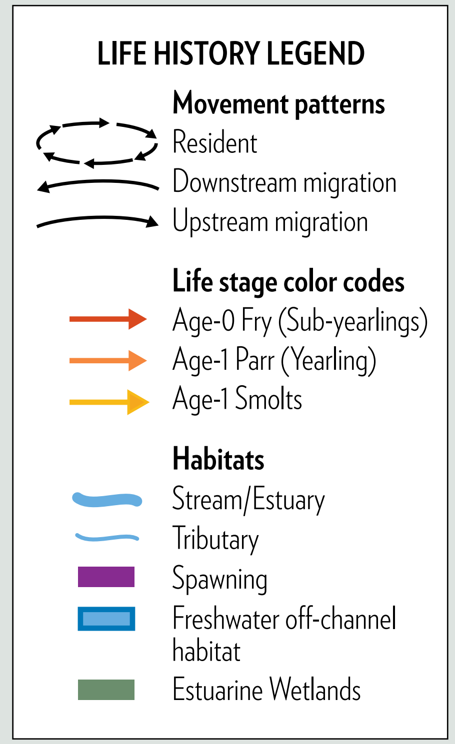
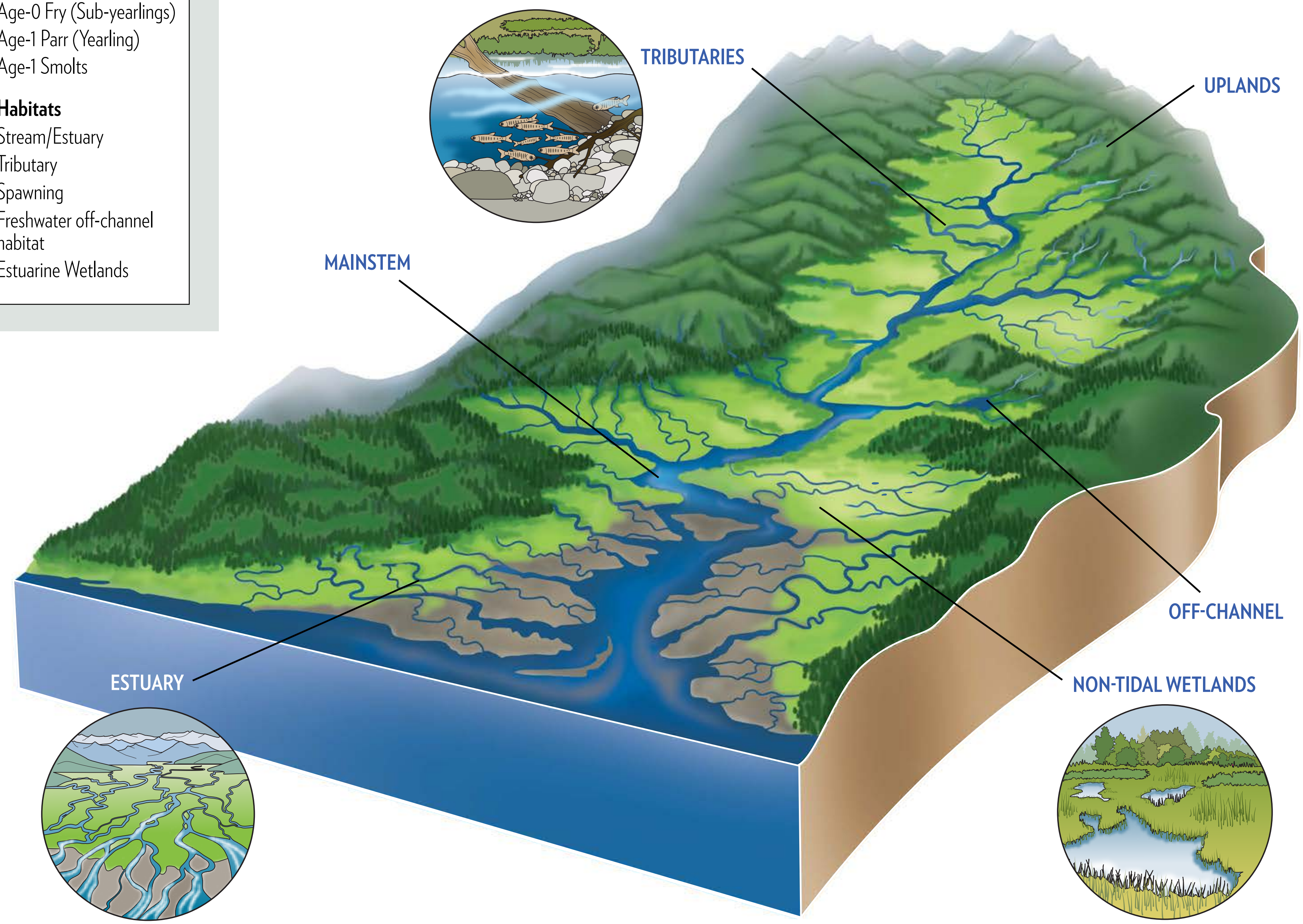


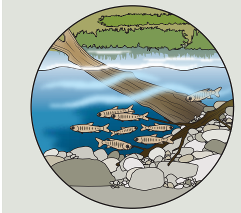
Figure 3.6. Components of a watershed. The map below is a conceptual illustration (not a map of the Siletz River) intended to show: 1) the major "habitat components" of a coastal watershed; and 2) selected "key ecological attributes" (KEAs) that are critical to the health of these components. This is not intended to provide an in-depth explanation of the habitat needs of coast Coho, but simply highlight several KEAs that this plan is focused on restoring.



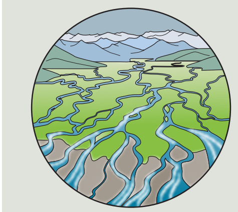
Artwork by Elizabeth Morales

Figure 3.7. The Siletz River watershed.

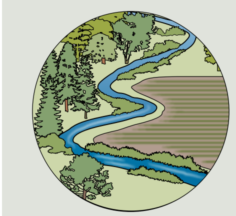
By 2045, the partnership will achieve the following Siletz Partnership restoration objectives.



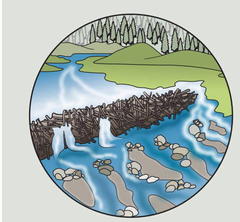
Instream Complexity
Add LWD in 78 miles of mainstem, tributaries, and sloughs.



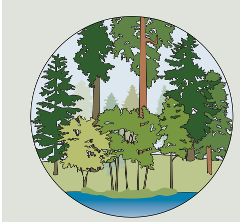
Reconnection
Increase rearing opportunities in 1,123 acres of floodplains and wetlands.



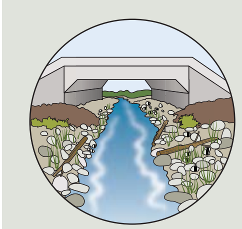
Protection
Protect 847 acresof freshwater, tidal wetlands, and floodplains through voluntary acquisitions.



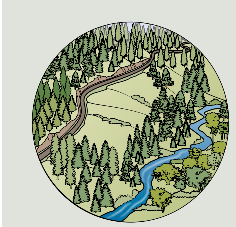
Beaver Persistence
Re-establish slow water and beaver habitats along 22 miles of tributary streams.



Riparian Enhancement
Enhance 40 miles of riparian areas in mainstem and tributaries.



Longitudinal Connectivity
Evaluate all crossings on Coho-bearing streams to restore longitudinal connectivity.



Large-Wood Delivery
Protect 8,689 acres of selected timber stands through policy and acquisitions for future LWD.

Artwork by Elizabeth Morales

Chapter 4

Development of the Siletz River Strategic Action Plan

The Siletz River SAP is the sixth population-scale restoration plan completed for an independent OC Coho population in Oregon. Like the others, the plan was developed following guidance described in OWEB's Strategic Action Planning for Ecological Restoration Partnerships along with many lessons learned from the previous planning processes.

The Siletz plan is constructed around three long-term habitat goals generated by the planning team. Work on the ground to achieve these goals is described in two key elements of the SAP: 1) a long-term "Strategic Framework" and 2) a short-term work plan.

Described in Chapter 5, the Strategic Framework seeks to answer two questions:

1. *Which watershed processes need to be restored in what locations to ensure a diversity of healthy, connected habitats sufficient to meet SAP goals?*

2. *How and where can targeted habitat restoration most effectively restore these watershed processes?*

Outlined in Chapter 6, the work plan lays out near-term projects that align with the long-term Strategic Framework. Simply stated, if the Strategic Framework is the long-term path to a restored watershed, the work plan represents the initial steps down that path.

In addition to these core elements, this SAP also provides a physical and demographic description of the watershed; the makeup and roles of the Siletz Partnership; Coho biology and variation of life history pathways; a description of stressors being exerted on critical "key ecological attributes" (KEAs); a monitoring and adaptive management strategy; and a section on project costs and financing.

The following provides an overview of the process used to generate the plan.

1. Develop a preliminary "Strategic Framework"

The Siletz Partnership's first step in developing this SAP was to establish a "preliminary Strategic Framework." The purpose of this step was to generally define initial points of consensus among planning team members on the scope and goals of the plan, as well as agree upon the terms, definitions, and key principles that would guide the plan's development. Over the course of the planning process, the Strategic Framework was continually refined to produce the final version presented in Chapter 5. Terms and definitions were adapted from "the Common Framework," a manual developed by a technical team facilitated by the Wild Salmon Center, to establish a baseline of terms and definitions for SAP development (Appendix 3).

Finally, this initial step in the process also included compiling all available habitat and population data, acknowledging data gaps, initiating Netmap modeling (see step 3), and reviewing existing resource management plans.

Coho smolt. Photo: Wild Salmon Center

SILETZ SAP GUIDING PRINCIPLES	
1	Employ a science-based approach first. Projects will be prioritized based on where the science points us, but ultimately implemented in the order that social, economic, and legal constraints allow.
2	While increasing abundance should be a goal, increasing diversity and resilience should be given higher priority. Projects should seek to increase abundance in the short term and resilience in the long term.
3	Use a whole-basin approach. Restoration work has been largely focused on small wadeable streams because that is where it is hypothesized that the majority of fish currently rear. Recognize that juveniles also rear in other areas of the watershed, e.g., estuary and the mainstem. A whole-basin approach —i.e., not restricting ourselves to just one part of the basin—will promote life history diversity.
4	Describe existing and potential life history strategies exhibited in the Siletz, and organize project prioritization around these strategies. Emphasize habitat diversity and connectivity in the project selection process.
5	Integrate the limiting factors approach into the diversity/resilience framework employed in this planning process. Expand the limiting factors approach beyond wadeable streams to develop LFAs for different life histories.
6	Recognize the complementary role of protection and prevention in crafting restoration priorities. Protection of critical habitats and prevention of loss are often more cost effective and have a higher assurance of success than restoration.
7	To the fullest extent possible, coordinate with other ongoing planning processes to leverage funding to support shared goals (examples: water planning, partner research, and planned restoration work). Build on existing plans, and consider goals and objectives already agreed upon in other documents.
8	Strive to ensure landowners and residents in the watershed understand the SAP and the process undertaken to generate it. When implementing it, respect and acknowledge neighbors' needs and private property; work only with willing landowners.
9	Consider climate change in all restoration scenarios. Consider the life span and trajectory of individual projects or project types in the project prioritization criteria.
10	Be aware of and resistant to shifting baseline syndrome—a phenomenon where each generation redefines what is considered a "normal" or acceptable state of the natural environment, often based on their limited personal experience, leading to a gradual acceptance of environmental degradation.

2. Determine and evaluate ecological priorities

With a preliminary Strategic Framework established, the Siletz planning team then considered the plan's ecological priorities, defined in the OWEB Guidance as "the ecosystem scale habitats and/or species that are the focus of the plan." In SAPs completed for other populations, this step has simply recognized the independent Coho population and the habitats it relies on as the priorities. To advance the plan's life history goal (Goal #1), the Siletz team decided not to establish the entire population as the ecological priority but to recognize each of the major life history strategies believed to be present in the population.

This decision sparked an extended review of the available Siletz Coho salmon population data and extensive conversation among biologists to determine what life history strategies were, in fact, being expressed. While additional life history types may exist (and others may have been extirpated), the team finally settled on the four major types described throughout this plan. The Siletz SAP is the first to put forth a Strategic Framework structured around the conservation of distinct life history strategies.

The planning team then evaluated each of the four life history types to determine their habitat needs, the availability and quality of those habitats at a population scale, and the stressors and threats facing them. The team also worked with NOAA modelers to determine whether a limiting factor could be determined for each life history type, but the absence of life cycle data confounded this exercise.

3. Evaluate watershed processes and determine restoration priorities by sub-watershed

With ecological priorities defined and agreed upon, the planning team then undertook an extensive evaluation of sub-watershed health throughout the population area. These assessments were intended to evaluate: 1) the degree to which (sub)watershed processes are functioning and able to generate and maintain spawning, rearing, and migratory habitats; and 2) the current stressors and threats that may lead to the loss of watershed function over time. This effort, which comprised a large part of the SAP development process, relied on a merger of advanced modeling and expert opinion.

Modeling watershed processes – Netmap

At the outset of the SAP process, NOAA commissioned TerrainWorks to use its Netmap tool to assess the optimal locations for restoration strategies best suited to address priority stressors. Netmap is a process-based model that develops a "virtual watershed" using a LiDAR digital elevation model (DEM) (with 10m DEMs where LiDAR is unavailable). The virtual watershed enumerates multiple aspects of watershed landforms, processes, and human interactions over a range of scales (Benda et al. 2015, Barquin et al. 2015). NetMap's virtual watershed contains six analytical capabilities to facilitate optimization analyses: 1) delineating watershed-scale synthetic river networks using DEMs; 2) connecting river networks, terrestrial environments, and other parts of the landscape; 3) routing watershed information downstream (such as sediment) and upstream (such as fish); 4) subdividing landscapes and land uses into smaller areas to identify interactions and effects; 5) characterizing landforms; and 6) attributing river segments with key stream and watershed information.

The TerrainWorks' analyses included a range of outputs that were considered by the planning team, including prioritized sites for riparian restoration, protection of thermal refugia, beaver recruitment, landslide protection zones (for large-wood delivery), road maintenance/decommissioning, and fish passage improvement. Through

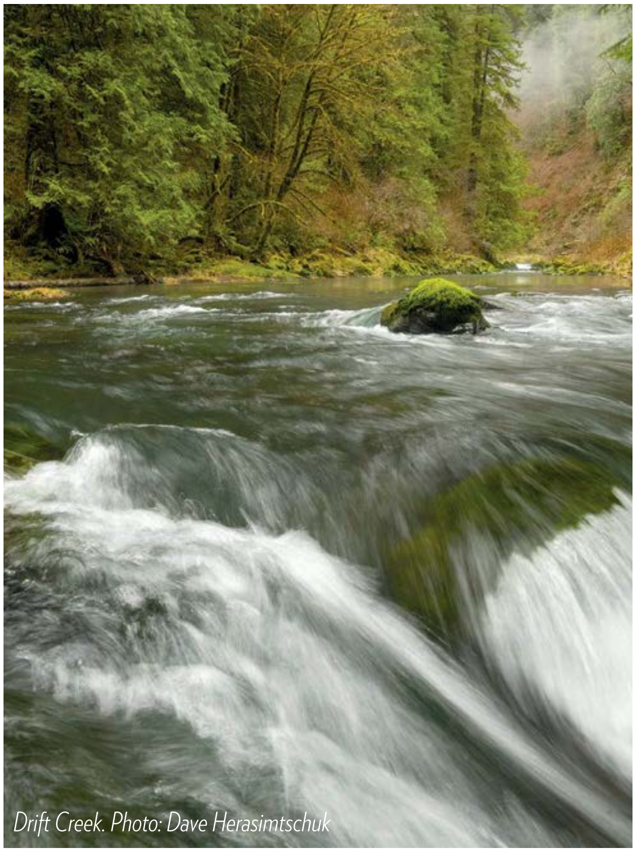

Photo: Seth Mead

all of these analyses, Netmap provided managers with modeled priority sites in sub-watersheds where data or participant expertise was limited.

A final note on Netmap: the Siletz Partnership retains a license to use the Siletz River Netmap data, as well as access to the Netmap software. Partners are encouraged to continue using Netmap to periodically update the analyses completed during the planning process and run new analyses as TerrainWorks makes them available in updates to the software.

Expert Opinion: Watershed Walks

Application of Netmap allowed the planning team to evaluate habitats and generate recommendations in areas of the watershed in which members of the planning team had limited data or on-the-ground experience. As a complement to the modelling, the planning team also undertook "watershed walks" to calibrate the modelling and describe areas where participants had firsthand knowledge. In small group meetings, aerial images were projected of each 6th-field watershed with the name of each tributary labeled. Participants then virtually walked every tributary and the mainstem to assess KEAs on the ground, describe stressors and threats, review


Drift Creek. Photo: Dave Herasimtschuk

any previously completed restoration projects, and prioritize where watershed processes and/or specific habitat types should be restored. In each sub-watershed, participants considered the seasonal needs of each of the four life history types described in the plan.

The combined modelling/expert-opinion process identified the reaches where protection and restoration treatments can restore targeted watershed functions and increase the long-term availability of high-quality habitats for each of the four life history types. These locations effectively reflect the team's consensus on "what needs to happen where" within each sub-watershed. They are contained in the "strategy maps" and narrative in Chapter 5.

During the watershed walk process, managers also identified any locations where restoration work is planned or underway. This information is reflected in the near-term projects presented in Chapter 6.

4. Prioritize projects at desired time horizon

With the Strategic Framework established and a shared understanding of "what needs to happen where" over the long term, participants then compiled and prioritized all of the near-term projects that align with the priorities laid out in Chapter 5. While the long-term strategy maps establish where work should happen, projects in Chapter 6 reflect where projects can happen in the near term. Projects presented here have, or are expected to receive, landowner and community support, regulatory approval, and funding. The planning team gave priority to projects that demonstrate the greatest potential benefit and have the highest assurance of implementation.

5. Estimate project costs; quantify outputs

Before final production of the plan, the last step undertaken by the team was to estimate the anticipated costs of projects summarized in Chapter 6. Costs were generated by reviewing the OWEB Oregon Watershed Restoration Inventory (OWRI) database and comparing costs from previous projects implemented in the Siletz River watershed by local implementers. Wild Salmon Center also assisted in estimating costs based on SAP projects it has funded under Cooperative Agreements with NOAA. Project costs are presented in Chapter 7.

6. Identify indicators, monitoring, and adaptive management

Following the identification of long-term and near-term priorities, the planning team generated a monitoring framework that partners can draw from to build out selected pieces as priorities dictate and funding allows. The monitoring framework outlines approaches to both implementation and effectiveness monitoring. The implementation monitoring section simply identifies a list of metrics designed to evaluate the degree to which the plan is being implemented over time. The effectiveness monitoring section presents selected indicators that allow partners to determine whether implementation of the plan is having the intended effect. Over the long term, implementation of selected elements of the monitoring framework will yield data that allows managers to assess and re-evaluate the priorities contained in the plan. To promote adaptive management, this section also highlights critical data gaps that emerged in the planning process and describes how new information generated to fill these gaps can be used to re-prioritize strategies and geographic priorities.

Chapter 5

Impaired Watershed Processes and the Strategies to Restore Them

This chapter describes the watershed functions that limit Coho production in the Siletz River watershed and the SAP's Strategic Framework or long-term restoration road map. The Strategic Framework includes: 1) the protection and restoration strategies that the Siletz Partnership deems essential to restore watershed function and support the full range of Coho life history types in the Siletz watershed, and 2) the locations where implementation of these strategies can generate the greatest benefit. Current and future managers and practitioners will use the Strategic Framework to guide how and where they invest in landowner outreach, habitat assessments, project implementation, and monitoring.

Federal and state recovery plans focus on restoration actions that support winter and summer rearing for juveniles in their natal streams as the primary mechanism to increase populations across the ESU. The primary limiting factor impeding juvenile and, thus, overall Coho recovery is insufficient stream complexity, which limits the availability and quality of winter and summer rearing habitat. Instream complexity is typically limited by a lack of large woody debris and off-channel habitat, such as beaver ponds, to serve as pools and slow-water refugia. Summer rearing can also suffer from poor water quality, such as high temperatures and nutrient inputs, and low water levels due to increased human uptake and little precipitation.

The need for more complex, high-quality Coho rearing habitat is a common problem in most Oregon coastal rivers and streams. The Oregon Coast Coho Salmon Recovery Plan states that "loss of stream complexity, including connected floodplain habitat, is the primary limiting factor for many Coho populations, and overwinter rearing of juvenile Coho is especially a concern. Instream habitat is critical to produce high enough juvenile survival to sustain productivity, particularly during periods of poor ocean conditions" (NMFS 2016). ODFW defines stream complexity as "habitat of sufficient quality to produce over-winter survival at rates high enough to allow Coho spawners to replace themselves at full-seeding during periods of poor ocean conditions (3% smolt to adult survival)" (ODFW 2007). "High-quality overwinter rearing habi-

Euchre Creek in a landscape of agriculture and timber. Photo: Holden Films

A restoration project on Starr Creek in the Yaquina watershed boasts ideal juvenile rearing habitat with connectivity to the floodplain and wetlands, off-channel refugia, and large wood for cover and complexity. Photo: Green Wave Media & Midcoast Watersheds Council

tat for juvenile Coho typically includes features such as large wood, pools, connected off-channel alcoves, side channels, beaver ponds, lakes, connected floodplains, and wetlands" (ODFW 2007, NMFS 2016).

In addition to the loss of physical habitat complexity, reduced water quantity and quality—especially low streamflows and high water temperature during summer months—are also identified as major stressors for Siletz Coho, particularly in the mainstem and lower tributaries (NMFS 2016). As the frequency of drought-year summers increases, concerns about future summer streamflow levels in the context of climate change and increased human population demands continue to rise. This is especially critical for the life histories that prioritize using lower mainstem reaches for summer rearing. Enhancing natural water storage to meet both instream and out-of-stream uses and improving water temperatures during summer rearing will improve egg-to-smolt survival and increase the expression of life histories currently limited by low summer flows and thermal barriers.

This chapter presents several protection and restoration strategies to address reduced instream complexity, lateral disconnectivity, and water quality impairments. In mainstem and tributary areas, strategies include reconnecting off-channel and floodplain habitats; securing and improving cold water refugia; restoring instream complexity by adding large wood, boulders, and beaver dam analogues; enhancing riparian cover and function by improving riparian buffers and planting vegetation, including beaver-preferred plants; removing physical barriers to fish passage for all Coho life stages; and protecting old growth timber stands. In tidally connected areas, strategies include restoring floodplain connectivity by removing levees and increasing complexity by installing large wood.

The Strategic Framework presented in this chapter seeks to generate sustainable improvements in the natural processes that maintain high-quality rearing habitats for Coho and to develop a complex, interconnected system of habitats for juveniles to express a full spectrum of life history strategies in the basin. The planning team considered four principles of "process-based restoration" (Roni and Beechie 2013) in examining how and where restoration can enhance watershed function. Two of these principles helped form the Strategic Framework: target the root causes of habitat and ecosystem change, and clearly define expected outcomes, including recovery time. When designing individual projects (see Chapter 6), implementing partners are encouraged to consider the two additional principles of process-based restoration: tailoring restoration actions to local potential and matching the scale of restoration to the scale of physical and biological processes targeted.

The strategies presented in this chapter describe steps that local restoration partners have the authority and capacity to implement. However, to fully address the root causes of historical and ongoing habitat loss and restore long-term watershed function, the Siletz Partnership also encourages state and federal partners to examine the adequacy of current resource management policies and regulations, some of which are highlighted as "Strategies" to restore Coho populations later in this chapter. Habitat restoration provides a net benefit only when the policies governing resource use sufficiently protect the remaining watershed functions.

5.1 Habitat Stressors and Limiting Factors That Affect Life History Diversity

As discussed in Chapter 3, the Coho population in the Siletz follows a variety of juvenile life history pathways in response to opportunities for growth and survival in complementary freshwater habitats. This diversity of life histories is one of the primary ways the Coho population can be resilient to the effects of climate change and environmental disturbance, as it allows the fish a variety of alternative pathways that spread the risk of mortality. Environmental conditions, watershed attributes, and the local adaptations of the population influence Coho use of different habitats in the watershed. The juvenile Coho migratory timing and rearing habitat selection vary from solely natal stream rearing to highly migratory spring and fall migrants, with the use of multiple freshwater and estuarine habitats before entering the ocean (Craig et al. 2014, Jones et al. 2014, Koski 2009, Roni et al. 2012, Sandercock 1991, Sethi et al. 2021).

The Siletz Partnership recognizes the importance of life history variation for Coho within

Summer low flows and lack of instream complexity reduce access to deep pools and cold water on the mainstem Siletz River. Photo: Holden Films

the watershed. Restoring and conserving this juvenile life history diversity is a critical strategy to advance Coho recovery in the Siletz Basin and the larger OC Coho salmon ESU. Expanding the portfolio of habitats that enable Coho to express their life history diversity fully will increase population abundance, promote stability, and foster resilience to future disturbances and climate change (Bisson et al. 2009, Bottom et al. 2005, Craig et al. 2014, Jones et al. 2021, Waples et al. 2009).

A connected system of diverse, healthy rearing habitats is needed in the Siletz River watershed to support the full expression of life history diversity. Improving natal stream rearing conditions in the Siletz Basin supports the standard life history strategy—where juvenile Coho rear in their natal stream for a full year before migrating to the estuary in the spring as smolts; however, increasing rearing habitat across the watershed will support other critical life histories where Coho fry or parr move to non-natal habitats. Access to lower tributary reaches, cold water refugia, connected off-channel rearing for slow-water refugia, and estuarine habitats are especially important because they support the variety of known life history strategies that Coho in the Siletz Basin need.

The lack of high-quality and diverse juvenile rearing habitat is a major factor limiting Coho in the Siletz Basin. Historically, juveniles likely used a broader range of habitats in the river system than is currently available because of habitat loss and degradation. Fortunately, because of their inherent genetic diversity and ability to adapt to changing conditions, wild salmon populations retain the ability to utilize diverse habitats in a watershed if they are made accessible and restored to sufficient quality (Waples et al. 2009). Recent studies have demonstrated that habitat conservation activities that increase the diversity of macrohabitat types available to juveniles can support life history pathways that depart from natal stream reaches and rear in alternative habitats before outmigration (Anthony et al. 2022, Hoem Neher et al. 2013, Jones et al. 2021, Koski 2009, Sethi et al. 2021, Waples et al. 2009). In short, restoring a diversity of habitats can increase the diversity of life history pathways available.

5.2 Strategic Framework to Support Coho Life History Diversity in the Siletz Watershed

To address the critical needs of Coho using different life history pathways across the watershed, the Siletz Partnership prioritized restoration strategies by sub-watersheds that are anticipated to have the greatest impact on juvenile rearing. Tables 5.1, 5.2, and 5.3 show highlighted res-

Siletz National Wildlife Refuge. Estuary channels provide critical slow-water refugia and food resources for juvenile Coho. Photo: Holden Films


Freshwater habitat with instream complexity, such as wood, pools, and alcoves, are important for juvenile rearing. Drift Creek. Photo: David Herasimtschuk

toration strategies prioritized for the different life history pathways by the 6th-field Hydrologic Unit Code (HUC) level. Three upper HUCs comprising the North Fork and South Fork Siletz River were not included as focal basins due to a natural barrier blocking access for Coho. These strategies were identified by the Partnership as having the greatest impact on specific life history pathways. Additional basin-wide strategies are included in this SAP that are not represented in the tables, such as recommendations for policy reform, which address ecological stressors across the entire watershed and impact all life history pathways.

The Strategic Framework presented in this chapter focuses on restoring habitat conditions that will address the limiting habitat factors for the most common juvenile Coho life history pathways in the Siletz watershed. Strategies are outlined for four life history pathways with the goal of increasing opportunities for the Siletz Coho population to exhibit the full diversity of survival and rearing strategies in an ever-changing landscape and climate. Overall, population productivity and resilience increase when proportions of the population utilize different niches throughout the watershed, thus spreading out the risks of mortality and increasing the population carrying capacity. This section identifies the restoration strategies that will increase the availability and diversity of rearing habitats to build future resilience in the Siletz Coho population.

The framework is intended to guide investments in landowner outreach, project implementation, and habitat monitoring over the long term (two or more decades). The Siletz Partnership recognizes that the strategies presented here do not represent all of the restoration opportunities present in the Siletz watershed. They simply represent those within the Siletz Partnership's purview that are most likely to improve watershed function and increase Coho habitat productivity over the long term. As these strategies are implemented, the Strategic Framework will be evaluated and adaptively managed. Priorities may change as new monitoring data becomes available.

Table 5.1. Strategies prioritized for each life history type to address limiting habitat factors by sub-watershed in the Siletz Bay.

Life History Type	Primary Limiting Habitat Factors	Restoration Strategy to Address Highest Priority Stressors	Habitat Component	6th-Field Sub-watersheds				
				Siletz Bay	Schooner Creek	Lower Drift	Upper Drift	Bear Creek
NATAL SITE REARING	Off-channel and slow-water refugia	Restore instream complexity through LWD	Tributaries					
		Plant beaver-favored forage and reduce stream velocities for beaver dam persistence	Tributaries					
SPRING FRY MIGRANT, MAINSTEM REARING	Temperature, water quality & off-channel refugia	Enhance native riparian vegetation, including livestock exclusion fencing	Tributaries					
			Mainstem					
		Reconnect floodplains	Mainstem					
			Tributaries					
		Restore instream complexity through LWD	Tributaries					
			Mainstem					
		Plant beaver-favored forage and reduce stream velocities for beaver dam persistence	Tributaries					
		Address fish passage issues on high IP streams	Tributaries					
SPRING FRY MIGRANT, ESTUARY REARING	Estuary connectivity	Remove levees and reconnect floodplains	Tidal wetlands					
		Restore instream complexity through LWD	Tidal wetlands					
FALL PARR MIGRANT, FRESHWATER REARING	Off-channel & slow-water refugia	Reconnect floodplains	Mainstem					
			Tidal wetlands					
		Restore instream complexity through LWD	Tributaries					
			Mainstem					
		Plant beaver-favored forage and reduce stream velocities for beaver dam persistence	Tributaries					

Table 5.2. Strategies prioritized for each life history type to address limiting habitat factors by sub-watershed in the lower tributaries.

Life History Type	Primary Limiting Habitat Factors	Restoration Strategy to Address Highest Priority Stressors	Habitat Component	6th-Field Sub-watersheds		
				Cedar Creek	Euchre Creek	Dewey Creek
NATAL SITE REARING	Off-channel and slow-water refugia	Restore instream complexity through LWD	Tributaries			
		Plant beaver-favored forage and reduce stream velocities for beaver dam persistence	Tributaries			
SPRING FRY MIGRANT, MAINSTEM REARING	Temperature, water quality & off-channel refugia	Enhance native riparian vegetation, including livestock exclusion fencing	Tributaries			
			Mainstem			
		Reconnect floodplains	Mainstem			
		Restore instream complexity through LWD	Mainstem			
		Plant beaver-favored forage and reduce stream velocities for beaver dam persistence	Tributaries			
		Address fish passage issues on high IP streams	Tributaries			
SPRING FRY MIGRANT, ESTUARY REARING	Estuary connectivity	No strategies prioritized in these sub-watersheds	N/A			
FALL PARR MIGRANT, FRESHWATER REARING	Off-channel & slow-water refugia	Reconnect floodplains	Mainstem			
		Restore instream complexity through LWD	Tributaries			
		Plant beaver-favored forage and reduce stream velocities for beaver dam persistence	Tributaries			

Table 5.3. Strategies prioritized for each life history type to address limiting habitat factors by sub-watershed in the mid-tributaries.

Life History Type	Primary Limiting Habitat Factors	Restoration Strategy to Address Highest Priority Stressors	Habitat Compo-nent	6th-Field Sub-watersheds				
				Sam Creek	Mill Creek	Sunshine Creek	Big Rock Creek	Little Rock Creek
NATAL SITE REARING	Off-channel and slow-water refugia	Restore instream complexity through LWD	Tributaries					
		Plant beaver-favored forage and reduce stream velocities for beaver dam persistence	Tributaries					
SPRING FRY MIGRANT, MAINSTEM REARING	Temperature, water quality & off-channel refugia	Enhance native riparian vegetation, including livestock exclusion fencing	Tributaries					
			Mainstem					
		Reconnect floodplains	Mainstem					
		Restore instream complexity through LWD	Mainstem					
		Plant beaver-favored forage and reduce stream velocities for beaver dam persistence	Tributaries					
		Address fish passage issues on high IP streams	Tributaries					
SPRING FRY MIGRANT, ESTUARY REARING	Estuary connectivity	No strategies prioritized in these sub-watersheds	N/A					
FALL PARR MIGRANT, FRESHWATER REARING	Off-channel & slow-water refugia	Reconnect floodplains	Mainstem					
		Restore instream complexity through LWD	Mainstem					
		Plant beaver-favored forage and reduce stream velocities for beaver dam persistence	Tributaries					

Restoration practitioners placing large wood at a tidal estuary project. Photo: Josh Havelind

1.) Strategies for Natal Site Rearing Juveniles

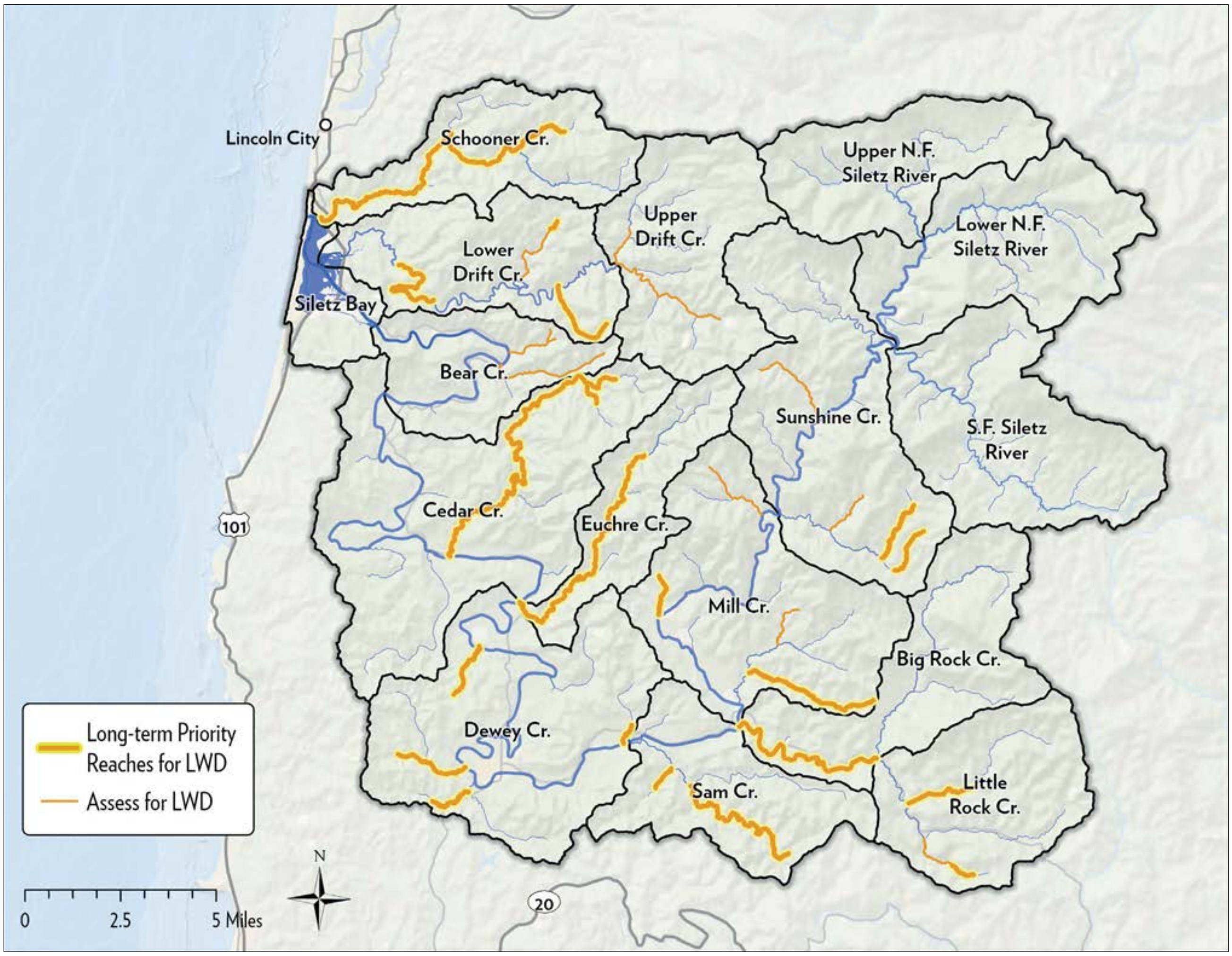
Historically called the "standard" life history, juvenile Coho following this pathway rear in their natal stream, typically smaller tributaries in the upper reaches of a basin, for a full year before migrating to the estuary in the spring (March through June) as smolts. They often feed and grow in lower mainstem, off-channel, and estuarine habitats for days or weeks before entering the nearshore ocean. The limiting habitat factor is often a lack of off-channel rearing in tributaries, in particular during the winter months when stream velocities can become too volatile for juvenile survival. Restoration strategies focus on actions that provide complex instream and riparian structures capable of generating and maintaining pools, slow-water refugia, and channel-floodplain interactions.

Strategy 1.a) Restore instream complexity and stream-floodplain interaction through the installation of large wood.

The presence of large trees and other instream structures can create hydrogeomorphic conditions, providing complexity that forms deep pools, slows high flows, and otherwise helps create a healthy stream ecosystem that provides velocity refuge, cover, food resources, and other features of high-quality juvenile rearing habitat. Improving connectivity between diverse, complex habitats, especially off-channel refugia through the reestablishment of stream-floodplain connection, supports Coho's diverse temporal and spatial use of these habitats. Connectivity allows juvenile Coho to move between mainstem

Post-implementation of a large wood project on Mill Creek. Photo: Josh Havelind

Figure 5.1. Long-term LWD placement priority reaches for natal site rearing juveniles.



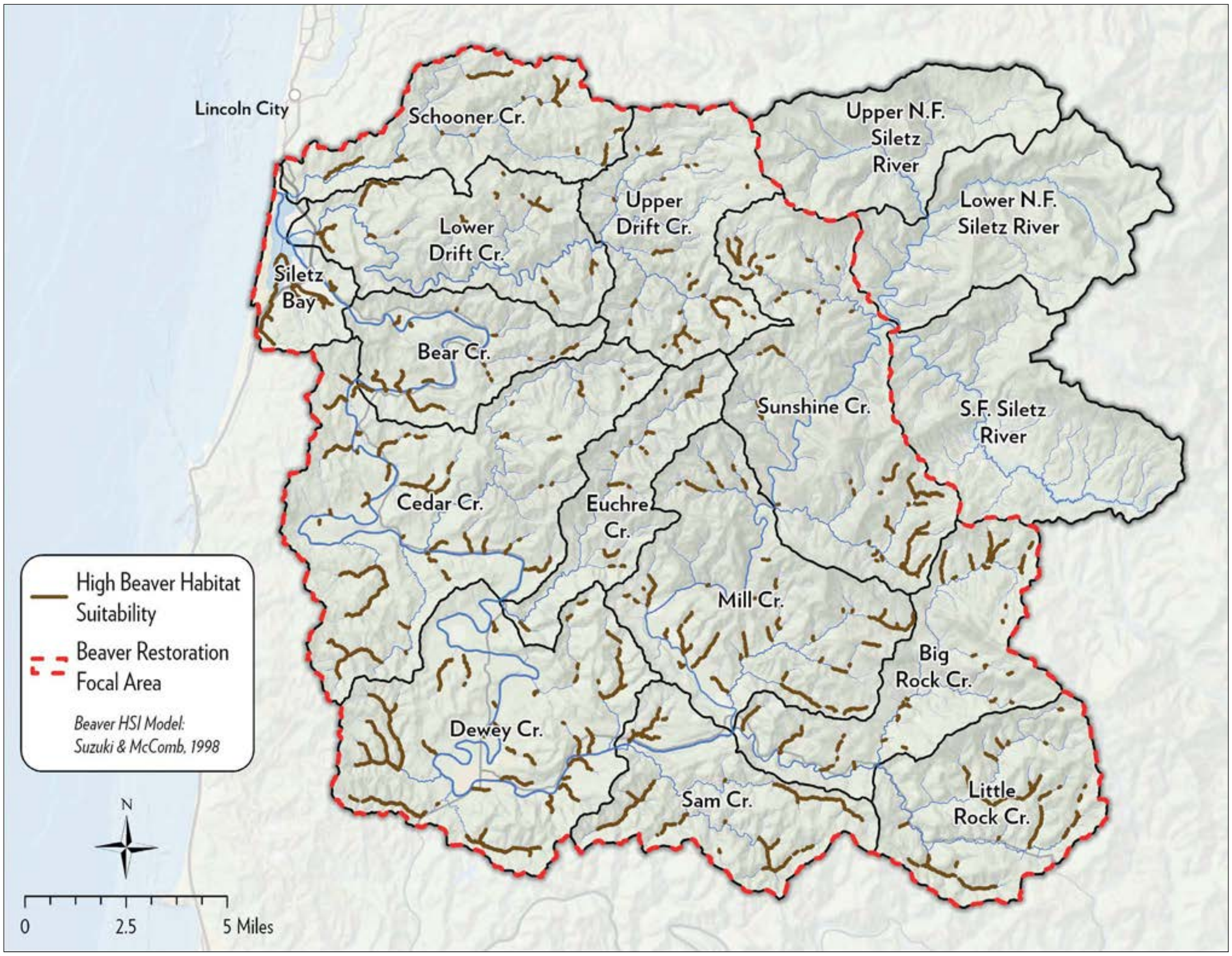
reaches, tributaries, alcoves, and other floodplain habitats as needed through the seasons to find refuge from high temperatures and flows, as well as to feed and grow. Due to the expansive use of tributaries for year-round rearing habitat, all basins within anadromy have streams highlighted as needing additional large wood input (Fig. 5.1). Figure 5.1 identifies specific stream reaches that are priority areas to conduct stream surveys within the near term due to a lack of data at those sites. These surveys will inform the need for LWD placement projects within those streams and, if so, the restoration methods and amount of wood needed to achieve desirable conditions.

Strategy 1.b) Encourage beaver persistence in tributary and floodplain habitats.

Beaver persistence on the landscape is important for rearing Coho due to the animal's ability to impound water through the creation of beaver dams. Beaver impoundments change the spatial distribution of water, creating stream systems with slow, deep pools and floodplain wetlands dominated by emergent vegetation and shrubs. This results in decreased peak flows during high-velocity winter storm events, expansion of slow-water refugia, and ample food and cover allowing for greater survival and fitness of Coho juveniles. Beaver ponds also store water on the landscape, retaining and redistributing flow during floods and then contributing that water back to the stream system during the increasingly longer, drier summer and fall months.

Beaver can be nomadic, and their time within a basin is fleeting if they do not have their preferred habitat attributes. Beaver show preferences for small- to medium-size, low-gradient streams that flow through unconfined valleys, which are often ideal habitats for juvenile Coho. Figure 5.2 shows areas in the Siletz watershed with high and medium-high beaver habitat suitability, as identified using the Suzuki and McComb (1998) beaver model

Figure 5.2. Stream reaches with high beaver habitat suitability.

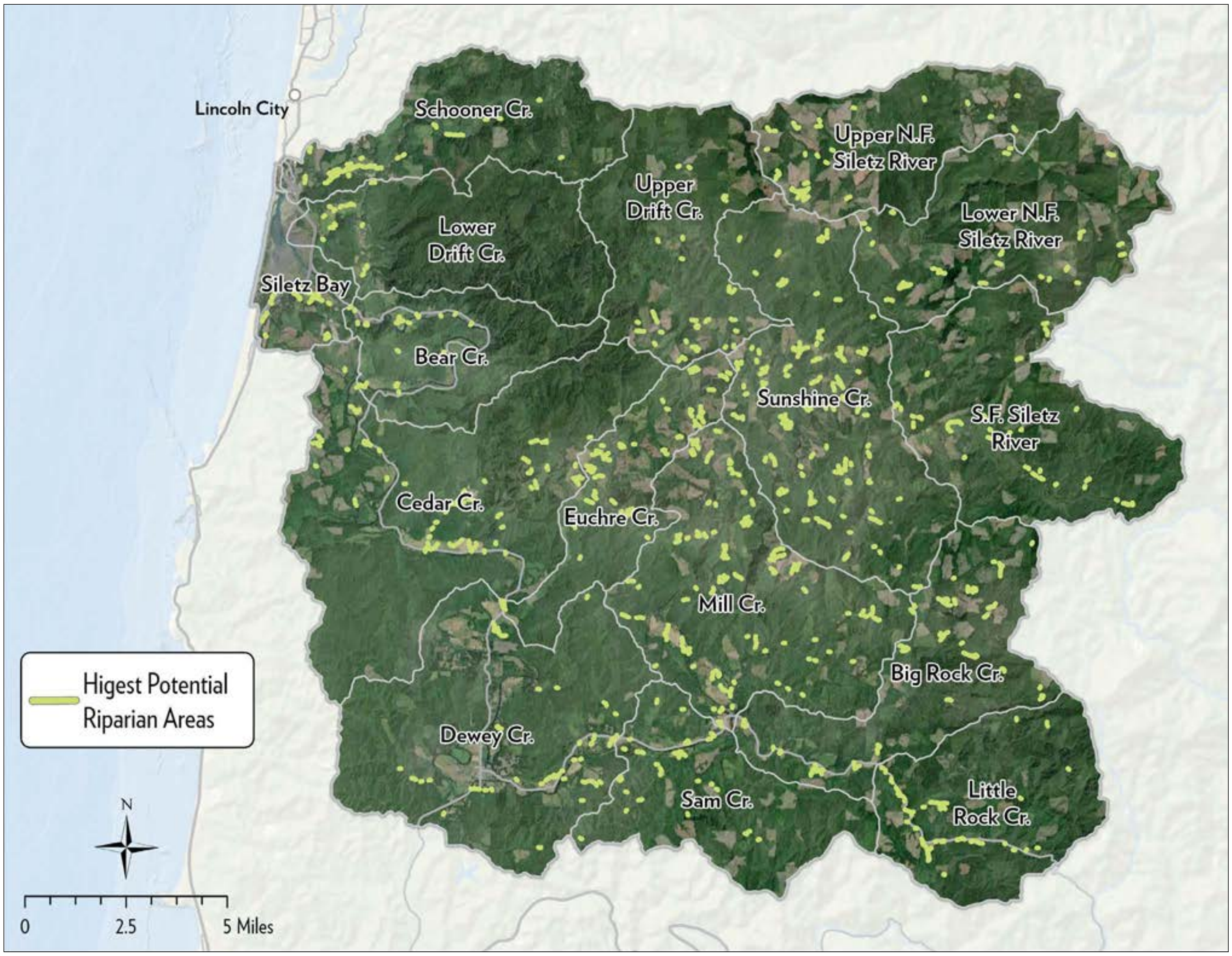


methodology. In addition to specific physical attributes, beaver require developed riparian areas that contain preferred vegetation for food and for construction materials to build dams. On the Oregon Coast, beavers typically prefer species from the Salix genus and vine maple (*Acer circinatum*).

This strategy focuses on providing beaver with the habitat conditions that will encourage longer residency within a stream system. To increase beaver pond habitat for juvenile Coho that rear a full year within their natal streams, restoration actions will focus on planting beaver-favored forage within locations highlighted in Strategy 1.a where the Siletz Partnership has reduced stream velocities through LWD placements. The Siletz Partnership will include beaver-favored forage at 25% of LWD restoration projects where the geomorphic conditions are appropriate. In addition to the Suzuki and McComb (1998) model presented in Figure 5.2, MCWC has received funding to ground-truth the Beaver Restoration Assessment Tool, developed by Utah State University, for the central Oregon Coast. When completed, the Siletz Partnership will overlap both modeling tools to identify high-priority beaver habitat locations.

Beaver dam in the Alsea watershed. Photo: Bureau of Land Management

Figure 5.3. Long-term priority reaches for riparian vegetation enhancement.



2) Strategies for Spring Fry Migrants, Mainstem Rearing Juveniles

Coho exhibiting this life history pathway emigrate from their natal stream in spring but continue rearing in other freshwater habitats, including mainstem edges, backwater and off-channel areas, beaver wetlands, non-natal tributaries, pockets of cold water refugia, and other slow-water areas. To reach these areas, the juveniles migrate upstream and downstream from the natal sites. These migrants move to the estuary in the spring at age one, with ocean entry as age-one smolts. Unlike the "standard" life history pathway, in which juveniles stay within their natal tributaries, spring migrants are potentially utilizing larger portions of the watershed throughout their first year and thus have a greater number of stressors to navigate. The biggest stressors for these fish are lethal summer stream temperatures and connectivity to slow-water refugia within access of the mainstem during winter. The Partnership recognizes that there is a lack of data regarding where migrants are rearing throughout their first year and is using best professional judgment when prioritizing specific locales and making long-term restoration strategy decisions.

Strategy 2.a) Enhance riparian habitats along tributaries through native plantings and the management of invasive species.

The state's Oregon Coast Coho Conservation Plan and the federal recovery plan establish that healthy riparian areas are a key component of high-quality rearing habitat for juvenile Coho. Increased water temperatures are the primary source of water quality impairment and the secondary limiting factor for OC Coho. Elevated summer temperatures in the mainstem and many lower tributaries create a thermal barrier to juvenile migration and rearing in summer, limiting access to critical habitats and diminishing overall habitat availability. In particular, the impaired juvenile migration and rearing conditions threaten the expression of alternative life history strategies; which, as previously discussed, reduce the viability and resilience of the Siletz Coho population.

This strategy focuses on restoring healthy riparian zones to ameliorate existing degradation and combat the impacts of climate change on thermal regimes in the Siletz. Functioning riparian habitats maintain channel connectivity to floodplains, wetlands, and side channels. They also provide shading, generate large wood and vegetative detritus, retain sediments, support macro-invertebrate communities, and provide other important aspects of a healthy stream ecosystem. These functions have been lost or reduced in many parts of the Siletz watershed.

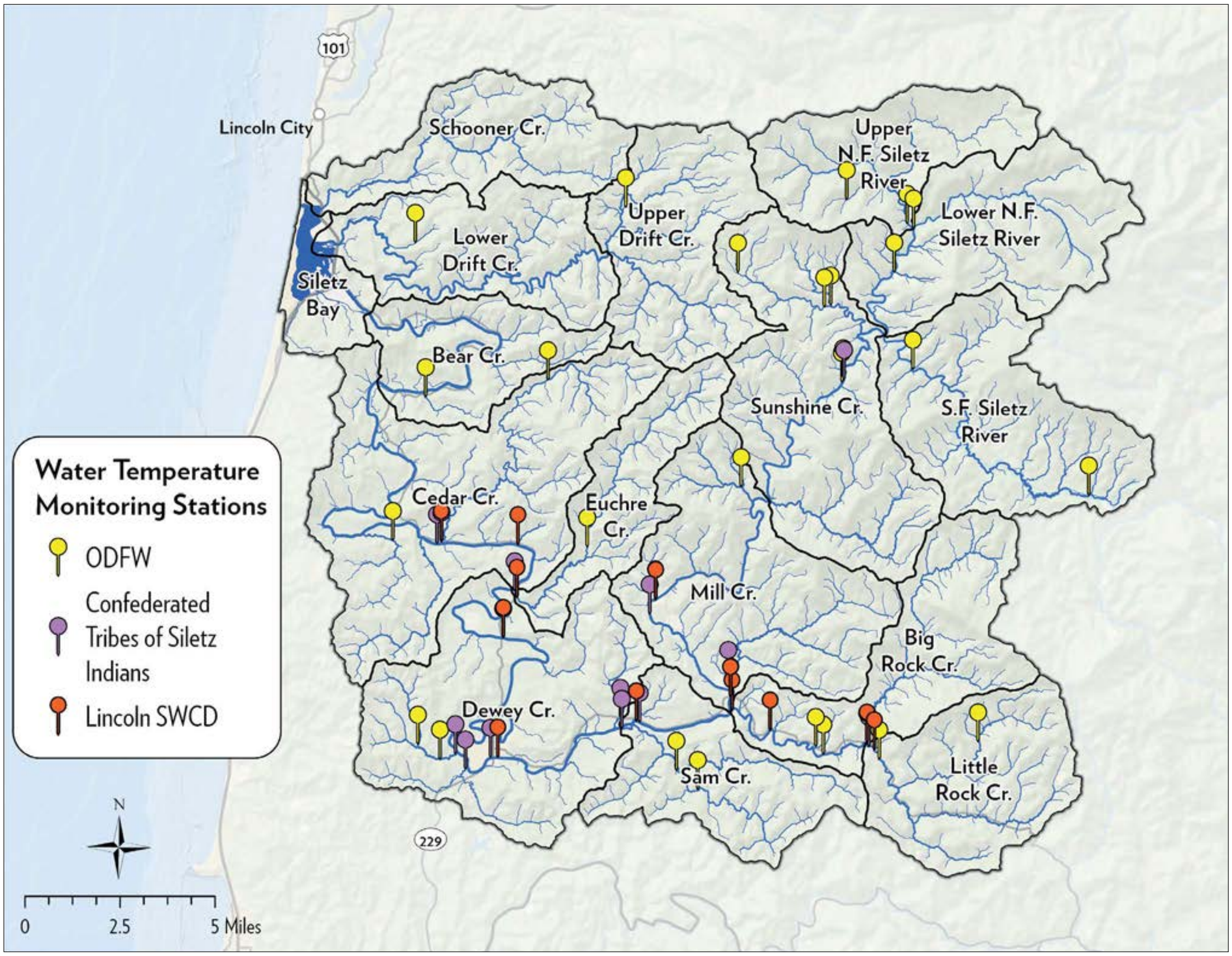
The riparian enhancement activities in this plan focus primarily on removing non-native vegetation and planting native vegetation. Managers may also incorporate livestock exclusion through fencing and off-channel watering when necessary. Figure 5.3 shows the riparian areas in the Siletz Basin with the highest potential for reduction in solar loading of Coho streams using a Netmap model. These locations will be used to focus outreach efforts. The Siletz Partnership will work with the Lincoln Soil and Water Conservation District (SWCD) to partner on their Siletz Source Water Protection Area initiative, which used data from the 2021 Siletz Streamside Vegetation Assessment (Appendix 2) to identify riparian restoration opportunities in the Dewey Creek, Sam Creek, Mill Creek, Big Rock Creek, and Little Rock Creek sub-watersheds (Appendix 4).

Strategy 2.b) Identify and protect cold water refugia.

Optimum temperatures for rearing Coho juveniles range between 12 and 15° C, and smoltification can be impaired by water temperatures above 15° C. However, many streams lower in the watershed reach over 25° C in the summer, and climate change is expected to exacerbate these already lethal temperatures. Cold water confluences in tributaries connected to the mainstem serve as lifeboats for juvenile salmonids seeking refuge from lower mainstem water temperatures. Flows released from these pockets of cold water also aid juvenile Coho by improving flows and water temperatures in downstream reaches and allowing juvenile movement between different mainstem and tributary habitats. Sometimes, the best locations to increase early-rearing habitat for Coho exist

Volunteers help plant native trees at North Creek. Photo: David Herasimtschuk

Figure 5.4. Existing temperature monitoring locations in the Siletz River watershed.



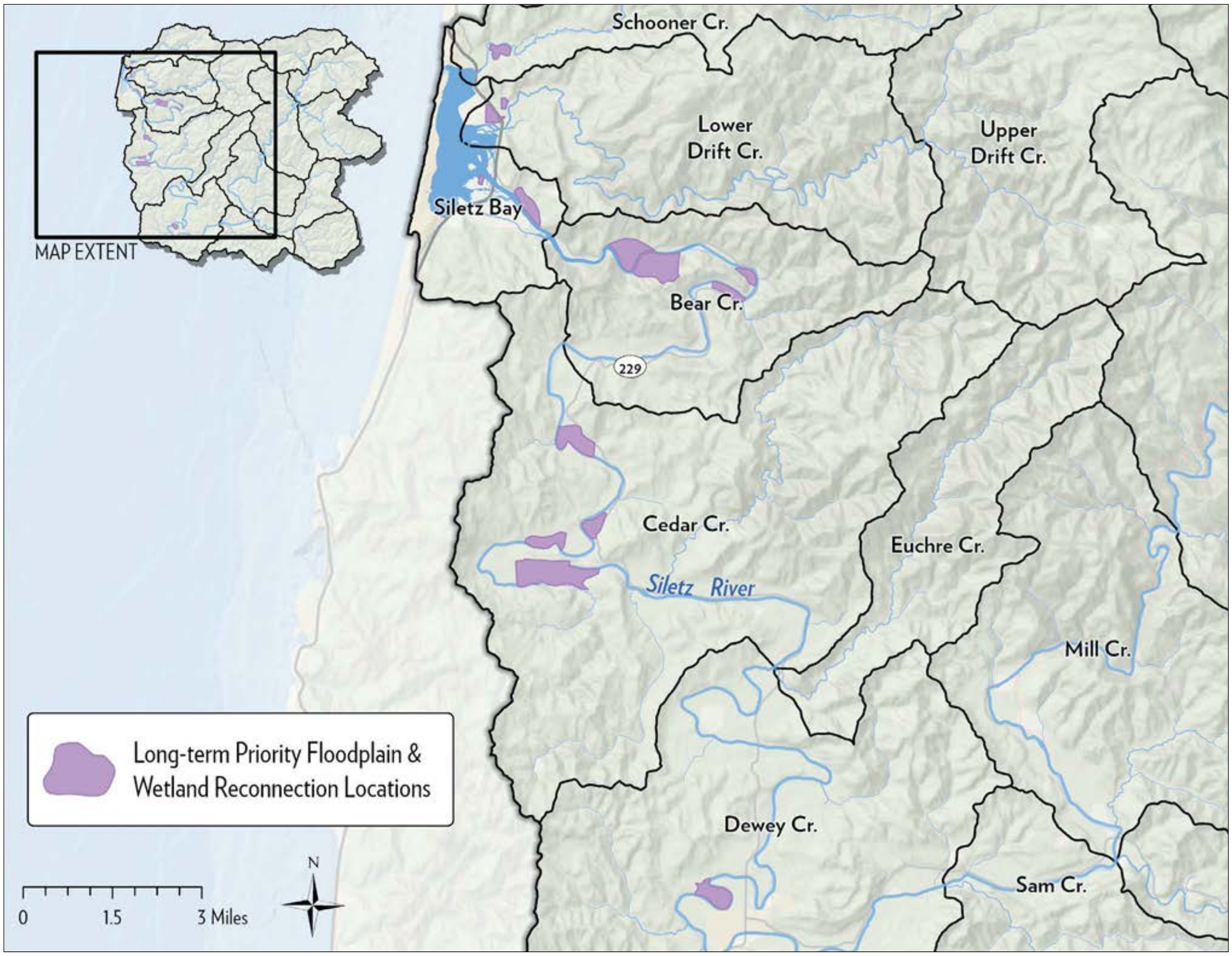
in confluence areas where tributary streams bring freshwater flows to lower marshy reaches.

This strategy seeks to identify areas of cold water refugia through temperature surveys and monitoring efforts. The Partnership will collaborate with ODFW hydrologists, who are working to identify the top third coldest streams on the coast and tributaries within each major watershed that are providing cold water inputs to their downstream systems. The model in development uses NorWeST data to identify regionally cold reaches and tributaries that are 2° C colder, and ODFW is undergoing an effort to collect and analyze field data to verify the model. The initial cold water refugia assessment is set to be published after the production of this plan, and, therefore, will be incorporated at a later date.

There are opportunities for future collaboration between the Partnership and ODFW as additional field data will need to be collected. Ground-truthing the model and collecting summer temperature data will be a vital component of understanding where these cold water lifeboats are within the watershed. Long-term monitoring of temperature will be a critical component of adaptive management and evaluation of restoration effectiveness between now and 2045. The Siletz Partnership is working to collect longitudinal temperature data of the mainstem Siletz River. There may also be additional opportunity to conduct a thermal infrared aerial survey if funding is available, which is a more efficient (yet expensive) method for finding cold water inputs along miles of a river system. An aerial survey was conducted in 2002 (Appendix 5), but technology has significantly advanced in 20 years, and operators now use updated forward-looking infrared ("FLIR") cameras to obtain high-resolution images of temperature changes.

Once cold water inputs have been identified, the Siletz Partnership will work with landowners

Figure 5.5. Long-term strategy locations for riverine floodplain reconnection.

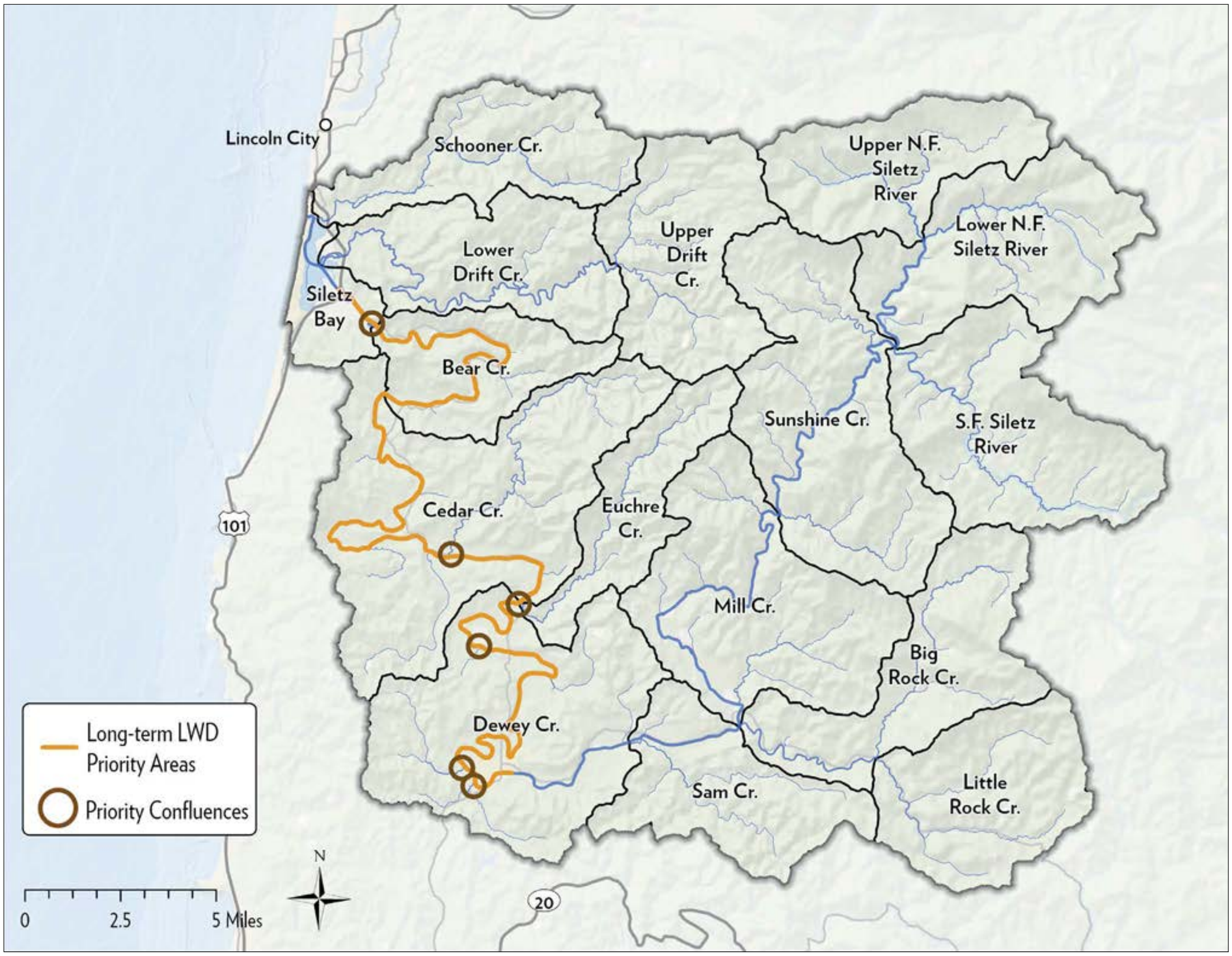


to protect and enhance critical cold water refugia. When appropriate, the stream systems of highest value may be protected by conservation easements or voluntary acquisitions. Restoration actions can also be taken that enhance the habitat quality for juvenile salmonids, such as placement of LWD for cover or encouraging beaver persistence for the creation of beaver ponds as slow-water refugia. Efforts can be focused at the confluences of tributaries known for cold water inputs, which provide mainstem rearing juveniles easy access to better habitat during the lethal summer months.

Strategy 2.c) Restore and reconnect riverine floodplains and associated habitats.

Similar to the standard life history type, mainstem rearing juveniles are also limited by a lack of slow-water refugia and off-channel habitat; however, the locations for this critical habitat type is needed in streams, floodplains, and edges associated with the mainstem river system rather than the upper tributaries. Since European settlement, rivers have been altered with the purpose of minimizing, controlling, or excluding the impact of water on floodplains to make the land more amenable to food production and livestock rearing. This often results in rivers that have been channelized and flanked by dikes, which reduces the connectivity of a stream system with its associated floodplain except at high water events, which can then result in fish being trapped behind a levee without an egress. When levees are removed and floodplain connection re-established, these areas become ideal habitats for juvenile rearing. Water is able to disperse over a greater area, thus reducing the velocity and creating critical slow-water refugia during winter storm events. The riparian or wetland vegetation often associated with floodplain habitat also provides ideal opportunities for foraging and cover for resting and hiding from predators. This

Figure 5.6. Long-term LWD placement priority reaches for mainstem rearing juveniles.



life history type is often associated with freshwater rearing, however, tidal influence may still be present lower in the system. Lower-basin tidal wetland habitats are essential to facilitate the physiological changes that occur in juvenile Coho as they migrate between freshwater and saltwater. The suitable tidal exchange, water flow, salinity, and water quality support the acclimation of downriver migrating Coho as they go through the smoltification process.

This strategy focuses on restoring riverine floodplain and wetlands associated with the mainstem (Fig. 5.5). Restoration actions include removing levees, drainage ditches, and tidegates and re-establishing complex channel networks, native vegetation, and beaver-favored conditions. Restoration projects of this type often completely transform the landscape and can be challenging for continued agricultural production; therefore, voluntary acquisitions are often needed.

Strategy 2.d) Restore instream complexity and stream-floodplain interaction through the installation of large wood.

Instream complexity is critical in creating over-winter refugia for spring migrants that have moved into the mainstems and lower tributaries. Large-wood placements provide instream structure that allows deep pools to form and can redirect high flows into the floodplain. For juveniles that are rearing in larger systems, such as mainstem rivers, instream complexity along stream edges or in accessible tributaries can be the deciding factor for survival.

In some cases, increased instream complexity is needed for summer rearing, with a focus at the cold water sites to improve habitat conditions and protect juveniles seeking to ride out summer hot spots in these cold water plumes. Unprotected juveniles can experience high predation in these areas when cover is limited by the lack of

Figure 5.7. Areas of high beaver suitability for mainstem rearing juveniles.

instream complexity. The Partnership will use the data collected from Strategy 2.b, which seeks to identify cold water inputs, to inform the placement of large wood. Figure 5.6 highlights both reaches of the mainstem Siletz River that would benefit from large-wood placements as well as confluences with tributary habitat, understanding that for spring migrants use of tributary habitat is most likely focused lower in a basin's system and potentially at confluences.

Strategy 2.e) Encourage beaver persistence in tributary and floodplain habitats.

Similarly to Strategy 2.d, which focuses on the use of LWD to create slow-water refugia, this strategy focuses on the persistence of beaver impoundments to provide critical habitat for over-winter survival. Beaver impoundments change the spatial distribution of water, creating deep pools and floodplain wetlands that are safe havens during high-velocity winter storm events. This strategy focuses on providing habitat conditions favorable for beavers in areas associated

An example of floodplain habitat associated with a mainstem river system. Project location known as "Y27" on the mainstem Yaquina River. Photo: MidCoast Watersheds Council

Newly installed 50 ft culvert on North Creek in the Siletz watershed. Photo: MidCoast Watersheds Council

with mainstems and lower tributaries (Fig. 5.7) by planting beaver-favored forage and reducing stream velocities where possible, either through LWD placements or beaver dam analogues as outlined in Strategy 1.b.

Strategy 2.f) Address high-priority fish passage barriers on streams with high Intrinsic Potential.

Fish passage barriers, such as undersized and perched culverts, can disproportionately affect spring migrants that are moving back and forth from the mainstem to tributary habitat during the summer and winter months. During the summer, when flows are at their lowest and temperatures are lethally high, spring migrants often need to re-enter tributaries to seek cold water refugia. A culvert perched mere inches above low summer flows impedes access to life-saving cold water. Access to tributaries is also critical during the winter months when juveniles need to escape the tumultuous conditions of a high-velocity mainstem river. At high water, undersized culverts can serve as velocity barriers for juveniles seeking slow-water refugia in tributaries.

This strategy seeks to identify and address high-priority fish passage barriers. Inventories have been completed within the Schooner and Drift Creek watersheds, and the Partnership will work with major landowners to do a full inventory of culverts crossing salmon-bearing streams (Fig. 5.4) in the remaining sub-watersheds. The Partnership will work closely with ODFW as the agency updates the Statewide Fish Passage Barrier Prioritization to ensure the highest barriers are included, and will then work to correct the highest priority barriers identified.

3) Strategies for Spring Fry Migrants, Estuary Rearing Juveniles

For this life history strategy, the fry emigrate from the natal stream in spring, moving downstream into larger-order streams. By midsummer, they reach tidally influenced estuarine habitats and rear over the summer, optimizing rearing locations in the estuary based on conditions such as temperature, flow, prey availability, and salinity. Estuarine residence continues through the winter and smolting occurs in the spring at age one, with ocean entry as an age-one smolt (~18 months). The primary limiting habitat factor for this life history pathway is connectivity to tidally influenced systems such as slough, marshes, forested Sitka spruce swamps, and scrub-shrub swamps.

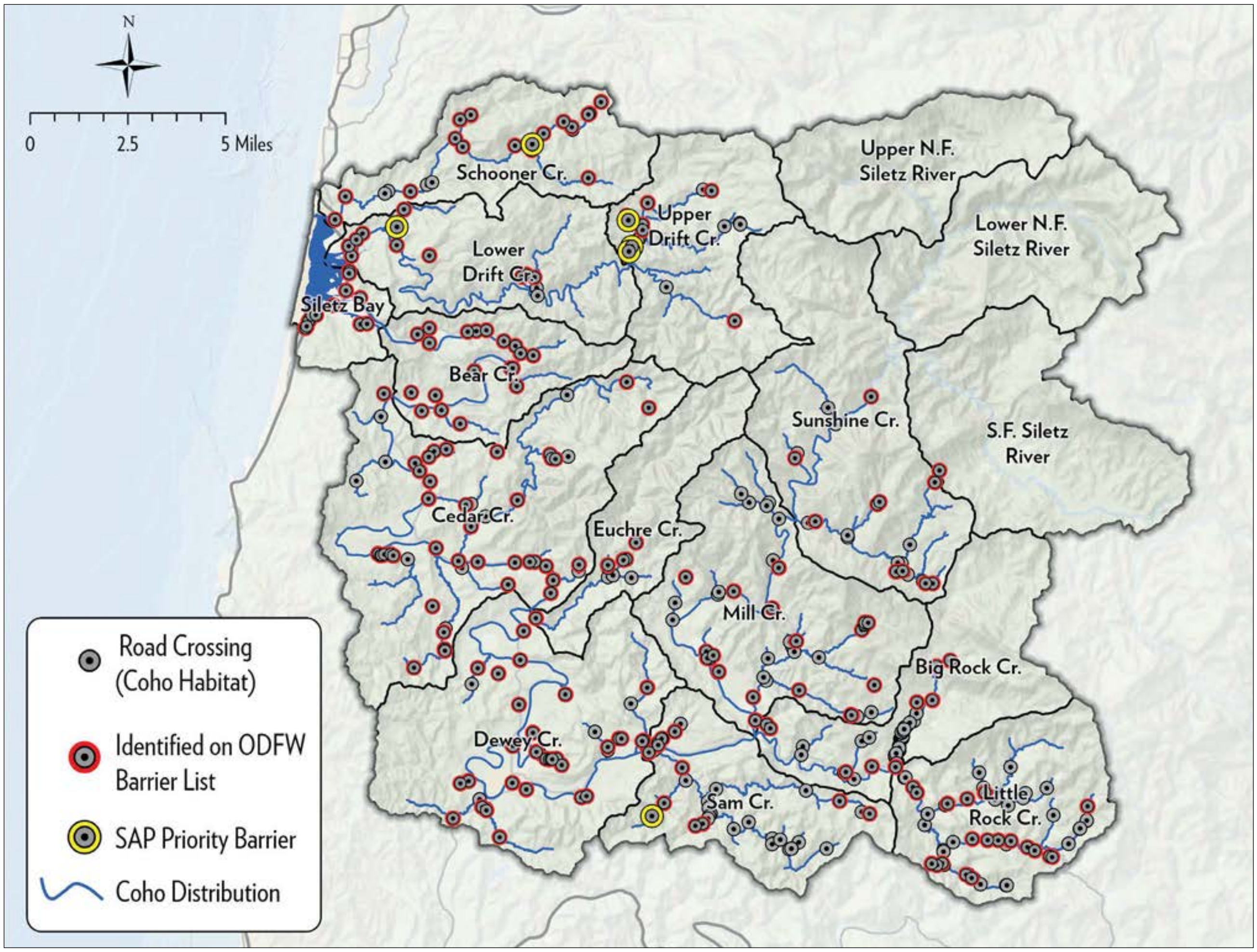
Strategy 3.a) Restore and protect tidal wetland habitat.

Intact tidal wetlands provide forage, such as aquatic invertebrates, as well as low tide and high-velocity refuge, in the form of aquatic vegetation, undercut banks, tidal marshes, and swamps that support juvenile growth and maturation. The loss and degradation of these habitats has been linked to reduced fitness and survival of salmon (NMFS 2016, Gallagher et al. 2012, Solazzi et al. 2000).

Estuarine wetlands are a finite and concentrated habitat type; therefore, protection and restoration actions are always a priority but often opportunistic. The Siletz Partnership will continue to work closely with the U.S. Fish and Wildlife Service to enhance properties held within and adjacent to the Siletz Bay National Wildlife Refuge, and continue to do outreach to private landowners within the estuary to find restoration opportunities.

The Partnership will consider the effects of climate change when planning for future conditions, and incorporate sea level rise modeling into the long-term strategy for estuary restoration. Tidal wetlands currently exist just at and above sea level, and healthy tidal wetlands are able to adapt to slow sea level changes. If sea level rises too fast, tidal wetland plant communities may not be able to persist at their current locations. To survive, these plants may have to move to areas of higher elevation. These higher areas are called “landward migration zones”; they are potential future tidal wetlands under sea level rise. Figure 5.10 shows a prioritization map from Brophy and Ewald (2017) for the Siletz Estuary based on the impact of a projected 4.7-foot sea level rise.

Figure 5.8. Stream crossings and known barriers on salmon-bearing streams.

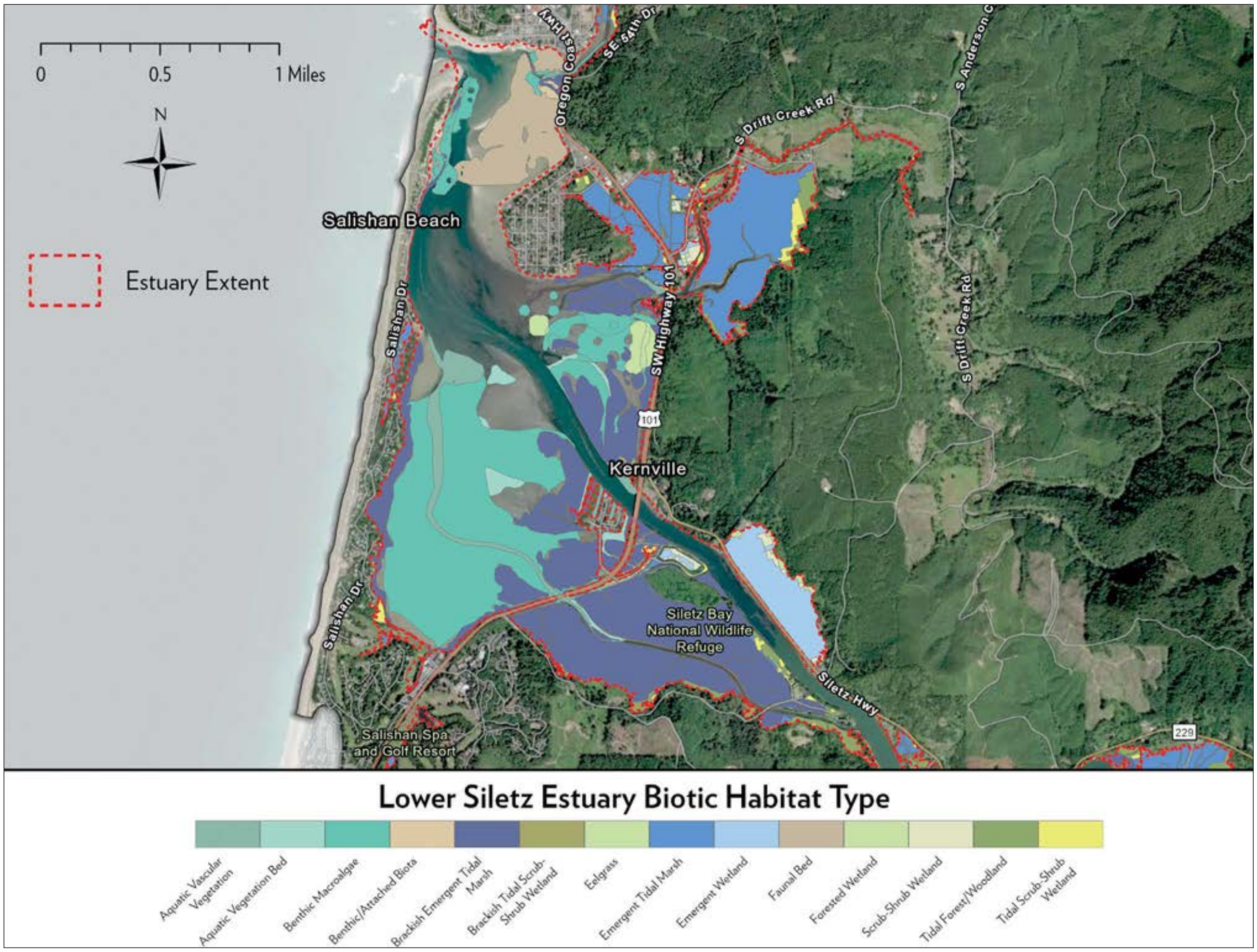


While extensive tidal marsh habitat remains in Siletz Bay, many existing estuary habitats are still separated from freshwater tributary streams by roads and dredged channels. These adjacent wetlands provide important habitat for pre-smolt Coho that have not adapted to a fully saline environment. Research in the lower Salmon River, which lies just north of the Siletz River, illustrates the importance of connectivity to intertidal habitats, where Jones et al. (2014) found that some cohorts of rearing Coho retreat to estuary-adjacent streams in fall and winter before re-entering the estuary in spring. The streams, often small and not easily recognized as critical habitat, provide a source of cold water refugia in summer and freshwater for juveniles not yet ready to enter the more saline habitats. These contributions strongly point to estuary-adjacent streams as a key habitat component for Coho and a priority for protection and restoration.

As opportunities arise, the Partnership will prioritize any possibility of increasing the quantity and quality of existing and future estuarine wetlands. Restoration actions may include removal of dikes, development of complex channel networks, placement of LWD, and establishment of native vegetation. When possible, the Siletz Partnership will focus on confluence areas where tributary streams bring freshwater to marshes to increase early-rearing habitat for Coho in estuary-adjacent streams.

Millport Slough estuary and the Siletz River. Photo: Holden Films

Figure 5.9. Biotic habitat type of the lower Siletz estuary.



4) Strategies for Fall Parr Migrants, Freshwater Rearing Juveniles

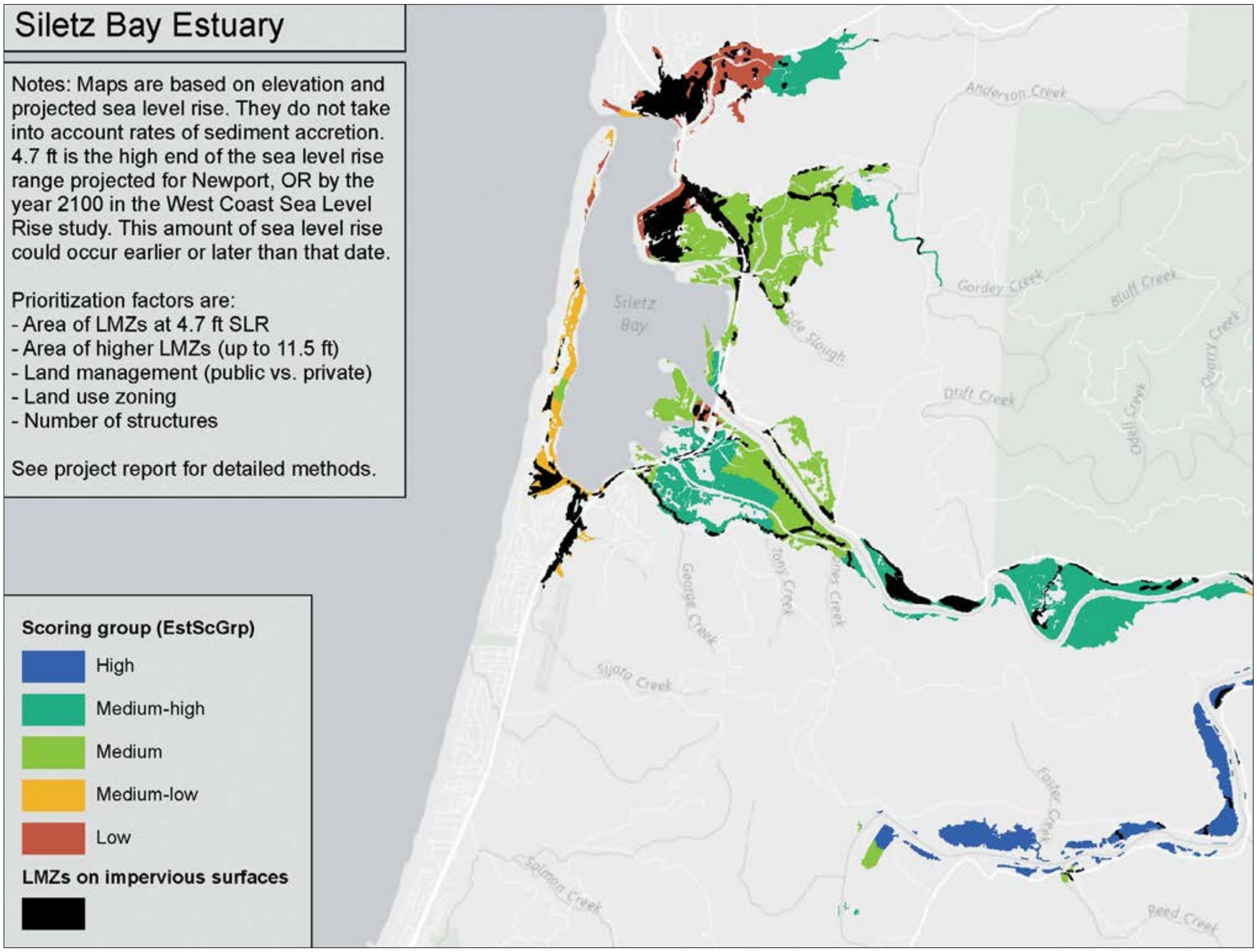
Juvenile Coho fry following this pathway rear in natal streams from early spring through the summer. In fall, often associated with decreasing temperatures and increasing flows, the Coho parr migrate to overwinter in downstream off-channel habitats (e.g., wetted floodplain, adjacent pond or freshwater tidally influenced wetlands). Outmigration occurs in the second spring, including a short time spent in the estuary (one to four weeks) before entering the ocean as an age-one smolt (~18 months).

The limiting habitat factors for this life history type are likely similar to that of the spring migrants, without as much concern for lethal summer temperatures due to emigration downstream occurring in the fall. Fish rearing in off-channel sites have been associated with higher growth rates, increased size at outmigration, and improved survival relative to natal stream-rearing counterparts (Craig et al. 2014, Gallagher et al. 2012, Solazzi et al. 2000). The limited availability and degraded condition of off-channel habitat restricts the carrying capacity of the entire watershed and limits the expression of the diverse juvenile life history pathways that were historically present. Increasing the diversity and connectivity of these habitat areas will improve population abundance and expand the expression of different life histories within the population. Restoration actions that focus on off-channel rearing and winter refugia, such as Strategies 2.c, 2.d, 2.e, and 2.f, will likely benefit the fish that express this life history pathway as well.

5) Opportunities for Protection of Watershed Processes

The Siletz Partnership recognizes that there are opportunities for habitat and species protection that provide ecological uplift across the entire watershed. Protection opportunities, such as policy changes or large acquisitions, can have wide-rang-

Figure 5.10. Prioritization of tidal wetland landward migration zones for 4.7-foot sea level rise.



ing impacts that are less expensive and ultimately more durable than a collection of individual restoration projects. This section highlights several priorities for protection in the Siletz River watershed.

5.a) Promote outreach and advocacy that encourages beaver persistence on the landscape.

The Siletz Partnership recognizes that protecting existing beaver habitats is more cost effective than restoring these habitats once beavers have been removed. The Partnership encourages collaboration with state and federal managers and policymakers to make changes to improve beaver management, including by providing support to private landowners seeking to implement non-lethal management strategies, limiting recreational hunting and trapping of beaver, and increasing awareness of the role of beaver in generating high-quality salmon habitat.

The Partnership continues to advocate that state and federal managers adjust policies to better protect beaver. In 2020, the Oregon Fish and Wildlife (OFW) Commission introduced efforts to change the Furbearer Regulations to curtail beaver trapping and hunting on federally managed public lands within the state, including the Siuslaw National Forest (SNF), which includes most of the Drift Creek sub-watershed. There has been broad support for this change in policy, including

Large wood placement in off-channel wetland habitat at Starr Creek in the Yaquina River watershed. Photo Green Wave Media & MidCoast Watersheds Council.

letters provided by the SNF Forest Supervisor and NOAA's West Coast Region Oregon Branch Chief requesting such a closure. In 2020, the OFW Commission set up a Beaver Management Working Group, which published the report Recommendations for Beaver Management on Federal Lands in May 2022. Among other points, it noted that there was sufficient justification to take immediate action at a landscape scale, including consideration of hunting and trapping closures, to maximize beaver-modified floodplain landscapes on federal lands. However, as of 2024, these recommendations have not been pursued. The Siletz Partnership supports the closing of recreational hunting and trapping of beaver on the SNF.

Strategy 5.b) Ensure future large-wood delivery and healthy watershed processes by promoting updated forest policy, landowner outreach, and acquisitions.

Forest Policy

Protecting high-quality habitats can be critical to conserving the natural ecological processes that support Siletz Coho viability. For example, while the installation of large wood in selected stream reaches is an excellent tool for increasing stream complexity, these projects typically provide benefits for a relatively short term (one to two decades). Complementary measures to protect selected stands of old-growth timber can secure the natural recruitment of large instream wood to the stream channel over a longer time horizon. This passive large-wood delivery provides a sustainable and cost-effective approach to increase and maintain habitat complexity over the long term.

Managing timber stands by establishing larger stream buffers and increasing harvest rotations supports this plan's goal of delivering large wood into high-priority habitats. Although this plan does not recommend specific forest management prescriptions, the Siletz Partnership supports the State's Private Forest Accord agreement for reducing harvest on steep slopes found on private timberlands. The Accord was developed through a historic process of collaboration with timber and conservation groups to overhaul the Oregon Forest Practices Act. The Accord agreements will protect cold water habitat across 10 million acres of private land in Oregon, including over 157,000 in the Siletz watershed. The Oregon Department of Forestry officially approved the Accord agreement in fall 2023. Implementation of its special resource site rules will protect old-growth sites and increase the long-term availability of large wood to streams.

In March 2024, the Oregon Board of Forestry approved moving forward with the Western Oregon State Forest Habitat Conservation Plan to protect habitat for 17 threatened or endangered

Photo: Holden Films

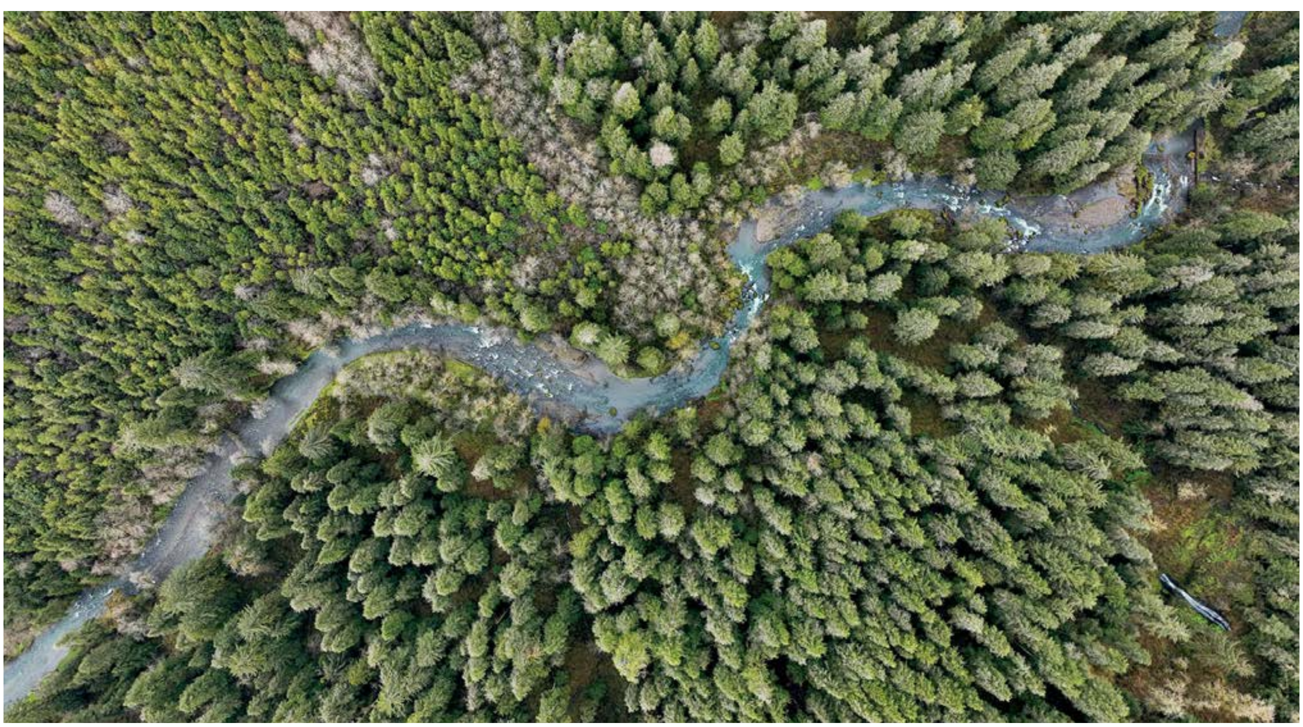
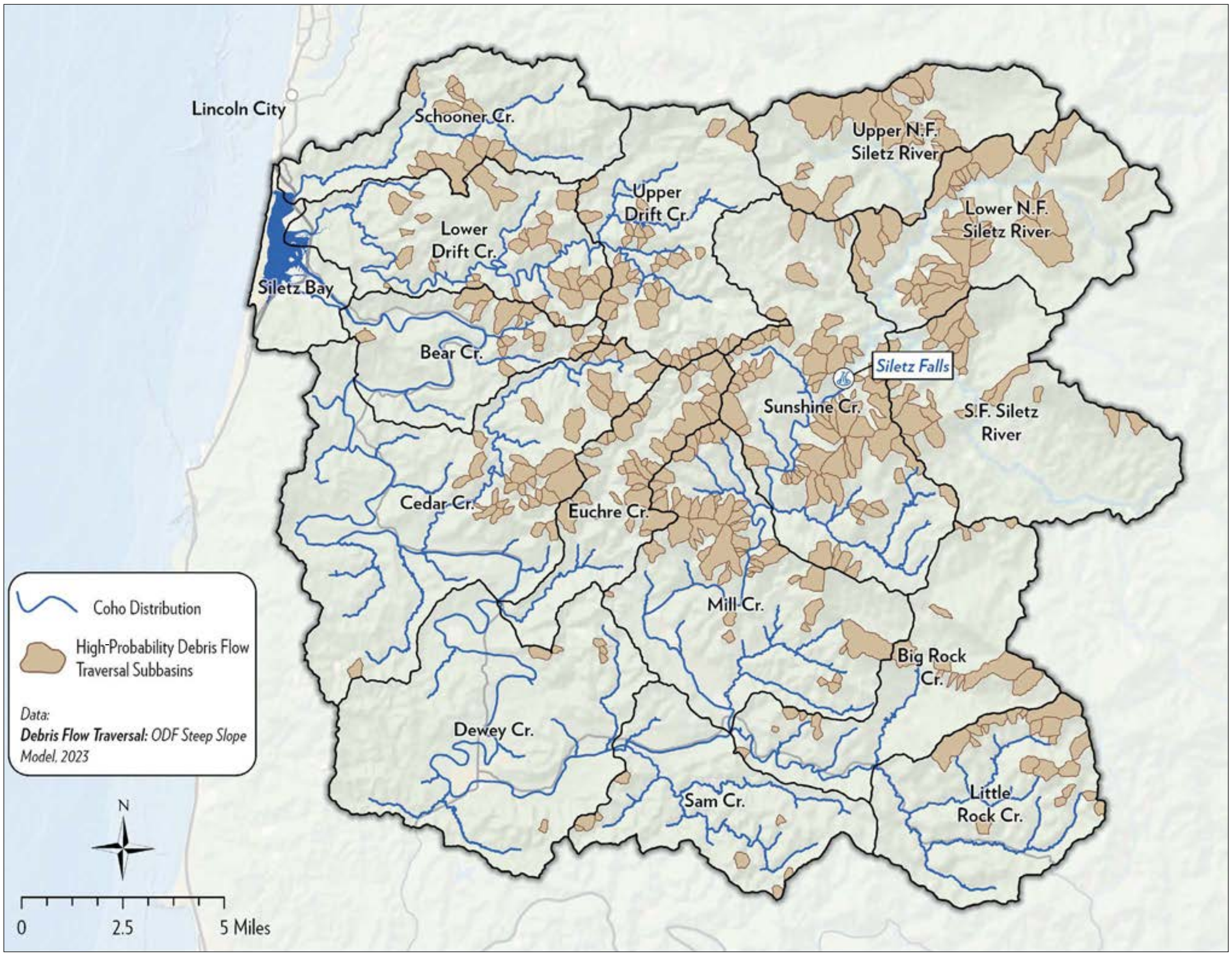


Figure 5.11. Priority uplands with high probability of LWD input from landslides.



species, including OC Coho, on 640,000 acres of Oregon Department of Forestry-managed state forests west of the Cascades. This includes 7,435 acres within the Siletz watershed. A key piece of the plan is the aquatic conservation strategy, which establishes riparian conservation areas with stream buffers designed to protect against increased sedimentation and stream temperature. Additional actions will create operational and design standards for roads, equipment use, harvesting on steep slopes, and the timing of activities to minimize effects on covered species and the stream environment. The ecosystem-based, collaborative plan is now awaiting approval from federal agencies, with implementation soon thereafter.

Upland Stands to Protect

In addition to updating forest policy to provide greater stream protections, the acquisition of selected timber stands can provide far-reaching benefits for decades to come. This plan includes long-term protection, either through acquisitions, easements, or agreements, of upland forest stands in high-priority areas, including those with existing old-growth timber and in areas that are prone to landslides. Landslide-prone areas are targeted because they have the highest likelihood of upslope delivery of large wood to the stream network, due to the presence of slopes greater than 40%.

In addition to targeting old-growth or second-growth timber stands, existing industrial timber plantation areas with young trees are also considered for acquisition. While the ecological uplift may take decades to be realized, this can be a more economical option that will still ensure future watershed benefits. This approach is based on the guidance and foresight from the Confederated Tribes of Siletz Indians, which acknowledges that these areas can be managed for old-growth conditions and provide long-term large-wood delivery, even if their capacity to provide suitable large wood is limited in the short term.

Low water during summer on the Siletz River. Photo: Holden Films

Strategy 5.c) Protect and enhance instream flow during critical summer and early fall seasons.

The Siletz River is a rain-dominated system with a shallow aquifer. Thus, changes in the amount and timing of precipitation have the potential to magnify the risk of extreme streamflow conditions during both high- and low-flow periods. High winter runoff events can flush juveniles from habitats and scour redds. This strategy focuses on dry summer conditions, which affect rearing juveniles by causing insufficient streamflows, lethal water temperatures, and restricting Coho access to areas that provide cold water refuge. Climate change is increasing the frequency and magnitude of these changes. Furthermore, many streams lack both legal protections for streamflows or established targets to guide instream flow restoration.

The Siletz watershed has insufficient water to meet the needs of all uses, both instream and out-of-stream, leading to ecological impacts on surface waters, insecurity for water users, and potential for conflict. Water use across all water user groups increases during the summer months, when stream flows are lowest, due to increased industrial production as well as higher demand from tourists and irrigation. Several major water users—Georgia Pacific Mill, City of Newport, City of Toledo, City of Siletz, and Seal Rock Water District—rely on water from the Siletz River during the summer months and most discharge water to the ocean or bays, thus the treated water is not available for other instream and out-of-stream uses downstream of their diversion points. The water rights for each of these users are senior to the instream water right on the Siletz River; however, Georgia Pacific Mill, City of Newport, and Seal Rock Water District all attempt to reduce their intake during low water to alleviate pressure on the Siletz River.

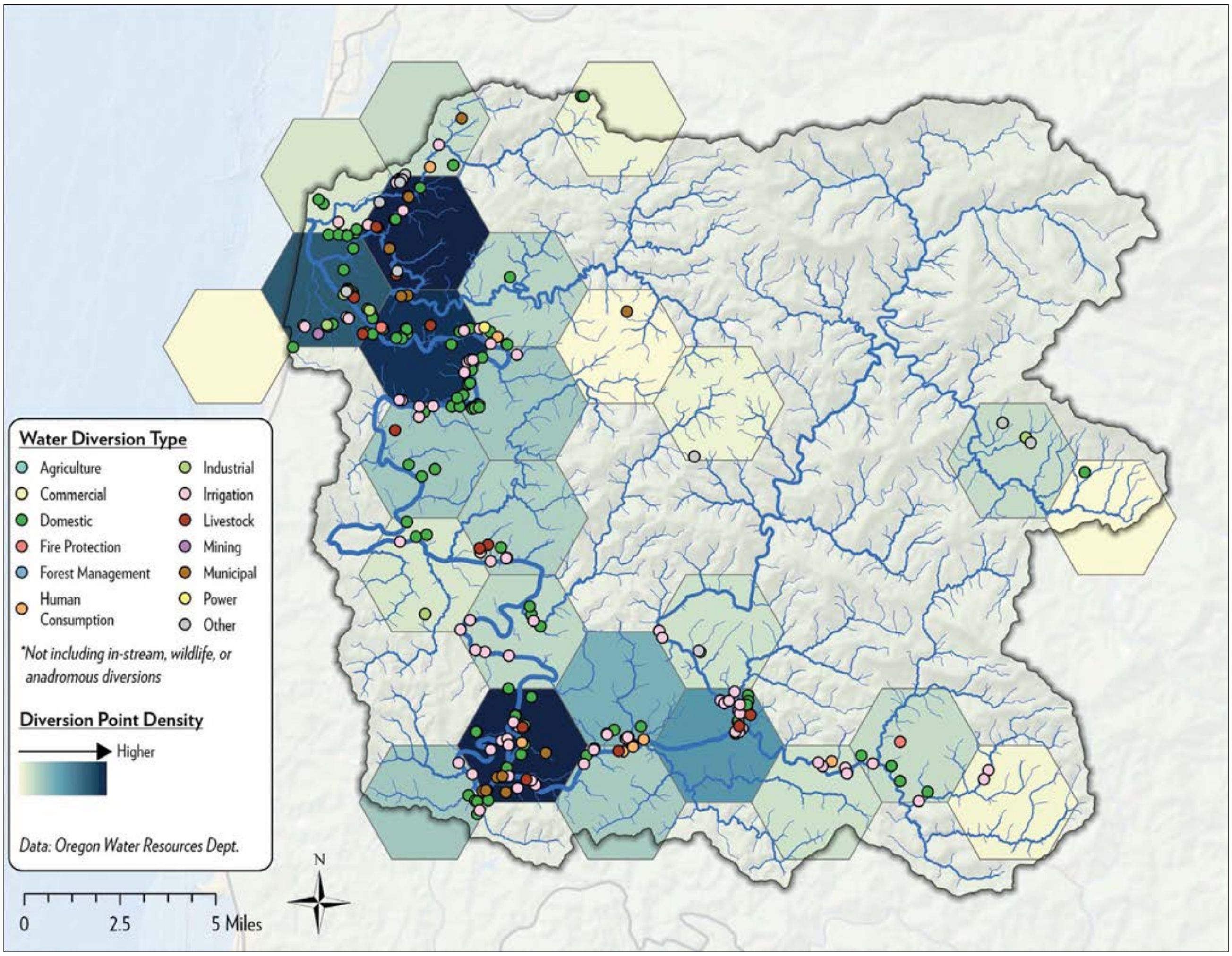
This strategy calls for members of the Siletz Partnership, including the MidCoast Watersheds Council, the Lincoln Soil and Water Conservation District, and others to continue their participation in the Mid-Coast Water Planning Partnership (MCWPP). The goal of the MCWPP is to convene a coordinated water conservation initiative that focuses on reducing water use, educating stakeholders, promoting incentives, and effectively using limited water supplies, especially during drought conditions. In 2022, the MCWPP-developed the MidCoast Water Action Plan, found at midcoastwaterpartners.com, which identified 59 actions across eight imperatives. The most relevant imperatives to Coho recovery and resilience are Imperative 3 (Monitoring and Data Sharing), Imperative 6 (Source Water Protection), and Imperative 8 (Ecosystem Protection and Enhancement). Table 5.4 highlights the relevant actions within these imperatives that will improve Coho habitat or increase knowledge about how to best restore habitat or stream flow.

Table 5.4. Relevant imperatives and actions within the Mid-Coast Water Planning Partnership's action plan to address water quantity and quality concerns. The highest priority actions for enhancing Coho habitat are **highlighted**.

MCWPP Imperative 3: Monitoring & Data Sharing	
Action 15	Installation of flow meters to gain a more accurate estimate of water use in the region.
Action 16	**Establish real-time streamgages in priority locations and enable innovative demand reduction actions during periods of critical ecological need.**
Action 17	Develop and implement a coordinated long-term water quality monitoring program throughout the region.
MCWPP Imperative 6: Source Water Protection	
Action 36	Support the reduction of nutrient, turbidity, and bacteria inputs and emerging contaminants of concern to source water.
Action 41	Protect critical lands within drinking water source areas through acquisition, conservation easements, or other tools.
MCWPP Imperative 8: Ecosystem Protection and Enhancement	
Action 44	**Support restoration projects that will achieve the greatest ecological returns on investment, such as cooler streams and improved summertime flows.**
Action 45	Prioritize stream reaches for riparian buffer restoration projects and increase woody vegetation on priority streams.
Action 46	Advocate for the restoration and conservation of native riparian vegetation.
Action 47	Implement more erosion control practices.
Action 48	Evaluate anthropogenic sources of fine sediment into streams.
Action 49	Protect beaver populations and encourage beaver pond creation.
Action 50	Implement restoration projects to address impairments and improve conditions.
Action 51	Restore stream flow by evaluating the mechanisms and conditions for restoring hyporheic flows.
Action 52	Protect stream flow by recommending limits on further appropriation of water on high-priority streams.
Action 53	Support projects that result in increased water retention in channels, floodplains, wetlands, and adjacent uplands.
Action 54	Determine ecological flow targets and identify basin-wide instream demands. Support development of additional instream water rights to reach targets.
Action 55	Use voluntary programs to convert existing water rights to instream uses.
Action 56	Control priority invasive species in streams and riparian corridors and establish native vegetation.
Action 58	Seek long-term protection of critical land areas managed for water quality.

The Siletz Partnership will support these efforts by promoting projects that overlap with the actions in Table 5.4, writing letters of support, identifying instream water rights acquisition opportunities, and detecting and protecting cold water seeps.

Figure 5.12. Water diversion type and quantity in the Siletz River watershed.



5.3 Combined Long-Term Outcomes by Restoration Strategy

The Siletz Partnership has identified seven primary restoration strategies to increase the abundance and resilience of the Siletz Coho population. By 2045, implementation of this plan will accomplish the following:

2045 Outcome #1: Floodplain-channel interaction and instream complexity are increased through the addition of LWD in 78 miles of mainstem systems, tributaries, and sloughs. An additional 23 miles of instream assessments will be conducted to increase potential restoration mileage.

2045 Outcome #2: Rearing opportunities are increased in 1,123 acres of floodplains and wetlands through the restoration of hydrologic regimes, fish access, and ecologically appropriate native plant communities in freshwater and brackish systems.

2045 Outcome #3: The long-term protection of 847 acres of freshwater and tidal wetlands and floodplains will be obtained through a series of voluntary acquisitions.

2045 Outcome #4: Beaver-focused restoration actions that reduce velocities and promote beaver-favored forage will be increased in 22 miles of streams.

2045 Outcome #5: Riparian function is enhanced along 40 miles of the Siletz River and its tributaries, reducing stream temperatures and erosion and increasing macro-invertebrate abundance and long-term potential for large-wood recruitment.

2045 Outcome #6: All stream crossings on Coho-bearing streams will be evaluated and longitudinal connectivity will be improved for juvenile rearing habitat by addressing high-priority fish barriers.

Table 5.5. Projected restoration outcomes of the Siletz SAP (2026–2045).

KEY ECOLOGICAL ATTRIBUTES RESTORED OR ENHANCED	Outcome Metric	Siletz Bay & Tribs	Lower Tributaries	Mid Tributaries	Upper Tributaries	Total
		Schooner, Drift, Bear	Dewey, Euchre, Cedar	Sunshine, Sam, Mill, Rock	North & South Fork Siletz	
Instream complexity	Miles enhanced	26	25	27	–	**78**
Lateral connectivity	Acres of floodplain /wetlands restored	452	671	–	–	**1,123**
Lateral connectivity	Acres of floodplain /wetlands protected	471	376	–	–	**847**
Beaver dam persistence (more miles will be added after further surveys)	Miles treated	2	–	6	–	**8**
Riparian function	Miles of buffers enhanced	–	7	19	5	**31**
Longitudinal connectivity	Miles reconnected	To be determined after inventory is complete				
Landscape array of structural diversity	Acres of upland and riparian stands protected	3,206	492	5,000	–	**8,698**

<u>2045 Outcome #7</u>: Through policy, outreach, or acquisitions, the long-term potential for the conservation and restoration of watershed processes is improved through the protection of 8,689 acres of selected timber stands throughout the Siletz Basin.

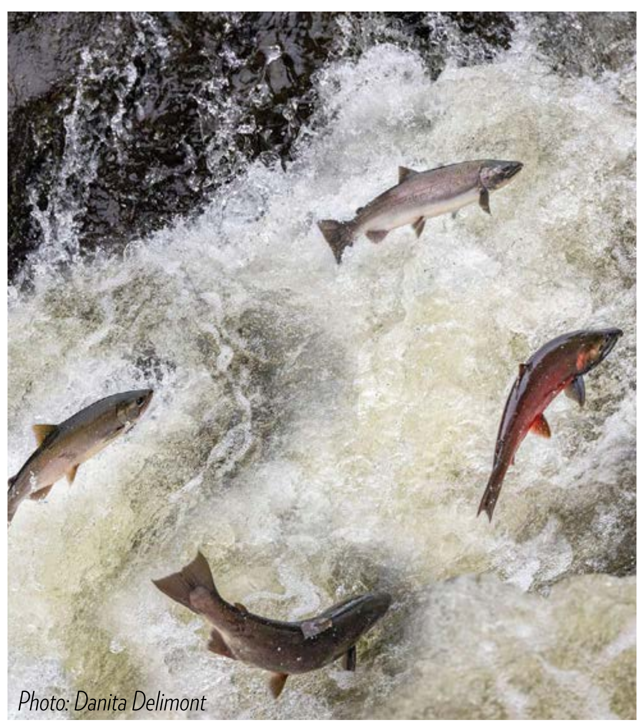


Photo: Danita Delimont

Near-Term Project Implementation Plan: 2026–2030

Chapter 5 describes the protection and restoration strategies that the Siletz Partnership will employ over the long term and the locations where the coordinated implementation of these strategies can generate the greatest benefit. The following chapter outlines a short-term work plan in which a subset of locations have been selected from priority areas for the implementation of projects within the next five years. The projects presented below reflect the locations where the scientifically determined priorities shown in Chapter 5 align with the conditions necessary for project implementation (willing landowners, high potential for funding, permit feasibility, etc.). In short, these are the locations where science and opportunity meet.

6.1 Emerging Opportunities

This SAP identifies anadromous reaches of the basin as the priority for focused investment and coordination. However, the Siletz Partnership recognizes that the contributions of restoration and protection outside of anadromy also contribute to basin-wide ecological processes. To that end, the Partnership agrees that focusing implementation in the focal areas does not restrict any participating partners from undertaking projects in the other sub-watersheds. However, to be recognized as a funding priority, projects outside of the focal areas should meet one or more of the following criteria: 1) demonstrate the application of new conservation incentives or techniques; 2) engage an influential landowner or partner who can accelerate work in the focal areas; 3) exploit a finite window of opportunity; and/or 4) advance a large-scale project with a high cost-benefit. Partners developing this SAP agreed to an 80-20 guideline, where each partner will seek to direct 80 percent of its investments in project implementation and landowner outreach within this plan's focal areas.

6.2 Near-Term Actions and Objectives

The Siletz Partnership proposes the following actions for implementation from 2026 to 2030. These proposed near-term actions are listed according to the long-term outcomes that they support.

MCWC Director Evan Hayduk and volunteers planting at North Creek. Photo: David Herasimtschuk

<u>2045 Outcome #1</u>: Floodplain-channel interaction and instream complexity are increased through the addition of LWD in 78 miles of mainstem systems, tributaries, and sloughs. An additional 23 miles of instream assessments will be conducted to increase potential restoration mileage.

Actions: By 2030, add LWD to 36.5 miles of priority streams and conduct 18.4 miles of instream assessments.	
Action 1.1	Add LWD to 6 miles of lower mainstem Siletz River estuary channels - GIS 2
Action 1.2	Add LWD to 4 miles of Rock Creek - GIS 5
Action 1.3	Add LWD to 6 miles of lower Big Rock Creek – GIS 6
Action 1.4	Add LWD to 3.2 miles of Little Rock Creek - GIS 7
Action 1.5	Add LWD to 4 miles of Steer Creek – GIS 8
Action 1.6	Add LWD to 10 miles of Cedar Creek – GIS 9
Action 1.7	Add LWD to 0.5 miles of tributary to Cedar Creek on USFS land – GIS 10
Action 1.8	Add LWD to 0.4 miles of North Creek on USFS land – GIS 11
Action 1.9	Add LWD to 2.4 miles of Wildcat Creek on USFS land – GIS 12
Action 1.10	Complete an instream complexity and LWD assessment for 1.8 miles of Skunk Creek – GIS 28
Action 1.11	Complete an instream complexity and LWD assessment for 3.4 miles of Bear Creek – GIS 29
Action 1.12	Complete an instream complexity and LWD assessment for 4 miles of Sampson Creek – GIS 30
Action 1.13	Complete an instream complexity and LWD assessment for 2.3 miles of North Creek – GIS 31
Action 1.14	Complete an instream complexity and LWD assessment for 1.4 miles of Deer Creek – GIS 32
Action 1.15	Complete an instream complexity and LWD assessment for 4 miles of Elk Creek – GIS 33
Action 1.16	Complete an instream complexity and LWD assessment for 1.5 miles of Brush Creek – GIS 34

2045 Outcome #2: Rearing opportunities are increased in 1,123 acres of floodplains and wetlands through the restoration of hydrologic regimes, fish access, and ecologically appropriate native plant communities in freshwater and brackish systems.

Actions: By 2030, 231 acres of floodplains and wetlands will be restored.	
Action 2.1	Restore 189 acres of floodplain and wetlands along the Siletz River in the Bear Creek watershed – GIS 40
Action 2.2	Reconnect 42 acres on adjacent parcels to Siletz NWR tracts – GIS 44

2045 Outcome #3: The long-term protection of 847 acres of freshwater and tidal wetlands and floodplains will be obtained through a series of voluntary acquisitions.

Actions: By 2030, 231 acres of floodplains and wetlands will be under long-term conservation protection.	
Action 3.1	Acquire 189 acres of floodplain and wetlands along the Siletz River in the Bear Creek watershed – GIS 41
Action 3.2	Acquire 42 acres on adjacent parcels to Siletz NWR tracts – GIS 45

2045 Outcome #4: Slow-water habitats and beaver-favored forage are re-established along 22 miles of tributary streams.

Actions: By 2030, 4 miles of beaver-focused restoration will be implemented.	
Action 4.1	Implement a beaver-focused habitat project on Scott Creek – GIS 57
Action 4.2	Implement a beaver-focused habitat project on Reed Creek – GIS 58
Action 4.3	Ground truth the Beaver Restoration Action Tool modeling in prioritized sub-watersheds

2045 Outcome #5: Riparian function is enhanced along 40 miles of the Siletz River and its tributaries, reducing stream temperatures and erosion and increasing macro-invertebrate abundance and long-term potential for large-wood recruitment.

Actions: By 2030, 10 miles of riparian buffer will be planted.	
Action 5.1	Restore riparian corridor on 0.4 miles of the Siletz River at three Lincoln County park properties – GIS 60
Action 5.2	Restore riparian corridor on 2.6 miles of Mill Creek – GIS 61
Action 5.3	Restore riparian corridor on 1 mile of Sam Creek – GIS 62
Action 5.4	Restore riparian corridor on 1.7 miles of Little Rock Creek – GIS 63
Action 5.5	Restore riparian corridor on 0.9 miles of Dewey Creek – GIS 64
Action 5.6	Restore riparian corridor on 3.2 miles of Big Rock Creek – GIS 65

2045 Outcome #6: All crossings on Coho-bearing streams will be evaluated and longitudinal connectivity will be restored in selected reaches with high-quality juvenile rearing habitat.

Actions: By 2030, the Siletz Partnership will inventory and address three known high-priority fish barriers.	
Action 6.1	Design and replace AOP at Anderson Creek (Drift Creek Road) – GIS 66
Action 6.2	Address concrete weir structure in NF Schooner Creek – GIS 71
Action 6.3	Address stream crossing on USFS road 1783 on NF Schooner Creek – GIS 72
Action 6.4	Inventory crossings on Coho-bearing streams to identify high-priority barriers

2045 Outcome #7: Through policy, outreach, or acquisitions, the long-term potential for the conservation and restoration of watershed processes is improved through the protection of 8,689 acres of selected timber stands throughout the Siletz Basin.

Actions: By 2030, the Siletz Partnership will support the acquisition of 6,182 acres of upland timber stands.	
Action 7.1	Provide long-term protection for up to 1,182 acres of upland forest in upper Drift Creek – GIS 76
Action 7.2	Provide long-term protection for 5,000 acres of upland forest in the Siletz River Gorge for future wood recruitment downstream – GIS 77

Riverine floodplain restoration project on the Yaquina River. Photo: MidCoast Watersheds Council

6.3 Schedule of Near-Term Restoration Projects by Focal Area

Table 6.1. Implementation schedule for near-term projects in the Siletz Bay sub-watersheds.

SILETZ BAY SUB-WATERSHEDS	RESTORATION PROJECT	WATERSHED	LEAD	Project Start		
				2026	27-28	29-30
SILETZ BAY SCHOONER CR. LOWER DRIFT UPPER DRIFT BEAR CR.	Siletz estuary LWD – GIS 2	Siletz Bay	CTSI	X		
	North Creek LWD – GIS 11	Lower Drift Cr.	USFS			X
	Wildcat Creek LWD – GIS 12	Lower Drift Cr.	USFS			X
	Skunk Creek LWD assessment – GIS 28	Bear Cr.	USFS		X	
	Bear Creek LWD assessment – GIS 29	Bear Cr.	USFS		X	
	Sampson Creek LWD assessment – GIS 30	Upper Drift Cr.	MCWC/LSWCD		X	
	North Creek LWD assessment – GIS 31	Lower Drift Cr.	MCWC/LSWCD		X	
	Restore 189 acres of floodplain and wetlands along the Siletz River – GIS 40	Bear Cr.	CTSI/MRT/ MCWC		X	
	Drift Creek estuary restoration – GIS 44	Drift Creek/ Siletz Bay	USFWS/ MCWC/ODFW	X		
	Protect 189 acres of floodplain and wetlands along the Siletz River – GIS 41	Bear Cr.	CTSI/MRT		X	
	Protect 42 acres of estuarine wetland adjacent to the Siletz Bay NWR – GIS 45	Siletz Bay	USFWS/MCWC	X		
	Reed Creek beaver habitat project – GIS 58	Bear Cr.	MCWC/CTSI		X	
	Address Anderson Cr. culvert – GIS 66	Lower Drift Cr.	Lincoln County/ MCWC		X	
	Address concrete weir structure in NF Schooner Creek – GIS 71	Schooner Cr.	USFS			X
	Address NF Schooner Cr. culvert – GIS 72	Schooner Cr.	USFS			X
	Protect 1,182 acres of upland forest– GIS 76 (not shown in map)	Upper Drift Cr.	USFS/Western Rivers Conservancy	X		

Figure 6.1. Near-term projects in the Siletz Bay sub-watersheds.

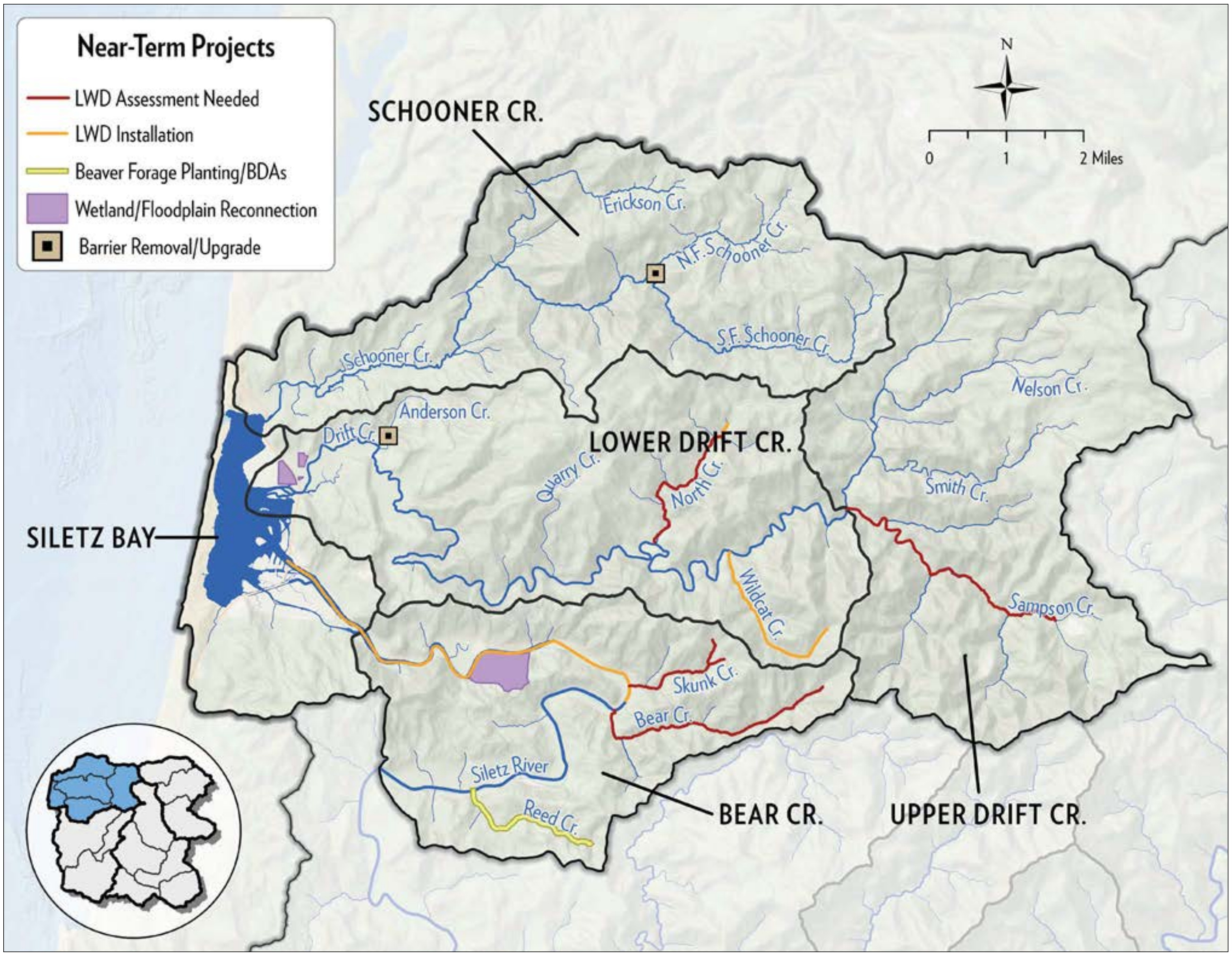


Table 6.2. Implementation schedule for near-term projects in the lower tributary sub-watersheds.

LOWER TRIBUTARY SUB-WATERSHEDS	RESTORATION PROJECT	WATERSHED	LEAD	Project Start		
				2026	27–28	29–30
CEDAR CR. EUCHRE CR. DEWEY CR.	Cedar Creek LWD – GIS 9	Cedar Cr.	CTSI/ MCWC		X	
	LWD in tributary to Cedar Creek – GIS 10	Cedar Cr.	USFS		X	
	Riparian restoration along 0.4 miles of Siletz at County park properties – GIS 60	Sunshine Cr.	LSWCD	X		
	Restore riparian corridor on 0.9 miles of Dewey Creek – GIS 64	Dewey Cr.	LSWCD		X	

Figure 6.2. Near-term projects in the lower tributary sub-watersheds.

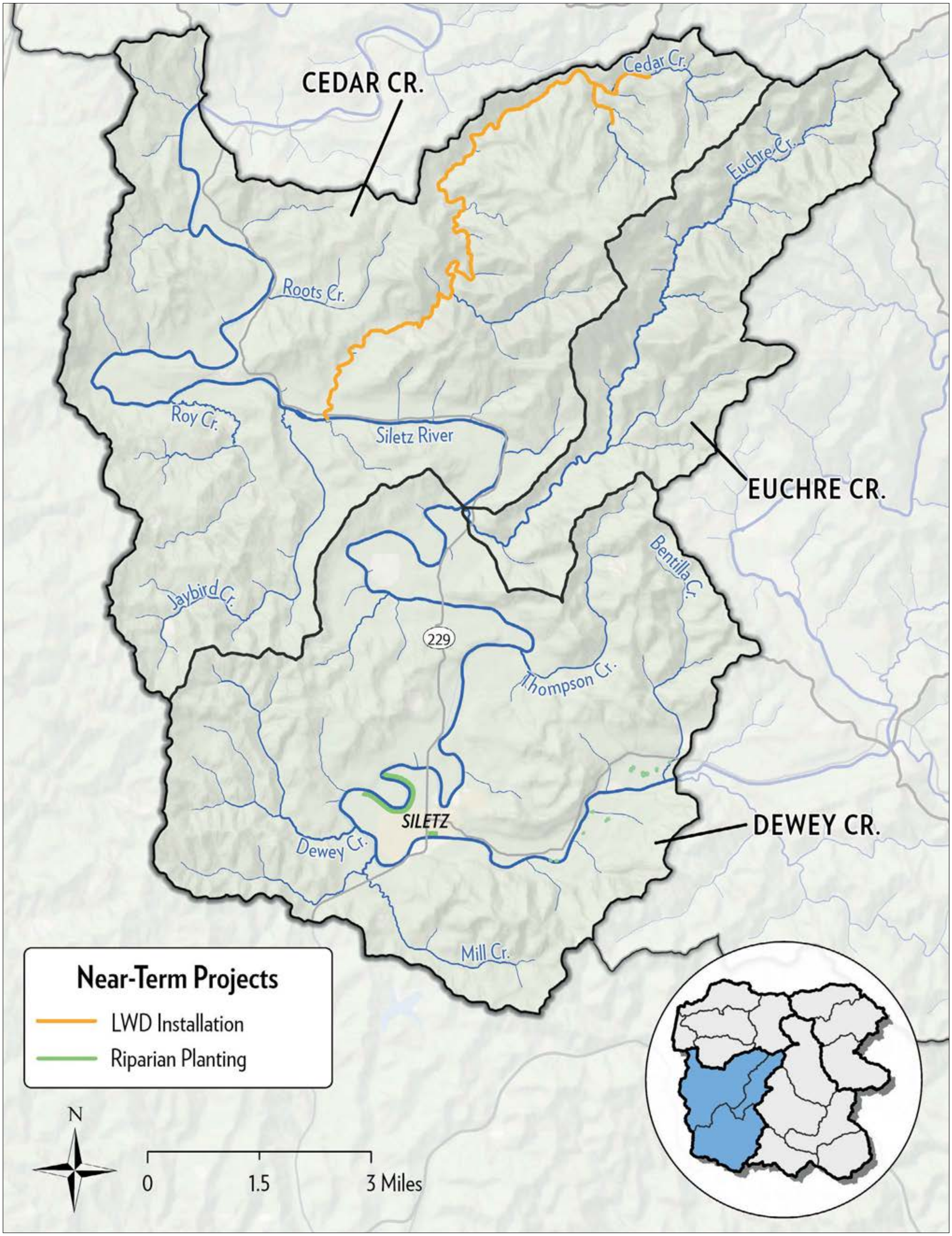
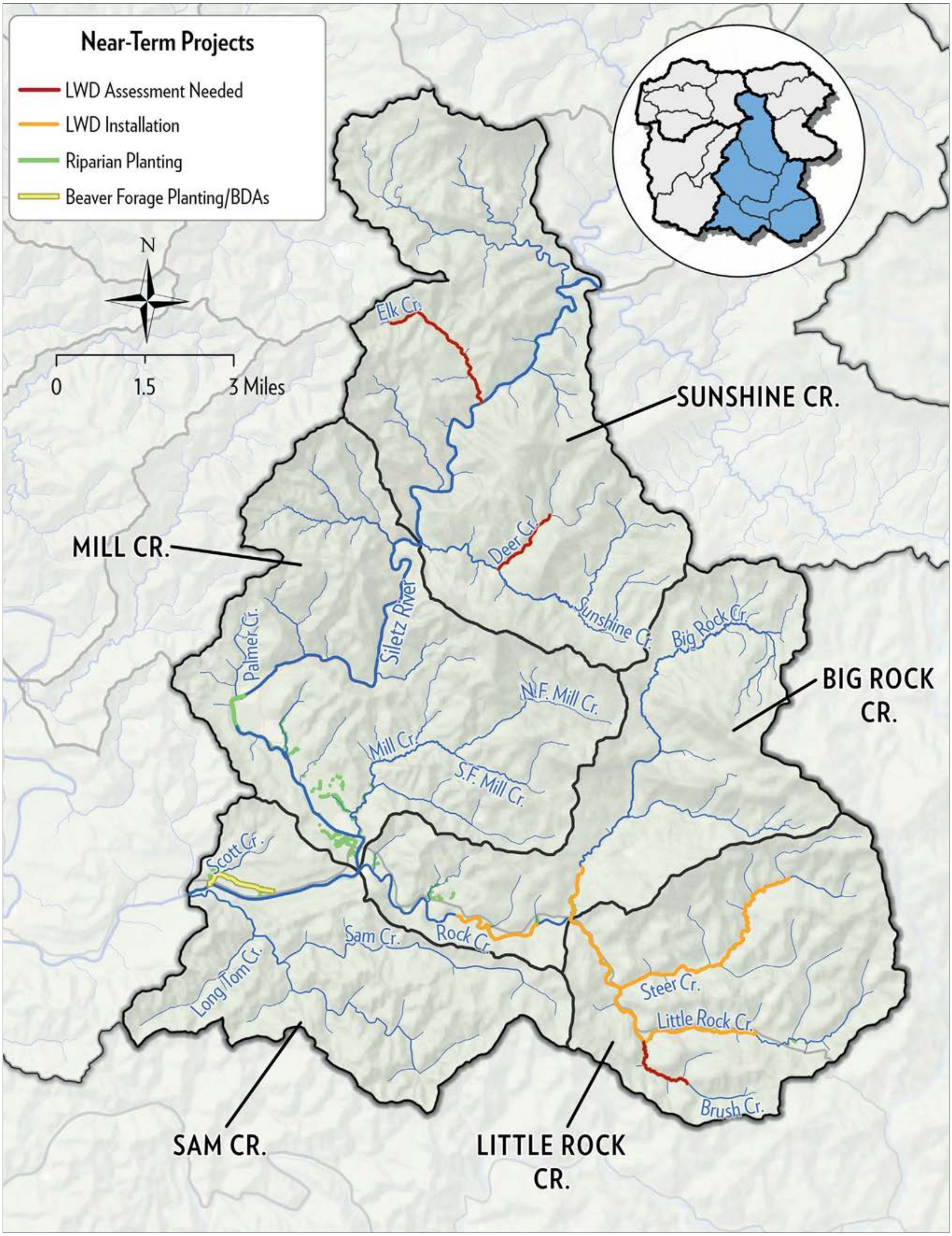


Table 6.3. Implementation schedule for near-term projects in the mid-tributary sub-watersheds.

MID-TRIBUTARY SUB-WATERSHEDS	RESTORATION PROJECT	WATERSHED	LEAD	Project Start		
				2026	27–28	29–30
SAM CR. MILL CR. SUNSHINE CR. BIG ROCK CR. LITTLE ROCK CR.	Rock Creek LWD – GIS 5	Rock Cr.	CTSI/ MCWC		X	
	Little Rock Creek LWD – GIS 7	Little Rock Cr.	CTSI/ MCWC		X	
	Lower Big Rock LWD – GIS 6	Rock Cr.	CTSI/ MCWC			X
	Steer Creek LWD – GIS 8	Little Rock Cr.	MCWC/LSWCD		X	
	Deer Creek LWD assessment – GIS 32	Sunshine Cr.	MCWC/LSWCD		X	
	Elk Creek LWD assessment – GIS 33	Sunshine Cr.	MCWC/LSWCD			X
	Brush Creek LWD assessment – GIS 34	Little Rock Cr.	MCWC/LSWCD		X	
	Beaver habitat project on Scott Creek – GIS 57	Sam Cr.	CTSI/ MCWC		X	
	Restore riparian corridor on 2.9 miles of Mill Creek – GIS 61	Mill Cr.	LSWCD			X
	Restore riparian corridor on 1 mile of Sam Creek – GIS 62	Sam Cr.	LSWCD		X	X
	Restore riparian corridor on 1.7 miles of Little Rock Creek – GIS 63	Little Rock Cr.	LSWCD		X	X
	Restore riparian corridor on 3.2 miles of Big Rock Creek – GIS 65	Big Rock Cr.	LSWCD		X	X

Figure 6.3. Near-term projects in the mid-tributary sub-watersheds.



Chapter 7

Costs

Costs for short-term projects were determined by the Siletz Partnership based on input from local partners who have been implementing this work in the Siletz Basin for over 25 years. Costs have increased dramatically since 2020, and these estimates incorporate the inflation partners are experiencing at the time of writing. Fortunately, project costs for LWD projects are lower in the Siletz Basin due to a high-functioning log salvage program, funded by OWEB and led by the Mid-Coast Watersheds Council. The MCWC works with private landowners, land developers, tree clearing contractors, local municipalities, and others to salvage logs for restoration that would otherwise be sent to a mill or used for firewood. This program provides 300–500 log pieces per year that are utilized in habitat projects by multiple partners. Some of the proposed projects are in “big water” systems, such as the mainstem or open water bay.

Project costs for recent work completed by CTSI informed estimates for similar project types. Tidal wetland restoration costs were informed by recent work within the Siletz estuary, but also in the nearby Salmon River estuary, Yaquina estuary, and Alsea estuary completed by partners from the Oregon Central Coast Estuary Collaborative. Acquisition costs are based on recent acquisitions by CTSI and the McKenzie River Trust in the central coast area, including upland stands, wetland areas, and other habitat types.

Confederated Tribes of Siletz Indians biologist Stan van de Wetering overseeing a restoration project on Tribal land. Photo: Holden Films

Table 7.1. Near-term project costs for Outcome 1: increased instream complexity (2026–2030).

Action	Project	Lead	Cost
Action 1.1	Add LWD to 6 miles of lower mainstem Siletz River estuary channels - GIS 2	CTSI/MCWC	$4,000,000
Action 1.2	Add LWD to 4 miles of Rock Creek - GIS 5	CTSI/MCWC	$1,000,000
Action 1.3	Add LWD to 6 miles of lower Big Rock Creek – GIS 6	CTSI/MCWC	$1,200,000
Action 1.4	Add LWD to 3.3 miles of Little Rock Creek - GIS 7	CTSI/MCWC	$900,000
Action 1.5	Add LWD to 4 miles of Steer Creek – GIS 8	CTSI/MCWC	$600,000
Action 1.6	Add LWD to 10 miles of Cedar Creek – GIS 9	CTSI/MCWC	$2,000,000
Action 1.7	Add LWD to 0.5 miles of tributary to Cedar Creek on USFS land – GIS 10	USFS	$125,500
Action 1.8	Add LWD to 0.4 miles of North Creek on USFS land – GIS 11	USFS	$100,000
Action 1.9	Add LWD to 2.4 miles of Wildcat Creek on USFS land – GIS 12	USFS	$600,000
Action 1.10	Complete an instream complexity and LWD assessment for 1.8 miles of Skunk Creek – GIS 28	USFS	$9,000
Action 1.11	Complete an instream complexity and LWD assessment for 3.4 miles of Bear Creek – GIS 29	USFS	$17,000
Action 1.12	Complete an instream complexity and LWD assessment for 4 miles of Sampson Creek – GIS 30	MCWC/LSWCD	$20,000
Action 1.13	Complete an instream complexity and LWD assessment for 2.3 miles of North Creek – GIS 31	MCWC/LSWCD	$12,000
Action 1.14	Complete an instream complexity and LWD assessment for 1.4 miles of Deer Creek – GIS 32	MCWC/LSWCD	$8,000
Action 1.15	Complete an instream complexity and LWD assessment for 4 miles of Elk Creek – GIS 33	MCWC/LSWCD	$15,000
Action 1.16	Complete an instream complexity and LWD assessment for 1.5 miles of Brush Creek – GIS 34	MCWC/LSWCD	$8,000
		TOTAL	**$10,614,000**

Table 7.2. Near-term project costs for Outcome 2: reconnected floodplains and wetlands (2026–2030).

Action	Project	Lead	Cost
Action 2.1	Restore 189 acres of floodplain and wetlands along the Siletz River in the Bear Creek watershed – GIS 40	CTSI/MRT/MCWC	$1,000,000
Action 2.2	Reconnect 42 acres on adjacent parcels to Siletz NWR tracts – GIS 44	USFWS/ MCWC/ ODFW	$1,000,000
		TOTAL	**$2,000,000**

Table 7.3. Near-term project costs for Outcome 3: Protection in perpetuity of floodplains and wetlands (2026–2030).

Action	Project	Lead	Cost
Action 3.1	Acquire 189 acres of floodplain and wetlands along the Siletz River in the Bear Creek watershed – GIS 41	CTSI/MRT/MCWC	$2,000,000
Action 3.2	Acquire 42 acres on adjacent parcels to Siletz NWR tracts – GIS 45	USFWS/ MCWC/ ODFW	$500,000
		TOTAL	**$2,500,000**

Table 7.4. Near-term project costs for Outcome 4: increased beaver habitat (2026–2030).

Action	Project	Lead	Cost
Action 4.1	Implement a beaver-focused habitat project on Scott Creek – GIS 57	CTSI/MCWC	$100,000
Action 4.2	Implement a beaver-focused habitat project on Reed Creek – GIS 58	MCWC/ CTSI	$200,000
Action 4.3	Ground-truth the Beaver Restoration Assessment Tool	MCWC	$20,000
		TOTAL	**$320,000**

Table 7.5. Near-term project costs for Outcome 5: enhanced riparian function (2026–2030).

Action	Project	Lead	Cost
Action 5.1	Restore riparian corridor on 0.4 miles of the Siletz River at three Lincoln County park properties	CTSI/MCWC	$70,000
Action 5.2	Restore riparian corridor on 2.9 miles of Mill Creek – GIS 61	MCWC/CTSI	$368,200
Action 5.3	Restore riparian corridor on 1 mile of Sam Creek – GIS 62	LSWCD	$112,000
Action 5.4	Restore riparian corridor on 1.7 of Little Rock Creek – GIS 63	LSWCD	$197,200
Action 5.5	Restore riparian corridor on 0.9 miles of Dewey Creek – GIS 64	LSWCD	$101,000
Action 5.6	Restore riparian corridor on 3.2 miles of Big Rock Creek – GIS 65	LSWCD	$366,000
		TOTAL	**$1,214,400**

MidCoast Watersheds Council native plant nursery. Photo: MidCoast Watersheds Council.

Table 7.6. Near-term project costs for Outcome 6: increased longitudinal connectivity (2026–2030).

Action	Project	Lead	Cost
Action 6.1	Design and replace AOP at Anderson Creek (Drift Creek Road) – GIS 66	Lincoln County/ MCWC	$2,500,000
Action 6.2	Address concrete weir structure in NF Schooner Creek – GIS 71	MCWC/CTSI	$750,000
Action 6.3	Address stream crossing on USFS road 1783 on NF Schooner Creek – GIS 72	LSWCD	$250,000
Action 6.4	Inventory crossings on Coho-bearing streams to identify high-priority barriers	LSWCD	$30,000
		TOTAL	**$3,530,000**

Table 7.7. Near-term project costs for Outcome 7: upland stands to protect (2026–2030).

Action	Project	Lead	Cost
Action 7.1	Provide long-term protection for up to 1,182 acres of upland forest in upper Drift Creek – GIS 76	USFS, Western Rivers Conservancy	$13,000,000
Action 7.2	Provide long-term protection for 5,000 acres of upland forest in the Siletz River Gorge for future wood recruitment downstream – GIS 77	ODFW	$20,000,000
		TOTAL	**$33,000,000**

Coho smolts. Photo: Brian Kelley

Table 7-8. Near-term project objectives and costs by outcome.

	Long-Term Outcomes (2045)	Near-Term Objectives (2026–2030)	Near-Term Costs
1	Floodplain-channel interaction and instream complexity are increased through the addition of LWD in 78 miles of mainstem systems, tributaries, and sloughs. An additional 23 miles of instream assessments will be conducted to increase potential restoration mileage.	• Add LWD to 36.5 miles of priority streams and conduct 18.4 miles of instream assess-ments	$10,614,000
2	Rearing opportunities are increased in 1,123 acres of floodplains and wetlands through the restoration of hydrologic regimes, fish access, and ecologically appropriate native plant communities in freshwater and brackish systems.	• Complete 231 acres of floodplain and wetland restoration projects	$2,000,000
4	Slow-water habitats and beaver-favored forage are re-established along 22 miles of tributary streams.	• Implement 4 miles of beaver habitat projects • Ground-truth the Beaver Restoration Action Tool model	$320,000
5	Riparian function is enhanced along 40 miles of the Siletz River and its tributaries, reducing stream temperatures and erosion and increasing macro-invertebrate abundance and long-term potential for large-wood recruitment.	• Plant 10 miles of prioritized riparian habitat	$1,214,400
6	All crossings on Coho-bearing streams will be evaluated and longitudinal connectivity will be restored in selected reaches with high-quality juvenile rearing habitat.	• Inventory crossings on Coho-bearing streams • Address three high-priority fish barriers	$3,530,000
Total Cost of SAP Restoration Implementation (2026–2030)			**$17,678,400**
3	The long-term protection of 847 acres of freshwater and tidal wetlands and floodplains will be obtained through a series of voluntary acquisitions.	• Protect 231 acres of floodplains and wetlands through conservation acquisitions	$2,500,000
7	Through policy, outreach, or acquisitions, the long-term potential for the conservation and restoration of watershed processes is improved through the protection of 8,689 acres of selected timber stands throughout the Siletz Basin.	• Support two acquisitions totalling 6,182 acres of upland forests	$33,000,000
Total Cost of SAP Conservation Acquisitions (2026–2030)			**$35,500,000**

Chapter 8

Evaluation and Adaptive Management

The Siletz Partnership recognizes that an adaptive management approach is essential to the long-term success of this plan. In essence, this Strategic Action Plan is the beginning of the adaptive management process for the Siletz Basin. Chapter 5 describes the protection and restoration strategies that the Partnership will implement over the long term and the locations where the strategies can generate the greatest benefits based on the analyses described in Chapter 4. Chapter 6 then provides a short-term work plan, identifying the projects selected for implementation in key locations within the next five years because of their ability to meet the science-based priorities described in Chapter 5 and their readiness for implementation. These pieces provide the focus for the Monitoring Framework outlined here in Section 8.1. The partners will use this Monitoring Framework to evaluate: 1) the rate at which the SAP is being implemented, and 2) whether implementation is generating the anticipated benefits. The chapter concludes by identifying the critical data gaps, in Section 8.2, that will frame future monitoring efforts and support the adaptive implementation of this plan.

8.1 The Monitoring Framework

Tables 8.1 through 8.6 present the Monitoring Framework for the Siletz Partnership to monitor SAP implementation and effectiveness. This framework is built around the SAP's seven outcomes and organized to evaluate quantifiable Key Ecological Attributes (KEAs) and indicators to assess effectiveness based on these specific outcomes and targets. The tables define the two types of monitoring, implementation monitoring and effectiveness monitoring, that should be conducted:

- **Implementation monitoring** seeks to assess the rate at which the SAP is being implemented. The columns on the left side of the goal statement list priority project locations and project tracking metrics that partners can use to evaluate the degree to which SAP implementation is occurring. Broadly, these metrics are intended to answer the question, "Is the SAP being implemented at the desired pace and scale?"
- **Effectiveness monitoring** aims to assess whether SAP implementation is producing the desired benefits. In Tables 8-1 through 8-6, the columns to the right of the goal statements show: 1) the KEAs that partners seek to improve for a particular habitat component; 2) the indicator(s) used to assess the KEA; and 3) the partner(s) responsible for the monitoring. Evaluating these KEAs using the selected indicators helps answer the question, "Are we moving toward our stated goals and desired outcomes?"

Many of the KEAs and indicators presented in the following tables were derived from the larger common framework but represent only those deemed by the SAP Planning Team as the highest priorities and most likely to reflect improving (or declining) watershed conditions for Coho. For a complete list of KEAs and indicators considered in this process, please refer to the "Common Framework" in Appendix 3. The Partnership has chosen to focus on KEAs rather than direct fish responses, as fish monitoring can be costly, time consuming, and difficult to determine casual relationships and trends. In-depth juvenile Coho monitoring programs have been and are being implemented elsewhere on the Oregon Coast (i.e., the Salmon, Coos, and Coquille watersheds). These findings will be incorporated into future adaptive management decisions.

The monitoring framework will support the development of a full monitoring plan for the Siletz, which will require significant resource investments. Currently, the Siletz Partnership's capacity to apply the Monitoring Framework below is limited. Consequently, the purpose of this chapter is not to present a full monitoring plan but to suggest a framework that aligns with SAP goals and can be selectively developed and implemented over time. The Siletz Partnership recognizes the considerable limitations on funding now available for monitoring and will develop specific plans for each of the KEAs as priorities dictate and funds allow. Some discrete project-by-project monitoring can be funded through implementation grants. The subsequent challenge for the Partnership will be securing funding to develop a holistic data management and analysis framework for basin-wide monitoring across multiple projects.

Summer temperature monitoring on the mainstem Siletz. Photo: MidCoast Watersheds Council

The Partnership also recognizes the magnitude of the challenge faced in detecting habitat responses at the sub-watershed scale from implementing actions contained in this SAP. As stated in the Oregon Coast Coho Conservation Plan (ODFW 2007), "restoration of ecological processes that support high-quality habitat requires time and is constrained by patchwork land ownership patterns, different regulatory structures, and historical land use practices. Even given an expected increase in the level of non-regulatory participation in habitat improvement work, it will take time to 1) produce detectable improvements in habitat quality, and 2) restore the biological and ecological processes across the ESU." This Monitoring Framework will serve as a blueprint that local partners can use to build incremental and scalable monitoring plans that track both SAP implementation and progress toward its goals.

SILETZ PARTNERSHIP TOP MONITORING PRIORITIES	
1	Water temperature and identification of cold water refugia
2	Effectiveness monitoring of large-wood placements
3	Strontium isotope monitoring of otoliths to better understand life history diversity

Table 8.1. Implementation and effectiveness of monitoring for long-term Outcome 1: increased instream complexity.

SAP Monitoring Framework				
Implementation Monitoring – *Is the SAP being implemented?*		**Effectiveness Monitoring –** *Is SAP implementation having the intended effects? Are we moving toward our goals?*		
Implementation Metric	***SAP 2045 OUTCOMES***	**Key Ecological Attribute (component)**	**Effectiveness Indicator (preferred in bold)**	**Locations to Monitor & Notes**
• Miles of priority habitats treated with LWD • Miles of river bank restored or enhanced • Miles of river with stream-floodplain interaction restored • Number of instream complexity and LWD assessments completed	**2045 Outcome #1** *Floodplain-channel interaction and instream complexity are increased through the addition of LWD in 78 miles of mainstem systems, tributaries, and sloughs. An additional 23 miles of instream assessments will be conducted to increase potential restoration mileage.*	Instream complexity (tributary and mainstem)	• **Amount of large wood remaining in rivers and streams meets NOAA's requirements for wood/ miles and is effectively increasing complexity and high-quality habitat** • % of treated priority habitats with improving width: depth ratio (use AQI protocol)[1, 2]	Focus monitoring at mainstem and open water bay locations to assess effectiveness

[1] Siletz Monitoring Framework included the following list of AQI metrics

- Miles of high-quality habitat: produce 2,800 smolts/mile
- % stream reach that is pool habitat
- % of stream reach that is slack water pool habitat
- % pools greater than 1 meter in depth
- # of wood pieces per 100m of stream
- # of key wood pieces (>12m long, 0.60 m dbh)
- Volume of LWD per 100 m
- # alcoves per reach

[2] Entrenchment indicator references:

- Aquatic and Riparian Effectiveness Monitoring Program (AREMP) Staff. 2005. Watershed Monitoring for the Northwest Forest Plan, Data Summary Interpretation 2005, Oregon/Washington Coast Province. USDA Forest Service, Pacific Northwest Regional Office; Bureau of Land Management, Oregon State Office; 4077 S.W. Research Way, Corvallis, OR 97333.
- EPA Watershed Academy. 2005. Fundamentals of the Rosgen Stream Classification System; Excerpts of copyrighted material used with permission from Rosgen, D.L. and H.L. Silvey. 1996. Applied River Morphology. Wildland Hydrology Books, Fort Collins, CO. http://www.epa.gov/watertrain/stream_class/index.htm

Table 8.2. Implementation and effectiveness monitoring for long-term Outcomes 2 & 3: floodplain and wetland restoration and long-term protection.

SAP Monitoring Framework				
Implementation Monitoring – *Is the SAP being implemented?*		**Effectiveness Monitoring –** *Is SAP implementation having the intended effects? Are we moving toward our goals?*		
Implementation Metric	***SAP 2045 OUTCOMES***	**Key Ecological Attribute (component)**	**Effectiveness Indicator (preferred in bold)**	**Locations to Monitor & Notes**
• Acres of floodplains, side channels, and wetlands restored, created, or reconnected	**2045 Outcome #2** *Rearing opportunities are increased in 1,123 acres of floodplains and wetlands through the restoration of hydrologic regimes, fish access, and ecologically appropriate native plant communities in freshwater and brackish systems.*	Lateral connectivity	• Acres of wetlands relative to historic condition • % of wetlands subject to disrupted hydrological condition • **Acres of tidal wetland permanently reconnected**	Review/conduct aerial surveys for lowland areas on the Siletz River main-stem and estuary
• Acres of floodplains and wetlands in long-term protection	**2045 Outcome #3** *The long-term protection of 847 acres of freshwater and tidal wetlands and floodplains will be obtained through a series of voluntary acquisitions.*			

Table 8.3. Implementation and effectiveness monitoring for long-term Outcome 4: increased beaver habitat.

SAP Monitoring Framework				
Implementation Monitoring – *Is the SAP being implemented?*		**Effectiveness Monitoring –** *Is SAP implementation having the intended effects? Are we moving toward our goals?*		
Implementation Metric	***SAP 2045 OUTCOMES***	**Key Ecological Attribute (component)**	**Effectiveness Indicator (preferred in bold)**	**Locations to Monitor & Notes**
• Miles of stream where beaver dam analogues or dam-building actions to support beaver are completed • Miles of stream where beaver-favored forage has been increased • Areas ground-truthed with Beaver Restoration Action Tool to prioritize watersheds	**2045 Outcome #4** *Slow-water habitats and beaver-favored forage are re-established along 22 miles of tributary streams.*	Beaver impoundment persistence	• % of areas identified as "high potential for beaver" that have beaver impoundments present • **% of LWD and riparian projects that have beaver present**	Monitor for presence/absence and count impoundments in tributaries Focus on Reed and Scott creeks where restoration is being implemented

Table 8.4. Implementation and effectiveness monitoring for long-term Outcome 5: enhanced riparian function.

SAP Monitoring Framework				
Implementation Monitoring – *Is the SAP being implemented?*		**Effectiveness Monitoring –** *Is SAP implementation having the intended effects? Are we moving toward our goals?*		
Implementation Metric	***SAP 2045 OUTCOMES***	**Key Ecological Attribute (component)**	**Effectiveness Indicator (preferred in bold)**	**Locations to Monitor & Notes**
• Miles of riparian buffers enhanced	**2045 Outcome #5** *Riparian function is enhanced along 40 miles of the Siletz River and its tributaries, reducing stream temperatures and erosion and increasing macro-invertebrate abundance and long-term potential for large-wood recruitment.*	Riparian function	• Statistically significant reduction in baseline temperatures in late summer • Plant mortality	Longitudinal temperature or FLIR monitoring of mainstem to identify cold water refugia, thermal barriers, and lethal areas Conduct a Streamside Vegetation Assessment in 10 & 20 years

Table 8.5. Implementation and effectiveness monitoring for long-term Outcome 6: longitudinal connectivity restored.

SAP Monitoring Framework				
Implementation Monitoring – *Is the SAP being implemented?*		**Effectiveness Monitoring –** *Is SAP implementation having the intended effects? Are we moving toward our goals?*		
Implementation Metric	***SAP 2045 OUTCOMES***	**Key Ecological Attribute (component)**	**Effectiveness Indicator (preferred in bold)**	**Locations to Monitor & Notes**
• Miles of longitudinal connection enhanced/ restored	**2045 Outcome #6** *All crossings on Coho-bearing streams will be evaluated and longitudinal connectivity will be restored in selected reaches with high quality juvenile rearing habitat.*	Longitudinal connectivity	• Coho presence/absence above pre-project baseline	Inventory during summer low water and winter high water events to capture different types of velocity and access barriers Note presence/absence of juveniles

Table 8.6. Implementation and effectiveness monitoring for long-term Outcome 7: upland stands protected.

SAP Monitoring Framework				
Implementation Monitoring – *Is the SAP being implemented?*		**Effectiveness Monitoring –** *Is SAP implementation having the intended effects? Are we moving toward our goals?*		
Implementation Metric	***SAP 2045 OUTCOMES***	**Key Ecological Attribute (component)**	**Effectiveness Indicator (preferred in bold)**	**Locations to Monitor & Notes**
• Acres under easement or protection	**2045 Outcome #7** *Through policy, outreach, or acquisitions, the long-term potential for the conservation and restoration of watershed processes is improved through the protection of 8,689 acres of selected timber stands throughout the Siletz Basin.*	Landscape array of structural diversity	• Amount of large wood available to be recruited to rivers and streams through watershed processes **• % of steep slopes in long-term protection**	Evaluate opportunities within the Drift Creek watershed and Siletz Gorge

8.2 Information Gaps

While developing this SAP, the planning team identified three primary information gaps that the Siletz Partnership will work to close through the development and implementation of future monitoring plans.

1) Life history diversity. This SAP focuses on restoring a network of connected and diverse habitats from upstream spawning tributaries into the estuary to rebuild and sustain the full portfolio of life history types present in the Siletz watershed. Currently, little is known about the movement of juvenile Coho within and between freshwater and estuarine habitats in the Siletz. An individual's physiological state, coupled with the environmental conditions experienced, is hypothesized to influence migration and other key life history decisions; however, more information is needed to understand the current or historical contributions of each life history strategy and the extent to which additional life histories are recruited in the basin as a result of improved habitat quality, quantity and connectivity.

The plan recommends restoration strategies that promote the vital life history diversity in the basin so the Coho population can persist in rapidly changing watershed conditions posed by climate change. These strategies increase and restore rearing habitats to support those Coho fry and parr that move to off-channel areas, estuarine reaches, and other non-natal habitats. They also call for research and monitoring to gain a better understanding of the prominent life history strategies followed by Coho in the Siletz Basin by examining temporal and spatial habitat usage (i.e., freshwater vs. estuarine vs. marine), which will allow the Siletz Partnership to focus and refine their efforts to best improve life history diversity by restoring critical habitats to support them. Currently, the Coast Coho Partnership and watershed partners on the south and mid-coasts are seeking funding to collect and analyze water samples and otoliths (ear bones) from Coho carcasses to measure strontium isotopes. This information, combined with adult return and habitat data, will provide a better understanding of the Coho population's life histories and adaptive capacity, and the most effective opportunities to promote population resilience and abundance.

Coastal Coho juveniles. Photo: John McMillan

2) Cold water refugia and water temperatures. Temperature data reviewed in the development of the SAP indicate that elevated water temperatures in the mainstem Siletz and the lower reaches of some tributaries limit juvenile movement and rearing to support alternative life histories. The impacts of climate change are exacerbating this problem. Summer now arrives earlier and stays longer, causing low flows and elevated water temperatures to persist for more extended periods.

During warm summer months, the pockets of cold water in tributaries connected to the mainstem provide critical relief for juvenile Coho seeking refuge from the lower mainstem water temperatures. Flows released from these cold water sites also feed into downstream reaches and reduce water temperatures that could restrict movement between different mainstem and tributary habitats. Additional data is needed to identify the existing cold water refugia locations in the watershed. Data is also needed to understand where water temperatures restrict the use of priority habitats and movement between habitats, and to target the SAP's restoration strategies (e.g., riparian enhancement, instream complexity restoration, and fish passage reconnection) to address the temperature concerns and promote life history diversity to safeguard the population into the future. Localized data combined with ODFW's cold water refugia model described in Strategy 2.b will inform future restoration and conservation efforts. After this information

STANDARD WATER QUALITY MONITORING PARAMETERS
Temperature
Dissolved oxygen
pH
Fecal bacteria
Fine sediment

becomes available, the Partnership will update the near-term project list to reflect newly realized opportunities to protect and enhance cold water refugia.

3) **Water quality.** In addition to better understanding water temperatures, there are a myriad of other factors that can impact salmonids having cold, clean water available in their habitats. Increased dissolved oxygen, bacteria loading, and sediment input are just some of the parameters that negatively affect summer rearing habitat.

There are over 40 monitoring stations in the Siletz River Basin with different types of data from multiple organizations. Many stations have limited data (e.g., used for one sampling event), whereas others are established sites used multiple times. Most stations with continuous data have extensive time series data for a specific period, but are limited to temperature and possibly dissolved oxygen. ODEQ maintains one longer-term bimonthly ambient water quality monitoring station on the Siletz River at Ojalla Bridge. A consistent record exists from 1993 to present. Aside from continuous temperature, the available data between 2001 and 2016 are mostly limited to small sample sizes at individual stations, with larger datasets recorded for turbidity and sediment by CTSI, ORDEQ, and LSWCD for certain stations. In 2017, partners completed additional data collection for total nitrogen, total phosphorus, and dissolved oxygen. In 2024, the Lincoln SWCD restarted monthly grab sample collection and deployed dissolved oxygen and temperature loggers at five stations from May to October.

While there are a number of partners, such as LSWCD, ORDEQ, and CTSI, who are committed to collecting water quality data, evaluating current water quality status at multiple locations across a large geographic area is challenging. The information and level of detail and thoroughness varies greatly, which affects the ability to understand water quality trends across the Siletz Basin. Available data typically fall into seven categories.

CATEGORIES OF AVAILABLE WATER QUALITY MONITORING
Monitoring has not been performed for some or all standard water quality parameters
Limited monitoring has been performed, but the data is at least 5 years old
Monitoring has not been performed for factors associated with dissolved oxygen levels (i.e., nutrients, organic matter, etc.)
Monitoring has not been performed for biological indicators (macro-invertebrate condition or algal indicators)
Watershed scale information on patterns of nutrient, organic matter, and fine sediment loading during wet season precipitation (“event loading”) vs dry flows (“background loads”)
Monitoring has not been performed for toxic, persistent, and/or bioaccumulative compounds
Lack of specific information on the contribution of certain pathways for pollutant transport to surface water (i.e., direct deposition, surface runoff, or connectivity with shallow groundwater)

In considering the breadth of available water quality data for the Siletz River Basin, it is important to note that data hosted on ORDEQ’s Ambient Water Quality Monitoring System (AMQMS – Oregon’s primary water quality data hub) does not encompass all data that has been collected. Several agencies and organizations known to have conducted monitoring in the watershed may lack the resources needed to complete the extensive QA/QC process required for data to be submitted to ORDEQ and determined fit to be uploaded into AWQMS. Due to these factors, it is possible that a somewhat more complete picture of baseline water quality could be painted for the Siletz watershed with data that has been collected, but not fully processed.

Chapter 9

Sustainability

The restoration strategies identified in this SAP aim to enhance watershed processes in the Siletz Basin, supporting a full range of Coho life history types that will allow the fish to survive and thrive for years to come. The Siletz Partnership is confident that the results of our cumulative efforts will be sustained over time through the slow but steady improvement of watershed function. The functional benefits resulting from adding LWD, reconnecting floodplains and wetlands, and promoting beaver recruitment, for example, will increase channel-floodplain interaction, providing greater habitat complexity and off-channel rearing for Coho in winter, while also elevating the water table and establishing more instream and off-channel temperature refugia in summer. As more and more habitats are enhanced through LWD installation, riparian enhancement, beaver colonization, and selected barrier replacements, we are confident that the hydrologic, geomorphic, riparian, and biological processes that generate and maintain critical Coho habitats will improve at scales beyond just the reach at which each project was implemented. Once these benefits can be realized at scale, much of our work can be sustained naturally, with minimal future intervention.

Restoring watershed function and processes is at the core of the Siletz Partnership's long-term approach to sustaining the benefits of SAP implementation. Ultimately, the goal of restoring function can only be achieved if local partners are coordinated and have sufficient capacity to sustain on-the-ground project implementation year after year. Core partners in the SAP's implementation include: MidCoast Watersheds Council, the Confederated Tribes of the Siletz Indians, Lincoln Soil and Water Conservation District, Natural Resources Conservation Service, Oregon Department of Fish and Wildlife, Oregon Coast National Wildlife Refuge Complex, and the McKenzie River Trust. It is inevitable that capacity and staffing for these groups will wax and wane over the lifespan of SAP implementation. However, most of these groups have worked together for over 20 years already, picking up the slack for each other in times of need. This SAP is expected to further strengthen these already strong partnerships.

Updating the SAP

The MCWC convened the team to develop this SAP and will serve as the long-term steward of the plan. The board of this organization will receive regular updates on project implementation. All partner organizations will also be reminded to update their boards and members on progress regularly. The council will also continually update the public on SAP implementation through outreach to print media, social media posts on their Facebook accounts, annual reports to boards of county commissioners, and ongoing outreach to numerous local agencies and organizations.

Finally, ensuring adaptive management of the plan will be a critical function of the council. The monitoring framework in Chapter 8 will, if funded, generate a steady stream of data that can be used to evaluate SAP implementation and refine priorities.

Coho jack. Photo: Seth Mead

References

1. Anthony, J., Huff, J., & Claire, C. 2022. Lower Coquille Tide Gate and Fish Passage Monitoring Project, 2021-2022.
2. Atlas, W. I., Ban, N. C., Moore, J. W., Tuohy, A. M., Greening, S., Reid, A. J., ... & Connors, K. 2021. Indigenous Systems of Management for Culturally and Ecologically Resilient Pacific Salmon (*Oncorhynchus spp.*) Fisheries. BioScience, 71(2), pp.186-204.
3. Beechie, T., Imaki, H., Greene, J., Wade, A., Wu, H., Pess, G., Roni, P., Kimball, J., Stanford, J., Kiffney, P. & Mantua, N. 2013. Restoring Salmon Habitat for a Changing Climate. River Research and Applications, 29(8), pp.939-960.
4. Bisson, P. A., Dunham, J. B., & Reeves, G. H. 2009. Freshwater Ecosystems and Resilience of Pacific Salmon: Habitat Management Based on Natural Variability. Ecology and Society, 14(1). https://www.jstor.org/stable/26268060
5. Bourret, S. L., Caudill, C. C., & Keefer, M. L. 2016. Diversity of Juvenile Chinook Salmon Life History Pathways. Reviews in Fish Biology and Fisheries, 26(3), pp.375–403. https://doi.org/10.1007/s11160-016-9432-3
6. Bottom, D. L., Jones K. K., Cornwell T. J., Gray A., & Simenstad C. A. 2005. Patterns of Chinook Salmon Migration and Residency in the Salmon River Estuary (Oregon). Estuarine, Coastal and Shelf Science, 64, pp.79-93.
7. Brophy, L.S., & Ewald M. J. Tidal Wetland Landward Migration Zones for 4.7 Ft Sea Level Rise for the Siletz Bay Estuary. 2017. Siletz River Estuary, Oregon, United States, (Hydrographic): MidCoast Watersheds Council.
8. Chapman, D. W. 1962. Aggressive Behavior in Juvenile Coho Salmon as a Cause of Emigration. Journal of the Fisheries Research Board of Canada, 19(6), pp.1047–1080. https://doi.org/10.1139/f62-069
9. Clemens, B. J., & Schreck, C. B. 2021. An Assessment of Terminology for Intraspecific Diversity in Fishes, with a Focus on "Ecotypes" and "Life Histories." Ecology and Evolution, 11(16), pp.10772-10793.
10. Craig, B. E., Simenstad, C. A., & Bottom, D. L. 2014. Rearing in Natural and Recovering Tidal Wetlands Enhances Growth and Life-history Diversity of Columbia Estuary Tributary Coho Salmon (*Oncorhynchus kisutch*) Population: Life Histories of Columbia River Oncorhynchus kisutch. Journal of Fish Biology, 85(1), pp.31–51. https://doi.org/10.1111/jfb.12433
11. Crozier, L.G., McClure, M.M., Beechie, T., Bograd, S.J., Boughton, D.A., & Carr, M. 2019. Climate Vulnerability Assessment for Pacific Salmon and Steelhead in the California Current Large Marine Ecosystem. PLoS ONE, 14(7). doi.org/10.1371/journal.pone.0217711
12. Dalton, M. M., & Fleishman, E. 2021. Fifth Oregon Climate Assessment.
13. Ebersole, J.L., Wigington P.J., Baker, J.P., Cairns, M.A., Church, M.R., Compton, E., Leibowitz, S.G., Miller, B., & Hansen, B. 2006. Juvenile Coho Salmon Growth and Survival Across Stream Network Seasonal Habitats. Transactions of the American Fisheries Society, 135, pp.1681–1697. doi.org/101577/T05-144.1
14. Ebersole, J.L., Colvin, M.E., Wigington, P.J., Leibowitz, S.G., Baker, J.P., Church, M.R., Compton, J.E., & Cairns, M.A. 2009. Hierarchical Modeling of Late-summer Weight and Summer Abundance of Juvenile Coho Salmon Across a Stream Network. Transactions of the American Fisheries Society, 138, pp.1138-1156. doi.org/10.1577/T07-245.1
15. Gallagher, S.P., Thompson, S. & Wright, D.W. 2012. Identifying Factors Limiting Coho Salmon to Inform Stream Restoration in Coastal Northern California. California Fish and Game, 98, pp.185-201.
16. Helfield, J.M. & Naiman, R.J. 2001. Effects of Salmon-Derived Nitrogen on Riparian Forest Growth and Implications for Stream Productivity. Ecology, 82(9), pp. 2403-2409.
17. Hoem, N., Rosenberger, T.D., Zimmerman, A.E., Walker, C.E., & Baird, S.J. 2013. Estuarine Environments as Rearing Habitats for Juvenile Coho Salmon in Contrasting South-Central Alaska Watersheds. Transactions of the American Fisheries Society, 142(6), pp.1481–1494. https://doi.org/10.1080/00028487.2013.815660

18. IPCC (Intergovernmental Panel on Climate Change). 2007. Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Metz, B., Davidson, O.R., Bosch, P.R., Dave, R. and Meyer, L.A. (eds.) Cambridge University Press, Cambridge, UK. https://archive.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4_wg3_full_report.pdf

19. IPCC. 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. [Core Writing Team, Pachauri, R.K. & Meyer, L.A. (eds.)]. Geneva, Switzerland. https://www.ipcc.ch/site/assets/uploads/2018/05/SYR_AR5_FINAL_full_wcover.pdf

20. Jiang, L.Q., Carter, B.R., Feely, R.A., Lauvset, S.K. & Olsen, A. 2019. Surface Ocean pH and Buffer Capacity: Past, Present and Future. *Scientific Reports*, 9:18624. doi.org/10.1038/s41598-019-55039-4

21. Jones, K.K., Cornwell, T.J., Bottom, D.L., Campbell, L.A., & Stein, S. 2014. The Contribution of Estuary-resident Life Histories to the Return of Adult *Onchorhynchus kisutch*. Journal of Fish Biology. April 2014.

22. Jones, K.K., Cornwell, T.J., Bottom, D.L., Campbell, L.A., Stein, S., & Anlauf-Dunn, K.J. 2018 Population Viability Improves Following Termination of Coho Salmon Hatchery Releases. North American Journal of Fisheries Management, 38(1), February 2018. https://doi.org/10.1002/nafm.10029

23. Jones, K.K., Cornwell, T.J., Bottom, D.L., Stein, S., & Starcevich, S. 2021. Interannual Variability in Life-stage Specific Survival and Life History Diversity of Coho Salmon in a Coastal Oregon Basin. Canadian Journal of Fisheries and Aquatic Sciences, 78(12), pp.1887–1899. https://doi.org/10.1139/cjfas-2020-0306

24. Jordan, C. E., & Fairfax, E. 2022. Beaver: The North American Freshwater Climate Action Plan. WIREs Water, 9(4), e1592. https://doi.org/10.1002/wat2.1592

25. Kavanagh, P., Jones, K., Stein, C., & Jacobsen, P. 2005. Fish Habitat Assessment in the Oregon Department of Forestry Upper Nehalem and Clatskanie Study Area. Corvallis, OR: Oregon Department of Fish and Wildlife

26. Koski, K V. 2009. The fate of Coho Salmon nomads: the story of an estuarine-rearing strategy promoting resilience. Ecology and Society 14(1): 4. http://www.ecologyandsociety.org/vol14/iss1/art4/

27. Lawson, P.W., Logerwell, E.A, Mantua, N.J., Francis, R.C., & Agostini, V.N. 2004. Environmental Factors Influencing Freshwater Survival and Smolt Production in Pacific Northwest Coho Salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences, 61, pp.360-373. doi.org/10.1139/f04-003

28. Lawson, P.W., Bjorkstedt, E.P., Chilcote, M.W., Huntington, C.W., Mills, J.S., Moore, K.M.S., Nickelson, T.E., Reeves, G.H., Stout, H.A., Wainwright, T.C., & Weitkamp, L.A. 2007. Identification of Historical Populations of Coho Salmon (*Oncorhynchus kisutch*) in the Oregon Coast Evolutionarily Significant Unit. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-79, p.129

29. Leibowitz, S.G., Comeleo, R.L., Wigington, P.J., Weaver, C.P., Morefield, P.W., Sproles, E.A., & Ebersole, J.K. 2014. Hydrologic Landscape Classification Evaluates Streamflow Vulnerability to Climate Change in Oregon, USA, Hydrol. Earth Syst. Sci., 18, pp.3367–3392, https://doi.org/10.5194/hess-18-3367-2014.

30. Meengs, C.C. & Lackey, R.T. 2005. Estimating the Size of Historical Oregon Salmon Runs. Reviews in Fisheries Science. 13(1), pp.51-66.

31. Merz, J.E. & Moyle, P.B. 2006. Salmon, Wildlife, and Wine: Marine-derived Nutrients in Human-dominated Ecosystems of Central California. June 2006. https://doi.org/10.1890/1051-0761(2006)016[0999:SWAWMN]2.0.CO;2

32. Miller, R.R. 2010. Is the Past Present? Historical Splash-dam Mapping and Stream Disturbance Detection in the Oregon Coastal Province. Master of Science Thesis. Department of Fisheries Science. Oregon State University. Corvallis, Oregon.

33. Miller, B.A., & Sadro, S. 2003. Residence Time and Seasonal Movements of Juvenile Coho Salmon in the Ecotone and Lower Estuary of Winchester Creek, South Slough, Oregon. Transactions of the American Fisheries Society, 132(3), pp.546–559. https://doi.org/10.1577/1548-8659(2003)132

34. Mullen, R.E. 1981. Oregon's Commercial Harvest of coho Salmon, *Oncorhynchus kisutch* (Walbaum), 1892-1960. Oregon Department of Fish and Wildlife Information Report (Fish) 81-3. Portland, Oregon.

35. Mullen, R. E. 1981. Estimates of Historical Abundance of Coho salmon *Oncorhynchus kisutch* (Walbaum), in Oregon Coastal Streams and in the Oregon Production Index area. Oregon Dept. Fish and Wildlife, Fish Div. Info. Rep. 81-5.

36. Naiman, R.J., Bilby, R.E., Schindler, D.E., Helfield, J.M. 2002. Pacific Salmon, Nutrients, and the Dynamics of Freshwater and Riparian Ecosystems. Ecosystems 5, pp.399-417. June 2002. https://doi.org/10.1007/s10021-001-0083-3.

37. National Marine Fisheries Service (NMFS). 1993. Listing Endangered and Threatened Species and Designating Critical Habitat: Petition to List Five Stocks of Oregon Coho Salmon. Federal Register [Docket No. 27, October 1993] 58(206), pp.57770–57771.

38. National Marine Fisheries Service (NMFS). 2008. Endangered and Threatened Species: Final Threatened Listing Determination, Final Protective Regulations, and Final Designation of Critical Habitat for the Oregon Coast Evolutionarily Significant Unit of Coho Salmon. Federal Register [Docket No. 071227892–7894–01, February 11, 2008] 73 (28), pp.7816–7873.

39. National Marine Fisheries Service (NMFS). 2016. Recovery Plan for Oregon Coast Coho Salmon Evolutionarily Significant Unit. National Marine Fisheries Service, West Coast Region, Portland, Oregon.

40. Nickelson, T.E. 1998. A Habitat-based Assessment of Coho Salmon Production Potential and Spawner Escapement Needs for Oregon Coastal Streams (No. 98). Portland: Oregon Department of Fish and Wildlife.

41. Oregon Department of Agriculture (ODA). 2019. Mid Coast Agricultural Water Quality Management Area Plan. Developed by the ODA Mid Coast Local Advisory Committee. September 2019.

42. Oregon Department of Environmental Quality (ODEQ). 2022. Oregon's 2022 Integrated Report on Surface Water Quality and 303(d) List of Water Quality Limited Waters. https://www.oregon.gov/deq/wq/Documents/IR2022-303dImpWaters-TMDL.xlsx

43. Oregon Department of Fish & Wildlife (ODFW). 1997. Siletz River Basin Fish Management Plan. November 1997.

44. Oregon Department of Fish & Wildlife (ODFW). 2007. Oregon Coast Coho Conservation Plan for the State of Oregon. Oregon Department of Fish and Wildlife, Salem Oregon.

45. Oregon Department of Fish and Wildlife (ODFW). 2014. Coastal Multi-Species Conservation and Management Plan. June 2014. p215.

46. Oregon Department of Fish and Wildlife (ODFW). 2016. Oregon Adult Salmonid Inventory and Sampling Project. Estimated Total Population, Ocean Harvest Impact Rate, and Spawning Population of Naturally Produced Coho. http://odfw.forestry.oregonstate.edu/spawn/pdf%20files/Coho/CoastalCohoESUSpawnHarvestSummary.pdf.

47. Oregon Department of Fish and Wildlife (ODFW). 2019. Oregon Coast Coho Conservation Plan: 2019 12-Year Plan Assessment. www.dfw.state.or.us/fish/CRP/docs/coastal_coho.

48. Oregon Department of Fish and Wildlife (ODFW). 2022. ODFW Salmon and Steelhead Recovery Tracker. http://www.odfwrecoverytracker.org/.

49. Oregon Mid-Coast Water Planning Partnership. 2018. Mid-Coast Water Resources Characteristics Water Quality. Version 2018. Prepared by Water Solutions, Inc. Corvallis, Oregon.

50. Oregon Mid-Coast Water Planning Partnership. 2022. Mid-Coast Water Action Plan. https://www.midcoastwaterpartners.com/mcwpp-water-action-plan.

51. Pazdral, R. 2021. Factors Influencing Streamflow Generation Processes in Rain-dominated Coastal Watersheds of Oregon. Doctor of Philosophy dissertation of Rosemary Pazdral presented August 26, 2021. Submitted to Oregon State University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

52. Portland State University. 2024. Population Research Center. Oregon Population Forecast Program. Oregon population report for Lincoln County.

53. Roni, P. & Beechie, T. 2013. Stream and Watershed Restoration A Guide to Restoring Riverine Processes and Habitats. Fish Ecology Division, Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle, WA.

54. Salmon Drift Creek Watershed Council and City of Lincoln City. 2018. Oregon and Washington Drinking Water Providers Partnership Schooner Creek Sediment Reduction Project. Report prepared by John Sanchez. Hood River, OR. https://www.lincolncity.org/home/showpublisheddocument/336/637655171711100000

55. Sandercock, F.K. 1991. Pacific Salmon Life Histories. UBC Press.

56. Seavy, N.E., Gardali, T., Golet, G.H., Griggs, F.T., Howell, C.A. , Kelsey, R., Small, S. L., Viers, J.H. & Weigand, J.F. 2009. Why Climate Change Makes Riparian Restoration More Important Than Ever: Recommendations for Practice and Research. Ecological Restoration, 27:3.

57. Sethi, S.A., Ashline, J., Harris, B.P., Gerken, J., & Restrepo, F. 2021. Connectivity Between Lentic and Lotic Freshwater Habitats Identified as a Conservation Priority for Coho Salmon. Aquatic Conservation: Marine and Freshwater Ecosystems, 31(7), pp. 1791–1801. https://doi.org/10.1002/aqc.3504

58. Solazzi, M.F., Nickelson, T.E., Johnson, S.L., and Rodgers, J.D. 2000. Effects of Increasing Winter Rearing Habitat on Abundance of Salmonids in Two Coastal Oregon Streams. Can. J. Fish. Aquat. Sci. 57, pp. 906–914.

59. Stout, H.A., Lawson, P.W., Bottom, D.L., Cooney, T.D., Ford, M.J., Jordan, C.E., Kope, R.G., Kruzic, L.M., Pess, G.R., Reeves, G.H., Scheuerell, M.D., Wainwright, T.C., Waples, R.S., Ward, E., Weitkamp, L.A., Williams, J.G., & Williams, T.H. 2012. Scientific Conclusions of the Status Review for Oregon Coast Coho Salmon (*Oncorhynchus kisutch*). U.S. Dept. Commer. NOAA Tech. Memo. NMFS-NWFSC-118, p.242.

60. Suzuki, N., & McComb, W. 1998. "Habitat Classification Models for Beaver (*Castor canadensis*) in the Streams of the Central Oregon Coast Range. Northwest Science. 72(2), pp.102-110

61. U.S. Census Bureau. 2024. U.S. Census Bureau QuickFacts statistics for states and counties. https://www.census.gov/quickfacts/fact/table/lincolncitycityoregon/PST120223#PST120223

62. U.S. Geological Survey. 2001. Monthly Streamflow Statistics for USA, U.S. Geological Survey, Washington, D.C.

63. Wainwright, T. C. & Weitkamp, L.A. 2013. Effects of Climate Change on Oregon Coast Coho Salmon: Habitat and Life-cycle Interactions. Northwest Science, 87, pp.219-242. doi.org/10.3955/046.087.0305

64. Wallace, M., Ricker, S., Garwood, J., Frimodig, A., Allen, S. 2015. Importance of the Stream-estuary Ecotone to Juvenile Coho Salmon (*Oncorhynchus kisutch*) in Humboldt Bay, California.

65. Waples, R.S., Beechie, T., & Pess, G.R. 2009. Evolutionary History, Habitat Disturbance Regimes, and Anthropogenic Changes: What Do These Mean for Resilience of Pacific Salmon Populations? Ecology and Society, 14(1). https://www.jstor.org/

Appendices

Included in Printed Publication

Appendix 1) Glossary of Terms and Definitions

Appendix 2) Siletz Streamside Vegetation Assessment Maps

Available Online at coastcoho.org/watershed-plans/

Appendix 3) Coast Coho Partnership SAP Common Framework

Appendix 4) National Water Quality Initiative Siletz River Source Water Assessment

Appendix 5) Aerial Surveys in the Siletz River Basin. Thermal Infrared and Color Videography

Appendix I. Glossary of Terms and Definitions

Abundance	The number of fish in a population. See also **population.**
Adaptive Management	Adaptive management in salmon recovery planning is a method of decision making in the face of uncertainty. It is a process for adjusting actions and/or direction based on new information. A plan for monitoring, evaluation, and feedback is incorporated into an overall implementation plan so that the results of actions can become feedback on design and implementation of future actions.
Anadromous Fish	Species that are hatched in freshwater, migrate to and mature in saltwater, and return to freshwater to spawn.
Anchor Habitat	A stream reach that provides all the essential habitat features necessary to support the complete Coho freshwater life history. An anchor site supports all of the seasonal habitat needs of Coho salmon from egg to smolt outmigration, including optimal gradient, potential for floodplain interaction, and accumulation of spawning gravels.
Artificial Propagation	Hatchery spawning and rearing of salmon, usually to the smolt stage.
Barrier	A blockage such as a waterfall, culvert, or rapid that impedes the movement of fish in a stream system.
Beaver Dam Analogues	Human-made, channel-spanning structures that mimic or reinforce beaver dams (Pollock et al. 2015).
Critical Habitat	Critical habitat includes: (1) specific areas within the geographical area occupied by the species at the time of listing, on which are found those physical or biological features that are essential to the conservation of the listed species and that may require special management considerations or protection, and (2) specific areas outside the geographical area occupied by the species at the time of listing that are essential for the conservation of a listed species. If a species is listed or critical habitat is designated, ESA section 7(a) (2) requires federal agencies to ensure that activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of such a species or to destroy or adversely modify its critical habitat (NMFS 2008).
Dependent Populations	Populations that rely on immigration from surrounding populations to persist. Without these inputs, dependent populations would have a lower likelihood of persisting over 100 years.
Diversity	All the genetic and phenotypic (life history, behavioral, and morphological) variation within a population. Variations could include anadromy vs. lifelong residence in freshwater, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, physiology, molecular genetic characteristics, etc.
Ecoregion	An integration of physical and biological factors such as geologic history, climate, and vegetation.
Ecosystem	A complex system, or group, of interconnected elements and processes and functions, formed by the interaction of a community of organisms with their environment.
Endangered Species	A species in danger of extinction throughout all or a significant portion of its range. See also **ESA and threatened species**.
Endangered Species Act	Passed by Congress in 1973, its purposes include providing a means to conserve the ecosystems on which endangered species and threatened species depend. See also **endangered species** and **threatened species**.
Escapement	Adult fish that escape from fisheries and natural mortality to reach the spawning grounds.
Estuarine Habitat	Areas available for feeding, rearing, and smolting in tidally influenced lower reaches of rivers. These include marshes, sloughs and other backwater areas, tidal swamps, and tide channels.

Evolutionarily Significant Unit	An evolutionarily significant unit (ESU) represents a distinct population segment of Pacific salmon that (1) is substantially reproductively isolated from conspecific populations and (2) represents an important component of the evolutionary legacy of the species. Equivalent to a distinct population segment (DPS) and treated as a species under the Endangered Species Act.
Flashy	A term that describes a river that is prone to reach high peak discharge in a short time frame and be more likely to flood.
Floodplain	A nearly flat plain along the course of a stream or river that is naturally subject to flooding, or using geological terms, a depositional landform in alluvial basins.
Freshwater Habitat	Areas available for spawning, feeding, and rearing in freshwater.
Fry	Young salmon that have emerged from the gravel and no longer have a yolk sac.
Full Seeding	In general, full seeding refers to having enough spawners to fully occupy available juvenile habitat with offspring. As applied in fisheries management for Oregon Coast Coho salmon, it refers to habitat quality sufficient for spawners to replace themselves when marine survival is 3% and is based on early models of juvenile rearing capacity.
Gradient	The slope of a stream segment.
Habitat Quality	The suitability of physical and biological features of an aquatic system to support salmon in the freshwater and estuarine system.
Hatchery	A facility where artificial propagation of fish takes place.
Historical Abundance	The number of fish produced before the influence of European settlement.
Hydrologic Units	Hydrologic units are areas of land that contribute surface water runoff to a specific point on a stream, such as its mouth or outlet. They are also known as drainage areas. HU boundaries are defined by following the highest elevation of land that divides the direction of surface water flow, known as the ridge line, from the outlet point back to itself. In the U.S. Geological Survey, hydrologic units have been divided at different scales.
Hydrology	The distribution and flow of water in an aquatic system.
Independent Population	A collection of one or more local breeding units whose population's dynamics or extinction risk over a 100-year period is not substantially altered by exchanges of individuals with other populations (migration). **Functionally independent populations** are net donor populations that may provide migrants for other types of populations. This category is analogous to the independent populations of McElhany et al. (2000).
Intrinsic Potential	The estimated relative suitability of a habitat for spawning and rearing of anadromous salmonid species under historical conditions inferred from stream characteristics including channel size, gradient, valley constraint, and mean annual discharge of water. Intrinsic potential in this report refers to a measure of potential Coho salmon habitat quality. This index of potential habitat does not indicate current actual habitat quality.
Jack	A male Coho salmon that matures at age 2 and returns from the ocean to spawn a year earlier than normal.
Juvenile	A fish that has not matured sexually.
Keystone Species	A species that plays a pivotal role in establishing and maintaining the structure of an ecological community. The impact of a keystone species on the ecological community is more important than would be expected based on its biomass or relative abundance.
Limiting Factors	Impaired physical, biological, or chemical features (e.g., inadequate spawning habitat, high water temperature, insufficient prey resources) that result in reductions in viable salmonid population (VSP) parameters (abundance, productivity, spatial structure, and diversity).

Lowland Habitat	Low-gradient stream habitat with slow currents, pools, and backwaters used by fish. This habitat is often converted to agricultural or urban use.
Marine Survival Rate	The proportion of smolts entering the ocean that survive to adulthood. May be harvested or return as escapement.
Metrics	Something that quantifies a characteristic of a situation or process; for example, the number of natural-origin salmon returning to spawn to a specific location is a metric for population abundance.
Migration	Movement of fish from one population to another.
Objectives	We use the term objectives to refer to formal statements of the outcomes (or intermediate results) and desired changes that we have identified as necessary to attain the goals. Objectives specify the desired changes in the factors (direct and indirect threats and opportunities) that we would like to achieve in the short and medium term. "A good objective meets the criteria of being *results oriented, measurable, time limited specific, and practical.*[1]"
Parr	The life stage of salmonids that occurs after fry and prior to smoltification (or smolting). Generally recognizable by dark vertical bars (parr marks) on the sides of the fish.
Population	A group of fish of the same species that spawns in a particular locality at a particular season and does not interbreed substantially with fish from any other group. See also **abundance.**
Population Dynamics	Changes in the number, age, and sex of individuals in a population over time, and the factors that influence those changes. Five components of populations that are the basis of population dynamics are birth, death, sex ratio, age structure, and dispersal.
Population Structure	Includes measures of age, density, and growth of fish populations.
Production	The number of fish produced by a population in a year.
Productivity	The rate at which a population is able to produce fish, such as the average number of surviving offspring per parent. Productivity is used as an indicator of a population's ability to sustain itself or its ability to rebound from low numbers. The terms "population growth rate" and "population productivity" are interchangeable when referring to measures of population production over an entire life cycle. Can be expressed as the number of recruits (adults) per spawner or the number of smolts per spawner.
Recovery	The reestablishment of a threatened or endangered species to a self-sustaining level in its natural ecosystem (i.e., to the point where the protective measures of the ESA are no longer necessary).
Recovery Plan	A document identifying actions needed to make populations of naturally produced fish comprising the OCCS ESU sufficiently abundant, productive, and diverse so that the ESU as a whole will be self-sustaining and will provide environmental, cultural, and economic benefits. A recovery plan also includes goals and criteria by which to measure the ESU's achievement of recovery, site-specific management actions as may be necessary to achieve the plan's goal, and an estimate of the time and cost required to carry out the actions.
Redd	A nest constructed by female salmonids in streambed gravels where eggs are deposited, fertilized by males, and buried in gravel.
Resilience	A measure of the ability of a population or ESU to rebound from short-term environmental or anthropogenic perturbations.
Run Timing	The time of year (usually identified by week) when spawning salmon return to the spawning beds.
Salmonid	Fish belonging to, or characteristic of, the family Salmonidae, which includes salmon, steelhead, trout, char, and whitefish. These are typically cold water groups of species.
Smolt	A life stage of juvenile salmon that occurs just before the fish leaves freshwater. Smolting is the physiological process that allows salmon to make the transition from freshwater to saltwater.

Spawner	Adult fish on the spawning grounds.
Spawner Survey	Effort to estimate the number of adult fish on spawning grounds. It uses counts of redds and fish carcasses to estimate escapement and identify habitat. Annual surveys can be used to compare the relative magnitude of spawning activity between years.
Species	Biological definition: A group of organisms formally recognized by the scientific community as distinct from other groups. Legal definition: Refers to joint policy of the USFWS and NMFS that considers a species as defined by the ESA to include biological species, subspecies, and DPSs. In this Plan, "the species" refers to the Oregon Coast Coho salmon ESU.
Stakeholders	Agencies, groups, or private citizens with an interest in recovery planning, or those who will be affected by recovery planning and actions.
Threatened Species	A species not presently in danger of extinction, but likely to become so in the foreseeable future. See also **endangered species** and **ESA**.
Threats	Human activities or natural events (e.g., road building, floodplain development, fish harvest, hatchery influences, and volcanoes) that cause or contribute to limiting factors. Threats may exist in the present or be likely to occur in the future.
Valley Constraint	The valley width available for a stream or river to move between valley slopes.
Viable, Viability	The likelihood that a population will sustain itself over a 100-year time frame. As used in this plan, viable and viability are the same, or nearly the same, as sustainable and sustainability.
Viable Salmonid Population	A viable salmonid population (VSP) is an independent population of any Pacific salmonid (genus Oncorhynchus) that has a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes (random or directional) over a 100-year time frame.
Wild Fish	Fish whose ancestors have always lived in natural habitats, that is, those with no hatchery heritage. See also **naturally produced fish**, for comparison.

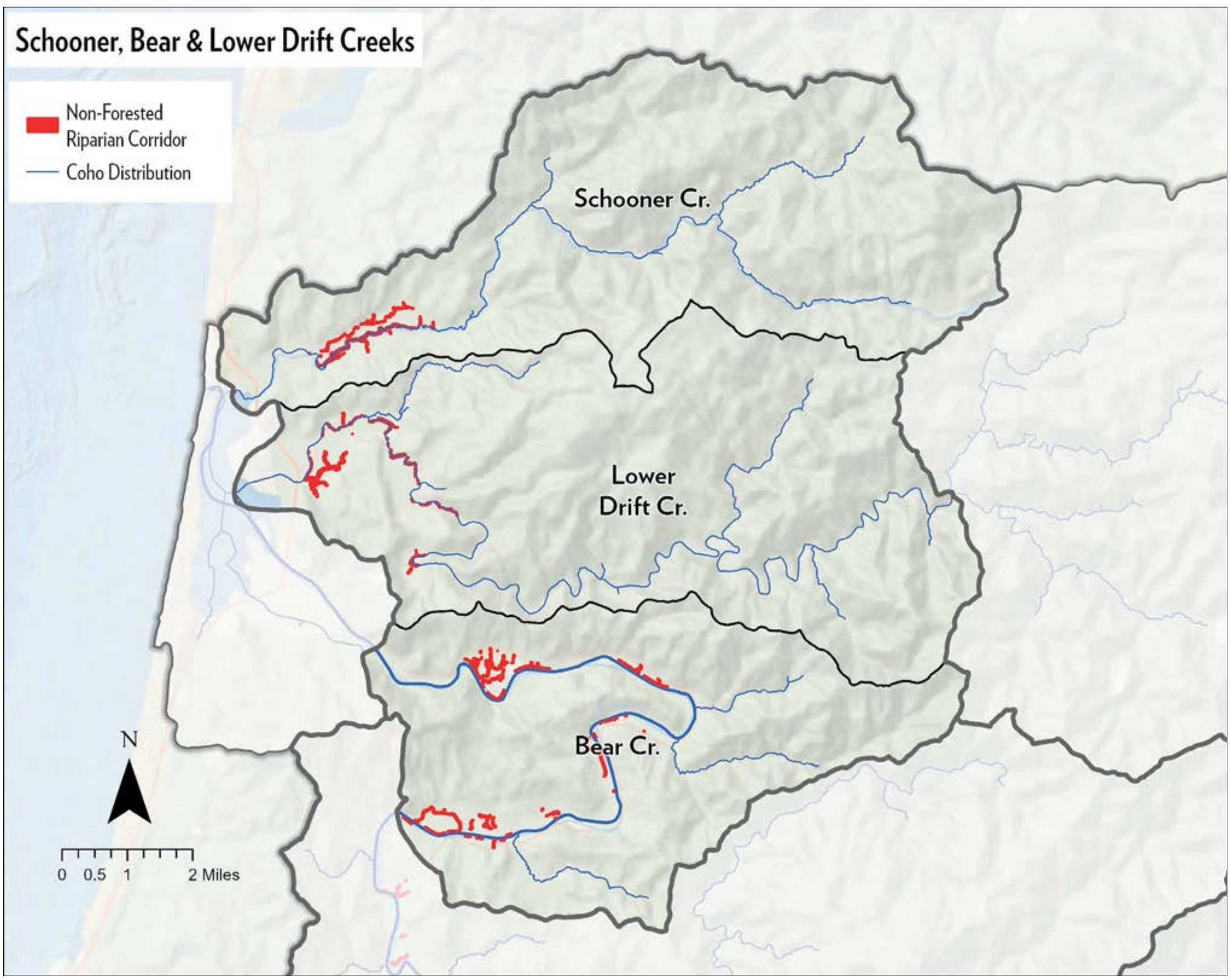
[1] Open Standards for the Practice of Conservation.

[2] Conservation Measures Partnership: Open Standards for the Practice of Conservation from Version 3.0 (April 2013).

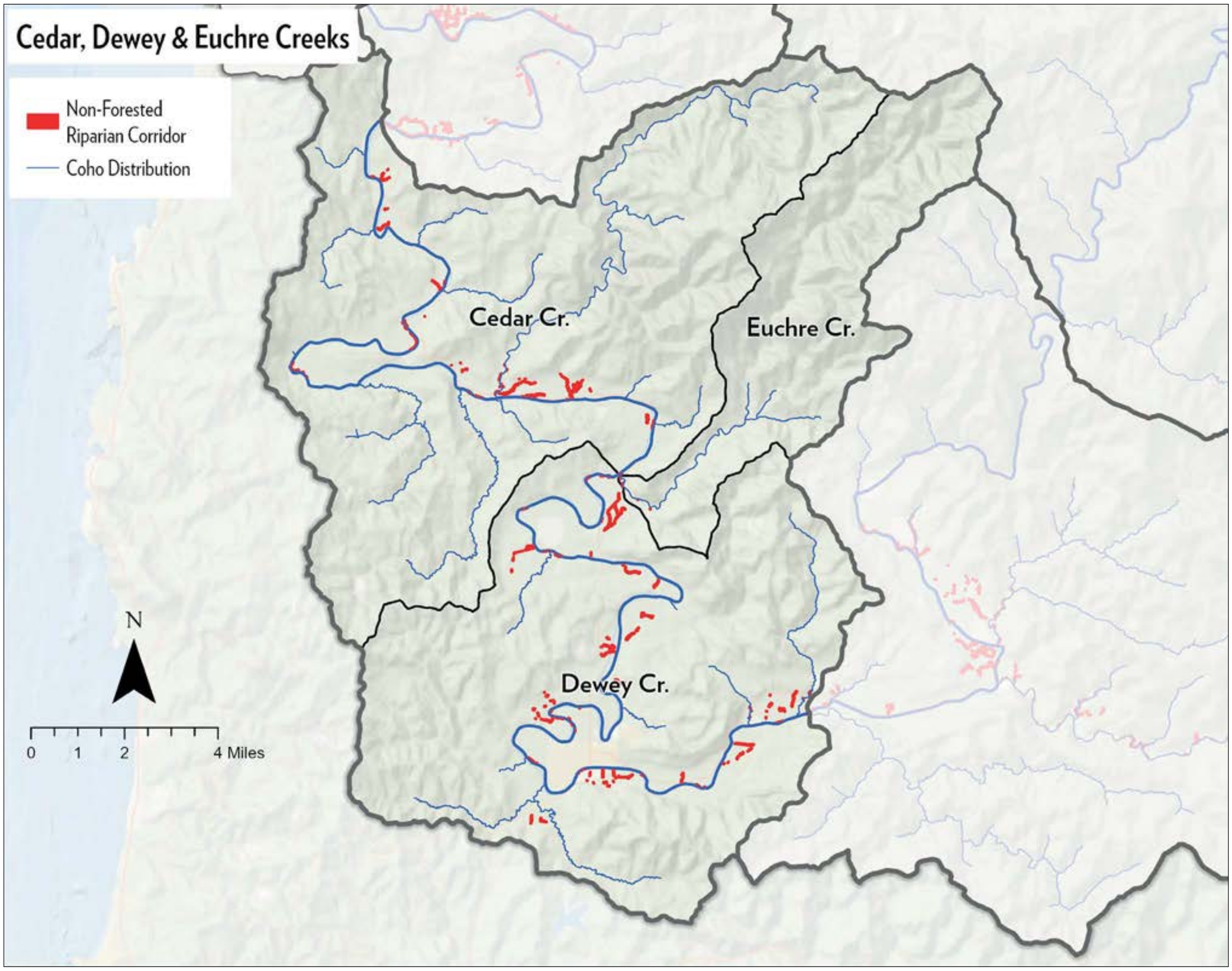
Appendix II

Maps show non-forested riparian corridors on Coho-bearing streams from the *Streamside Vegetation Assessment Maps* (2021) developed by the Lincoln Soil and Water Conservation District. Non-forested riparian corridor includes the attributes of "Ag infrastructure", "Bare", "Bare-Ag", "Grass", "Grass-Ag" combined.

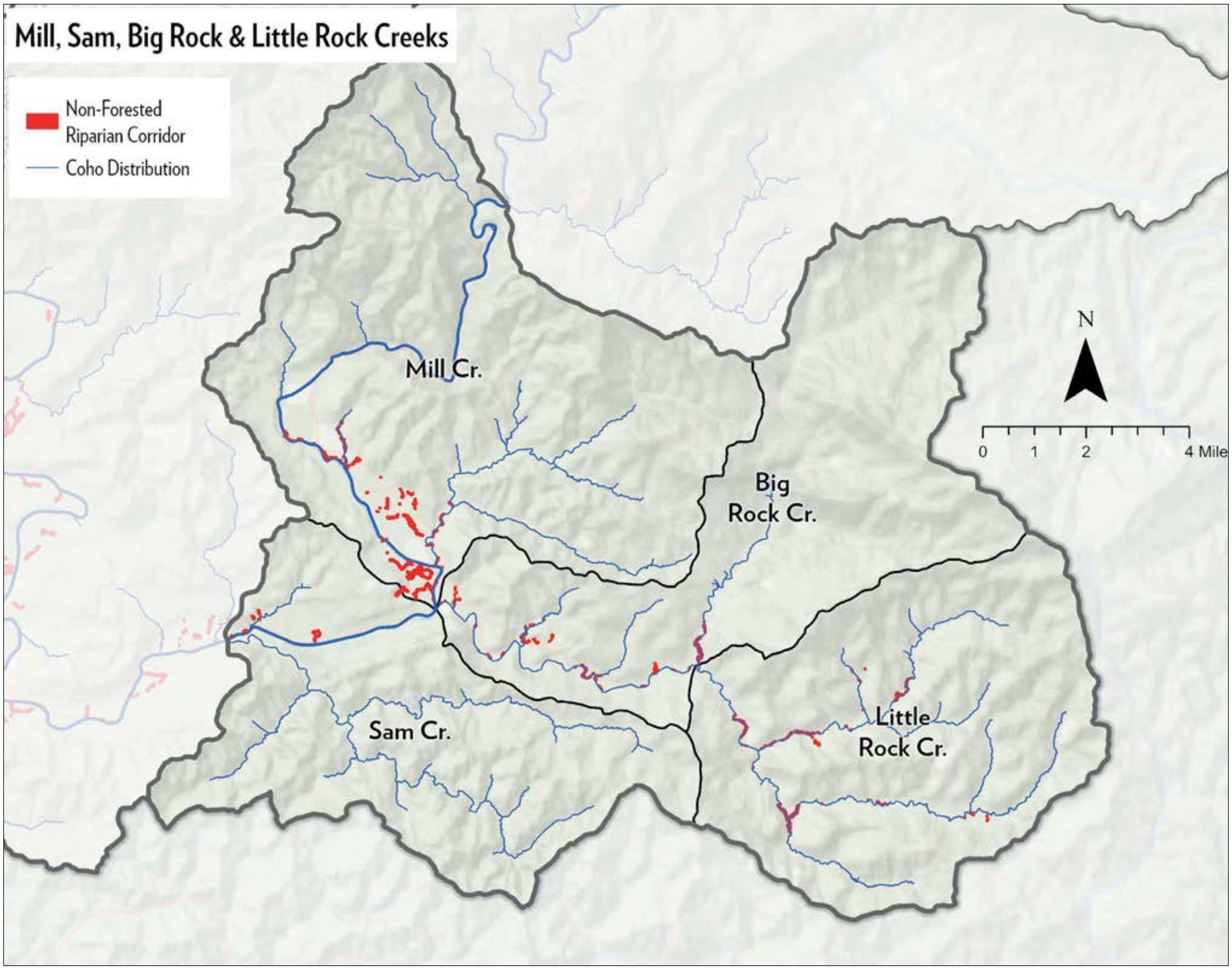
Appendix 2.1. Non-forested riparian corridors in the Schooner, Lower Drift, and Bear Creek sub-watersheds.



Appendix 2.2. Non-forested riparian corridors in the Cedar, Dewey, and Euchre Creek sub-watersheds.



Appendix 2.3. Non-forested riparian corridors in the Mill, Sam, Big Rock, and Little Rock Creek sub-watersheds.



A summary of terms and definitions used in the development of Strategic Action Plans for Coast Coho Habitat Restoration in Oregon

Coast Coho Common Framework, V 2.6

Coast Coho Partnership

Updated: October 15, 2019

1. Introduction and Purpose

The following document has been developed by the Coast Coho Partnership (Partnership), a group of state and federal agencies and non-profit organizations leading development of the "Oregon Coast Coho Business Plan" (Business Plan). The Business Plan is intended to leverage financial support for the implementation of high priority projects contained in locally developed, population scale recovery plans called "Strategic Action Plans."

This document advances a Partnership goal to establish a common language for coast coho recovery that links federal, state, and local recovery planning by consistently describing the habitats that coast coho rely on; the ecosystem processes that generate and maintain these habitats; and a suite of indicators that can be used to assess trends in habitat quantity and quality. In addition, the Partnership seeks to establish consistent terminology for partners to describe the factors that limit coho production, and the human activities that give rise to these limiting factors.

The Partnership includes: the Oregon Department of Fish and Wildlife (ODFW), National Fish and Wildlife Foundation (NFWF), National Oceanic and Atmospheric Administration (NOAA) Fisheries, NOAA Restoration Center, Wild Salmon Center (WSC), and Oregon Watershed Enhancement Board (OWEB).

1.1 Common Framework

The Partnership drafted this Common Framework to provide a uniform approach for describing and classifying ecosystems, processes, species, and associated human-induced threats important to coho recovery. The initial draft was created by the Partnership working with consultants who had developed and employed a similar approach to support recovery planning for Puget Sound Chinook. Following creation of a draft framework, the Partnership convened a two-day workshop with scientists and resource managers with extensive experience in coastal watersheds to review and refine the document. The resulting framework was then further refined by partners working on population scale recovery and the development of three pilot SAPs in the Nehalem, Siuslaw, and Elk Rivers.

The common framework is intended for use at a variety of scales (reach, sub-watershed, watershed, ESU) and will allow information and planning efforts to be shared and communicated consistently up and down the coast. The Framework builds on several interrelated categories of information, or "elements," which are defined as follows:

- **Components** –Habitats that if conserved can support the continued viability or recovery of coho (example: tributaries).

- **Key ecological attributes (KEAs) –** Aspect of a component's biology or ecology that if present, defines a healthy component and, if missing or altered, would lead to the outright loss or extreme degradation of that component over time (example: water quality).

- **Indicators** – Metrics that can be tracked to assess the condition of KEAs (example: temperature).

- **Stresses** – Symptoms that a component is degraded; similar to a limiting factor but often more specific (example: reduced riparian wood vs. limited instream complexity).

- **Threats –** Human activities that stress and degrade the health of components (example: roads).

At the start of the SAP planning process, watershed teams will use the Common Framework to select the components, KEAs, indicators, stresses, and threats relevant to their understanding of what limits coho populations in their watershed. This customization of the Common Framework reflects individual watershed conditions and the context for recovery that drive the selection of actions and strategies.

The Partnership drafted this Common Framework using existing ODFW and NMFS terminology and standardized concepts taken from a planning tool called *Open Standards for the Practice of Conservation (Open Standards)*[1]. The *Open Standards* are scalable, adaptable, and widely used to design, manage, and monitor conservation projects around the world.

2. Components, KEAs, Indicators

The characterization of watersheds through the identification of components, stresses, and key ecological attributes (KEAs) is critical for consistently describing the current physical and biological context for coho recovery in the watershed. This information also clearly defines the elements being improved or protected by the strategies and actions in the forthcoming SAPs.

2.1 Components

Components are the things we care about conserving. They can be individual species, habitat types, ecological processes, or ecosystems chosen to encompass the full breadth of conservation objectives for a specific project. In the Common

[1] Additional information regarding the Open Standards may be found at http://www.conservationmeasures.org

Framework, components are *priority habitats for coho recovery*, such as mainstem river and off-channel habitats. In the SAP, the "Conservation/Restoration targets" section will reference both the habitat components from the Common Framework relevant to the watershed and the coho population(s).

Coast Coho Habitat Components and Definitions

Component	Definition
Mainstem River	Portions of rivers above head of tide (Coastal and Marine Ecological Classification Standard (CMECS) definition); typically 4th order, downstream of coho spawning distribution, non-wadeable. The mainstem river component includes riparian and floodplain areas.
Tributaries	All 1st – 3rd order streams with drainage areas > 0.6 km2. This includes fish-bearing and non-fish-bearing, intermittent streams, and the full aquatic network including headwater areas. The tributary component includes riparian and floodplain areas.
Off-channel	Any area other than the main or primary channel of mainstem or tributary habitats that provides a velocity refuge for coho. This includes slack water habitats such as alcoves, side channels, and oxbows. This includes riparian and floodplain areas.
Freshwater Non-Tidal Wetlands	Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Habitats include depressions, flat depositional areas that are subject to flooding, broad flat areas that lack drainage outlets, sloping terrain associated with seeps, springs and drainage areas, areas associated with bogs, and open water bodies (with floating vegetation mats or submerged beds). This component is restricted to those wetlands that are hydrologically connected to coho streams. Estuarine associated wetlands are addressed in the estuarine section.

Estuaries	The areas historically available for feeding, rearing, and smolting in tidally influenced lower reaches of rivers that extend upstream to the head of tide and seaward to the mouth of the estuary. Head of tide is the inland or upstream limit of water affected by a tide of at least 0.2 foot (0.06 meter) amplitude (CMECS). This includes tidally influenced portions of rivers that are considered to be freshwater (salinity <0.5 ppt). We are extending the definition laterally to the uppermost extent of wetland vegetation (mapped by CMECS). Habitats include saltmarsh, emergent marsh, open water, subtidal, intertidal, backwater areas, tidal swamps, and deep channels. This includes the ecotone between saltwater and freshwater and the riparian zone.
Uplands	All lands that are at a higher elevation than adjacent water bodies and alluvial plains. They include all lands from where the floodplain/riparian zones terminate and the terrain begins to slope upward forming a hillside, mountain-side, cliff face, or other non-floodplain surface.
Lakes	Inland bodies of standing water; for purposes of OC coho salmon recovery. Habitats include deep and shallow waters in the lakes, including alcoves, and confluences with streams.

2.2 Key Ecological Attributes (KEAs)

KEAs are the characteristics of a component that, when present, support a viable component but, if missing or altered, lead to loss or degradation of the component over time. KEAs can be used to assess the status of a component, develop protection and restoration objectives for conservation, and focus monitoring and adaptive management programs. In the Common Framework, KEAs are *characteristics necessary for coho recovery*, such as riparian function and habitat complexity. The core KEAs that every watershed team should include in their local framework are indicated in the table below.

KEAs by Component

Component	**Key Ecological Attributes** (definitions below)
Mainstem River	Water Quality Flows (high and low) Habitat complexity Riparian Function Geomorphic processes Lateral connectivity Longitudinal connectivity
Tributaries	Water quality Flows (high and low) Habitat complexity Beaver ponds Riparian Function Geomorphic processes Lateral connectivity Longitudinal connectivity
Freshwater Non-tidal wetlands	Water Quality Hydrologic Regime Landscape arrays of habitats Riparian function (relevant to wetland type) Beaver ponds Hydraulic Connectivity
Off-channel	Habitat complexity Riparian Function Beaver ponds Geomorphic processes Lateral connectivity Longitudinal connectivity
Estuary	Water Quality Landscape array of habitats Sediment dynamics Channel morphology Inundation regime Connectivity (lateral and longitudinal)
Uplands	Connectivity Landscape Array of Structural Diversity (upland forests)

KEAs by Component

Component	Key Ecological Attributes (definitions below)
Lakes	Habitat complexity Connectivity (lateral and longitudinal) Water quality

KEA Definitions

Water Quality: The biological, chemical, and physical conditions of a waterbody. It is a measure of a waterbody's ability to support beneficial uses (EPA, CWA). In tributary and mainstem habitats of coastal watersheds good water quality reduces potential health impacts to coho adult and juvenile life stages. Poor water quality can have direct mortality impacts, make them more susceptible to disease, impair their swimming ability, create a tendency for avoidance of habitat, alter the timing of migration, and delay hatching and emergence and rate of maturation.

High Flows: In mainstem, tributary, and off-channel habitats, peak high flows for channel maintenance are important to create diversity of habitat and move sediments through the system. Sustained high flows reconnect the stream to floodplain and trigger adults to return to freshwater to spawn. High flows provide physical access to smaller tributaries to spawn. In tributary and mainstem habitats spring high flows are important for smolt survival. Wetlands need high flows to maintain their health and recharge the associated groundwater. High flow transfers nutrients and food sources from the wetlands into stream habitats.

Low Flows: In tributary, mainstem, and off-channel habitats it is important that low flows are sufficient to allow access to habitats and sustain good water quality. When flows are too low, fish are concentrated and density issues are created in available habitats. Low flows create conditions where wetlands are able to discharge their stored water and are important for bug production. In wetland habitats, low flows create conditions where wetlands are able to discharge their stored water and are important for bug production.

Habitat Complexity: Stream complexity is important for wintering habitat for juveniles in some areas of the mainstem and in tributaries, wetlands, and off-channel habitats. Complexity includes one or more of the following features: large wood, a lot of wood, pools, connected off-channel alcoves, beaver ponds, lakes, connected floodplains and wetlands. In tributary streams and off-channel habitats, complexity is also important for juveniles in the summer.

Riparian Function (overlaps with connectivity): Streamside vegetation in tributaries, off-channel habitats, and some mainstem and wetland habitats can provide shade to regulate stream temperature, create cover for coho rearing, provide a source of food and nutrients, help stabilize sediment supply, filter out pollutants including pesticides and nutrients, and provide a source of in-stream complexity.

Beaver ponds: off-channel habitats resulting from the impoundment of surface water and hyporheic flow by beavers.

Geomorphic processes: The land forming aspects of erosion and deposition. In the estuary, this includes the movement of sediment and wood.

Lateral connectivity: The periodic inundation of the floodplain and the resulting exchange of water, sediment, organic matter, nutrients, and organisms. This is the lateral extent of the streams connectivity to the adjacent riparian, floodplain, and off-channel habitats.

Longitudinal connectivity: the pathways along the entire length of a stream.

Hydrologic Regime: Patterns of seasonal and inter-annual hydrology changes. Wetlands need water inputs to maintain their health and recharge the associated groundwater. High stream flow transfers nutrients and food sources from the wetlands into stream habitats.

Landscape Array of Habitats: A range of functioning wetland and estuary habitat types appropriate to the landscape that provide biologically productive areas for coho to rear, find refuge, and go through physiological changes before migrating to the ocean.

Hydraulic Connectivity: The extent to which surface water bodies interact with adjacent wetlands through lateral surface and/or subsurface connections.

Sediment Dynamics: In estuaries, the movement of sediments throughout the system is an important component of what helps create and maintain tidal channels. When sediment processes are impaired it can reduce the connectedness and amount of tidal channel habitat available to coho salmon. Retention of sediment by marshes also is important to the productivity of subtidal estuarine waters. Sediments not stabilized by marshes remain suspended in the water column, especially in estuaries characterized by persistent upwelling currents and waves. Suspended sediments reduce available light and consequently reduce the primary production essential to estuarine food webs (Adamus 2005).

Habitat Diversity: A mosaic of functioning habitat types that provide biologically productive areas for coho to rear, find refuge, and go through physiological changes before migrating to the ocean. The combination of appropriate habitat types is unique to each estuary but will likely include beaches, mudflats, tidal marsh, and tidally influenced riverine habitats.

Channel morphology: Channels systems created through tidal action. Length, width to depth ratios, and sinuosity are important features of tidal channel morphology.

Inundation regime: The frequency, duration, and depth of tides flowing into estuarine habitats.

Connectivity (uplands): The lateral extent of uninterrupted physical pathways that facilitate the transport of organic and inorganic materials from an upland area into a surface water body, and/or its riparian zone and floodplain.

Landscape Array of Structural Diversity (upland forests): The range and distribution of forest stand size, type, age, and composition within a defined uplands area.

Shoreline habitat complexity (lakes): TBD

Hydraulic connectivity to wetlands (lakes): TBD

2.3 Status Indicators

Defining and tracking status and condition information is a critical step in developing an SAP, and will allow recovery partners to assess progress toward recovery status and goals up and down the coast. Ecosystem status information will be used to track changes in the current and future status of habitat features and processes over time as SAPs are implemented. Ecosystem indicators will provide information about the relationship between the effects of strategies or actions and current and desired future status.

Common Framework Definition

Status indicators are specific units of information measured over time that document changes in the status of a KEA or another element (e.g., a threat). Indicators can be measured directly or computed from one or more directly measured variables. Indicators should be measurable, precise, consistent, and sensitive. In the Common Framework, indicators are *metrics to assess coho recovery*, such as the number of pools present in off-channel habitat. Other indicators, such as implementation metrics, should be added in to the local framework later in the process (e.g. miles of levees removed or acres of riparian plantings installed).

The list below is not an exhaustive list of all potential indicators but represents a sampling of indicators that are broadly applicable and a good place from which to start a discussion. This process will be iterative, and new status information will be integrated as it becomes available.

2.4 Indicators by Component and KEA

Component	Key Ecological Attributes	Indicators (metrics) for this KEA Local teams will annotate each as…. **Bold = Sufficient data exists to evaluate the indicator with a reasonable/replicable amount of analysis**. *Italics = Aspirational indicator.* *1) Data is not readily available (i.e no monitoring program exists or is planned); OR* *2) current sampling is not sufficient to characterize at appropriate scale; OR* *3) available data requires extensive (not easily replicated) analysis to assess.*
Mainstem River	Water Quality	• Temperature: % of monitored stream reaches meeting temperature criteria • Average DEQ ambient site condition • Turbidity • Disease/pathogens
	Flows (high and low)	• Number of days reach not meeting instream flow • Number of days/year that flow levels in the mainstem fall below in-stream flow rights (5 year running mean) • Amount of water allocated • % of historic flow • Trends in peak hydrograph (system flashiness)
	Habitat complexity	• % pool habitat • Amount and volume of wood • Number of large pieces of wood • Reaches with connected off-channel alcoves, flood plains and wetlands • Spawning gravel density • Depth to width ratio
	Riparian Function	• Riparian road density (mi road/mi stream) in one site potential buffer (e.g. 164” in Nehalem) • % of forest riparian areas with conifers > 20” dbh in one site potential tree buffer • % of 6th fields basins with > 50% of riparian area in late seral • % of open lands with wooded buffers along streams • % of riparian area with diverse, healthy native vegetation appropriate to site potential • Proportion of riparian areas containing invasive species

		• Width • Percentage of sites that have reached max potential or are demonstrating improving trends for effective shade
	Geomorphic processes	• % fine sediment in pools • Fast water units • Pool tailouts • % gravel • % bedrock in stream reach • Geological composition of reaches • Lineal distance of side channel habitat • Ratio of side channel to mainstem length
	Lateral connectivity	• % of the potential fish use stream length with entrenchment ratio > 2.2
	Longitudinal connectivity	• Presence of a thermal barrier in the lower mainstem that prevents migration/movement of fish during warm periods (7 day moving mean of daily summer max temp is < 20°C) • Number of fish passage barriers

Component	**Key Ecological Attributes**	**Indicators (metrics) for this KEA**
Tributaries	Water quality	• # of days where monitoring locations exceed standards • % of monitored stream reaches meeting temperature criteria • Average DEQ ambient site condition • Turbidity • % of macro-invertebrate sampling sites in "most disturbed" DEQ condition class
	Flows (high and low)	• Percentage of water allocated verses capacity • Number of days not meeting instream flow
	Habitat complexity	• Miles of high quality habitat (produce 2,800 smolts/mile) • % of stream reaches with HabRate model rating of "good" for winter rearing, summer rearing, spawning and emergence. • % stream reach in pool habitat • % of stream reach in slackwater pool habitat • % pools greater than 1 meter in depth • # of wood pieces per 100m of stream • # of key wood pieces (>12m long per 100 meters stream length, >60 cm dbh • Volume of LWD per 100 m • # alcoves per reach

		• % of riffle that is sand/silt/ organics (from geomorphic processes in off-channel) • % fine sediment across stream reach (from geomorphic processes in OC) • % fine sediment in fast water habitat (from geomorphic processes in OC) • Fast water units (from geomorphic processes in OC) • Pool tailouts (from geomorphic processes in OC) • % gravel within a reach (from geomorphic processes in OC) • % bedrock in stream reach (from geomorphic processes in OC) • <u>Summary indicator</u>: % of stream reaches, suitable for key life stages, with HabRate model rating of "good"* (Incorporates the following Aquatic Inventory Attributes: % gradient, unit width, active channel width, floodprone width, % pools, scour pool depth, riffle depth, large boulders/100m, % fines, % gravel, % cobble, % boulder, pieces of large woody debris (LWD)/100m, % undercut, residual pool depth, average pieces LWD in pools, average key pieces LWD in pools, and average % sheltered pools)
	Beaver ponds	• # and area of beaver ponds • % of potential beaver habitat occupied by beaver sign
	Riparian Function	• Riparian road density (mi road/mi stream) in one site potential tree buffer (e.g. 164' in the Nehalem) • % of forest riparian areas with conifers > 20" dbh in 164' buffer • % of 6^{th} fields basins with > 50% of riparian area in late seral • % of open lands with wooded buffers along streams • % of riparian area with diverse, healthy native vegetation appropriate to site potential • Percentage of sites that have reached max potential or are demonstrating improving trends for effective shade • Proportion of riparian areas containing invasive species • Width
	Geomorphic processes	• % of riffle that is sand/silt/ organics • % fine sediment across stream reach • % fine sediment in fast water habitat • Fast water units • Pool tailouts • % gravel within a reach • % bedrock in stream reach • Geological composition of reaches

	Lateral connectivity	• % total channel area represented by secondary channels • % of the potential fish use stream length with entrenchment ratio > 2.2 • Lineal distance of side channel habitat • Ratio of side channel to trib length • % of historic aquatic habitats still connected • % of the historical floodplain area that has been excluded from overbank inundation
	Longitudinal connectivity	• Incidence of blocked passage due to low flows or high temperature in the summer • % of total basin stream length blocked by road crossings, dams, culverts, or other artificial blockages • # of fish passage barriers • % of historic aquatic habitats still connected
Component	**Key Ecological Attributes**	**Indicators (metrics) for this KEA**
Freshwater Non-Tidal Wetlands	Water Quality	• % of wetlands that meet water quality standards (H_20 temp, sediment, nutrients, and DO)
	Hydrologic Regime	• Duration of soil saturation within rooting zone (NWI and hydric soil mapping)
	Landscape Array of Habitats	• Change in wetland acres (hydric soil mapping (NRCS) compared to NWI) • Acres of wetland • Distribution of different wetland types compared to historic (NWI) • Number of seasonally or year round connected freshwater wetlands • Secondary channel area as a % of total channel area
	Riparian Function (relevant to wetland type)	• Plant community diversity • Large wood • Width • Dominant over story
	Beaver ponds	• % of potential beaver habitat occupied by beaver sign • # and area of beaver ponds
	Hydraulic Connectivity	• Frequency of floodplain wetland inundation • Subsurface connectivity • Fish presence (% accessible to fish)

Component	Key Ecological Attributes	Indicators (metrics) for this KEA
Off-channel	Habitat complexity	• % total channel area represented by secondary channels • % pools greater than 1 meter in depth • #of wood pieces per 100m of stream • # Key wood pieces (>12m long, 0.60m dbh) • Volume of LWD per 100 m • # alcoves per reach • Diversity and abundance of off-channel habitat types.
	Riparian Function	• Riparian road density (mi road/mi stream) in one site potential tree buffer (e.g. 164' in the Nehalem) • % of forest riparian areas with conifers > 20" dbh in 164' buffer • % of 6^{th} fields basins with > 50% of riparian area in late seral • % of open lands with wooded buffers along streams • % of riparian area with diverse, healthy native vegetation appropriate to site potential • Percentage of sites that have reached max potential or are demonstrating improving trends for effective shade • Proportion of riparian areas containing invasive species • Width
	Beaver ponds	• % of potential beaver habitat occupied by beaver sign • # and acres of beaver ponds
	Geomorphic processes	• % fine sediment across stream reach • % fine sediment in fast water habitat • Fast water units • Pool tailouts • % gravel within a reach • % bedrock in stream reach
	Connectivity (lateral and longitudinal)	• Fish presence/absence • Miles/acres of off-channel area connected to mainstem or tributary

Component	Key Ecological Attributes	Indicators (metrics) for this KEA
Estuary	Water Quality	• Indicator for salinity patterns • % of monitored Bay sites meeting bacteria or other WQ criteria
	Landscape Array of Habitats	• Acres of connected tidal wetland • Acres of wetland relative to historic condition (use Coastal and Marine Ecological Classification (CMECS) and Coastal Change Analysis Program (C-CAP) data) • Distribution of habitat types relative to historic condition (CMECS/C-CAP data) • Riparian condition (use Coastal Landscape Analysis Modeling Study (CLAMS) or C-CAP data) • % of historic native wetland habitats lost or altered • % of total estuary area not impacted by levees, dikes, or roads • Amount of large wood, open water, deep channels, salt pans • Acres of beaver ponds
	Sediment dynamics	• Length of connected tidal channels • Width to depth ratios and sinuosity of tidal channels • Channel density • Feet of tidal channels per acre
	Channel morphology (geomorphic processes)	• Length of connected tidal channels • Width to depth ratios and sinuosity of tidal channels • Channel density
	Inundation regime	• Acres of tidal wetlands relative to historic (CMECS) • Number of flow barriers restricting water flow within estuary(dikes, tidegates, and restrictive culverts, roads, railroads, and fill material) (CMECS)
	Connectivity (lateral and longitudinal)	• Number of culverts and tide gates restricting water flow within the estuary

Component	Key Ecological Attributes	Indicators (metrics) for this KEA
Uplands	Connectivity	• % of the watershed that contains steep slope clearcuts (> 65% slope) • % of CLAMS delivery-weighted debris torrent model high-risk areas potentially impacted by timber harvest • Road density • % high debris flow areas intersected by roads • % riparian corridors intersected by roads • % of roads in the watershed where BMPs for the maintenance of designed drainage features are applied (or meet Forest Service road criteria) • % sediment delivery (fine, coarse) over historic
	Landscape Array of Structural Diversity (upland forests)	• % steep slope in clearcut • % of forest classified as: regeneration, closed single canopy; understory; layered; older forest. • Proportion of area in different seral stages (early, mid, late, plantation) • % of the watershed with an OGSI (Old Growth Structural Index) value > 50 (see Spies et al. 2007) • % high risk landslide areas with forest stands in layered or older forest structure. • % high risk landslide areas with forest stands in understory or layered structure.

Component	Key Ecological Attributes	Indicators (metrics) for this KEA
Lakes	Habitat complexity	• Amount of LWD at the Edge (#s of logs by size category: large and not large) • % natural shoreline • riparian composition may not be available
	Connectivity	• % of potential wetlands that are connected subsurface or surface • Barrier inventory (indicator of extent of fish passage)
	Water quality	• Water quality in lakes (H_20 temp, sediment, nutrients, toxics, and DO)

3. Stresses and Threats

The next step in customizing the Common Framework is to describe the primary stresses and threats causing degraded habitat conditions within your watershed. Using consistent terms and methods to describe the effects of different stresses and threats on different components is helpful for prioritizing recovery strategies, actions, and monitoring both within your watershed and across coastal watersheds. After completing this section of the Toolkit, your watershed team will have a documented understanding of relations between threat-stress-components. These relationships will be important later as you select strategies to address threats and build logic models.

3.1 Stresses

Stresses are impaired attributes of an ecosystem. Stresses are equivalent to altered or degraded KEAs. Stresses are not threats, but rather degraded conditions or "symptoms" that result from threats, such as increased water temperature or decreased longitudinal connectivity.

Stresses by Component

Component	Associated Stresses
Mainstem	Increased water temperature
	Increased toxins
	Increased turbidity
	Increased nutrients
	Reduced DO
	Reduced flows (habitat availability)
	Increased flashy flows
	Lack of natural storage
	Increased velocity (that reduces winter rearing habitat)
	Decreased longitudinal connectivity (fish Passage)
	Reduced riparian wood inputs (frequency and size/composition of wood in streams, recruitable wood)
	Lack of pools
	Altered riparian function (species of complexity, age complexity, width of buffer)
	Decreased lateral connectivity
	Increased fine sediment
	Bed coarsening
	Loss of sediment supply
	Reduced extent of habitat
	Increased velocity (that reduces winter rearing habitat)

Tributary	Increased water temperature
	Increased toxins
	Increased turbidity
	Increased nutrients
	Reduced DO
	Reduced flows (habitat availability)
	Increased flashy flows
	Lack of natural storage
	Increased velocity that reduces winter rearing habitat
	Decreased longitudinal connectivity (fish Passage)
	Lack of pools
	Decreased beaver ponds
	Reduced riparian wood inputs (frequency and size/composition of wood in streams, recruitable wood)
	Altered riparian function (species of complexity, age complexity, width of buffer)
	Decreased lateral connectivity
	Increased fine sediment
	Bed coarsening
	Loss of sediment supply
	Reduced extent of habitat
Freshwater Non-tidal Wetlands	Increased water temperature
	Increased nutrients
	Reduced DO
	Reduced quantity for access
	Reduced forage habitat availability
	Lack of natural storage
	Reduced frequency of wood
	Reduced size of wood
	Altered species complexity
	Altered age complexity
	Decreased connectivity
	Decreased beaver ponds
	Reduced extent of habitat
Off-channel	Increased water temperature
	Increased toxins
	Increased turbidity
	Increased nutrients
	Reduced DO
	Reduced flows (habitat availability)
	Increased flashy flows
	Lack of natural storage
	Increased velocity (that reduces winter rearing habitat)
	Decreased longitudinal connectivity (fish Passage)
	Decreased beaver ponds

	Lack of pools
	Reduced riparian wood inputs (frequency and size/composition of wood in streams, recruitable wood)
	Altered riparian function (species of complexity, age complexity, width of buffer)
	Decreased lateral connectivity
	Increased fine sediment
	Bed coarsening
	Loss of sediment supply
	Reduced extent of habitat
Estuary	Increased water temperature
	Increased toxins
	Increased nutrients
	Reduced DO
	Increase estuarine acidification
	Reduced habitat diversity
	Reduced bar area (gravel bar or mud flats)
	Increased velocity that reduces winter rearing habitat
	Reduced frequency of wood in estuary
	Reduced size of wood in estuary
	Reduced riparian width (buffer size)
	Reduced riparian species complexity
	Altered riparian age complexity
	Decreased riparian connectivity
	Increased fine sediment (loss of eel grass)
	Reduced extent of habitat
	Loss of sediment supply (loss of sand)
	Modified salinity regime
	Altered marine mixing
	Reduced tidal wetland connectivity (includes subsidence)
	Reduced forage
	Altered freshwater hydrology
Uplands	Fragmentation
	Loss of connectivity to stream networks
	Altered forest composition
	Increased sediment and hydrology delivery
Lakes	Increased water temperature
	Increased toxins
	Increased nutrients
	Reduced DO
	Reduced quantity for access
	Reduced for habitat availability
	Reduced frequency of wood
	Reduced size of wood
	Reduced riparian wood

	Altered riparian species complexity
	Decreased longitudinal connectivity
	Invasive species/altered species composition
	Reduced extent of habitat

3.2 Threats

Threats are defined as human activities that have caused, are causing, or may cause the destruction, degradation, and/or impairment of components and/or their KEAs. Threats deliver stresses directly to components. The Common Framework includes a list of threats with definitions and common stressors. This list is based on threats listed (sometimes using different terms) in existing coho recovery plans (NOAA, ODFW). The definitions are based on previous classifications (IUCN 2001; Salafsky et al, 2008) with minor modifications reflecting the work of the Partnership.

Common Framework Threats and Definitions

Code (not order of priority)	**Threat**	**Definition**
1	Levees, dikes and bank armoring	These threats refer to shoreline hardening practices and the creation of hard linear surfaces along a beach or stream bank. Erosion and flooding in these areas are reduced, but an unnatural riparian area is created that reduces habitat use by salmonids. These structures disrupt shoreline processes, flow regimes, and reduce habitat extent.
2	Gravel mining (placer, suction dredge, other)	The mining of gravel or mineral deposits in a stream bed can lead to degradation to salmonid habitat through the production of effluents that pollute waters, create sediment and toxic chemical runoff, and can cause major changes in stream structure. Sedimentation is common as is a loss of spawning gravel where mining takes place.
3	Tidegates, culverts and other fish passage impairments	These threats taken together refer to structures that impede the movements and migrations of fish. These can include structures in, along-side, and across water bodies. Structures that impede fish movements cause habitat fragmentation resulting in loss of rearing habitat and prevent successful spawning. Dams are included in a different category of threats.
4	Removal of beavers and beaver ponds	The loss of ponds created by beaver dams has resulted in significant loss of rearing habitat for coho salmon. The removal of beavers and beaver ponds

		can alter stream flow, raise water temperature, and removes important feeding and resting habitat.
5	Conversion	Conversion represents changes in land management or development to practices and uses that are less compatible with healthy salmon ecosystems than those that existed previously. Conversion may be viewed as a spectrum with intact and functioning ecosystems on one end and heavily modified areas (such as urban areas, industrial feedlots etc) on the other. As conversion takes place and lands move down this spectrum, watershed health declines due to increased impervious surfaces, altered flow regimes and stream structure, increased pollutant and effluent loading, and/or other adverse impacts to habitat and water quality. Conversion typically reduces both the extent and quality of habitats, while impairing the processes that can restore and create them.
6	Incompatible/poorly managed roads/railroads	Both paved and unpaved roads including logging roads can all be considered threats to salmon habitat. The general expansion of roads causes terrestrial habitat fragmentation, increased fine sediment, impervious surfaces, and causes debris and pollution impacts.
7	Water withdrawals (urban, ag and potential for future water storage)	Water withdrawals can create a threat to salmonid populations by reducing stream flow, changing stream structure, and increasing water temperature. All types of water withdrawals fit into this category, which includes water for private use, agricultural use, and water storage. Water withdrawals from groundwater can also impact surface water availability. This category also includes future water storage projects (dams to store water in winter for use by communities during the summer) which will alter hydrology and water availability.
8	Incompatible/poorly managed stormwater/wastewater	Stormwater and wastewater become threats to salmon populations when they cause toxins and other pollutants to enter salmon habitats. These can be from both point and non-point sources and includerunoff, wastewater discharge, persistent chemical cycling, historic (legacy) sources, non-persistent toxics, and discharge through stormwater conveyance systems. The threat from stormwater and wastewater generally depends on the toxicity and quantity of the discharge or runoff that enters habitats.

9	Dredging	Activities that excavate or remove substrate from estuaries, sloughs, and tidally-influenced river reaches to maintain channels for navigation, prepare an area for development, and support other economic uses. Dredging can cause sedimentation and reduce habitat availability and complexity.
10	Dams and off-channel water storage	Dams and off-channel water storage fall under the same threat category. These threats deal with water storage concerns and are similar in impact to water withdrawal in that flow regimes are modified. Dams and water storage threats can also impede the movements and migrations of fish. Flashy flow regimes can also be caused by dams and off-channel water storage.
11	Incompatible/poorly managed agricultural practices	Incompatible/poorly managed agricultural practices include ongoing and historic agricultural practices that result in higher water temperature, increased effluents, simplified stream structure, and other adverse impacts on habitats and watershed function.
12	Fertilizers/pesticides	Threats from fertilizers and pesticides can impact water quality and introduce pollutants into salmonid habitat.
13	Incompatible/poorly managed timber practices	Incompatible/poorly managed timber practices includes current and legacy (especially splash damming) silvicultural practices that result in higher water temperature, increased effluents, simplified stream structure, and other adverse impacts on habitats and watershed function.
14	Invasive species	Plants, animals, or pathogens that are non-native (or alien) to the ecosystem under consideration and whose introduction causes or is likely to cause harm. Invasive aquatic species can cause increased predation and competition for salmonid populations, as well as displacement of native fish and the introduction of non-native genetic material. Invasive non-native plants can negatively impact riparian habitat by displacing native species.
15	Climate change	Climate change can threaten salmon populations by contributing to sea level rise, increased water temperatures, changes in the patterns of upwelling events, changes in nutrient and oxygen levels, pH decreases, and precipitation changes.

16	Recreation	Recreation includes activities that rely on the passive or active use of natural resources. Such activities are many and varied and may produce a variety of impacts such as wood removal, disturbance to flora and fauna, degraded water quality and others.

3.3 Threat-Stress-Component Linkage

The linkages between threats, stresses and habitat components will help watersheds better articulate and come to a common understanding of what is causing the specific degradation to specific coho habitats. The following table includes the Partnership's assumption of links between components, stresses and threats for the whole Oregon coast. These may or may not be relevant in your watershed.

Component	Key Stresses associated with the component	Threats associated with the stress
Mainstem River	Increased water temperature	1,4,5,6,7,8,10,11,13,15
	Increased toxins	5,8,11,12
	Increased turbidity	1,2,4,5,6,8,9,11,13,15
	Increased nutrients	5,8,11
	Reduced DO	3,5,11,12
	Reduced flows (habitat availability)	4,5,7,10,13
	Increased flashy flows	1,2,3,4,5,6,8,11,13,15
	Lack of natural storage	1,3,4,5,6,7,9,10,11,13
	Increased velocity that reduces winter rearing habitat	1,2,3,4,5,6,8,9,11,13
	Decreased longitudinal connectivity (fish Passage)	2,3,9,11,13
	Lack of pools	1,2,3,4,5,6,9,11,13
	Reduced frequency of wood in streams	1,2,3,5,9,11,13
	Reduced size of wood in streams	13
	Reduced riparian width (buffer size)	1,2,3,5,6,9,11,13
	Reduced riparian wood	1,5,6,9,11,13
	Altered riparian species complexity	1,4,5,6,11,13,14
	Altered riparian age complexity	1,4,5,6,11,13
	Decreased lateral connectivity	1,2,3,4,5,6,9,11,13
	Increased fine sediment	2,4,5,6,8,9,11,13
	Bed coarsening	1,2,4,5,8,9,11,13
	Loss of sediment supply	1,2,3,4,5,6,9,10,11,13
	Reduced extent of habitat	1,2,3,4,5,6,7,8,9,10,11,13,14,15
Tributaries	Increased water temperature	1,4,5,6,7,8,10,11,13,15

	Increased toxins	5,8,11,12
	Increased turbidity	1,2,4,5,6,8,9,11,13,15
	Increased nutrients	5,8,11
	Reduced DO	3,5,11,12
	Reduced flows (habitat availability)	4,5,7,10,13
	Increased flashy flows	1,2,3,4,5,6,8,11,13,15
	Lack of natural storage	1,3,4,5,6,7,9,10,11,13
	Increased velocity that reduces winter rearing habitat	1,2,3,4,5,6,8,9,11,13
	Decreased longitudinal connectivity (fish Passage)	2,3,9,11,13
	Lack of pools	1,2,3,4,5,6,9,11,13
	Reduced frequency of wood in streams	1,2,3,5,9,11,13
	Reduced size of wood in streams	13
	Reduced riparian width (buffer size)	1,2,3,5,6,9,11,13
	Reduced riparian wood	1,5,6,9,11,13
	Altered riparian species complexity	1,4,5,6,11,13,14
	Altered riparian age complexity	1,4,5,6,11,13
	Decreased lateral connectivity	1,2,3,4,5,6,9,11,13
	Increased fine sediment	2,4,5,6,8,9,11,13
	Bed coarsening	1,2,4,5,8,9,11,13
	Loss of sediment supply	1,2,3,4,5,6,9,10,11,13
	Reduced extent of habitat	1,2,3,4,5,6,7,8,9,10,11,13,14,15
Freshwater Non-Tidal Wetlands	Increased water temperature	1,4,5,6,7,8,10,11,13,15
	Increased nutrients	5,8,11
	Reduced DO	3,5,11,12
	Reduced quantity for access	1,2,3,4,5,6,7,8,9,10,11,13
	Reduced for habitat availability	1,2,3,4,5,6,7,8,9,10,11,13
	Lack of natural storage	1,2,3,4,5,6,7,9,10,11,13
	Reduced frequency of wood	1,2,3,5,9,11,13
	Reduced size of wood	13
	Altered species complexity	1,4,5,6,11,13,14
	Altered age complexity	1,4,5,6,11,13
	Decreased connectivity	1,2,3,4,5,6,9,11,13
	Reduced extent of habitat	1,2,3,4,5,6,7,8,9,10,11,13,14,15
Off-Channel	Increased water temperature	1,4,5,6,7,8,10,11,13,15
	Increased toxins	5,8,11,12
	Increased turbidity	1,2,4,5,6,8,9,11,13,15
	Increased nutrients	5,8,11
	Reduced DO	3,5,11,12
	Reduced flows (habitat availability)	4,5,7,10,13
	Increased flashy flows	1,2,3,4,5,6,8,11,13,15
	Lack of natural storage	1,3,4,5,6,7,9,10,11,13

	Increased velocity that reduces winter rearing habitat	1,2,3,4,5,6,8,9,11,13
	Decreased longitudinal connectivity (fish Passage)	2,3,9,11,13
	Lack of pools	1,2,3,4,5,6,9,11,13
	Reduced frequency of wood in streams	1,2,3,5,9,11,13
	Reduced size of wood in streams	13
	Reduced riparian width (buffer size)	1,2,3,5,6,9,11,13
	Reduced riparian wood	1,5,6,9,11,13
	Altered riparian species complexity	1,4,5,6,11,13,14
	Altered riparian age complexity	1,4,5,6,11,13
	Decreased lateral connectivity	1,2,3,4,5,6,9,11,13
	Increased fine sediment	2,4,5,6,8,9,11,13
	Bed coarsening	1,2,4,5,8,9,11,13
	Loss of sediment supply	1,2,3,4,5,6,9,10,11,13
	Reduced extent of habitat	1,2,3,4,5,6,7,8,9,10,11,13,14,15
Estuary	Increased water temperature	1,4,5,6,7,8,10,11,13,15
	Increased toxins	5,8,11,12
	Increased nutrients	5,8,11
	Reduced DO	3,5,11,12
	Increase estuarine acidification	15
	Reduced habitat diversity	1,2,3,4,5,6,9,11,13,15
	Reduced bar area (gravel bar or mud flats)	1,2,3,5,9,11,13
	Increased velocity that reduces winter rearing habitat	1,2,3,4,5,6,8,9,11,13
	Reduced frequency of wood in estuary	1,2,3,5,9,11,13
	Reduced size of wood in estuary	13
	Reduced riparian width (buffer size)	1,2,3,5,6,9,11,13
	Reduced riparian species complexity	1,4,5,6,11,13,14
	Altered riparian age complexity	1,4,5,6,11,13
	Decreased riparian connectivity	1,2,3,4,5,6,9,11,13
	Increased fine sediment (loss of eel grass)	2,4,5,6,8,9,11,13
	Reduced extent of habitat	1,2,3,4,5,6,7,8,9,10,11,13,14,15
	Loss of sediment supply (loss of sand)	1,2,3,4,5,6,9,10,11,13
Uplands	Fragmentation	1,3,4,6,13
	Loss of connectivity to stream networks	1,3,6,11,13
	Altered forest composition	13,14
Lakes	Increased water temperature	1,3,4,5,6,7,10,11,13,15
	Increased toxins	5,6,8,11
	Increased nutrients	5,8,11,13,15

	Reduced DO	1,3,4,7,11,12,13,14
	Reduced quantity for access	1,3,4,5,6,7,10,11,13
	Reduced for habitat availability	1,3,4,5,6,7,11,13,14,15
	Reduced frequency of wood	1,2,3,5,9,11,13
	Reduced size of wood	13
	Reduced riparian wood	1,5,6,9,11,13
	Altered riparian species complexity	1,4,5,6,11,13,14
	Decreased connectivity	1,3,4,5,6,7,8,11,13
	Reduced extent of habitat	1,2,3,4,5,6,7,8,9,10,11,13,14,15

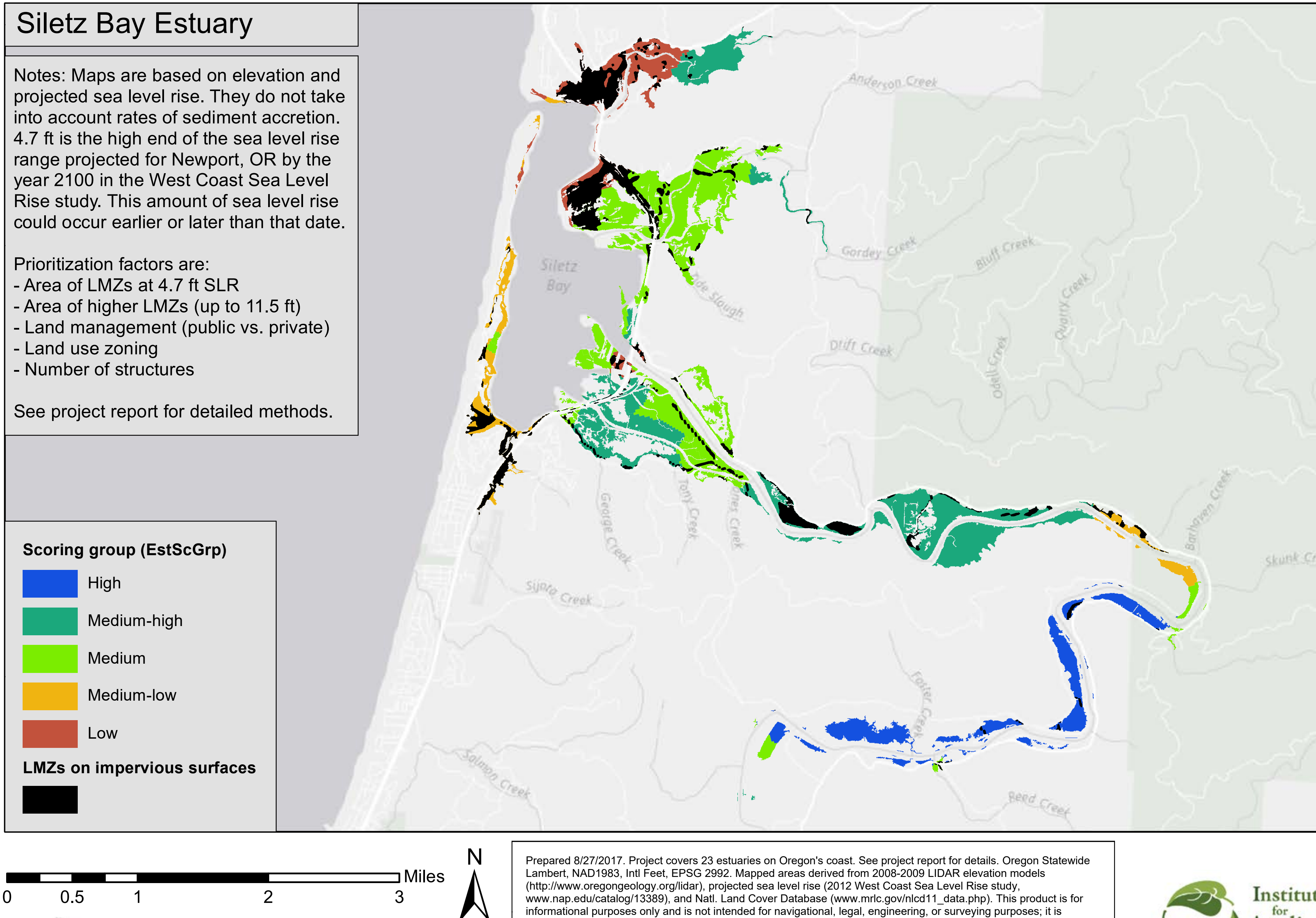
Tidal wetland landward migration zones (LMZs) for 4.7 ft sea level rise: Total score for 5 prioritization factors

Siletz Bay Estuary

Notes: Maps are based on elevation and projected sea level rise. They do not take into account rates of sediment accretion. 4.7 ft is the high end of the sea level rise range projected for Newport, OR by the year 2100 in the West Coast Sea Level Rise study. This amount of sea level rise could occur earlier or later than that date.

Prioritization factors are:
- Area of LMZs at 4.7 ft SLR
- Area of higher LMZs (up to 11.5 ft)
- Land management (public vs. private)
- Land use zoning
- Number of structures

See project report for detailed methods.



Prepared 8/27/2017. Project covers 23 estuaries on Oregon's coast. See project report for details. Oregon Statewide Lambert, NAD1983, Intl Feet, EPSG 2992. Mapped areas derived from 2008-2009 LIDAR elevation models (http://www.oregongeology.org/lidar), projected sea level rise (2012 West Coast Sea Level Rise study, www.nap.edu/catalog/13389), and Natl. Land Cover Database (www.mrlc.gov/nlcd11_data.php). This product is for informational purposes only and is not intended for navigational, legal, engineering, or surveying purposes; it is provided with the understanding that conclusions drawn from the information are the responsibility of the user. A project of the MidCoast Watersheds Council, funded by the Oregon Watershed Enhancement Board and U.S. Fish and Wildlife Service, with support from Pacific States Marine Fisheries Commission. ArcGIS 10.3.1, Prioritiz_landscape_20170827.mxd.

MidCoast Watersheds Council

Institute for Applied Ecology

Oregon and Washington Drinking Water Providers Partnership

Schooner Creek Sediment Reduction Project

Salmon Drift Creek Watershed Council &
City of Lincoln City

Funders

Oregon DEQ, Drinking Water Revolving Loan Fund,
Drinking Water Source Protection Grant Program &
US Forest Service, US Forest Service Partnership Agreement

Report Prepared by:
John Sanchez
12.29.18
Cutthroat Country Consulting LLC PO
Box 2051, Hood River, OR 97031

Table of Contents

Introduction

January 2017 the Salmon Drift Creek Watershed Council staff partnered with the City of Lincoln City submitting a successful road sediment reduction project grant application to The Oregon – Washington Drinking Water Providers Partnership. The sediment reduction assessment focuses on the 4.6-mile stretch of Lincoln County Road 106 (Road Miles 4.7 to 9.3) that runs adjacent to Schooner Creek. Schooner Creek stream bank stability was also assessed upstream of Lincoln City's drinking water plant intake. Lincoln County Road 106 is also known as South Schooner Creek Road or simply Schooner Creek Road; we will usually refer to the project area road as Schooner Creek Road. The project vicinity map is found in Attachment A.

Schooner Creek is the primary source of water for Lincoln City residents. The treatment facility draws water from Schooner Creek by weir or infiltration gallery to meet the domestic water needs of Lincoln City residents. The water intake at River Mile 3.1 is adjacent to Schooner Creek Road at Road Mile Post 2.7; Attachment B is an aerial photo with marked road mileposts.

This Schooner Creek Sediment Reduction Drinking Water Providers Partnership project is an opportunity to address the City's desire to protect Schooner Creek water quality, which has been a local priority for many years. Salmon Drift Creek Watershed Council used an OWEB Technical Assistance Grant from April 2012 as background information for this successful Drinking Water Partners grant application. The successful Watershed Council and Lincoln City applicants are also working with Oregon Department of Fish and Wildlife and the US Forest Service through the Hebo Ranger District on this assessment.

It should be noted that the Lincoln County Public Works Road Maintenance and Operations Department current road maintenance practices have improved drainage and road surface condition when compared to road conditions observed in the 2011 road review. Lincoln County Public Works staff has done an excellent job in the past few years. Many of the issues the April 2012 grant application have been addressed with improved attention to road maintenance. Our suggestions for road drainage and stream bank stability improvements are designed to help landowners and road managers meet the drinking water providers grant objectives.

Ten drinking water protection actions lists as recommendations are found at the end of this assessment report. The recommendations are ranked by priority. The next step will be crafting grant proposals, working with Lincoln County Public Works staff and landowners to meet the Drinking Water Providers Partnership Sediment Reduction objections. Salmon Drift Creek Watershed Council can take the lead on the grant application process and coordinate landowner agreements. Lincoln County Public Works, Schooner Creek Road managers, would implement grant-funded improvements.

Findings

Road Drainage Assessment Summary

Assessment staff walked the nearly five-mile long project area examining; culverts, ditches, road cut banks, uplands near the road, fill slopes, and the road surface. The assessment recommendations are identified by road mile. Lincoln County Integrated Road Information System (IRIS) database lists 66 Schooner Creek Road culverts within the project area. IRIS database information includes culvert cross drain diameter, length, culvert material, and condition. The original IRIS database information provided by Lincoln County staff is found in Attachment C. Culvert mileposts were often marked on the edge of the road on posts driven into the ground. Culverts lacking a monument were located by measuring from a milepost. Lincoln County Public Works staff has GPS locations for each culvert on file. We recorded GPS coordinates for culverts using a Garmin, Oregon 650t during our fieldwork.

Project culvert notes, organized by road mileposts, are found in Attachment D. This table lists sites by road mile and longitude and latitude (GPS) the proposed action, existing culvert condition, and a brief description of the suggested work at each location. Column 1 of the table lists the ranked priority of each of the Project Opportunities given in the Recommendations. The following comments group culvert sites and road segments with similar conditions to show our first steps toward crafting recommendations. Our goal is to promote stable ditches that transport road surface water runoff to the forest floor entering Schooner Creek as ground water seepage. We hope to pass perennial streams under the road with limited sediment transport to Schooner Creek. A few ditches drain directly to Schooner Creek.

Techniques to improve road drainage and stabilize road surfaces to reduce sediment delivery to Schooner Creek is summarized and described by road mile. US Forest Service's typical drawings describe cross drain replacement work and roadway reconditioning recommendations. The National Road Construction Specifications are available online with a Google search (Road drawings USFS R-6). The information is public property made available for use by professional engineers qualified to adapt these drawing to local conditions. Recommendations are an example of one way to achieve the sediment reduction goal. Culvert replacement and patch paving edge transition to grave road surface examples are available in Appendix E. The professional engineer may choose another technique to achieve the sediment reduction outcome.

CULVERTS – No Change

No Changes are proposed at 20 existing culverts in good or very good condition. The IRIS database does not list the condition for culvert 7.75; we found it in good condition. A culvert in good condition that is not on the Lincoln County IRIS list was found at road milepost 7.53. We could not locate the twelve inch diameter, forty six foot long corrugated metal pipe listed at MP 7.06 in the IRIS database.

No Change culverts are currently benefiting from good road maintenance practices that maintain inlet ditch drainage and stable culvert outlets.

CULVERTS – Proposed Improvements, Replacements, and New Culverts
High Priority
Two culverts with inlet failures encroaching on the road surface are identified as high priority replacements. Culvert 4.912 is listed on IRIS as a timber culvert, 5.84 is identified as a precast concrete culvert; both are 15" diameter and listed in fair condition. Both sites are stream sediment and road maintenance challenges with ditches prone to plugging.

Seven culvert replacements between Road Miles 4.903 and 7.83 are proposed for replacement to reduce road sediment transport to Schooner Creek. Downspouts with rock dissipaters are included at each site protecting road fill and the forest floor from storm runoff erosion. Recommended culvert diameters are slightly larger and the preferred material is PVC to improve ditch drainage. Improved ditch drainage reduces road related erosion and promotes road stability by reducing water saturation of road subgrades.

The addition of 5 culverts is proposed to drain standing ditch water and shorten the distance between culverts. Standing ditch water can wet and weaken the road subgrade. Ditch erosion is reduced when water velocity is kept slow, even during storm events, with a short run to the culvert inlet. Downspouts and rock dissipaters will be added as needed to protect road fills and the forest floor from high velocity water leaving the culvert outlets.

CULVERTS – Proposed Replacements
Lower Priority
Five culverts with inlet-plugging risks (RM: 6.98, 7.14, 7.45, 7.89, and 8.310) are not a drinking water protection priority. These culverts are maintenance challenges with inlets that tend to plug with storm runoff. Each culvert would benefit from an increased diameter or minor adjustment to the culvert inlet location or material change to PVC. Consider these culverts for future replacement, especially if the project area road is paved in the future.

If there is an opportunity to fund Schooner Creek Road drainage structure upgrades from Road Mile 4.7 to its junction with US Road 17, consider replacing each of the culverts listed below. They are currently functioning in fair condition or are maintenance challenges but are not a threat to Schooner Creek water quality.
(Road Mile: 4.793, 5.433, 6.61, 6.640, 6.98, 7.92, 8.01, 8.14, 8.70, 8.830, and 8.98)

DRAINAGE IMPROVEMENTS - Road Shoulders and Cut Banks

The seven turnouts identified in recommendations for road drainage improvement are well used throughout the year. Turnouts are rutted and generate mud and turbid water each winter. They currently meet the needs of traffic flow. Schooner Creek water quality could benefit from improved road surface strength with the addition of base rock and surface gravel. Each turnout should be sloped to drain to the forest floor. We do not recommend increasing turnout length or width if it would encourage parking or dispersed recreation.

A road shoulder slide at RM 7.18 has received truckloads of large riprap to help stabilize the site. It is a site that remains wet throughout the year and will continue to be a challenge. We do not recommend any additional treatment at this time.

We struggled and were unable to identify a solution to stabilize the eroding cut bank at MP 7.21. It is a site that has raveled for years and continues to drop both large and small amounts of soil and rock on Schooner Creek Road. This site will continue to be a high road maintenance priority.

Schooner Creek road at MP 7.84 has a narrow running surface and steep drop to the waters of Schooner Creek. We recommend a focus on techniques to slow traffic approaching the narrow, 80' long site from both directions. Consider signage and road shoulder paddles to encourage drivers to slow as approaching this site. We do recommend dust abatement at this site to stabilize road surface fines adjacent to Schooner Creek.

Identification of Road Slide Soil Storage Areas

Steep road cut banks have slid onto the roads of Lincoln County for generations. Schooner Creek Road, within the project area, is no exception. Most stream sediment entering the creek is from episodic debris torrents that occur in first and second order stream channels (Drift Siletz WA, 1996) often blocking roads. Road maintenance crews are often tasked with opening roads throughout the County when winter storms bring both wind and rain. The road slide soil is loaded into dump trucks and carried to the closest storage area allowing crews to quickly move onto the next road hazard. Maintenance actions generate truckloads of soil requiring stable, local storage. The need for local, stable, road slide soil storage was identified early in the assessment. Storage areas along Schooner Creek Road are full highlighting the need for more short haul soil storage options to keep road slide soils out of Schooner Creek. Proposed soil storage areas are described and mapped in Attachment F.

Proposed Waste Storage Sites

Hancock Soil Storage Site
Hancock Forest Management Company manages the forestland accessed by a closed road at milepost 7.69. The gravel spur road climbs to the north and northwest with favorable grades less than 10%. Currently the road is closed at the County Road junction with large rocks. A gate and spot rocking is needed, as well as minimal ditch line construction to improve road drainage.

The beginning of the proposed soil storage site is located about 1100 feet from the Schooner Road junction. The waste area extends southwest of the main road as it continues climbing to the northwest and ends 400 feet later at an overgrown landing. Side slopes at the proposed waste site drop from the road edge at about 60% for twelve feet and the extend for fifty feet or more down slope at just over 20% slope. The site location is flagged with red ribbon along the upper side of the existing road from beginning to end. The flagged area is four hundred feet long, forty five to fifty feet wide, and with an average depth of twelve to fifteen feet could hold 7,000 to 8,000 cubic yards of material and only occupy about ½ to ¾ acre at full development. The recommendation for Lincoln County use is to start by expanding the existing road in the designated area by about one additional road width of twenty feet. Soil would be placed below the existing road and brought up to road level with a 1¼:1 fill slope. Then the surface would be compacted, sloped to drain, and rocked with pit run. This amount of development would require little more than ¼ of an acre to start and hold about 1000 to 1200 cubic yards of material. Future use would continue to expand the site by an additional road width, and each pass would hold substantively more material.

Miniski Soil Storage Site

The US Forest Service Schooner Rock Restoration Project Environmental Analysis (April 2017) includes development and use of the Miniski Quarry within the existing rock pit development plan. Quarry development includes a soil storage site. Hebo Ranger District staff support Lincoln County road maintenance use of the site for road slide soil storage through a Memorandum of Understanding. The Salmon Drift Creek Watershed Council will apply for grant funding to develop the soil storage site. Attachment G is a map of the project area.

Existing Roadside Waste Piles

We propose excavation and transport of 1,150 CY of road slide soils currently stored on the roadside of Schooner Creek Road at MP 5.98 to 6.04 and MP 7.51 to 7.53. Slide soils would be transported by dump truck and stored at the Miniski site on US Forest Service land. The cleared roadside sites would be rocked and sloped to drain for use as temporary roadside soil storage when Lincoln County road maintenance is responding to storm damage throughout the County.

Road Shoulder Excavation

Cracks along the road shoulder at Road Mile 6.34 are evidence of an estimated 100 cubic yards of unstable side cast perched above Schooner Creek. Adjacent road shoulder west of this site has slid. This road shoulder has shown cracks for the past few years; it can slide at any time. A slide would reach Schooner Creek and could mobilize soil down slope resulting in more than 100 cubic yards of soil reaching the creek. An 18" diameter by 40' culvert passes through the unstable side cast draining the cut bank ditch. The existing culvert is prone to plugging in the winter, ponding water that increases the chance of shoulder failure by wetting the road fill. Replacement of the existing corrugated metal culvert with a PVC culvert and downspout with rock dissipater is proposed. We recommend fitting the existing culvert inlet with a slotted standpipe while unstable road fill remains onsite. A site photo and road fill profiles are found in Attachment H.

Road Surface Paving Options

Paving Short Segments

Five short road segments, Attachment G, are drinking water protection paving candidates. Road runoff, ditch water, and dust at each site are likely to find its way to Schooner Creek. A floodplain dissipation option for road drainage water is limited even with a fully functional road drainage system. A stable road surface is a good water quality protection option. Highest priority paving projects are found closest to the down stream Schooner Creek drinking water intake. We recommend not paving the narrow residential road surface from end of pavement, RM 4.7 to 5.028. Necessary road widening would disturb stable cut banks creating a high risk of slide debris delivery to Schooner Creek from the road surface and ditch.

Paving Segment 1 -Road Miles 5.028 to 5.159 (900 Feet)

Paving this 900-foot long road section will harden the road surface draining directly into Schooner Creek without restricting adjacent residential traffic to one lane. The school bus turnaround and private industrial timberland road junction are within the proposed paved segment. Rain runoff currently runs down the logging road ruts and ponds on Schooner Creek Road before finding the ditch and culvert draining into Schooner Creek. Our patch paving recommendation includes the addition of a culvert with a floodplain outlet and rock dissipater, east of the bus turnaround at Road Mile 5.17. The goal at this site is to reduce the creation of road related fine grain sediments, including clay. The post project ditch water with less sediment will be directed to a better culvert outlet site with sediment trapping floodplain soils and vegetation.

Paving Segment 2 -Road Miles 5.578 to 5.582 (200 feet)

The shotgun culvert draining directly into Schooner Creek at 5.58 is at a low point dividing this road segment. The road is immediately above and adjacent to Schooner Creek delivering ditch water directly to the stream. There is no practical floodplain culvert outlet option for ditch water discharge. The best water quality option is to keep ditch water as sediment free as possible with an improved road surface.

Paving Segment 3 - Road segment 5.71 to 5.94 (1,150 feet)

Much of this road segment is built on a stream bank rock buttress with ditch water draining directly to Schooner Creek. The existing 24” diameter, fair condition, corrugated metal pipe, at RM 5.77 passes a 42” wide perennial stream. We recommend replacing this culvert before paving with a 48” diameter culvert with inlet wings. Counter sink the new pipe matching the road cover depth of the existing culvert. Consider placing hand rocks and 2” minus rock throughout the culvert to trap downstream migrating streambed material. Before paving consider replacing a second pipe, the Precast Concrete culvert at RM 5.84 is currently in fair condition. The culvert inlet on the road shoulder has failed and could become a road hazard.

Paving Segment 4 - Road segment 6.60 to 6.725 (350 feet)

This Schooner Creek road segment is found in a low spot on the floodplain adjacent to the OWEB funded helicopter large wood aquatic habitat restoration project. We recommend replacing three culverts before paving. Tributary streams draining the hillsides come off steep slopes that are known to transport slide material plugging Schooner Creek Road culverts. Debris flows have plugged the existing culvert at RM 6.69 in the past. Replacing the culvert with a 48” diameter culvert with inlet wings is suggested. The rusting corrugated metal pipes at 6.61 and 6.64, both in fair condition, are recommended for replacement with larger diameter PVC culverts to reduce the risk of plugging.

Paving Segment 5 - Road segment 9.16 to 9.27 (580 feet)

This road segment is found on the floodplain near the headwaters of Schooner Creek. Schooner Creek water quality benefits are minimal due to the long distance from the Lincoln City water intake. This road/stream crossing site is suggested as both a benefit to emergency evacuation to the rally point at the junction of USFS Road 17 and Schooner

Creek Road as well as benefit upstream fish passage to both spawning and rearing habitat. Two side-by-side 48” diameter culverts pass the stream under the existing road. Side-by-side culverts are prone to plugging and road fill erosion is evident at the road-crossing inlet. Replacing these culverts with a twelve foot span concrete box culvert or squash pipe would protect the road from winter storm event.

Road Surface Dust Abatement Options

Road surface dust abatement treatments are another option to consider to better retain fine road rock and soil particles on the road and out of the ditch where ditch water can transport sediments to Schooner Creek. Dust abatement treatment is recommended on five road segments (2.1 miles) adjacent to Schooner Creek shown in Attachment H. The dust abatement product can be applied once or twice a year for up to five years for best results. We suggest Earthbind 100 dust abatement product manufactured by EnviRoad LLC in Portland, Oregon, Attachment I. The Earthbind 100 product is listed as approved by Oregon Department of Transportation. It is always important to apply the dust abatement product to the road surface with dry weather.

1. Road Miles 4.7 to 5.2

This Schooner Creek Road segment starts at end of pavement and runs adjacent to the Creek for one half-mile. The school bus turnaround and private industrial timberland road junction are at the eastern end of the road segment. Log trucks use the bus turnaround at the bottom of the industrial forest road to stop and tighten their bindings. Water runs down the logging road ruts and ponds in the Schooner Creek Road ditch before draining to Schooner Creek. We recommend adding a culvert with downspout and rock dissipater at RM 5.17, draining water onto the floodplain.

2. Road Segment 5.4 to 6.0

The shotgun culvert at 5.58 is at a low point dividing this road segment. The road is adjacent to Schooner Creek delivering road dust and ditch water directly to the creek. Much of this road is built on a stream bank rock buttress with ditch water draining directly to Schooner Creek.

3. Road segment 6.4 to 6.9

Consider replacing the RM 5.77 undersized corrugated metal culvert, currently in fair condition, with a 48” wide culvert with inlet wings to pass water and debris from the 42” bank full width tributary stream. Consider replacing the Precast Concrete culvert at RM 5.84, currently in fair condition. The culvert inlet on the road shoulder has failed and could become a road hazard.

4. Road segment 7.6 to 7.9

This portion of road above Schooner Creek is narrow with limited road shoulder between RM 7.84 and 7.85. We recommend replacing the culvert at RM 7.83 with an 18”x50’ PVC pipe placed at a south 10° west angle with a down spout draining to the floodplain. Dust abatement treatment will benefit water quality and may also help with traffic safety by defining the road edge around the approaches to the short segment with narrow road shoulder.

5. Road segment 9.0 to 9.4

This road segment is found on the floodplain near the headwaters of Schooner Creek. Two side-by- side 48" diameter culverts at RM 9.19 pass the stream under the existing road. Side-by-side culverts are prone to plugging and road fill erosion is evident at the road-crossing inlet. Replacing these culverts with a twelve foot span squash pipe or concrete box culvert would protect the road from winter storm events and improve upstream fish passage to both spawning and rearing habitat. Consider extending the dust abatement treatment beyond the project area to the junction with Forest Service Road 17 at Schooner Creek Road Mile 9.7.

Stream bank stability assessment

This Schooner Creek Sediment Reduction Assessment's primary focus is on road/stream fine soil and rock particle retention to improve Schooner Creek water quality. The stream bank stability assessment component of the assessment looked upstream of the drinking water intake in this 9,650 acres watershed for stream bank, riparian area, and upland soil stability and erosion control opportunities.

The land ownership pattern is similar to many other north coast watersheds with private, stream adjacent land low, and National Forest and private timber company lands upstream. Approximately 70% of Schooner Creek watershed land is in Federal ownership, the majority managed by the Siuslaw National Forest. Private timber holdings comprise 29% of the watershed. The National Forest manages for old growth forest characteristics through the Late Successional Reserve (LSR) land allocation. Private timberland is managed on a 40 to 45 year harvest rotation through State Forest Practices Act standards.

The City of Lincoln City water treatment plant water intake structures are found at Schooner Creek River Mile 3.1 adjacent to South Schooner Creek Road Mile 2.7. This narrative will use River Miles for site reference locations. Water treatment plant operators can deal with turbid water (within limits) but treating clear water is always preferred. As such we wanted to identify potential problem areas that might contribute sediment to the stream. We assessed floodplain and stream bank stability to look for potential chronic or episodic sediment sources.

Private residential stream adjacent lands were unobtrusively observed or entered with landowner permission. We looked at 7.5 stream miles above the water intake (4.6 miles Schooner Creek, 2.0 miles North Fork, and 0.9 miles South Fork). Stream survey information, Schooner Creek Watershed Assessments, and restoration project accomplishment reports aided in the efficiency of the assessment.

Residential property dominates Schooner Creek floodplain private ownership from the water plant intake at River Mile 3.1 to River Mile 5.5. This stream reach is actually below the gravel portion of Lincoln County Road 106, Schooner Creek Sediment Reduction Project focus (Road Mile 4.8 to 9.4). It is important to look at the floodplain above the water treatment plant as an area that can have a direct impact on water quality above the intake. Schooner Creek stream gradient flattens out 0.6 miles above the water intake. Peak stream flows spread out across the wide, flat floodplain and water velocity slows down. Flat, vegetated floodplains can slow water velocity and capture stream sediments.

We found few examples of human debris in Schooner Creek, no trash dumping, and only one dispersed recreation camper on Schooner Creek. Recommendations are intended to serve the current level of residential and commercial traffic with drinking water protection upgrades. We did not want to draw more visitors to the Schooner Creek watershed.

Photo 1. Private residential property at River Mile 3.45 managed as wildlife habitat with a vegetated floodplain.

Photo 1. River Mile 3.45 is an example of a flat, vegetated floodplain that is a good fine sediment catcher. There are seven landowners in this important stream reach. Several landowners are managing for wildlife habitat. The SDCWC can explore ways to help the landowners keep their floodplains well vegetated.

The Schooner Creek stream reach from River Mile 3.7 to 5.5 is a mixture of private residential and private industrial forest. Private forestland with Schooner Creek floodplain is found on the east bank, accessed by logging systems that would yard away from Schooner Creek.

One half-mile of the 1.8-mile Schooner Creek floodplain between River Miles 3.7 and 5.5 is residential. A few of these properties could benefit from riparian planting on the stream edge to improve stream bank stability. The undeveloped floodplain in the reach is well-vegetated, stable, and not in need of erosion control. Stream reaches with limited floodplain typically have stable basalt stream banks.

Schooner Creek, from the upstream extent of residential property at River Mile 5.5 to the North/South Forks junction at River Mile 7.7 is mixed private industrial forestland and US Forest Service ownership. The floodplain is typically narrow and well vegetated; stream banks are stable. Two mature knotweed plants were found that could spread this invasive plant down stream reducing vegetation floodplain function and wildlife habitat. We recommend Lincoln Soil and Water Conservation District add these two sites to their invasive plant control efforts.

Knotweed photos taken above River Mile 6.5.

Stream gradient flattens between River Miles 6.9 and 7.2. Helicopter placed large wood is found functioning as aquatic habitat and trapping streambed fine sediment. There are no floodplain or stream bank areas, unrelated to Schooner Creek Road, which would benefit from erosion control or riparian planting.

Photos taken along South Fork Schooner Creek Road Decommissioning.

South Fork Schooner Creek is a stream with a long domestic water source history. The dam and fish ladder are both intact with a very low risk of failure that could trigger an episodic muddy water event. Stream banks and floodplains below and above the dam are stable and well vegetated. No differences were noted from my previous walk in 2011. South Fork Schooner Creek Stream survey data (Woods and Stone, 2011) describes a stream 34 feet to 25 feet wide at a moderate gradient of 2 to 4 percent. Winter stream flows are confined to a relatively narrow stream channel with a flood prone area width less than twice the active stream channel width. We found stable stream banks and few key large wood pieces.

The 1.5 mile long US Forest Service road running parallel to South Fork Schooner Creek was decommissioned. Access to the fish ladder was retained. The decommissioned road surface is not a South Fork Schooner Creek sediment source. Culverts were removed to prevent plugging and road fill failure. We did find continuing erosion at culvert removal locations and recommend follow-up erosion control. Straw and shrub planting erosion control on excavated slopes would be helpful. Five wetted stream channels through the road footprint would benefit from willow planting and rock dissipaters where tributary streams are head cutting.

The mouth of North Fork Schooner Creek is a fish passage structured originally built in 1985, damaged in 1995 and repaired with a constructed roughened chute fish passage structure in 2007. This is the entrance to a steep V-shaped channel with a narrow floodplain and an average gradient of over 8% extending for approximately 1,000 feet. This stream reach opens up on a relatively flat, wide floodplain that has been the site of large wood placement to improve aquatic habitat. No erosion control actions are needed in this stream reach.


North Fork Schooner with flat stream gradient and well-vegetated floodplains.

North Fork Schooner Creek (Woods and Stone, 2007) flattens out to an average stream gradient of 1.0%. Two aquatic habitat restoration projects have added large wood to this area of North Fork Schooner with good success. The large wood complexes are intact, trapping stream sediments, and providing good winter rearing habitat conditions for juvenile coho salmon. Braded stream channels are common. North Fork Schooner does get up on its floodplain during high stream flows, slowing velocity and dropping fine sediments. There are no erosion control measures needed on the floodplains of North Fork Schooner Creek.

Recommendations

Drinking water protection recommendations are grouped by potential grant packages and ranked in priority order. The opportunities are described in necessary detail to select and group actions for grant funding. Cost estimates are included to help group actions to match minimum and maximum grant funding available for each grant opportunity considered.

Project Opportunities – ranked by priority

1. **Prepare the Miniski soil storage site on National Forest land**
   The US Forest Service Schooner Rock Restoration Project Environmental Analysis (April 2017) includes use and development of the Miniski Quarry within the existing pit development plan. Quarry development includes a soil storage site. Hebo Ranger District staff support Lincoln County road maintenance use of the site for road slide soil storage through a Memorandum of Understanding. The Salmon Drift Creek Watershed Council will apply for grant funding to develop the soil storage site. Attachment G is a map of the soil storage area project areas.

   An existing landing would be expanded with additional fill material while maintaining the existing level of the landing and roadway with all work meeting the EA Project Design Criteria and seasonal and daily time restrictions. Fifteen to 20 merchantable plantation trees (10”-16”dbh) would be cut and stacked. Landing slash and brush piled on the landing will be removed to prepare an area for dump trucks to maneuver. Brush and slash removed from the landing will be piled and prepared for burning. This initial clearing would prepare an area that could contain 2,500 to 4,000 cubic yards of soil. However, the potential development of the entire 1.5-acre area as a waste site is quite large, and it could hold 15,000 to 20,000 cubic yards for quarry development.

Cost	
$ 600	Sawyer
$2,450	70 CY 1½ x ¾ inch rock delivered @35/CY
$1,050	30 CY ¾ inch minus rock delivered @35/CY
$ 750	Erosion control
$4,200	325 Cat Excavator – 2 days + Move in-Move out

Total Cost $9,050

2. **Reopen roadside temporary soil storage sites**
   Excavate and transport 1,150 Cubic Yards of road slide soils stored on the roadside of Schooner Creek Road. The soil is stored in piles along the road shoulder at two sites; MP 5.98 to 6.04 and MP 7.51 to 7.53. The dirt piles will be loaded into dump trucks by excavator and hauled to a nearby permanent soil storage site. The Miniski site on US Forest Service land is a possible storage location and will be used for estimating haul costs. The cleared roadside sites would be rocked and sloped to drain for use as temporary roadside soil storage when Lincoln County road maintenance is responding to storm damage throughout the County. Attachment F is a map of the project areas.

Cost	
$ 3,150	90 CY 1½ x ¾ inch rock delivered @35/CY
$ 1,050	30 CY ¾ inch minus rock delivered @ 35/CY
$ 700	Erosion control
$17,250	1,150 Cubic Yards @ $15 per yard with 9 mile round trip haul

Total Cost $22,150

3. **Road shoulder excavation**

Excavate and haul 100 cubic yards of unstable road shoulder soil perched at Road Mile 6.3 above Schooner Creek. Place the soil in an area designed for permanent storage.

Cracks along the road shoulder running for 69 feet have been exposed for over five years at Road Mile 6.34 above Schooner Creek. The concave remnant of past road shoulder, adjacent to the west of this site, is evidence of a past slid. An 18" diameter by 40' corrugated metal culvert passes through the unstable side cast draining the cut bank ditch. The existing culvert is prone to plugging in the winter, ponding water that increases the chance of shoulder failure by wetting the road fill. An episodic slide event could happen at any time of year. A slide would reach Schooner Creek and could mobilize down slope soil in addition to road shoulder resulting in more than 100 cubic yards of soil reaching the creek.

We recommend excavating an estimated 100 CY road shoulder soil. Using a track-mounted excavator, remove and haul soil to a permanent storage site. Place a silt fence at the bottom of the clearing area to prevent loose soil from reaching the waters of Schooner Creek. Covering bare soil with straw is recommended for erosion control. Native shrubs and brush will soon cover the newly disturbed site but we do recommend planting potted shrubs to jumpstart recovery. Replacement of the existing corrugated metal culvert with a larger diameter PVC culvert will help the ditch pass cut bank slide soils. A downspout with rock dissipater is also recommended. A site photo and road fill profiles are found in Attachment H.

Rock the turnout. We also recommend fitting the existing culvert with a slotted standpipe to prevent culvert inlet plugging while unstable road fill remains onsite.

Cost

$5,600	Culvert replacement – 18" x 50' with downspout and rock dissipater
$1,050	30 CY 1½ x ¾ inch rock delivered @$35/CY
$ 750	20 CY ¾ inch minus rock delivered @ $35/CY
$1,750	Erosion control + shrub planting
$5,700	325 Cat Excavator – 3 days + Move in-Move out
$1,500	Haul 100 CY soil @ $15/CY

Total Cost $16,350

4. **Soil storage site development**

Hancock Forest Management staff will work with SDCWC to develop a soil storage area on land managed by Hancock. The potential area for soil storage is extensive. An area four hundred feet long, fifty feet wide, with an average depth of twelve to fifteen feet has been flagged. The site could hold, at full development, up to 8,000 cubic yards of soil dumped, while occupying less than ½ acre. Soil storage will expand the area of the existing landing that will be needed for timber harvest in an estimated twenty five years.

The spur road at Schooner Creek Road Mile 7.69 accesses the site climbing to the north and northwest at 5% to 15%. Currently the road is closed and blocked by large rocks about 40 feet from the Schooner junction. The road surface is currently rocked with pit run, has a ditch line in a few places, and no culverts. This road is heavily brushed over by blackberry and nearly impassible in many sections. The road was hand brush for field inspection and site flagging.

Machine brushing 1,100 feet of road between Schooner Creek Road and the soil storage site is needed to access the storage site. The soil storage site would be cleared of extensive brush, numerous non-merchantable plantation conifers, and old logging slash. The short spur road to the east at the beginning of the proposed waste site offers a good area for slash disposal site. Trees and slash debris from the clearing the soil storage area will be windrowed on the downhill area boundary. At the base of each fill, a shallow ditch with a 2' tall berm will be prepared to allow water to drain laterally away from the storage area. Attachment F is a map of the project areas.

Road preparation will require 1½ minus rock placed twelve feet wide and eight inches deep. Rock will be stock piled at the storage site to cover the compacted soil surface expanding the landing area. A drivable drain dip is flagged three hundred feet from the Schooner Creek Road junction where road gradient breaks from 4% to near 10% draining into brush on relative flat ground. Two turnouts will be rocked on the 1,100' long access road. A gate will be placed on the spur road near the Schooner Creek Road junction. In addition, sufficient room for a truck turn-around for a ten cubic yard dump truck will be cleared on the landing.

The recommendation for Lincoln County use is to start by expanding the existing road in the designated area by about one additional road width of twenty feet. Road slide soil would be dumped and brought up to the existing road level with a 1¼:1 fill slope. Then the surface would be compacted, rocked with pit run, and sloped to drain. This amount of development would require little more than ¼ of an acre to start and hold about 1,000 to 1,200 cubic yards of material – if developed to the full length along the road way. Future use would continue to expand the site by an additional road width, and each pass would hold substantively more material. An access permit between Hancock Forest Management and Lincoln County Publics works, renewable, not to exceed three years, is required.

Cost

$15,000	500 CY 1½-inch minus rock delivered @$30
$ 1,050	30 CY ¾ inch minus rock delivered @$35
$ 1,350	Erosion control
$ 1,500	Cat dozer - 2 days + Move in-Move out
$ 5,400	325 Cat Excavator – 3 days + Move in-Move out
$ 4,500	Pre-fabricated Gate installed

Total Cost $28,800

5. **Road drainage improvement**

Culvert upgrades with downspouts and rock dissipaters and rocking well-used turnouts will reduce gravel road chronic sediment delivery to Schooner Creek. The highest priority culverts and turnouts have been selected for the first round of grant applications. These high priority culverts are mapped in Attachment K.

Culverts at Mile Posts 4.793, 4.912 and 5.84 are fifteen-inch diameter pipes in fair condition with damaged inlets. The three culvert inlets are encroaching on the road surface. Upgrading these culverts with eighteen inch diameter PVC culverts will solve ditch drainage maintenance issues. Moving the culvert inlet back to the proper location at the ditch will reduce road surface fine particle delivery to Schooner Creek.

Replace 7 culverts, one each at Road Miles: 4.903, 5.26, 5.374, 6.16, 6.46, 6.98, and 7.83. Add downspouts and rock dissipaters to these culverts.

Add rock dissipaters to the outlets of the 7 culverts listed below.

Rock and slope to drain, 7 traffic turnouts, each at the following Road Miles: 5.159, 5.55, 6.34, 6.98, 8.10, 8.16, and 8.35. These turnouts hold turbid water all winter and are rutted well into the summer. Each is a source of road surface soil particles to Schooner Creek.

Cost	
$12,000	Replace 4.793, 4.912 and 5.84 culverts–18”x30’ PVC culverts @ $4,000 ea.
$20,000	Replace 4.903, 5.26, 5.374, and 6.16 precast concrete culverts –with 18”x30’ PVC culverts and downspouts 12’, 12’, 30’, and 10’ long @ $5,000 each
$12,000	Replace 6.46 and 7.83 culverts – with 18”x 68’ and 18”x50’ culverts and downspouts 25’ long @ $6,000 each
$ 2,800	Add rock dissipaters at 5.69, 6.51, 6.81, 7.08, 7.53, 7.58, and 7.61 culvert outlets
$ 7,500	Replace the culvert at MP 6.98 – 18”x33’ PVC culvert and add a rock dissipater. Rock the turnout at this site with 8 inches deep 1½ inch minus rock covered by ¾ minus rock four inches deep.
$17,500	Slope to drain and rock seven traffic turnouts; 5.159, 5.55, 6.34, 6.98, 8.10, 8.16, and 8.35 with 8 inches deep 1½ inch minus rock covered by ¾ minus rock 4 inches deep. Estimate $2,500 each per turnout
Total Cost	**$71,800**

6. **Add 5 new culverts**

Each of these proposed new culverts address ditches that hold standing water, several well into late spring and early summer. Aiding ditch drainage helps maintain dry and stable road subgrade, improving road strength and stability. Ditches do not drain well to down slope culverts at these sites. Each new culvert will improve road drainage and reduce chronic fine sediment delivery to Schooner Creek. These proposed project sites are mapped in Attachment L.

Cost	
$6,500	MP 5.17 – 18”x60’ PVC culvert with 20’ downspout and dissipater
$4,000	MP 5.34 – 18”x30’ PVC culvert only
$4,800	MP 6.03 – 18”x50’ PVC culvert only
$5,500	MP 7.50 – 18”x25’ PVC culvert with 40’ downspout
$4,000	MP 9.275 – 18”x30’ PVC culvert

Total Cost $24,800

7. **Road drainage improvement – prevent road fill erosion**

Replace three culverts (Road Mile: 4.998, 5.77, and 6.69) with larger diameter structures. Consider adding wing walls at culvert inlets. These proposed project sites are mapped in Attachment M.

RM 4.998 culvert – The project site is adjacent to private road 4969 and property owned by JD Liswig. The landowner reports high water overtopping the road when debris from storm flows plug the culvert inlet. The culvert alignment to the stream has shifted over the years to near 90° with flow turning at the road fill base.

We propose leaving the existing culvert in place as an overflow culvert. Add a 48”x45’ long corrugated metal pipe culvert with the new culvert inlet in alignment with the stream. The new culvert outlet could exit the five foot deep road fill near the current culvert outlet. This site will require maintenance after storm events but will be less likely to plug, reducing the threat of road fill failure. Cost estimate is using installation techniques that will allow traffic to pass during construction.

$5,000	Design
$3,500	MP 4.998 – 48”x45’ Corrugated Metal Pipe culvert
$1,000	Traffic control
$6,500	Installation

Total Cost $16,000

RM 5.77 culvert – The existing culvert is a 24”x32’ corrugated metal pipe passing a perennial stream with a 3.5 foot bank full width. The current culvert passes seasonal high stream flows but is prone to plugging with storm events. Road fill over the culvert is less than two feet.

We propose replacing the existing undersized culvert with a 48”span x 40’ long squash corrugated metal pipe to reduce the chance of plugging during storm flows. The top of the new culvert would be set at the elevation of the existing culvert. The new culvert would be installed at a flat grade. The culvert outlet will be near the bottom of the existing plunge pool. Place riprap in the bottom of the existing plunge pool to prevent erosion and down cutting. The streambed above the new culvert inlet will adjust to the lower elevation of the new pipe but we do recommend placing hand rocks within the new culvert, near the culvert inlet to catch native stream bed sediments within the new pipe. Cost estimate is using installation techniques that will allow traffic to pass during construction.

$5,000 Design
$7,160 MP 5.77 – 48"x40' Corrugated Metal Squash Pipe culvert
$1,000 Traffic control

Total Cost $13,160

RM 6.69 culvert – The existing culvert, a 30"x44' corrugated metal pipe, passes flow from a perennial stream. The current culvert passes seasonal high stream flows but is prone to plugging when storm events bringing debris slide rock and wood filling and overtopping the culvert. The culvert can be placed at 2% grade with a rock dissipater at the outlet. Consider a concrete inlet wing walls and collar.

$ 5,000 Design
$ 7,500 MP 6.69 – 48"x44' Corrugated Metal Squash culvert, riprap wing walls
$ 1,000 Traffic control
$6,500 Installation

Total Cost $20,000

8. **Road drainage improvement**

Replace 8 culverts that are ditch inlet maintenance challenges with larger diameter culverts that will remain free flowing with storm runoff. Chronic road surface fine delivery to Schooner Creek will be reduced with stable, well functioning culvert inlets. These proposed project sites are mapped in Attachment N.

Cost
$4,000 MP 5.028 – 18"x24' PVC culvert
$4,500 MP 5.20 – 18"x30' PVC culvert
$4,500 MP 5.228 – 18"x31' PVC culvert
$6,500 MP 6.61 – 24"x40' PVC culvert and rock dissipater
$4,500 MP 6.64 – 18"x36' PVC culvert, 6' downspout and rock dissipater
$5,500 MP 6.87 – 18"x40' PVC culvert
$7,500 MP 7.14 – 48"x 65' CMP culvert
$4,500 MP 7.45 – 18"x 41' PVC culvert and rock dissipater

Total Cost $41,500

9. **Strengthen the road surface – Grant funded test application**

Consider 2.4 miles of dust abatement treatment to road segments adjacent to Schooner Creek. Earthbind 100 manufactured by EnviRoad LLC in Portland, Oregon is marketed as an environmentally friendly dust control palliative and soil stabilizer. It is a liquid concentrate diluted in water, designed to replace calcium or magnesium chlorides commonly used for dust abatement. Earthbind is an emulsion and is mixed with water for application purposes; the weather needs to be dry enough for the water in the Earthbind solution to evaporate. Earthbind is considered cured when all the water in the solution evaporates. Also there should not be a threat of rainfall for at least seventy two hours to ensure curing. Attachment I is a map of the proposed project areas.

A treated road surface would better retain fine rock and soil particles, reducing the likelihood of ditch transport of sediments to Schooner Creek. Dust abatement products are often applied after road blading. The work can be done once or twice a year, late spring and/or early fall. It must be applied in dry weather.

$ 3,000	Application by one distributor truck in one day
$ 1,800	Truck and trailer freight charge for 2 loads @ $900/load
$13,141	3,092 gallons @ $4.25/gallon Earthbind 100 stabilizer/dust suppressant

Total Cost $17,941 – For each treatment of 2.44 miles at 18 feet wide

10. **Pave 5 short road segments**

Pave five short segments of Schooner Creek Road, a total length of 0.6 miles x 18 feet wide, each located between MP 4.7 and MP 9.4 adjacent to Schooner Creek. The minimum acceptable full width paving length is 200 feet. Pave 4" depth with two 2" lifts of nominal compacted depth hot mix asphalt. Total paving area is (+/-) 57,024 square feet. Asphalt base prep work is not included in cost estimates. Ten culverts are likely replacement candidates before pavement application. Attachment O is a map of the proposed project areas.

Asphalt cost per mile is an estimated $231,000 per mile for asphalt only. Asphalt base preparation and culvert replacements are not included in this price. The cost of asphalt only from end of pavement at Road Mile 4.7 to junction with FS Road 17 at Road Mile 9.7 is not less than $1,155,000. This estimate does not include road base preparation, turnout paving, culvert replacement, and a survey of paving locations and dimensions. The cost of paving the gravel portion of Schooner Creek Road between MP 4.7 and 9.7 could easily exceed $1.5 million dollars. The cost of patch paving 0.6 miles of road adjacent to Schooner Creek with culvert replacements at MP 6.69, MP 5.028, and MP 6.61 would exceed $ 200,000.

$ 3,000	Mobilization
$ 136,620	1,584 tons of hot mix asphalt @ $86.25 per ton
$ 174,000	1584 tons hot mix asphalt delivery
$ 5,000	Replacement cost of each culvert - new 18" diameter culvert

Total Cost $318,620 – 0.6 miles 18' wide, 4" deep hot mix asphalt only

Conclusion

Lincoln County Public Works road maintenance and operations department is doing an excellent road maintenance job on the gravel road within our project area. Our suggestions for road drainage improvements are designed to help road managers meet the drinking water providers grant objectives.

The ten project opportunities are identified and ranked by priority. They are also grouped in potential grant packages. We feel it is necessary to develop local soil storage site options before excavation, haul, and storage of large volumes construction material and road slide soil. Both potential soil storage sites require memorandums of understanding or special use agreements before development, one with the US Forest Service on Federal land and the other on private industrial forestland. It might be possible to modify existing agreements.

Schooner Creek Road culverts and road drainage system, within the project area are functioning well. Twenty of 66 culverts are in good condition and not recommended for replacement or upgrade under any recommendation. Our recommendations are intended to help local government staffs stretch their road maintenance budgets to meet the public needs for both transportation and the highest quality drinking water possible.

Our stream bank and floodplain assessment is very positive. Schooner Creek, above the Lincoln City water treatment plant intake are well vegetated, stable, and are not in need of erosion control or riparian planting. Two small patches of knotweed were found near River Mile 6.6 (44° 56.884', -123° 55.647') and another patch at River Mile 6.8 (44° 56.886', -123° 55.633'). We suggest working with the Lincoln County Soil and Water Conservation District for early noxious weed control. The forest road decommissioned along South Fork Schooner Creek, past the fish ladder road, is very stable. The old running surface is well vegetated. Culvert removal excavation slopes would benefit from additional erosion control and willow planting.

John Sanchez, Principal
Cutthroat Country Consulting, LLC

References

Drift (Siletz) Landscape Watershed Analysis. September 1996. Available at: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5194225.pdf

Schooner Rock Restoration Project Environmental Analysis, April 2017. EA is available at the Hebo Ranger District, Siuslaw National Forest.

Woods and Stone, June 2007. Oregon Department of Fish and Wildlife Aquatic Inventory Project Stream Report, North Fork Schooner Creek. The aquatic inventory is available at the MidCoast Watershed Council Office, Newport, Oregon.

Woods and Stone, August 2011. Oregon Department of Fish and Wildlife Aquatic Inventory Project Stream Report, South Fork Schooner Creek. The aquatic inventory is available at the MidCoast Watershed Council Office, Newport, Oregon.

Aerial Surveys in the Siletz River Basin
Thermal Infrared and Color Videography

April 24, 2002

Report to:

Confederated Tribes of the Siletz Indians
PO Box 549
201 SE Swan Ave.
Siletz , OR 97380

by:

Watershed Sciences
712 NW 4th Street
Corvallis, OR 97330

Final Report

Table of Contents

Introduction

Thermal infrared remote sensing has been demonstrated as a reliable, cost-effective, and accessible technology for monitoring and evaluating stream temperatures from the scale of watersheds to individual habitats (Karalus et. al., 1996; Torgersen et. al. 1999; Torgersen et. al. 2001). In 2001, the Siletz Indian Tribe contracted with Watershed Sciences, LLC (WS, LLC) to map and assess stream temperatures in the Siletz River Basin using thermal infrared (TIR) remote sensing.

This report presents longitudinal temperature profiles for each survey stream as well as a discussion of the thermal features observed in the basin. TIR and associated color video images are included in the report in order to illustrate significant thermal features. An associated ArcView GIS[1] database includes all of the images collected during the survey and is structured to allow analysis at finer scales. Appendix A presents a collection of selected TIR and visible band images from the surveys. Appendix B portrays the longitudinal profile for each stream surveyed in a range of 8-25^{o}C for respective comparisons.

Methods

Data Collection

Data were collected using a TIR sensor and a visible band color video camera co-located in a gyro-stabilized mount that attached to the underside of a helicopter. The helicopter was flown longitudinally along the stream channel with the sensors in a vertical (or near vertical) position. Figure 1 illustrates the extent of the TIR surveys and Table 1 summarizes the dates and times of each survey.

TIR images were collected digitally and recorded directly from the sensor to an on-board computer. The TIR sensor detects emitted radiation at wavelengths from 8-12 microns and records the level of emitted radiation in the form of an image. Each image pixel contains a measured value that can be directly converted to a temperature. The raw TIR images represent the full 12 bit dynamic range of the instrument and were tagged with time and position data provided by a Global Positioning System (GPS). Visible band color images were recorded to an on-board digital videocassette recorder at a rate of 30 frames/second. GPS time and position were encoded on the recorded video. The color video camera was aligned to present the same ground area as the TIR sensor.

[1] Geographic Information System

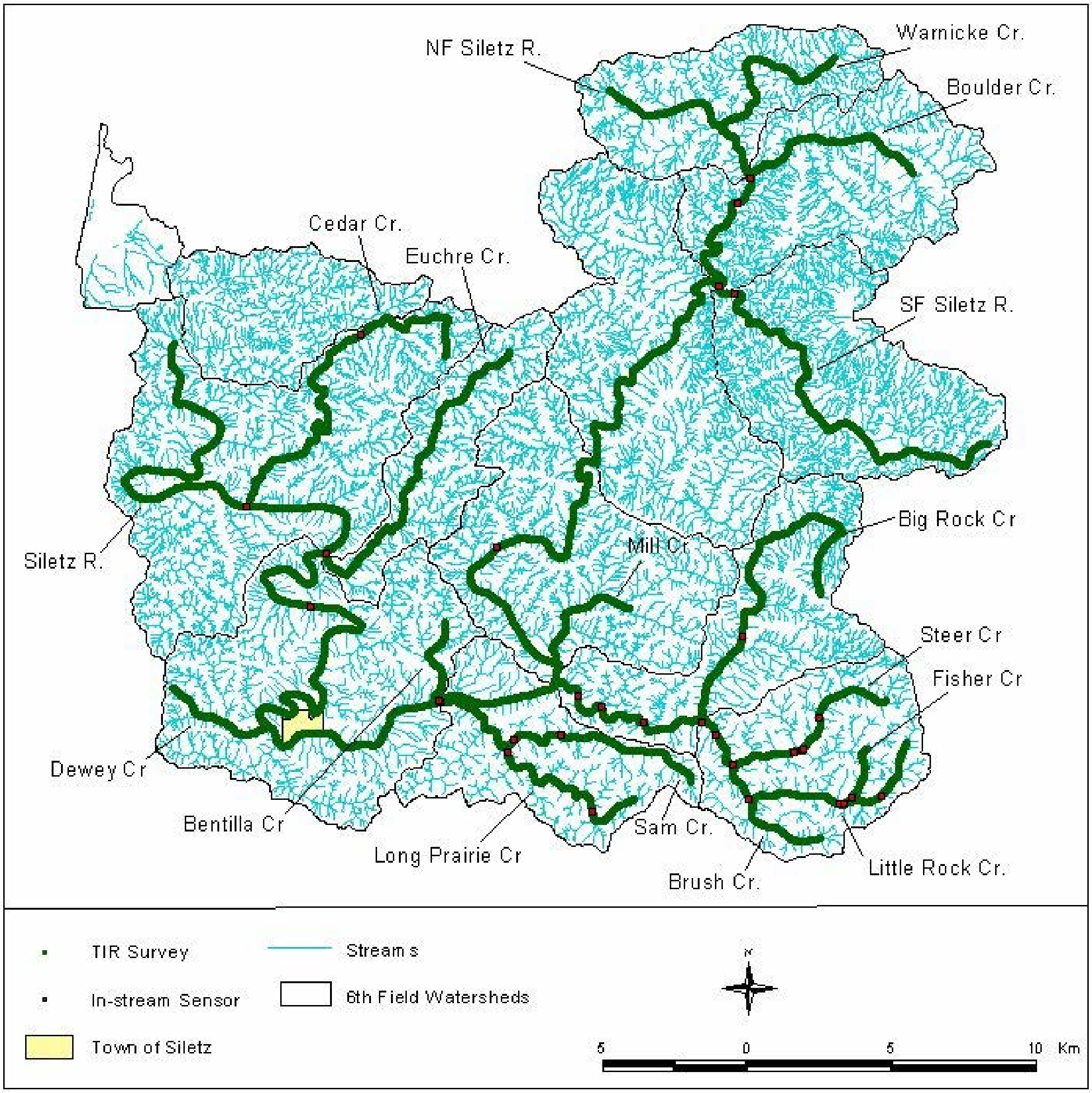


Figure 1 – Map of the Siletz River watershed showing the streams surveyed using TIR and visible band color video. Included in the figure are the locations of in-stream sensors that were used to verify the accuracy of the radiant temperatures.

The survey of the Siletz River was conducted at an altitude of 1800 ft above ground level (AGL). At this altitude, the image has a 192-meter wide footprint with a pixel size of 0.32 meters. The North and South Forks of the Siletz River, Sam Creek, Rock Creek, Cedar Creek, and Euchre Creeks were all surveyed at 1400ft AGL, resulting in a 150-meter wide image footprint and a pixel size of .25 meters. All the other surveys in the basin were conducted at 1200 ft AGL in order to better capture the smaller channel width. At this altitude, the image footprint is 130 meters with a pixel size of .2 meters. The flight direction was upstream for all of the rivers and creeks in the survey and the images are oriented in the flight direction.

Table 1 - Time, date and distance for the Siletz River basin surveys.

Stream	Date	Time (PM)	Mileage
Siletz R.	5-Aug	13:46-15:00	54.4
North Fork Siletz R.	5-Aug	15:01-15:20	9.7
Warnicke Cr.	5-Aug	15:22-15:33	5.3
Boulder Cr.	5-Aug	15:36-15:47	5.3
South Fork Siletz R.	5-Aug	15:52-16:14	11.3
Sam Cr.	6-Aug	13:44-14:03	8.3
Long Prairie Cr.	6-Aug	14:07-14:20	5.2
Rock Cr.	6-Aug	14:22-14:38	5.3
Little Rock Cr.	6-Aug	14:39-14:53	8.0
Fisher Cr.	6-Aug	14:55-14:59	1.5
Brush Cr.	6-Aug	15:02-15:07	2.4
Steer Cr.	6-Aug	15:09-15:21	5.3
Big Rock Cr.	6-Aug	15:24-15:56	9.7
Cedar Cr.	7-Aug	14:00-14:33	11.4
Euchre Cr.	7-Aug	14:37-14:58	8.8
Dewey Cr.	7-Aug	15:05-15:12	2.9
Bentilla Cr.	7-Aug	15:16-15:25	2.5
Mill Cr.	7-Aug	15:33-15:41	3.1

WS, LLC distributed in-stream temperature data loggers (Onset Stowaways) at 8 locations in the basin prior to the surveys (Figure 1). This sensor information was supplemented by additional locations provided by Siletz Tribes. The in-stream sensors were used to ground truth (i.e. verify the accuracy of) the radiant temperatures measured by the TIR sensor. The advertised accuracy of the Onset Stowaway's is $\pm 0.2^{o}C$.

Meteorological conditions for August 5-7 were recorded using a portable weather station located at Moonshine Park along the Siletz River, located between Baker and Palmer Creeks, at river mile 50.7. Weather conditions for all three days are summarized in Table 2.

Table 2 – Meteorological conditions recorded in the Siletz River basin for the dates and times of the TIR surveys.

Time	*Temp (*F)*	*Temp (*C)*	*RH (%)*
August 5, 2001			
13:30	69.7	21.0	63.2
14:00	70.4	21.3	59.6
14:30	72.5	22.5	54.9
15:00	73.8	23.2	53.8
15:30	74.5	23.6	53.3
16:00	73.8	23.2	51.8
16:30	71.1	21.7	57.0
August 6, 2001			
13:30	70.4	21.3	74.3
14:00	71.8	22.1	71.3
14:30	72.5	22.5	71.3
15:00	73.8	23.2	67.8
15:30	73.8	23.2	68.3
16:00	73.8	23.2	66.8
August 7, 2001			
14:00	74.5	23.6	58.0
14:30	75.2	24.0	58.0
15:00	77.3	25.2	54.4
15:30	75.2	24.0	55.9
16:00	75.2	24.0	54.9

Data Processing

A computer program was used to create an ArcView GIS point coverage containing the image name, time, and location it was acquired. The coverage provided the basis for assessing the extent of the survey and for integrating with other spatially explicit data layers in the GIS. This allowed WS, LLC to identify the images associated with the ground truth locations. The data collection software was used to extract temperature values from these images at the location of the in-stream recorder. The radiant temperatures were then compared to the kinetic temperatures from the in-stream data loggers.

The image points were associated with a river kilometer within the GIS environment. The river kilometers were derived from 1:100K "routed" stream covers from the Environmental Protection Agency (EPA). The route measures provide a spatial context for developing longitudinal temperature profiles of stream temperature. In the laboratory, a computer algorithm was used to convert the raw thermal images (radiance values) to ARC/INFO GRIDS where each GRID cell contained a temperature value. A GIS program was used to display the GRID associated with an image location selected in the point coverage. The GRID was color-coded to visually enhance temperature differences, enabling the user to extract temperature data (Figure 2). The legend on the left of "Grid View" specifies the temperature range associated with each color. The other view window shows the point coverage with the displayed GRID location highlighted in yellow. Each point in the "Siletz River" view represents another image location.

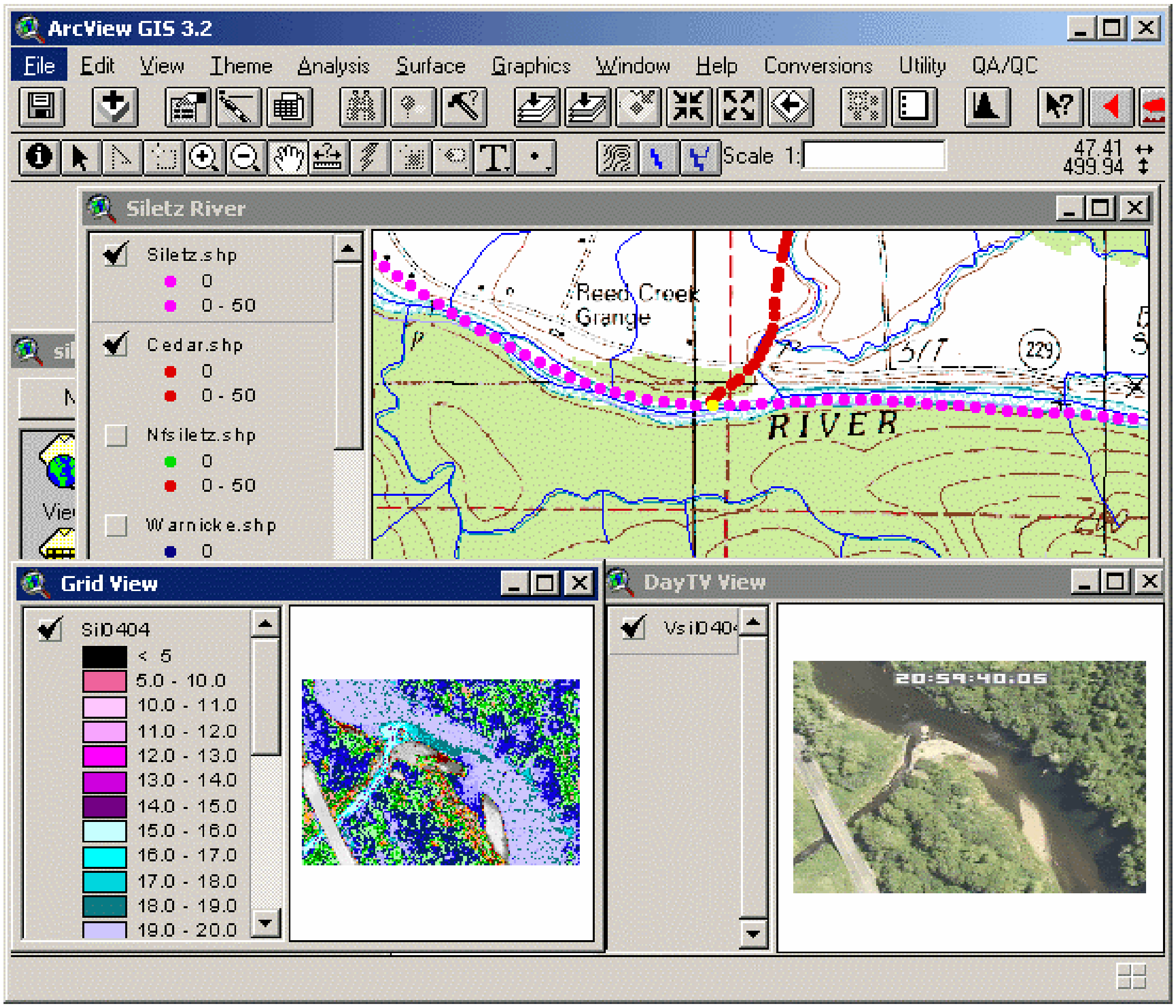
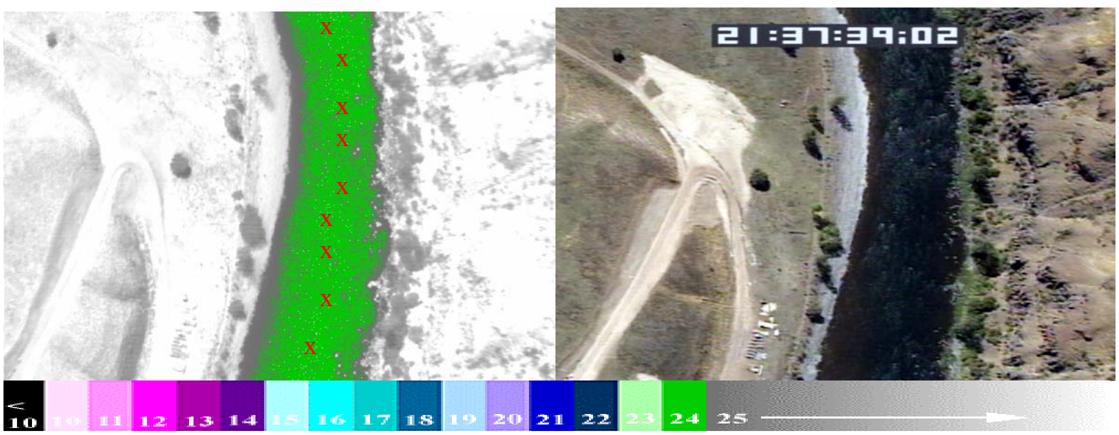


Figure 2 – ArcView display showing a color-coded temperature GRID in one window and the geographic location of the GRID in the other. The orientation of the image is always in the flight direction, which in this case is upstream and opposite the map.

Once in the GRID format, the images were analyzed to derive the minimum, maximum, and median stream temperatures. To derive these measures, a computer program was used to sample the GRID cell (temperature) values in the stream channel. Ten sample points were taken longitudinally in the center of the stream channel. Figure 3 provides an example of how temperatures are sampled. The red "x"s on the psuedo-color TIR image show typical sample locations. Samples were taken to provide complete coverage without sampling the same water twice. Where there were multiple channels, only the main channel (as determined by width and continuity) was sampled. For each sampled image, the sample minimum, maximum, median, and standard deviation was recorded directly to the point coverage attribute file. The median value is the most useful measure of stream temperatures because it minimizes the effect of extreme values. The temperature of tributaries and other detectable surface inflows were also sampled from images. These inflows were sampled at their mouth using the same techniques described for sampling the main channel. If possible, the surface inflows were identified on the USGS 24K base maps. The inflow name and median temperature were then entered into the point coverage attribute file.

Visible band images corresponding to the TIR images were extracted from the database using a computer-based frame grabber. The images were captured to correspond to the TIR images and provide a complete coverage of the stream. The video images were "linked" to the corresponding thermal image frame in the ArcView GIS environment.



TIR/visible band color image

Figure 3 – Image pair showing typical temperature sampling locations. Temperatures are presented in ^{o}C.

Data Limitations

TIR sensors measure thermal infrared energy emitted at the water's surface. Since water is essentially opaque to thermal infrared wavelengths, the sensor is only measuring surface water temperature. TIR data accurately represents bulk water temperatures in reaches where the water column is thoroughly mixed, however, thermal stratification can form in reaches that have little or no mixing. Approximately half of the streams in the Siletz River Basin showed evidence of thermal stratification. These regions are addressed further in the individual stream discussions.

In addition to vertical mixing, TIR reflections and spatial resolution may also influence the accuracy of the radiant temperatures. The TIR reflections result from changes in background parameters and water surface conditions. Torgersen (2001) documented a difference in the apparent temperatures between pools and riffles, which were related to differences in reflective characteristics at the water's surface. The differences in apparent temperatures between pools and riffles are typically on the magnitude of 0.5°C. Riparian vegetation and topography can also change the level of reflected energy received at the TIR sensor. As channel and riparian conditions change through the stream course, the level of TIR reflections also change. However, since the reflectivity of water in the TIR wavelengths is low, changes in the reflective component have a relatively small influence (e.g. $<$1.0°C) on apparent stream temperatures in a natural environment.

Hybrid pixels are pixels that integrate features such as rocks and vegetation with the water surface resulting in a higher temperature reading. When the stream channel is narrow relative to the pixel size, a greater number of hybrid pixels can exist within the sample. Consequently, small channel widths can result in higher inaccuracies and more "noise" in the temperature profile. Smaller mainstream widths were observed in Warnicke, Sam, Little Rock, Steer and Cedar Creeks. In addition to small channel widths, the canopy on either stream bank may obstruct the view of the mainstream, preventing accurate sampling. This occurrence was apparent in Little Rock, Big Rock, Steer and Cedar Creeks. The influence of these factors on temperature sampling is addressed during the discussion of individual streams.

Results

Thermal Accuracy

Temperatures from the in-stream data loggers were compared to radiant temperatures derived from the imagery for each survey (Table 3). The data were assessed at the time the image was acquired, with the radiant values representing the median of ten points sampled from the image at the data logger location. Each surveyed stream was calibrated separately based on the meteorological conditions recorded at the time of the survey. If a consistent difference was observed for all the in-stream sensors, the parameters used to convert radiant values to temperatures were adjusted to provide a better fit to the in-stream sensors. Thirty-seven ground truth locations were used to verify the accuracy of the temperatures in the streams surveyed in the Siletz River Basin. All of the points showed a difference less than or equal to ±0.9°C between the in-stream and the radiant temperatures. The average differences of -0.1°C (Aug. 5), -0.2°C (Aug. 6) and .2°C (Aug. 7) were consistent with TIR surveys conducted in the PNW since 1994 (Torgersen et. al. 2001).

Table 3 – Comparison of ground-truth water temperatures with radiant temperatures derived from the TIR images, August 5-7, 2001. Temperatures are reported in ^{o}C.

Stream	Image	Time	In-stream Temp ^{o}C	Radiant Temp ^{o}C	Difference
		August 5, 2001			
Siletz R	sil0731	2:10 PM	20.3	20.2	0.1
Siletz R	sil1292	2:29 PM	16.3	16.7	-0.4
Siletz R	sil1621	2:40 PM	16.5	16.5	0.0
NF Siletz R	sil2226	3:00 PM	15.7	16.0	-0.3
NF Siletz R	nfs0013	3:01 PM	15.7	15.5	0.2
NF Siletz R	nfs0217	3:08 PM	15.5	15.7	-0.2
Boulder Cr	nfs0260	3:10 PM	14.3	14.6	-0.3
Boulder Cr	bldr0008	3:36 PM	14.5	14.9	-0.4
Boulder Cr	bldr0008	3:36 PM	14.5	14.6	-0.1
SF Siletz R	sfs0040	3:53 PM	17.1	17.0	0.1
		August 6, 2001			
Sam Cr	sam0023	1:44 PM	15.6	16.6	-1.0
Sam Cr	sam0032	1:44 PM	16.9	16.6	0.3
Sam Cr	sam0224	1:51 PM	16.1	15.8	0.3
Sam Cr	sam0329	1:54 PM	16.1	15.6	0.5
Long Prairie Cr	lp0028	2:07 PM	14.8	15.3	-0.5
Long Prairie Cr	lp0292	2:16 PM	14.2	14.5	-0.3
Rock Cr	rock0079	2:25 PM	17.8	18.1	-0.3
Rock Cr	rock0140	2:27 PM	19.8	19.0	0.8
Rock Cr	rock0244	2:30 PM	17.5	18.1	-0.6
Little Rock Cr	rock0398	2:35 PM	18.8	18.8	0.0
Little Rock Cr	lr0015	2:39 PM	19.7	19.4	0.3
Steer Cr	lr0015	2:39 PM	18.5	18.7	-0.2
Little Rock Cr	lr0082	2:41 PM	18.8	19.4	-0.6
Little Rock Cr	lr0237	2:47 PM	18.0	17.9	0.1
Little Rock Cr	lr0250	2:47 PM	16.6	17.2	-0.6
Fisher Cr	lr0270	2:48 PM	21.7	21.0	0.7
Little Rock Cr	lr0334	2:50 PM	16.7	19.8	-3.1
Little Rock Cr	ste0016	3:09 PM	19.7	18.8	0.9
Steer Cr	ste0024	3:10 PM	19.0	18.5	0.5
Beaver Cr	ste0130	3:13 PM	15.6	16.4	-0.8
Little Steer Cr	ste0144	3:13 PM	15.6	15.8	-0.2
Steer Cr	ste0148	3:14 PM	18.0	17.9	0.1
Steer Cr	ste0215	3:17 PM	15.9	16.4	-0.5
Big Rock Cr.	br0011	3:24 PM	18.3	18.6	-0.3
Big Rock Cr.	br0248	3:33 PM	15.2	15.0	0.2
		August 7, 2001			
Cedar Cr	ced0040	2:07 PM	16.6	15.1	1.5
Siletz Cr	ced0037	2:07 PM	21.0	19.5	1.5
Cedar Cr	ced0521	2:27 PM	14.3	14.9	-0.6
Siletz R.	euc0009	2:37 PM	19.9	20.2	-0.3
Euchre Cr.	euc0020	2:38 PM	16.0	16	0
Siletz R.	ben0024	3:17 PM	20.2	20.9	-0.7
Siletz R.	ben0055	3:17 PM	21.7	20.8	0.9
NF Siletz R	sfb0007	3:51 PM	17.47	17.7	-0.2
SF Siletz R	sfb0012	3:51 PM	19.34	19.2	0.1

Temporal Differences

Figure 4 shows in-stream temperature variation at two locations in the Siletz River as well as the time bracket of the TIR remote sensing flights. The region of the Siletz River at river mile 28.9 had a daily maximum stream temperature of 21.6°C which occurred between 4 PM and 5:40 PM. At river mile 51.8 of the Siletz River, the maximum daily stream temperature of 18.1°C was recorded between 7:30 PM and 9:50 PM. The survey of the Siletz River concluded 1 hour before the maximum at river mile 29.8 and ended 4.5 hours before the highest temperature read at river mile 51.8. During the survey, the stream temperature increased from 19.9-21.1°C at river mile 29.8 and from 15.8-16.8°C at river mile 51.8.

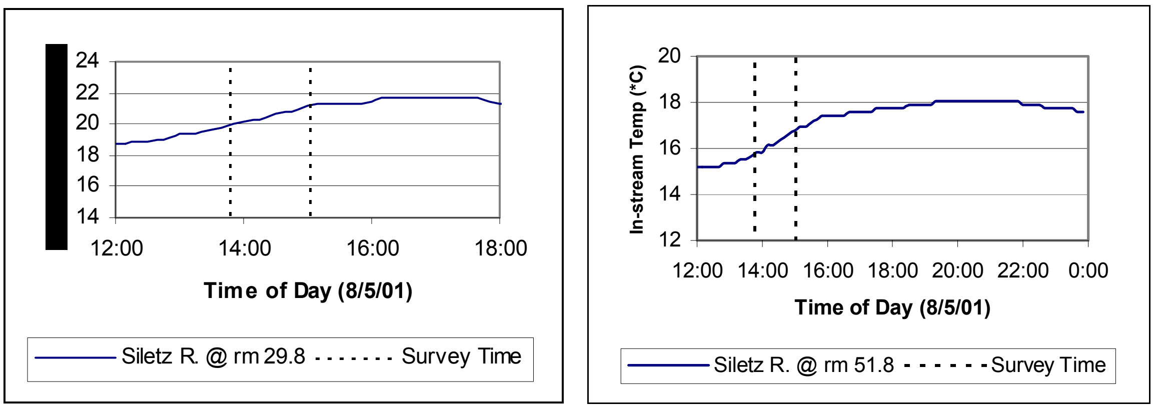


Figure 4 – Stream temperature variation and time of TIR remote sensing over flight for two locations in the Siletz River on August 5, 2001.

Longitudinal Temperature Profiles

Siletz River

The median temperatures for each sampled image of the Siletz River were plotted versus the corresponding river mile (Figure 5). The plot also contains the median temperature of all surface water inflows (e.g. tributaries, canals) that were visible in the imagery. Tributaries are labeled in Figure 5 by river mile with their name and temperature listed in Table 4.

The Siletz River was surveyed from river mile 11.1 (*just downstream of Morgan Landing*) to the confluence of the North and South Forks at river mile 63.5. At the confluence, water temperatures in the Siletz River were ≈15.5°C. The South and North Forks were not significantly different at 15.9°C and 15.6°C respectively. Moving downstream, water temperatures warmed slightly reaching ≈16.6°C at river mile 63.4. Between river miles 62.7 and 61.4, Elk Creek, Falls Creek, and an apparent seep were sampled and contributed to a slight decrease (≈0.7°C) in the main stem temperature. Stream temperatures remained near (±0.4°C) 16.0°C before starting to increase again at river mile 60.3. The longitudinal profile shows an apparent dip (≈0.6°C) in stream temperatures between river miles 59.2 and 58.3 and no surface water inflows were detected to account for the shift in temperatures at this location. However, the magnitude of the change is only slightly larger than the ±0.4°C noise typical of TIR images (*reference data limitations*) and no definitive conclusions can be made about the source of this decrease.

From river mile 58.5, stream temperatures increased slightly in the downstream direction reaching a local maximum of ≈17.6°C at river mile 53.8. An apparent cooling trend was observed between river mile 53.8 and 51.6 and no tributaries were sampled in this segment. The topographic map shows that the stream changes aspect through this reach and differential heating due to local topography may account for the observed decrease in temperature through this reach. River mile 51.6 is just downstream of a location labeled as the Powderhouse Hole on the topographic map and marks the location of the downstream end of the Siletz River gorge. At the time of the survey, the Siletz River showed a net increase of ≈0.8°C through the 13.7-mile gorge reach with maximum temperatures of 17.4°C (±0.4°C) observed between river miles 57.5 and 53.3.

Stream temperatures increased from ≈16.3°C at river mile 51.6 to ≈18.3°C at river mile 46.8. This reach covers from the upstream end of Moonshine Park to the confluence of Rock Creek. Downstream of Rock Creek, stream temperatures remained consistently near 18.4°C (±0.4°C) until river mile 40.7. Five tributaries were sampled between river mile 40.7 and 47.3. With the exception of Rock Creek, the tributaries contributed water that was cooler than the Siletz River and most likely helped buffer temperature increases through this reach. Rock Creek contributed water that was approximately the same temperature as the main stem. Between river mile 40.2 and 37.5, stream temperatures increased steadily reaching a local maximum of 19.5°C. Water temperatures remained near 19.5°C to river mile 36.2 before showing a slight decrease to 18.3°C at river mile 35.2. No tributaries or other surface inputs were sampled within this segment that would account for the decrease, which occurs near the downstream end of the Oxbow reach around the town of Siletz.

From river mile 35.2, water temperatures in the Siletz River increased steadily to a survey maximum of 20.6°C at river mile 32.3. An overall cooling trend was observed between river mile 32.3 and 17.7 with local thermal variability observed throughout the reach. Six tributary inflows were sampled through this reach. Each contributed water that was cooler than the main stem and contributed to the observed local variability. Stream temperatures increased slightly to ≈19.3°C at river mile 16.2 and remained relatively consistent to river mile 11.1. The tidal influence on the observed temperature patterns in the lower river was not assessed as part of the survey.

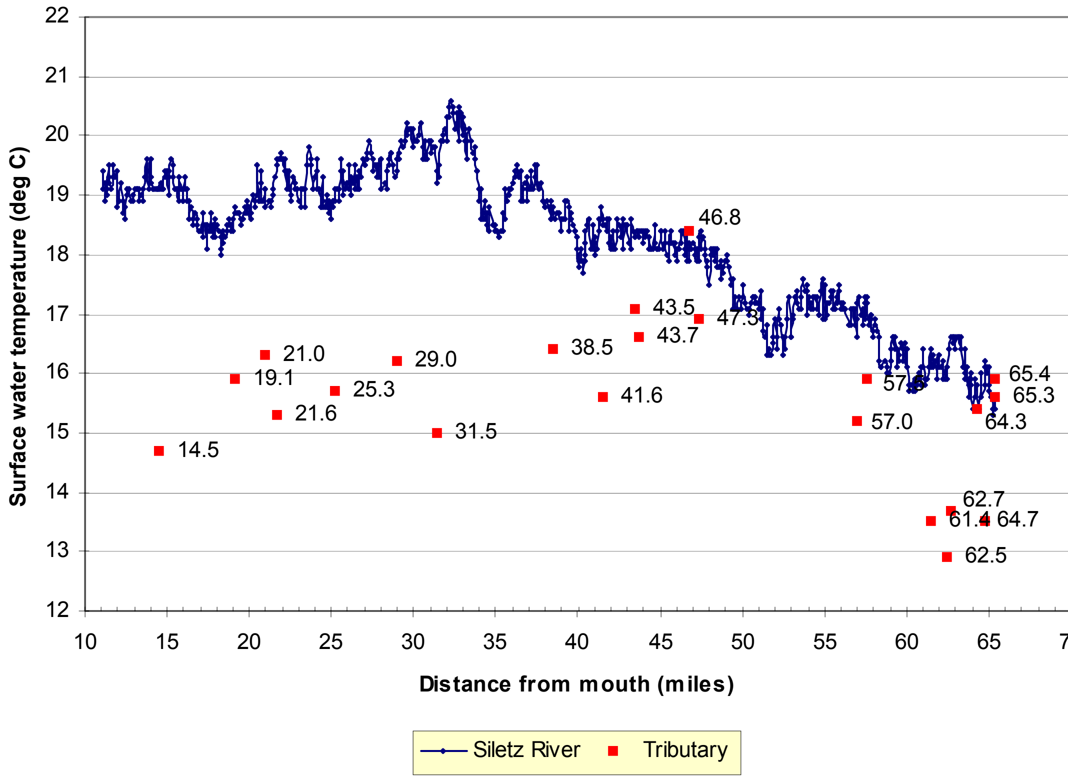


Figure 5 - Median channel temperatures versus river mile for the Siletz River, OR along with the location of tributary and other surface water inputs (8/5/01).

Table 4 - Tributary temperatures for the Siletz River, OR. River miles correspond to data labels shown in Figure 5.

Tributary Name	Image	Km	Mile	Tributary Temp ^oC	Siletz R. Temp ^oC	Difference Temp ^oC
Roots Creek (RB)	sil0128	23.3	14.5	14.7	19.1	-4.4
Unnamed (LB)	sil0303	30.8	19.1	15.9	18.7	-2.8
Jaybird Creek (LB)	sil0382	33.8	21.0	16.3	18.8	-2.5
Cedar Creek (RB)	sil0404	34.8	21.6	15.3	19.5	-4.2
Euchre Creek (RB)	sil0552	40.7	25.3	15.7	19.1	-3.4
Ollaja Creek (LB)	sil0698	46.6	29.0	16.2	19.4	-3.2
Thompson Creek (RB)	sil0796	50.6	31.5	15.0	19.4	-4.4
Mill Creek (LB)	sil1083	62.0	38.5	16.4	18.7	-2.3
Unnamed (LB)	sil1205	66.9	41.6	15.6	18.5	-2.9
Bentilla Creek (RB)	sil1283	70.0	43.5	17.1	18.3	-1.2
Sam Creek (LB)	sil1292	70.4	43.7	16.6	18.3	-1.7
Rock Creek (LB)	sil1410	75.3	46.8	18.4	18.1	0.3
Mill Creek (LB)	sil1439	76.2	47.3	16.9	18.3	-1.4
Buck Creek (RB)	sil1849	91.7	57.0	15.2	16.9	-1.7
Sunshine Creek (LB)	sil1874	92.6	57.5	15.9	17.3	-1.4
Elk Creek (RB)	sil2053	98.9	61.4	13.5	16.4	-2.9
Falls Creek (LB)	sil2094	100.6	62.5	12.9	15.9	-3.0
Cool Seep (RB)	sil2104	100.9	62.7	13.7	16.6	-2.9
Side Channel (RB)	sil2181	103.5	64.3	15.4	15.8	-0.4
Gravel Creek (RB)	sil2194	104.1	64.7	13.5	15.8	-2.3
NF Siletz R. (RB)	sil2225	105.1	65.3	15.6	15.4	0.2
SF Siletz R. (LB)	sil2226	105.2	65.4	15.9	15.6	0.3

On the Siletz River, a higher degree of local thermal variability was observed than typically observed in TIR remote sensing of streams (within the same image and between consecutive TIR images). The variability can be due to a number of factors including differences in ambient background conditions. However, contributions from reflections are typically small ($<0.5^oC$) and exist on all airborne TIR surveys. On streams that are mixing slowly (or not at all), differential heating at the stream surface is another factor that can contribute to increased spatial variability. A stratified boundary layer can form differentially on the stream surface based on the instantaneous heating rate coupled with the mixing rate at any given location. Consequently, the water surface in a shaded area may have a cooler apparent temperature than in the non-shaded portion of the main channel (Appendix A – Frame:sil0189). While under these conditions the surface temperatures measured by the TIR sensor may measure bulk streams as accurately as in a well-mixed areas, the evidence from in-stream sensors and from measurements in obviously mixed areas such as in riffles indicates that the magnitude of this type of boundary layer effect is relatively small (i.e. $<1.0^oC$). Local thermally variability in well-mixed areas such as the gorge reach was $\approx\pm0.5^oC$ and more typical of TIR surveys.

North Fork Siletz River

The Siletz River survey continued up the North Fork Siletz River and ended near the headwaters when the stream was no longer consistently visible through the riparian canopy for a total of 9.6 miles. The median temperatures for each sampled image of the North Fork Siletz River were plotted versus the corresponding river mile (Figure 6). Tributary locations and temperatures sampled during the analysis are labeled on Figure 6.

Stream temperatures at the upstream end of the survey were relatively cold at $\approx 8.5^{o}C$. From river miles 9.6 to 6.7, the North Fork Siletz River was intermittently visible through the riparian canopy (*Appendix A - frame: nfs0433*). Although no temperature samples were taken between river miles 9.0 and 8.5, the stream was generally detected at a high enough spatial frequency to create a continuous temperature profile. A consequence of the closed canopy was the inability to detect tributaries or other surface inflows that may exist within this reach.

The North Fork Siletz River showed a classic pattern of downstream warming from the upstream end of the survey to river mile 3.8 where stream temperatures reached a local maximum of $15.4^{o}C$. Warnicke Creek and Boulder Creek at river miles 6.1 and 4.4 respectively were the only tributaries sampled through this reach. Warnicke Creek contributed water that was $\approx 1.2^{o}C$ warmer than the North Fork and caused a slight, local increase in main stem temperatures. Boulder Creek contributed flow that was essentially the same temperature as the North Fork. However, a slight decrease in main stem temperatures was observed at the Boulder Creek confluence.

A decrease in stream temperatures of $\approx 1.7^{o}C$ was observed between river mile 3.8 and 2.6. Canyon Creek contributed cooler water to the North Fork at river mile 3.0, however, the observed cooling trend through this reach could not be directly attributed to any surface water inflows. Stream temperatures remained relatively consistent at $\approx 14.1^{0}C$ ($\pm 0.3^{o}C$) to river mile 1.7. From river mile 1.7, water temperatures increased steadily to $\approx 15.3^{o}C$ at the confluence with the South Fork Siletz River.

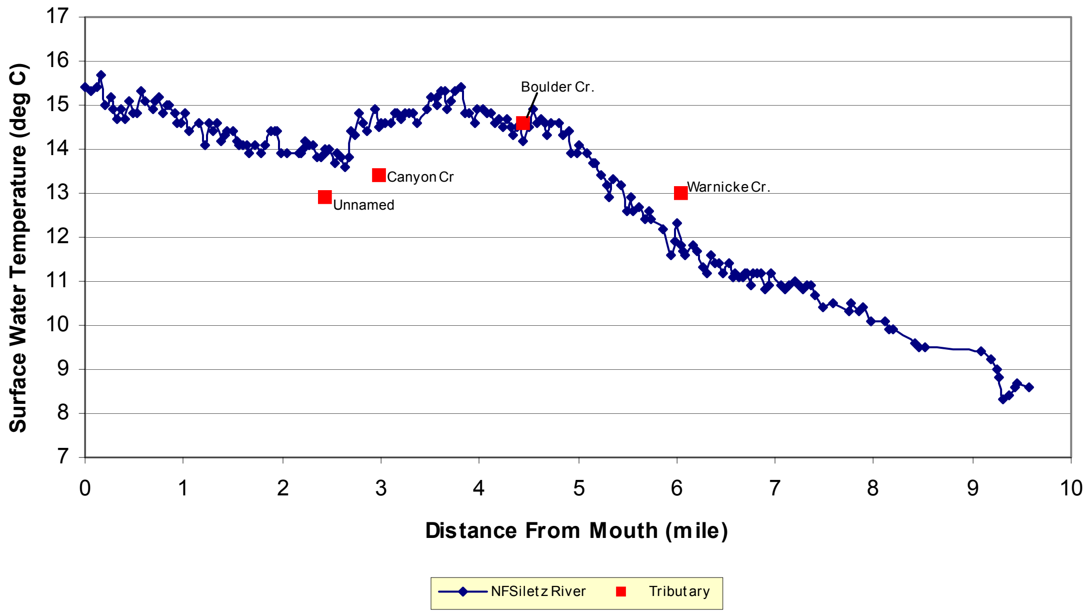


Figure 6 - Median channel temperatures versus river mile for the North Fork Siletz River, OR along with the location of tributary and other surface water inputs (8/5/01).

Warnicke and Boulder Creeks

The surveys include Warnicke and Boulder Creeks, two major tributaries to the North Fork Siletz River. Both tributaries were surveyed from their mouth upstream until the surface water could no longer be detected in the TIR images. Figures 7 and 8 illustrate the longitudinal temperature profiles developed for Warnicke Creek and Boulder Creek respectively.

Warnicke Creek (Figure 7) appeared to originate within a marshy meadow near river mile 5.3. The survey followed surface water upstream to an apparent spring (*Appendix A – frame: war0322*), which had surface temperatures of ≈7.6°C. From the spring, stream temperatures warmed rapidly through the meadow reaching 16.1°C at river mile 4.4. The topographic maps show a relatively low gradient through this reach and imagery shows some signs of thermal stratification behind small impoundments in the stream (*Appendix A – frame: war0303-0305*). Stream temperatures decrease rapidly between the bottom of the meadow (river mile 4.4) and a waterfall at river mile 3.7 (*Appendix A – frame: war0230-234*). The stream channel is relatively small through this reach and often difficult to detect due to the riparian canopy. No tributaries or other surface water inflows were detected through this reach. However, the vegetation near the stream channel may have masked small tributaries. The rapid decrease in stream temperatures combined with local topography suggests groundwater discharge into the stream channel at the bottom end of the meadow. Between river mile 3.7 and 2.7, stream temperatures remained consistently near 11.0°C before showing a general warming trend downstream. Local temperature variability was observed between river mile 2.7 and the mouth. However, the variation between images was less than 1.0°C and the source of small variation (real or artifact) is often difficult to assess on small streams.

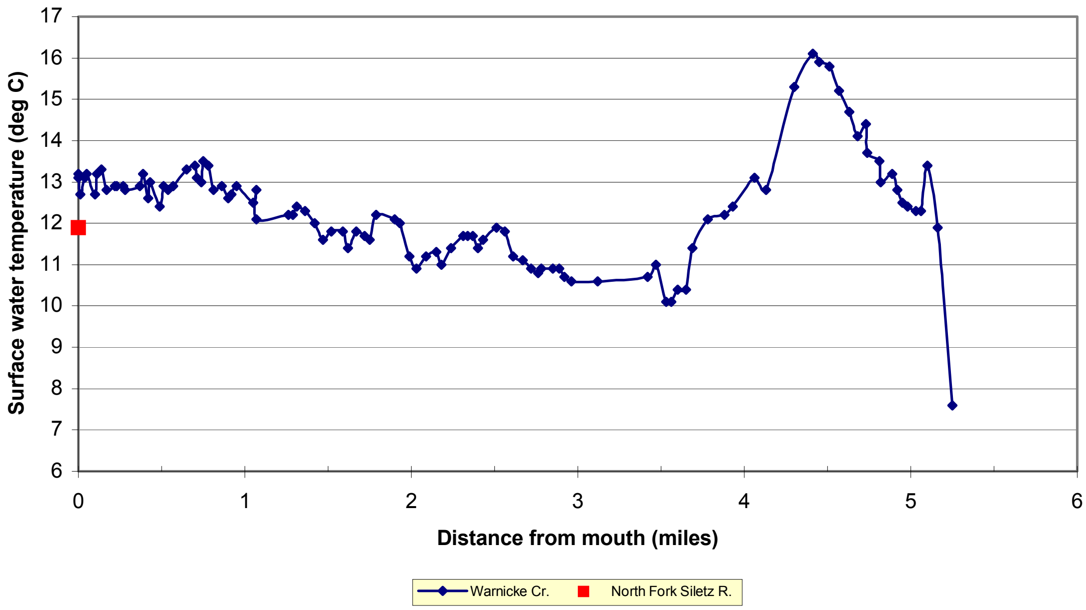


Figure 7 - Median channel temperatures versus river mile for Warnicke Creek, OR (8/5/01).

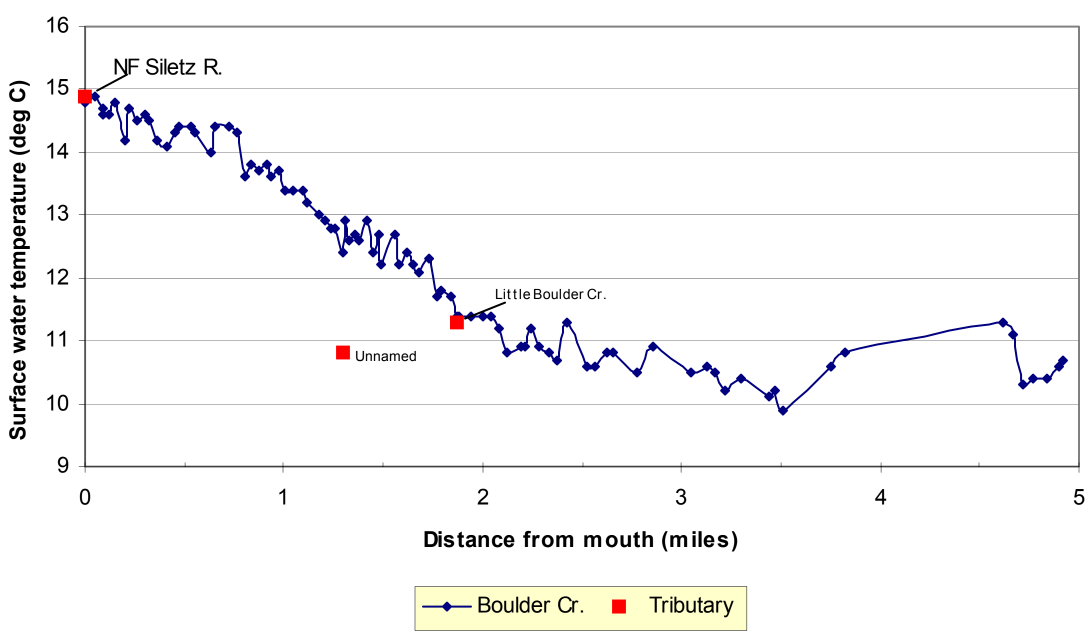


Figure 8 - Median channel temperatures versus river mile for Boulder Creek, OR (8/5/01).

Boulder Creek was surveyed upstream from the mouth to river mile 5.3. However, upstream of river mile 3.8, the stream was only intermittently visible through the riparian canopy. Stream temperatures were ≈10.0°C at river mile 3.5 and increased steadily in the downstream direction reaching 14.9°C at the confluence with the North Fork Siletz River. Little Boulder Creek enters at river mile 1.9 and had essentially the same temperature. A small inflow was sampled at river mile 1.3 (*Appendix A – frame: bldr0083*), but was not identified on the topographic map.

South Fork Siletz River

The South Fork (SF) Siletz River was surveyed upstream from the mouth to the headwaters, a total of 11.2 miles. The flight followed the primary channel through the old Valsetz Lakebed between river miles 4.4 and 6.6. The median temperatures for each sampled image of the SF Siletz River were plotted versus the corresponding river mile (Figure 9). Tributaries are labeled in Figure 9 by river mile with their name and temperature listed in Table 5.

At the extreme upstream end of the survey (river mile 11.1), stream temperatures measured ≈13.3°C. For the first 0.3 miles, the SF Siletz River was visible in the imagery despite relatively narrow channel widths. Temperature samples were taken within this reach although higher inaccuracies are expected due to the narrow channel widths and occurrence of hybrid pixels. Between river mile 10.8 and 9.5, vegetative canopy became more of a factor in the ability to detect the stream and obtain accurate temperature samples. Surface water was detected intermittently though the canopy and often in small pools (*Appendix A – frame: sfs0602*). In some cases, a thermally stratified surface layer appeared to have developed on some of the pools in this reach. These areas resulted in a high degree of variability in measured surface temperatures through this reach. Surface water was not visible in the imagery between river miles 9.5 and 8.5.

Surface water was intermittently visible between river mile 8.5 and the mapped location of McSherry Creek at river mile 7.3. Temperature samples were taken where surface water was clearly visible in both the TIR and visible band image and ranged from 13.9°C to 15.1°C. The discontinuity in temperature sampling was due in part to canopy masking of the stream channel. However, the topographic map shows that the stream travels through a low gradient, marsh area between Sand Creek and McSherry Creek. The inability to detect a continuous channel through this reach suggests that flow between the pools may be largely sub-surface. Between McSherry Creek and the top of the Valsetz Lakebed, stream temperatures measured between 15.8°C and 14.2°C.

The channel was easily detected through the Valsetz Lakebed and surface temperatures ranged from 14.7°C at the upstream end to 21.7°C at the outlet. Three tributary inflows were detected within this reach, which contributed to the observed thermal variability. In addition, the river had no signs of obvious mixing (i.e. riffles, rapids) through the lakebed. Partial thermal stratification was observed near the outlet of the lake from river miles 4.9 to 4.4. The thermal variability measured through the lakebed was attributed to differential heating at the water surface and slow mixing within the channel.

Water temperatures in the South Fork Siletz River were ≈18.5°C downstream of the outlet Valsetz Lake (river mile 4.3). Moving downstream, water temperatures generally decreased reaching 17.4°C at river mile 3.5. Rodgers Creek at river mile 3.3 and Pigeon Creek at river mile 3.1 further lower main stem temperatures to ≈15.5°C. The SF Siletz River warms to 17.0°C at river mile 2.6. At river mile 2.5, Drift Creek contributes cooler water and main stem temperatures dropped back to 15.5°C by river mile 2.2. Stream temperatures increased to 17.2°C at river mile 0.7, but then appeared to decrease to 16.1°C at the confluence with the North Fork Siletz. Slate Creek was the only tributary inflow sampled in the lower 2 miles of the South Fork.

Table 5 - Tributary temperatures for the South Fork Siletz River, OR. River miles correspond to data labels shown in Figure 9.

Tributary Name	Image	km	mile	Tributary Temp °C	SF Siletz R. Temp °C	Difference Temp °C
Slate Creek (RB)	sfs0104	2.8	1.7	14.9	16.1	-1.2
Drift Creek (LB)	sfs0145	4.0	2.5	13.5	16.8	-3.3
Pigeon Creek (LB)	sfs0182	5.0	3.1	13.3	15.5	-2.2
Rogers Creek (RB)	sfs0194	5.3	3.3	13.8	15.9	-2.1
Unnamed (RB)	sfs0224	6.0	3.8	11.8	17.4	-5.6
Unnamed (RB)	sfs0265	7.1	4.4	16.0	21.7	-5.7
Handy Creek (RB)	sfs0285	7.5	4.7	16.2	20.3	-4.1
Beaver Creek (LB)	sfs0309	8.1	5.0	15.3	16.9	-1.6
Callahan Creek (RB)	sfs0579	16.0	10.0	14.9	21.4	-6.5

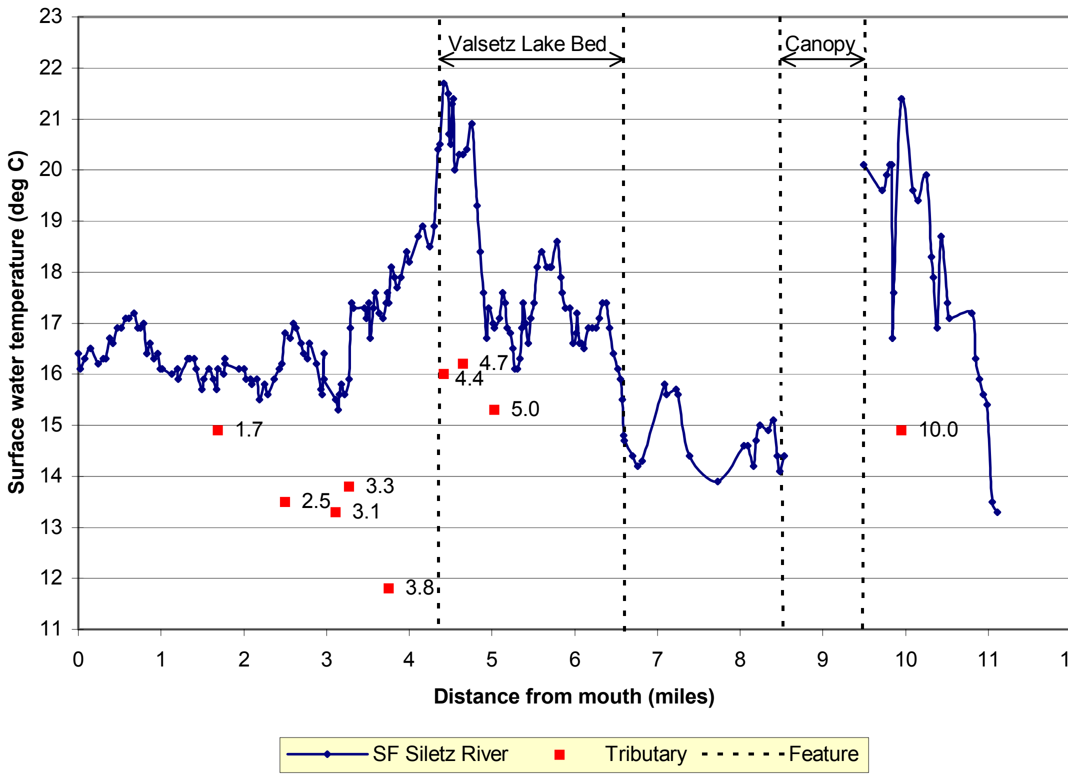


Figure 9 - Median channel temperatures versus river mile for the South Fork Siletz River, OR along with the location of tributary and other surface water inputs (8/5/01).

Sam Creek and Long Prairie Creek

Sam Creek was surveyed upstream from its confluence with the Siletz River to the headwaters, a total of 8.2 miles. Although Sam Creek was visible to river mile 8.2, the stream channel was too narrow relative to the pixel size to obtain an accurate sample upstream of river mile 6.3. Long Prairie Creek was surveyed from its confluence with Sam Creek to its headwaters, however the creek's surface temperatures were only sampled for the first 4.4 miles due to narrow channel width and canopy masking. Figures 10 and 11 illustrate the median channel temperature for each sampled image versus river mile for Sam Creek and Long Prairie Creek respectively.

Over the sampled reach, water temperatures in Sam Creek were relatively constant at 16.1°C (±0.5°C). Although local spatial variability was noted, the magnitude of temperature change was within the noise level considered normal for TIR remote sensing of small streams and no significant warming (or cooling) was observed at the reach scale. TIR images upstream of river mile 6.3 showed cooler temperatures near the headwaters (*Appendix A – frame: sam0574*) as would be expected. Long Prairie Creek was the only tributary detected and it contributed water that was slightly cooler than Sam Creek. The confluence of Sam Creek and Long Tom Creek, a major tributary, was completely masked by the vegetation canopy. Sam Creek was a cooling source to the Siletz River.

Stream temperatures in Long Prairie Creek remained near 15.2°C (±0.2°C) between river miles 4.4 and 2.4. Surface temperatures of 17.8°C were measured on the surface of a pool at river mile 3.6. The pool was formed upstream of a road crossing and review of the image indicated that the pool surface was probably stratified (*Appendix A – frame: lp0272*). Between river miles 2.3 and 1.9, stream temperatures showed an apparent increase of ≈1.0°C. A surface temperature of 17.8°C was measured at river mile 1.8, which was inconsistent with local temperatures up and down stream. Review of the imagery (*Appendix A – frames: lp0130-139*) showed stream temperatures were warmer behind a small impoundment (possibly a log in the stream) and this pool was most likely stratified. Warmer apparent temperatures upstream of this location (to river mile 2.3) may be the result of differential heating on water that is mixing slowly. Canopy cover partially masked Long Prairie Creek throughout the survey and made it difficult to detect all surface water inflows. Although no tributaries were sampled, slight temperature changes were noted at the mapped location of Thayer Creek at river mile 0.6 (*Appendix A – frame: lp0057*) and Mann Creek at river mile 1.5 indicating possible influences from these tributaries.

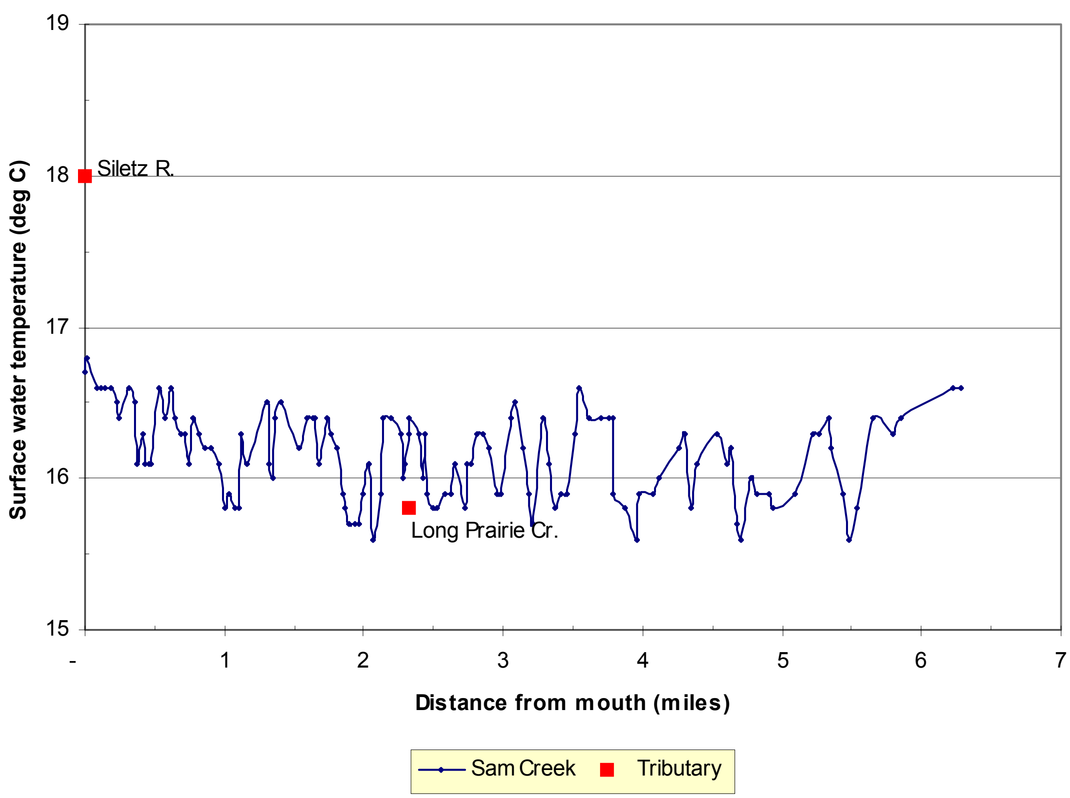


Figure 10 – Median channel temperatures versus river mile for Sam Creek, OR (8/6/01).

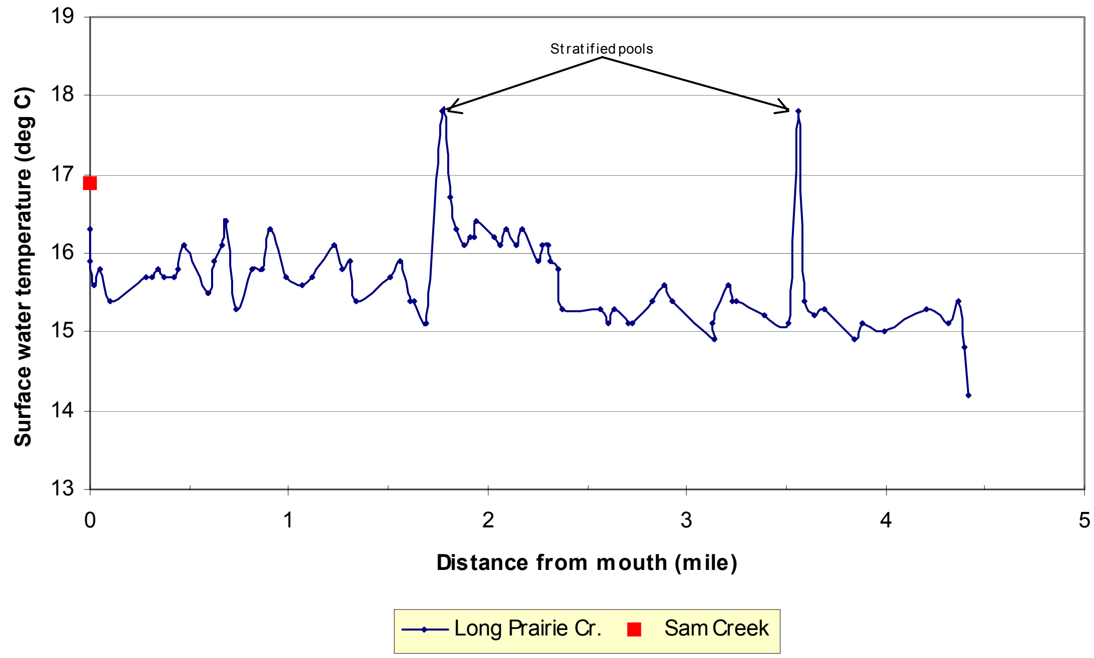


Figure 11 – Median channel temperatures versus river mile for Long Prairie Creek, OR (8/6/01).

Rock Creek

Airborne TIR surveys were conducted on five streams in the Rock Creek sub watershed including Rock Creek, Little Rock Creek, Big Rock Creek, Brush Creek, Steer Creek, and Fisher Creek. Brush Creek and Fisher Creek are tributaries of Little Rock Creek. Although these streams were surveyed, narrow stream widths combined with canopy closure precluded sampling images and developing longitudinal temperature profiles for these streams.

Rock Creek was surveyed from the Siletz River upstream to the confluence of Big and Little Rock Creeks, a total of 5.3 miles. Figure 12 illustrates the longitudinal temperature profile developed from the sampled images of Rock Creek. At the confluence, Big Rock Creek was ≈2.0°C cooler than Little Rock Creek. Water temperatures in Rock Creek were ≈19.3°C downstream of the mixing zone at river mile 4.9. Stream temperatures appeared to cool from ≈19.5°C at river mile 4.7 to ≈18.1°C at river mile 4.2. No surface water inflows were detected through this reach. Between river miles 4.7 and 3.0, stream temperatures remained relatively constant at 18.1°C (±0.3°C). Stream temperatures showed a slight decrease to a local minimum of 17.5°C at river mile 2.8 before increasing slightly over the lower 2.5 miles to reach 19.1°C at the mouth. Apparent temperatures of ≈19.5°C were observed between river mile 0.8 and 0.5. However, review of the imagery shows no obvious mixing and signs of intermittent stratification through this segment. Consequently, the temperature increase may represent differential heating at the stream surface and not a shift in bulk water temperatures. At its mouth, water temperatures in Rock Creek were essentially the same temperature as the Siletz River.

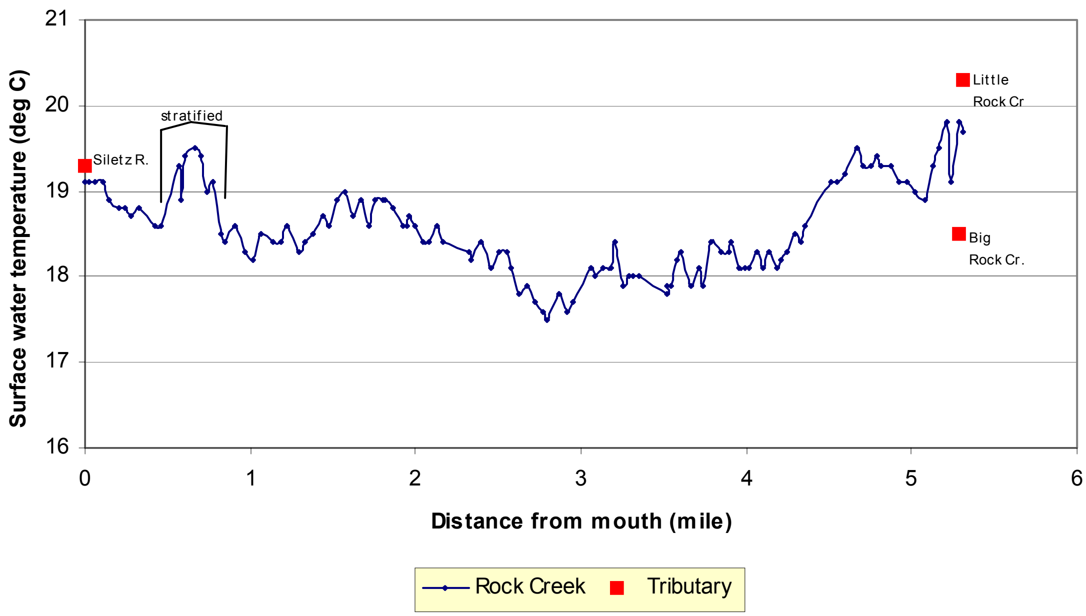


Figure 12 - Median channel temperatures versus river mile for Rock Creek, OR (8/6/01).

Little Rock Creek

Little Rock Creek was surveyed upstream from its mouth to the point where surface water was not longer detected in the TIR images, a total of 8 miles. As with most tributaries surveyed in the basin, the width of the stream channel near the headwaters was narrow relative to the image pixel size. Temperatures were sampled where surface water was clearly visible in the image, which occurred intermittently from the mouth to river mile 7.0. Figure 13 illustrates the longitudinal temperature profile for developed from the sampled images of Little Rock Creek.

The upstream most temperature sample at river mile 7.0 was 17.3°C. Sampled temperatures showed a high degree of variability between over the next 1.7 miles reaching ≈19.9°C at river mile 6.4 and returning to 17.0°C by river mile 5.3. The small size of the channel, partial canopy cover, and increased noise due to hybrid pixels made it difficult to identify the source of the observed variability. From river mile 5.3 to 3.0, water temperatures in Little Rock Creek remained near 17.1°C (±0.8°C). The stream traveled through a marsh and pond at river mile 5.0, which was labeled as Moser Pond on the topographic maps. The surface of the pond appeared stagnant was not sampled. Stream temperatures appeared slightly cooler (≈0.9°C) below the marsh/pond than those recorded above the pond. Between river mile 3.0 and 1.8, surface temperatures increased from ≈16.9°C to ≈20.0°C. The apparent increase occurs though a low gradient reach with almost no riparian vegetation (*Appendix A – frame: lr0092*). Brush Creek entered Little Rock Creek at mile 2.8 and had a local cooling influence. At river mile 2.6, stream temperatures dropped from ≈20.2°C to 17.2°C. No surface water inputs were detected or mapped at this location. The rapid decrease suggests either sub-surface influences at this location or that surface temperatures did not represent bulk stream temperatures between river mile 2.0 and 2.5. No signs of mixing were visible through this reach that support or discredit either hypothesis. Between river mile 2.5 and the mouth, stream temperatures showed a general warming trend with some degree of local variability. Thermal stratification was interpreted at river miles 2.0 and partial stratification was interpreted at river mile 0.8 resulting in spikes in the longitudinal temperature profile. These areas suggest that differential heating at the stream surface and slow (or no) mixing contributed to the spatial variability in the temperature patterns in the lower 5 miles of Little Rock Creek.

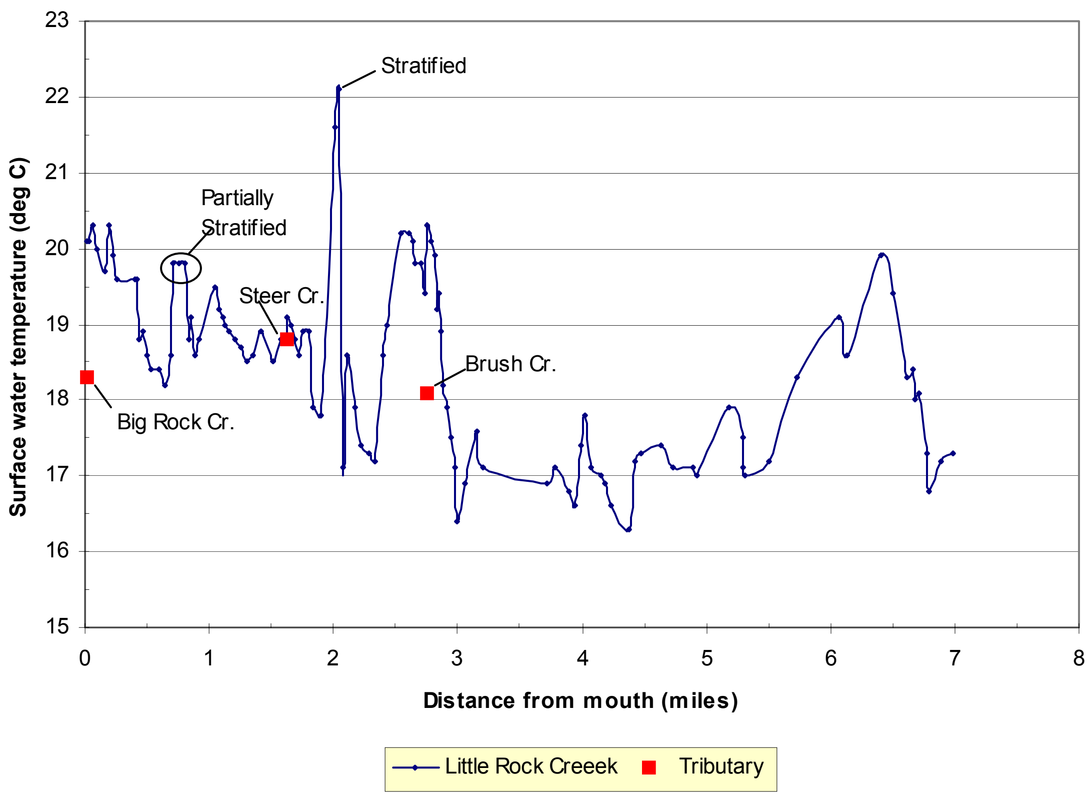


Figure 13 – Median channel temperatures versus river mile for Little Rock Creek, OR (8/6/001).

Big Rock Creek

Big Rock Creek was surveyed from the mouth upstream to the headwaters; a total of 9.7 miles, Figure 14 illustrates the longitudinal temperature profile developed from the sampled images of Big Rock Creek. Canopy intermittently masked the stream over the extent of the Big Rock Creek survey. The small stream and riparian canopy precluded temperature sampling upstream of river mile 7.5. Upstream of river mile 7.5, a marsh area was observed at river mile 8.2 and the flight followed the largest of the three mapped inflows to the marsh for the last 1.4 miles of the survey. However, little surface water was visible upstream of the marsh.

At the upstream most sample point (river mile 7.5), water temperatures in Big Rock Creek were ≈13.6°C. Stream temperatures showed no net gain between river mile 7.5 and 6.0, although the temperature profile showed surface temperatures as high as 15.3°C through this reach. Young Creek was detected at river mile 5.7 and contributed cooler water to Big Rock Creek. Despite the inflow of Young Creek, temperatures showed a steady warming trend between river mile 5.5 and 6.0. A spike in surface temperatures was observed at river mile 5.4. Review of the imagery showed apparent impoundments and possible stratification in the pools. Canopy closure masked the stream between river miles 5.2 and 4.4. At river mile 4.4 stream temperatures were ≈14.6°C, which were cooler than those sampled at river mile 5.2. From river mile 4.4, stream temperatures generally warmed downstream reaching a local maximum of 16.9°C at river mile 3.2. From river mile 3.2, stream temperatures showed an apparent decrease reaching 15.2°C at river mile 2.6. No surface water inflows were sampled through this reach, although several perennial streams were illustrated on the topographic map through this reach. Fall Creek entered the main stem at river mile 2.2 and had essentially the same temperature. Downstream of Fall Creek, water temperatures in Big Rock Creek warmed steadily reaching 18.5°C at the confluence of Little Rock Creek.

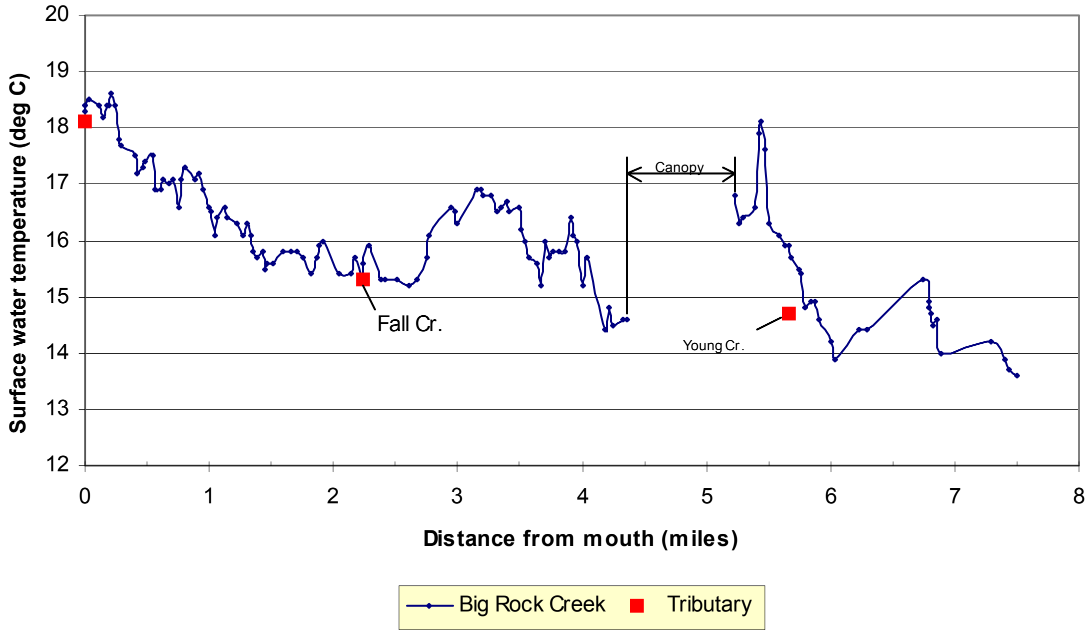


Figure 14 – Median channel temperatures versus river mile for Big Rock Creek (8/6/01).

Steer Creek

Steer Creek was surveyed upstream from Little Rock Creek to the headwaters, a total of 5.1 miles. Temperatures were sampled for the first 3.8 miles, but not sampled further upstream due to a combination of small stream widths and canopy closure. The median temperatures for each sampled image were plotted versus river mile (Figure 15). At the upper most sample point (river mile 3.8), stream temperatures were ≈14.7°C. Stream temperatures generally warm in the downstream direction and water temperatures were ≈19.0°C at the confluence with Little Rock Creek. Local minimums were observed at river miles 1.4 (17.1°C) and 2.7 (15.9°C). Beaver Creek entered at river mile 1.7 and contributed to the general cooling trend between river miles 1.7 and 1.4.

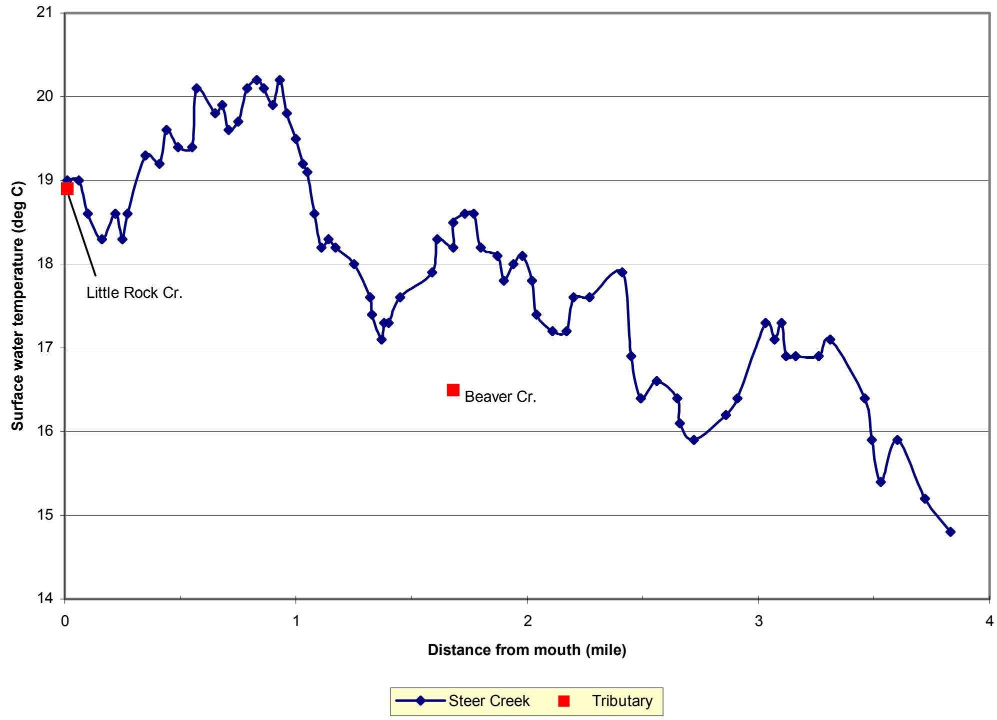


Figure 15 – Median channel temperatures versus river mile for Steer Creek (8/6/01).

Cedar Creek

Cedar Creek was surveyed from the Siletz River upstream to the headwaters, a total of 11.4 miles. Surface temperatures were obtained from the images to river mile 10.5 before canopy cover and small stream size precluded further sampling. Figure 16 illustrates the longitudinal temperature profile derived from the TIR images for Cedar Creek. At river mile 10.5, stream temperatures were relatively cold at 12.2°C. Stream temperatures warmed downstream, reaching 15.2°C at river mile 8.8. An unnamed tributary was sampled at river mile 8.8, which contributed cooler water to the main stem. Between mile 8.8 and 7.1, stream temperatures remained relatively constant at 14.9°C (±0.5°C). Moving downstream, stream temperatures generally warmed reaching a local maximum of 16.6°C at river mile 5.3. Local thermal variability was observed through this reach, but the source of variability was not evident from the imagery. An unnamed tributary was sampled at river mile 5.1, which contributed cooler water to Cedar Creek. Stream temperatures remained near 15.7°C (±0.5°C) between river mile 5.1 and 2.2. Between river mile 2.2 and 1.8, stream temperatures appeared to decrease by ≈1.4°C. No surface water inflows were detected through this reach. The topographic map shows a transition from a canyon reach to a more open, lower gradient reach, which suggests possible subsurface exchange at this location. At the mouth, Cedar Creek was a cooling source to the Siletz River. Ground truthing (Table 3) indicated that radiant temperatures at the mouth of Cedar Creek were ≈1.5°C cooler than measured in-stream temperatures.

As a consequence, the longitudinal temperature profile (Figure 16) might under-represent actual downstream warming in Cedar Creek.

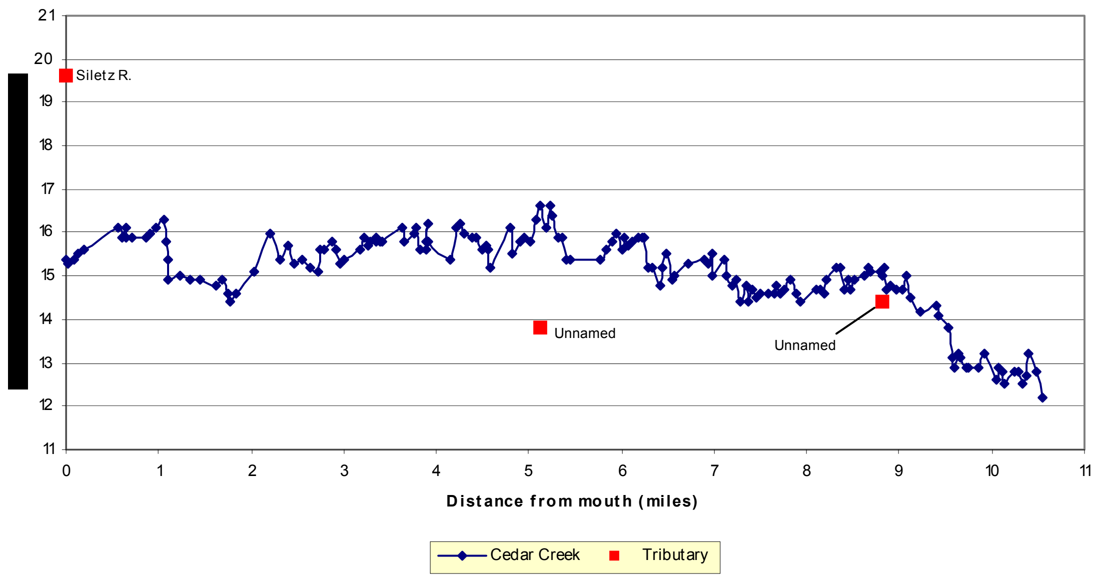


Figure 16 – Median channel temperatures versus river mile for Cedar Creek, OR (8/7/01).

Euchre Creek

Euchre Creek was surveyed from the Siletz River to the headwaters, a total of 8.8 river miles. Median channel temperatures from each sampled image of Euchre Creek were plotted versus river mile (Figure 17). The plot also shows the location of all surface water inflows (tributaries, springs, etc.) that were visible in the imagery. Tributaries are labeled in Figure 17 by river mile with their name and temperature listed in Table 6. Although canopy intermittently masked the streams, temperature samples were acquired over nearly the full extent of the Euchre Creek survey.

At the upstream end of the survey (river mile 8.4), stream temperatures were relatively cold at 12.1°C. Moving downstream, water temperatures in Euchre Creek warmed to 14.6°C at river mile 6.1 and then remained relatively constant at 14.6°C (±0.3°C) to river mile 4.7. Between river mile 4.7 and 4.2, stream temperatures warmed again to ≈16.2°C. Stream temperatures showed a slight decrease at river mile 3.5 to 15.6°C and remained relatively constant at this temperature (±0.5°C) to mile 1.8. A logjam was observed at river mile 0.5 that extended over several images (*Appendix A – frame: euc0025-0029*). At its mouth, stream temperatures were 16.1°C and Euchre Creek was a source of cooling to the Siletz River.

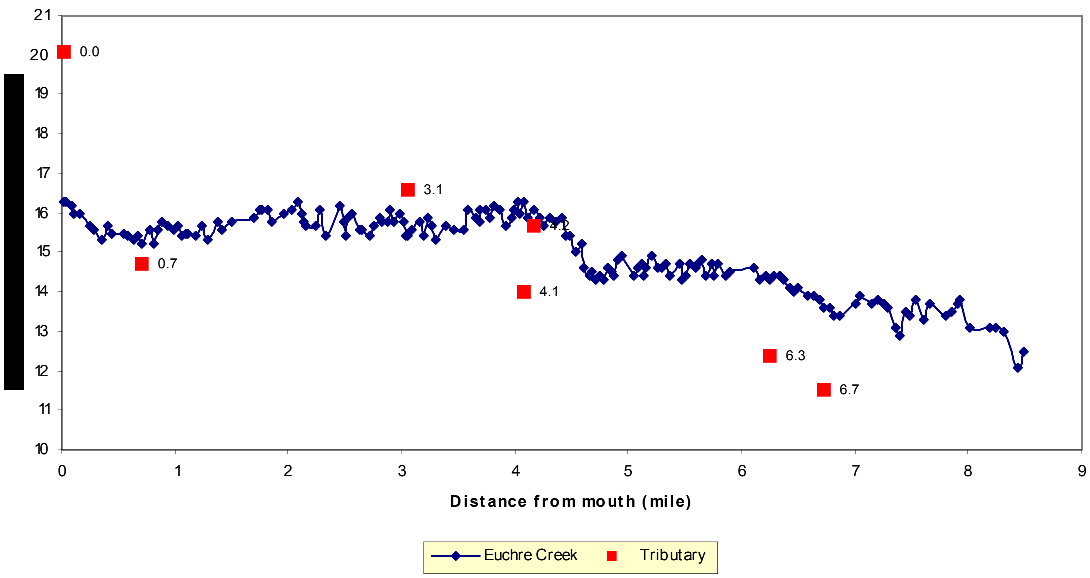


Figure 17 – Median channel temperatures versus river mile for Euchre Creek, OR along with the location of tributary and other surface water inflows (8/7/01).

Table 6 – Tributary temperatures for Euchre Creek, OR. River miles correspond to data labels shown in Figure 17.

Tributary Name	Image	km	mile	Tributary	Euchre Cr	Difference
Siletz R. ()	euc0008	0.0	0.0	20.1	16.3	3.8
Unnamed (LB)	euc0054	1.1	0.7	14.7	15.2	-0.5
Coon Creek (LB)	euc0234	4.9	3.1	16.6	15.4	1.2
Spring (LB)	euc0304	6.6	4.1	14.0	16.3	-2.3
Spring (LB)	euc0310	6.7	4.2	15.7	16.1	-0.4
Unnamed (RB)	euc0446	10.1	6.3	12.4	14.3	-1.9
Unnamed (LB)	euc0479	10.8	6.7	11.5	13.6	-2.1

Dewey Creek, Bentilla Creek and Mill Creek

Dewey Creek, Bentilla Creek, and Miller Creek were surveyed upstream from the Siletz River. On Bentilla Creek and Dewey Creek, the stream was not visible through the canopy through much of the survey length. Temperatures were sampled where surface water was visible in the imagery. Figures 18, 19, and 20 present the longitudinal temperature profiles developed for Dewey Creek, Bentilla Creek, and Mill Creek respectively.

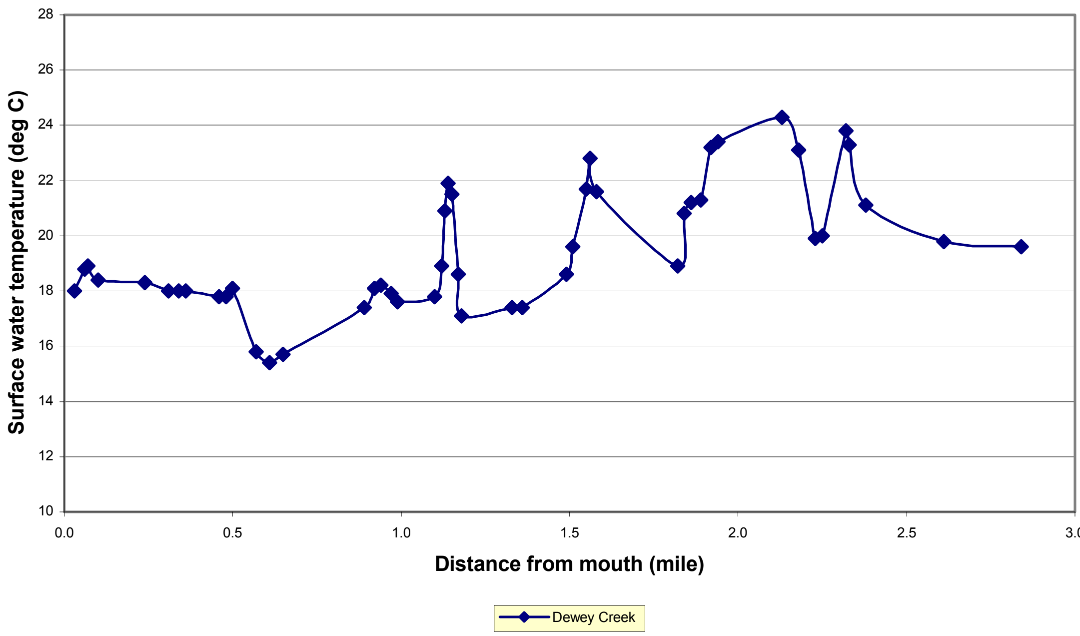


Figure 18 – Median channel temperatures versus river mile for Dewey Creek, OR (8/7/01).

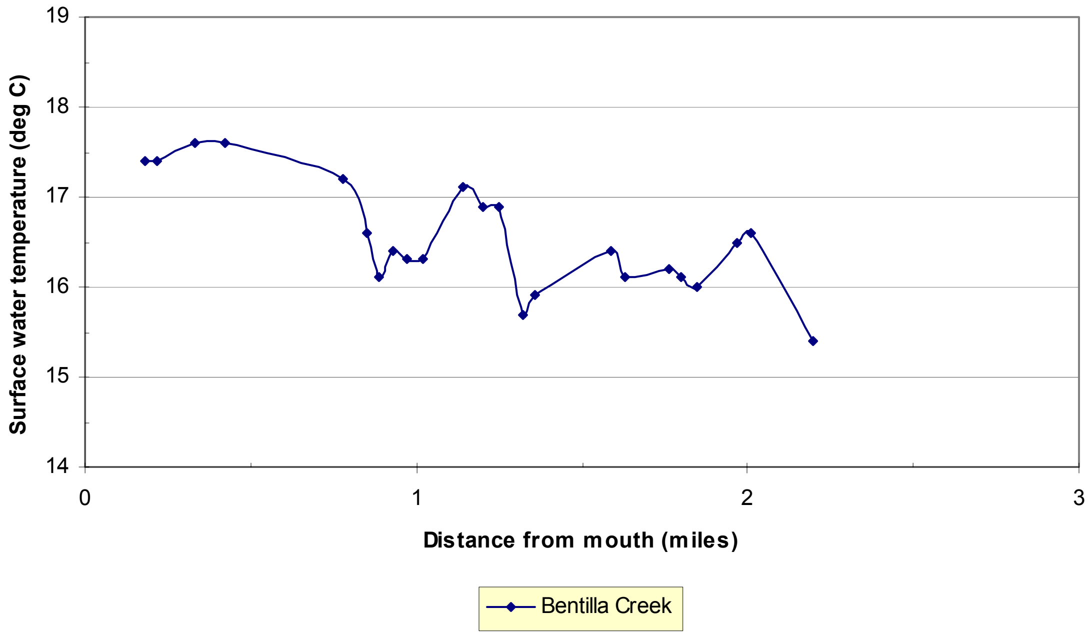


Figure 19 – Median channel temperatures versus river mile for Bentilla Creek, OR (8/7/01).

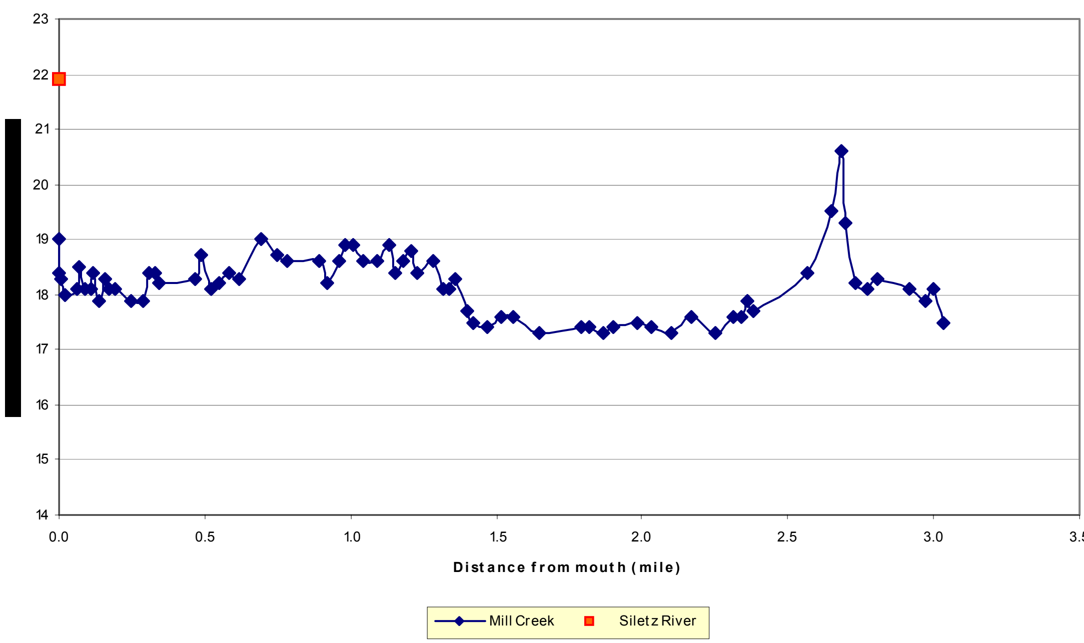


Figure 20 – Median channel temperatures versus river mile for Mill Creek, OR (8/7/01).

Discussion

TIR remote sensing was used to map stream temperatures for the Siletz River and major tributaries in the basin. The data were collected between August 5th and 7th in order to assess low flow high summer temperatures. Maximum daily air temperatures measured at Moonshine Park were between 72.5^{o}F and 77.4^{o}F for the survey days. Sky conditions were partially cloudy in the mornings with clearing by the mid-afternoon. These conditions were considered good, though the morning clouds resulted in generally cool conditions. Analysis of the thermal accuracy of the TIR images compared to in-stream sensors was on average within 0.5^{o}C.

With the exception of the Siletz River, canopy masking was a factor in the ability to continuously detect the stream surface. However, on most surveyed tributaries the stream was visible through the canopy at frequent enough intervals to develop a coherent longitudinal temperature profile. Fisher Creek and Brush Creek were too narrow and hidden to obtain reasonably accurate temperature samples and longitudinal temperature profiles were not developed for these streams. Bentilla and Dewey Creeks were similarly difficult to detect due to their small size and canopy closure; however, surface water was visible at varying intervals allowing irregular sampling. Temperature patterns were presented for these streams although the sampling was not continuous.

A high degree of thermal spatial variability was observed on many of the streams surveyed in the Siletz River basin. High thermal variability is common in small streams where energy inputs (sub-surface inputs, solar radiation, etc.) can have a dramatic impact on stream temperatures over relatively short spatial scales (< 0.5 miles). However, partial canopy cover combined with narrow channels widths also increases the incidence of hybrid pixels, which in turn increases the "noise" or apparent variability in the profile. The surveys also identified stream segments that were thermally stratified over short spatial scales (i.e. pool surfaces, behind impoundments). These locations were identified on the longitudinal temperature profiles for the individual streams. Thermal stratification is inherently unstable in moving streams and usually detectable in the imagery.

The TIR surveys lay a basic groundwork for follow-on temperature analysis and for watershed planning and restoration. In particular, water temperature modeling can provide a powerful tool to address the biophysical parameters the biophysical parameters that are driving stream temperature patterns and suggest multiple pathways for remediation. In addition, the longitudinal temperature patterns provide a robust template to construct a monitoring program, in particular the deployment of in-stream sensors.

Follow-on

The following is a list of potential uses for these data in follow-on analysis (based on Faux et. al. 2001 and Torgersen et. al. 1999):

1. The patterns provide a spatial context for analysis of seasonal temperature data from in-stream data loggers and for future deployment and distribution of in-stream monitoring stations. How does the temperature profile relate to seasonal temperature extremes? Are local temperature minimums consistent throughout the summer and among years?

2. The database provides a method to develop detailed maps and to combine the information with other spatial data sets. Additional data sets may include factors that influence heating rates such as stream gradient, elevation and aspect, vegetation, and land-use. In viewing the temperature patterns in relation to other spatial factors, correlations are often apparent that provide a more comprehensive understanding of how the stream is thermally structured.

3. What is the temperature pattern within critical reach and sub-reach areas? Are there thermal refugia within these reaches that are used by coldwater fish species during the summer months?

4. The TIR and visible band images provided with the database can be aggregated to form image mosaics. These mosaics are powerful tools for planning fieldwork and for presentations.

5. The longitudinal temperature profiles provided in this report present a spatially extensive, high-resolution reference for water temperature status in the basin. Because stream temperature patterns can change as a result of landscape alteration or disturbance, the data provided in this report can be used to assess the impacts of land-use practices and the effects of restoration efforts in the basin.

6. Stream temperature profiles provide a spatially continuous data set for the calibration of reach and basin scale stream temperature models.

Bibliography

Faux, R.N., H. Lachowsky, P. Maus, C.E. Torgersen, and M.S. Boyd. 2001. **New approaches for monitoring stream temperature: Airborne thermal infrared remote sensing**. Inventory and Monitoring Project Report -- Integration of Remote Sensing. Remote Sensing Applications Laboratory, USDA Forest Service, Salt Lake City, Utah.

Karalus, R.S., M.A. Flood, B.A. McIntosh, and N.J. Poage. 1996. **ETI surface water quality monitoring technologies demonstration. Final Report**. Las Vegas, NV: Environmental Protection Agency.

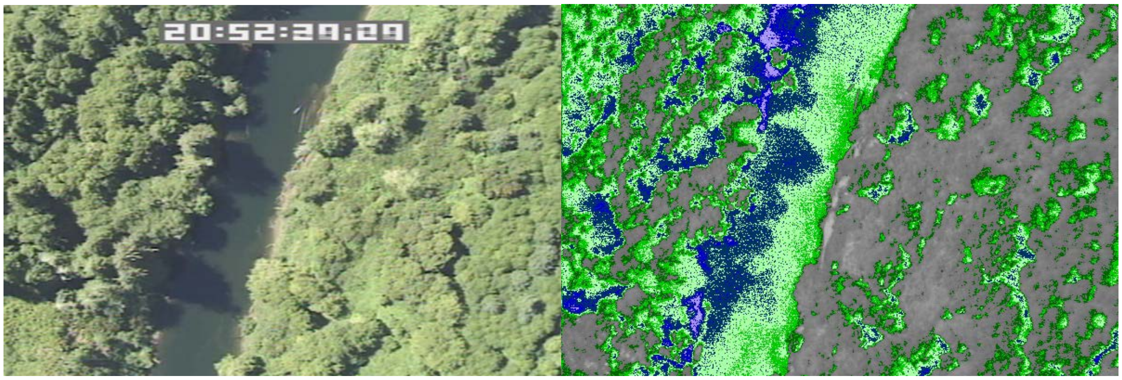
Torgersen, C., R. Faux, and B. McIntosh. 1999. **Aerial survey of the Upper McKenzie River: Thermal infrared and color videography**. Report to the USDA, Forest Service, McKenzie River Ranger District.

Torgersen, C.E., D.M. Price, H.W. Li, and B.A. McIntosh. 1999. Multiscale thermal refugia and stream habitat associates of chinook salmon in Northeastern Oregon. *Ecological Applications*. 9(1), pp 301 – 319.

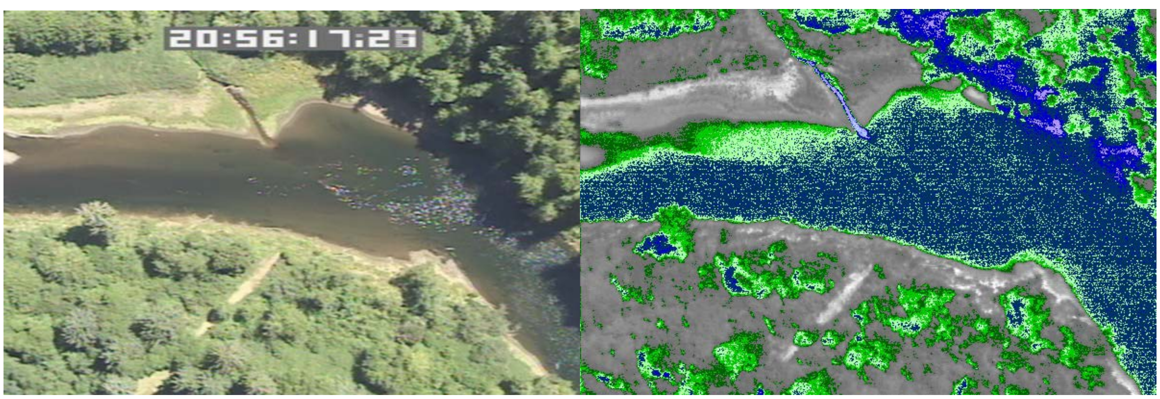
Torgersen, C.E., R. Faux, B.A. McIntosh, N. Poage, and D.J. Norton. 2001. Airborne thermal remote sensing for water temperature assessment in rivers and streams. *Remote Sensing of Environment* 76(3): 386-398.

Appendix A – Selected Images

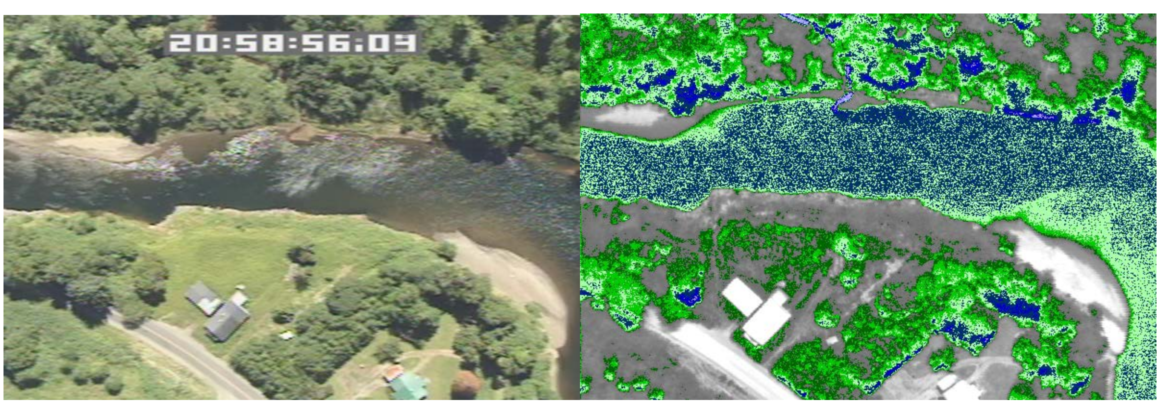
Siletz River



Frame: sil0189 – Lateral differences in surface temperatures along the right bank are associated with visible shadows. Center stream temperature 19.6^{o}C; temperatures in the shadows were 18.5^{o}C. The cooler apparent temperatures may be the result of differential heating at the stream surface in poorly mixed reaches.

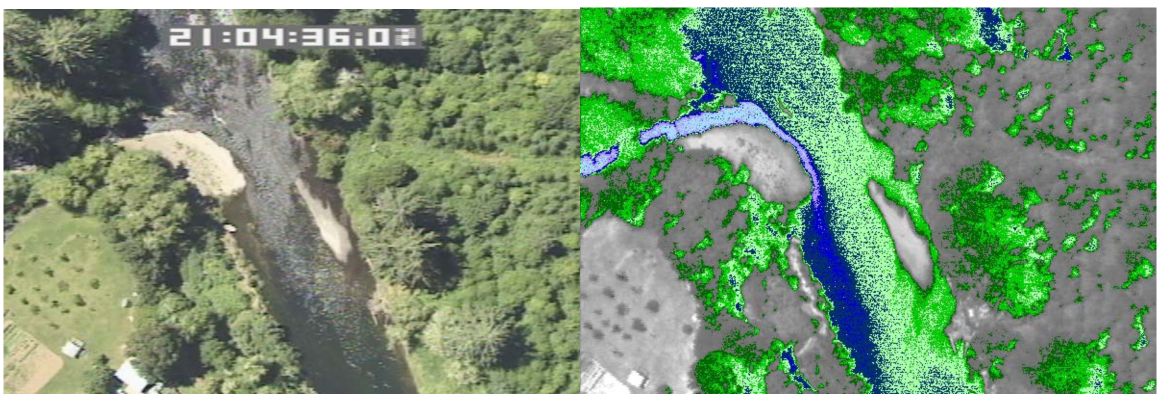


Frame: sil0303 – This image pair shows the confluence of an unnamed tributary (15.9^{o}C) to the left bank of the Siletz River (18.7^{o}C) at river mile 19.1.

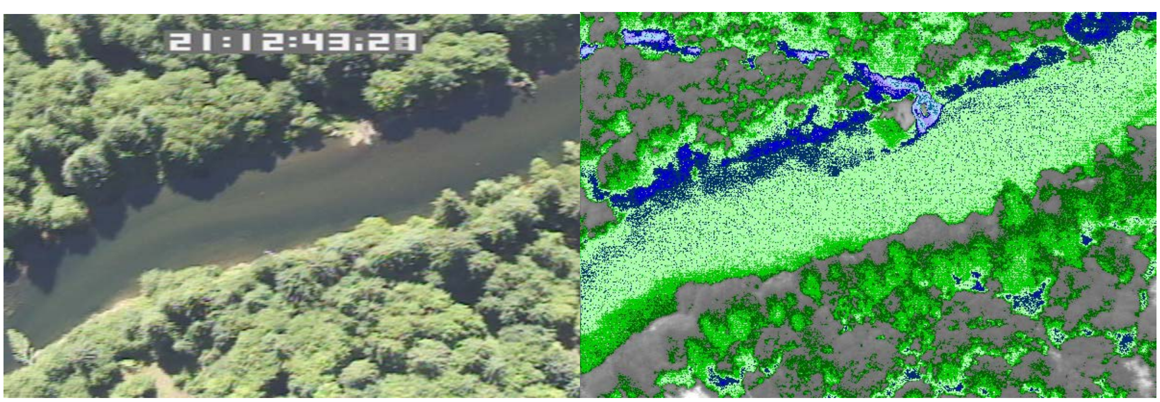


Frame: sil0382 – Jaybird Creek (16.3^{o}C) empties into the left bank of the Siletz River (18.8^{o}C) at river mile 21.

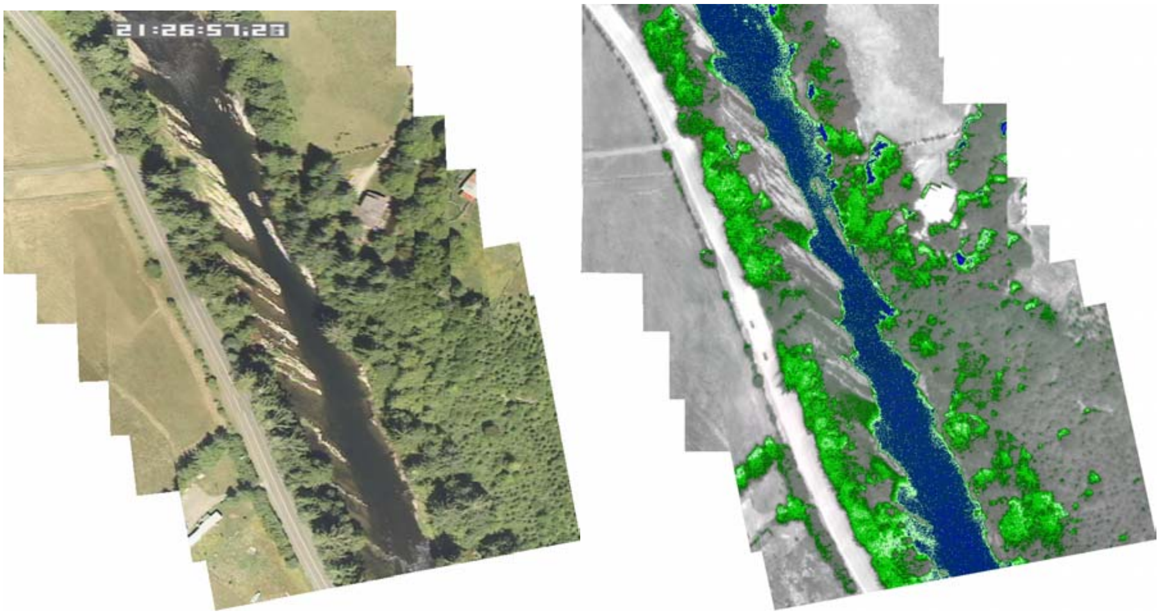
Frame: sil0404 – These images depict the confluence of Cedar Creek (15.3^{o}C) to the right bank of the Siletz River (19.5^{0}C) at river mile 21.6.



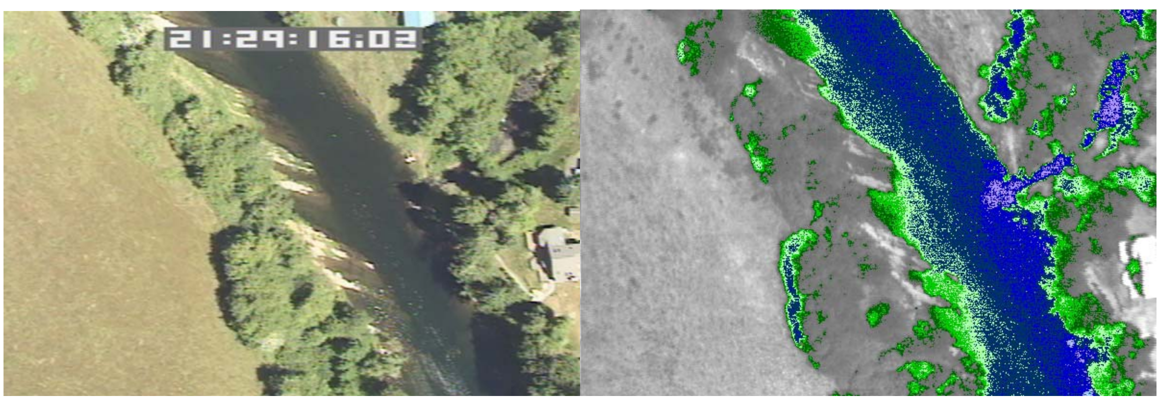
Frame: sil0552 – At river mile 25.3, Euchre Creek (15.7^{o}C) empties into the right bank of the Siletz River (19.1^{o}C).



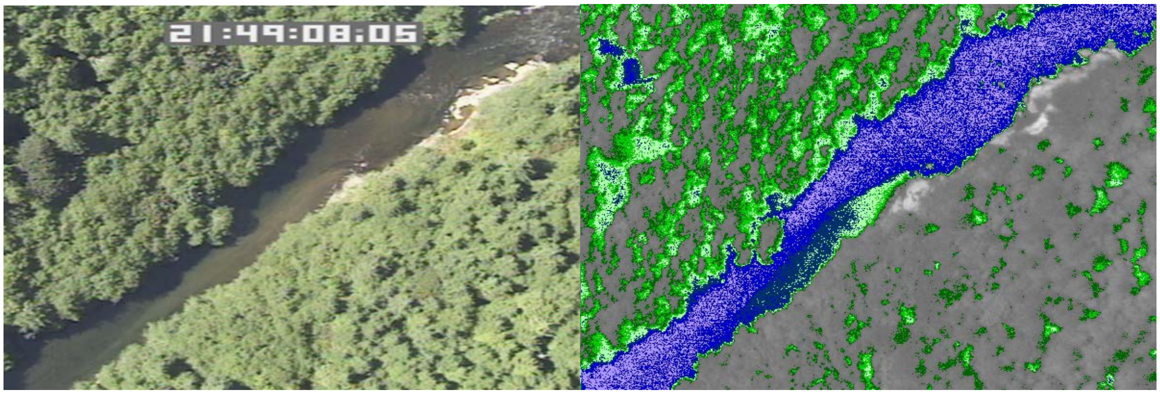
Frame: sil0796 – This image pair shows the Siletz River (19.4^{o}C) and Thompson Creek (15.0^{o}C) on its right bank at river mile 31.5.



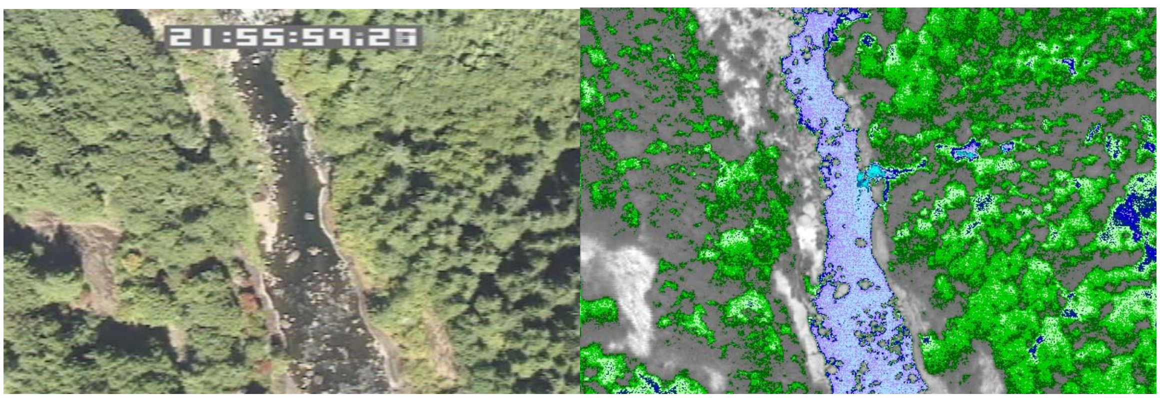
Frame: sil1217-1223 – These mosaics show channel characteristics in the Siletz River (18.2°C) at river mile 41.9.



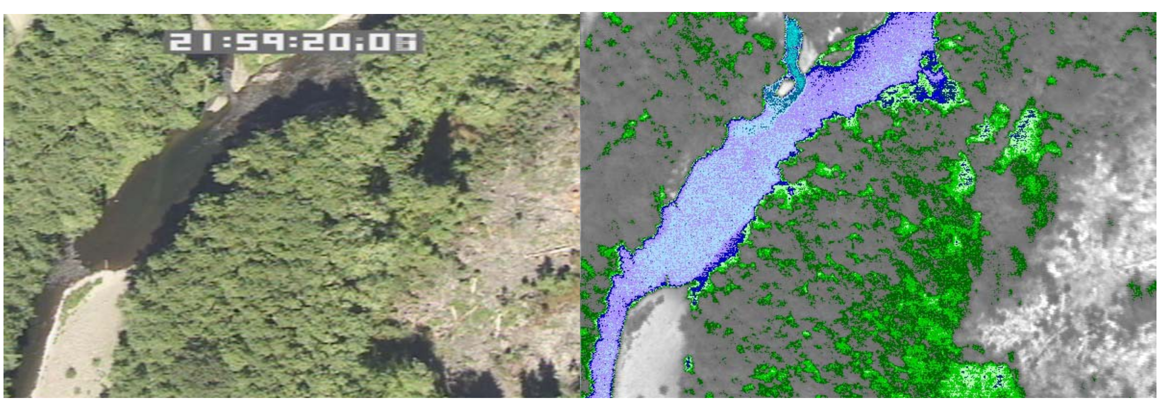
Frame: sil1292 – These images show the confluence of Sam Creek (16.6°C) to the left bank of the Siletz River (18.3°C) at river mile 43.7.



Frame: sil1888 - Visible band/TIR image showing the Siletz River (17.0°C) at river mile 57.8. A warm water plum is visible along the left bank that was not associated with a tributary or other surface water inflows. These areas are often due differential heating of surface water that is not part of the main flow.

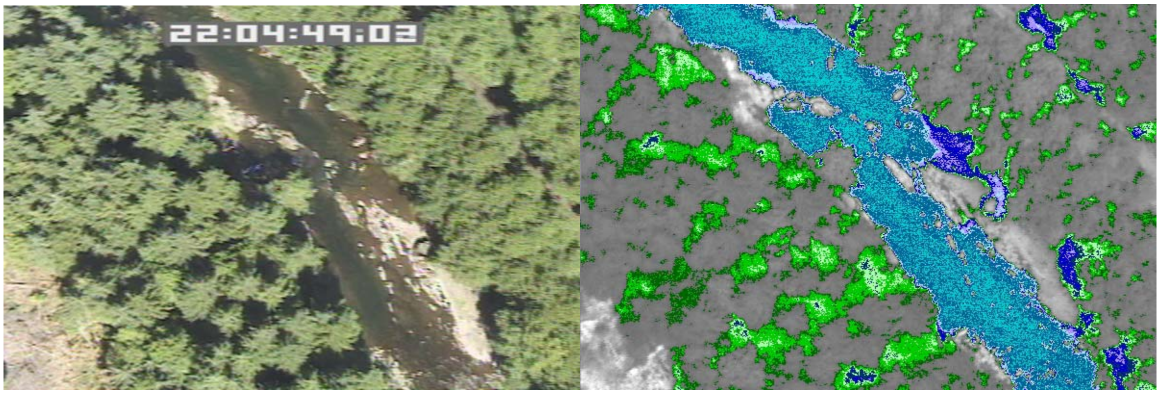


Frame: sil2094 – At river mile 62.5, Falls Creek (12.9°C) empties into the left bank of the Siletz River (15.9°C).

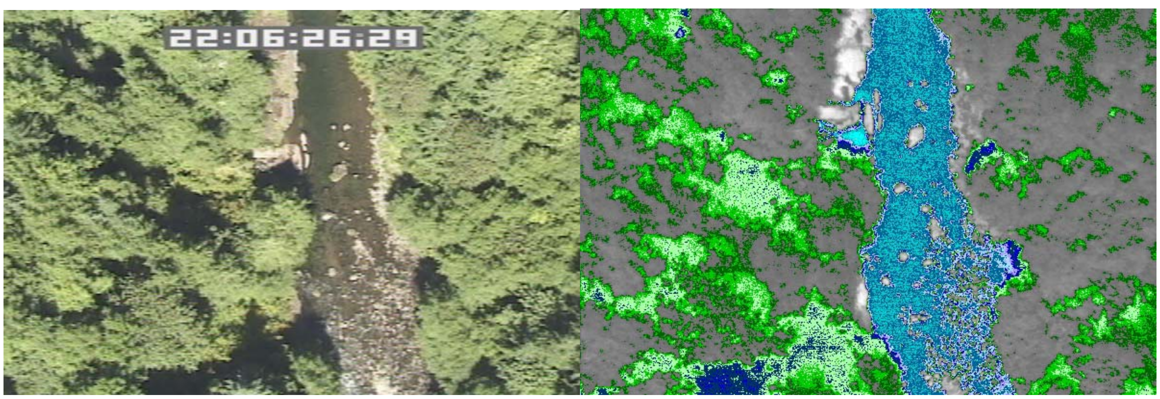


Frame: sil2194 – This image pair shows the confluence of Gravel Creek (13.5°C) to the right bank of the Siletz River (15.8°C) at river mile 64.7.

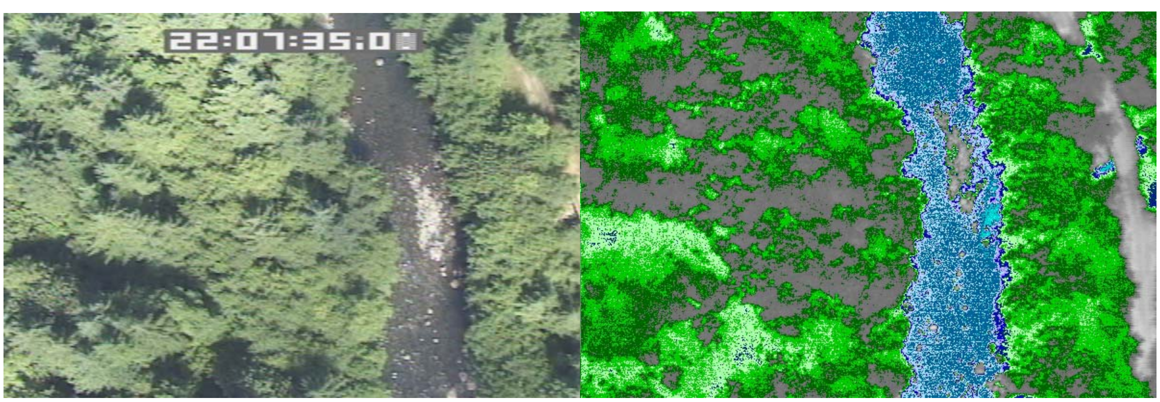
North Fork Siletz River



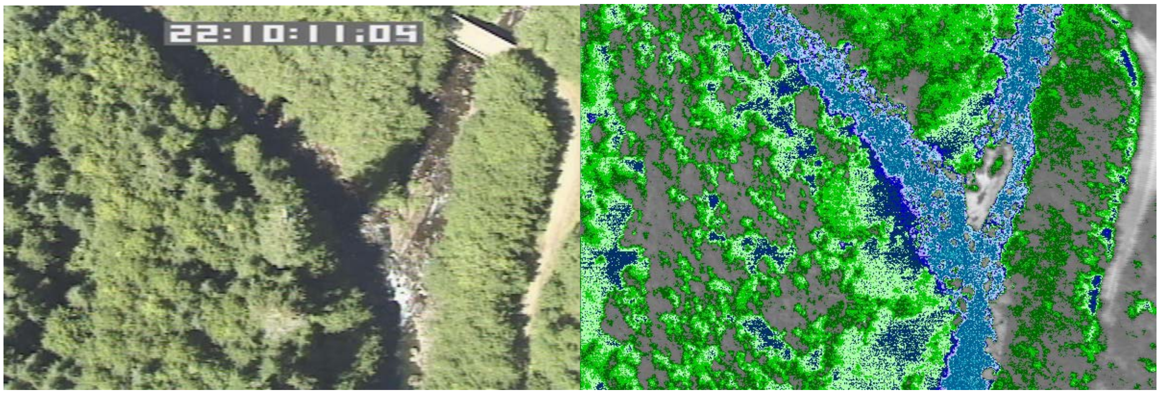
Frame: nfs0099 – This image pair shows a warm region on the left bank of the North Fork Siletz River at river mile 1.6. The mainstream measures 14.1°C, while the segment on the left bank measures 17.5°C.



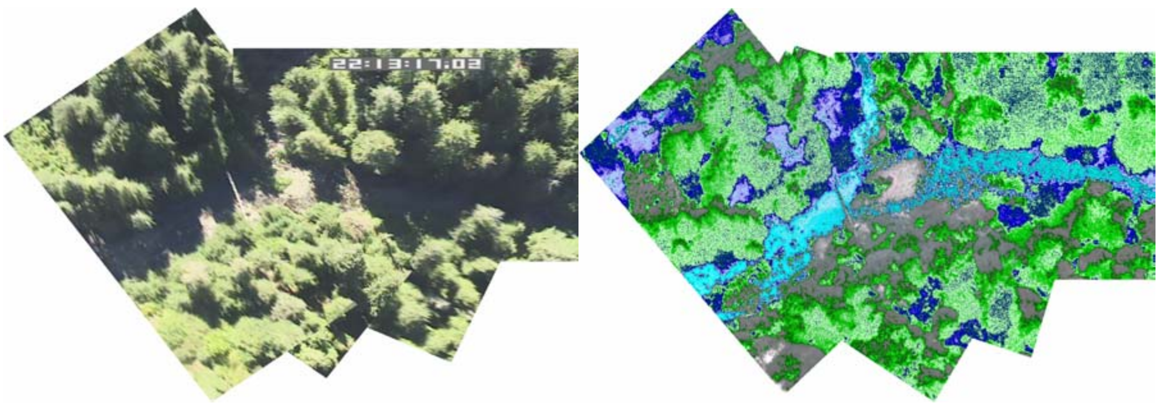
Frame: nfs0148 – At river mile 2.4, an unnamed tributary (12.9°C) empties into the right bank of the NFSiletz River (14.0°C).



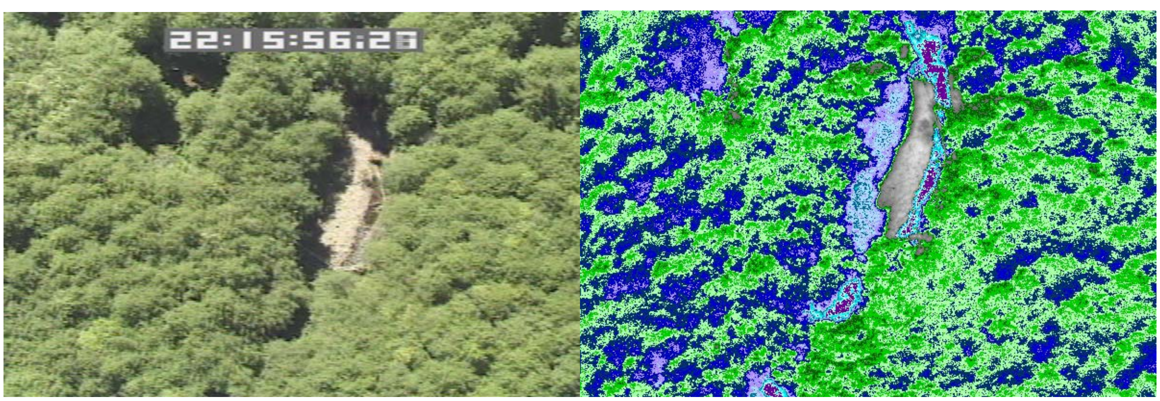
Frame: nfs0182 – These images show the confluence of Canyon Creek (13.4°C) to the left bank of the NFSiletz River (14.5°C) at river mile 3.0.



Frame: nfs0260 – At river mile 4.4, Little Boulder Creek (14.6°C) empties into the left bank of the NFSiletz River (14.2°C).

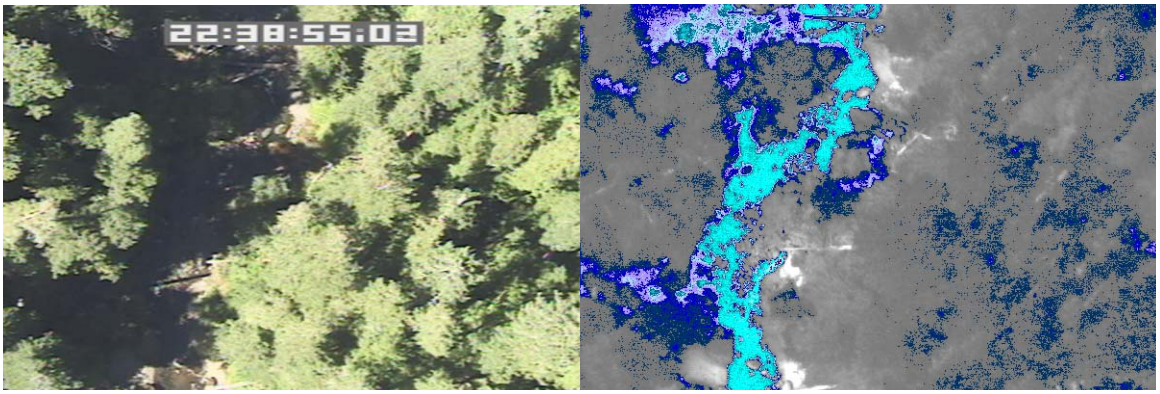


Frame: nfs0350-0353 – These mosaics show the confluence of Warnicke Creek (13.0°C) and the NFSiletz River (11.8°C) at river mile 6.1.

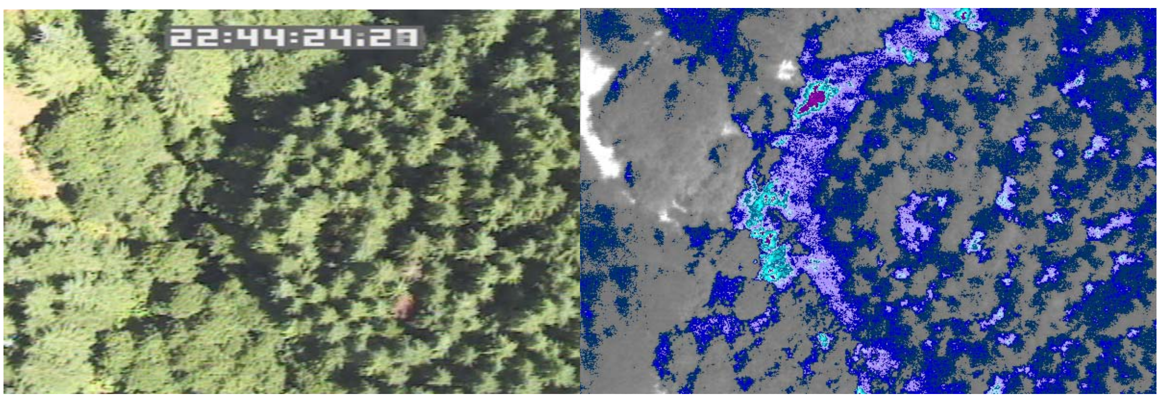


Frame: nfs0433 – Visbile band/TIR image showing the North Fork Siletz River (10.9°C) at river mile 7.3. The images are an example of the intermittent "looks" at the stream through the riparian canopy.

Boulder Creek

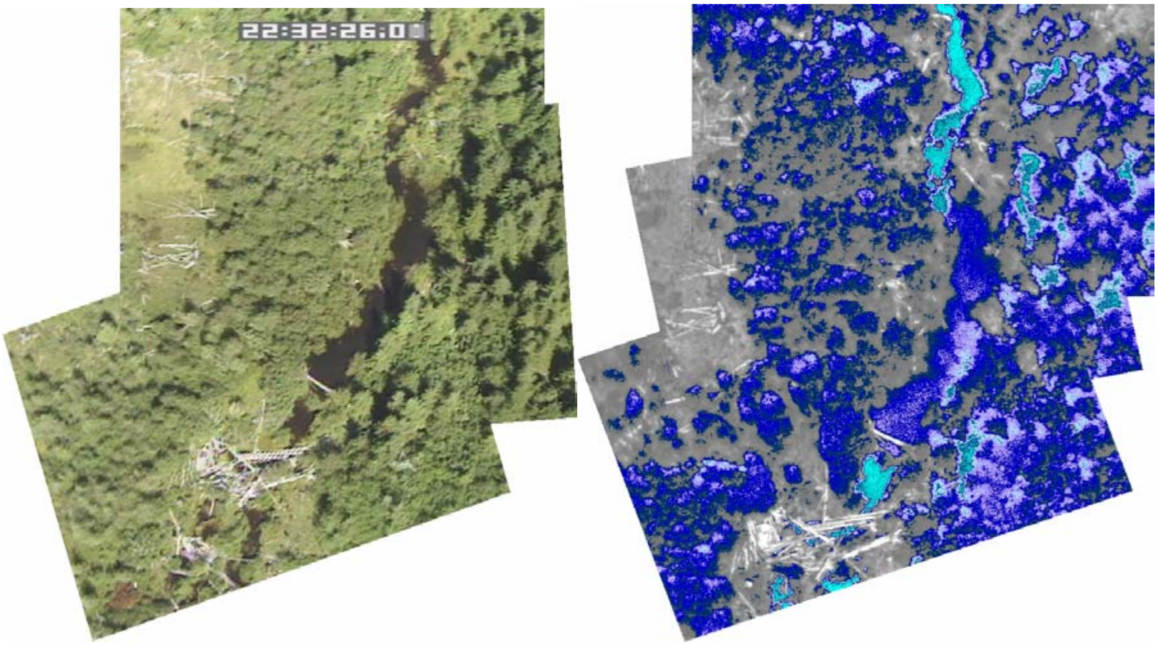


Frame: bldr0083 – Visible band/TIR image pair showing Boulder Creek (12.4^{o}C) at river mile 1.3. A small inflow (10.8^{o}C) was detected along the left bank (looking downstream). The inflow was not identified on the topographic maps and due to its small size; some uncertainty exists about the classification.

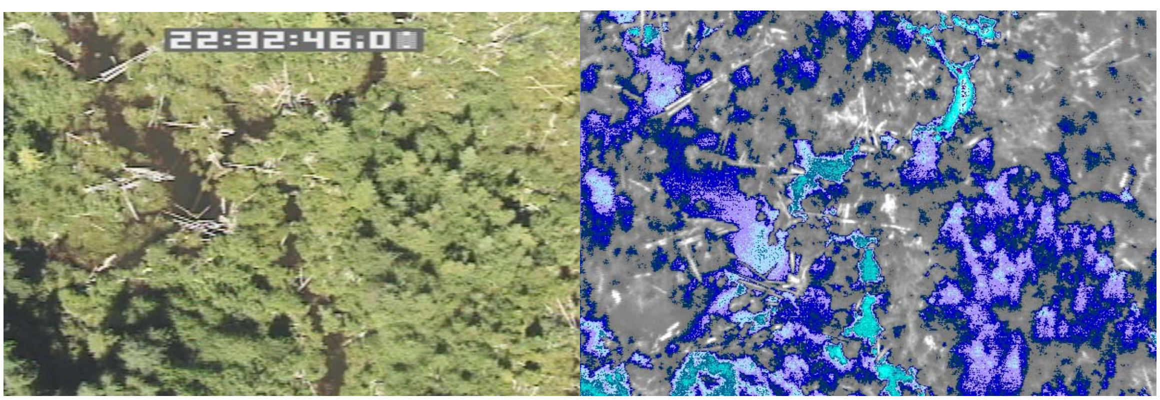


Frame: bldr0248 – Visible band/TIR image pair showing Boulder Creek at river mile 4.0. Although the stream is detected in the TIR image, not enough surface water was visible to get a reliable temperature sample. The images through this reach were not sampled.

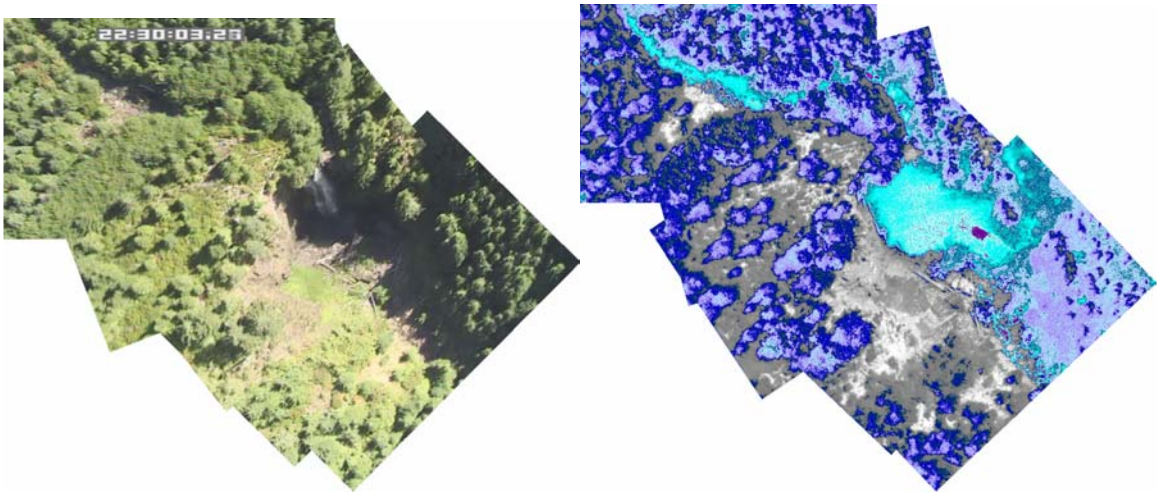
Warnicke Creek



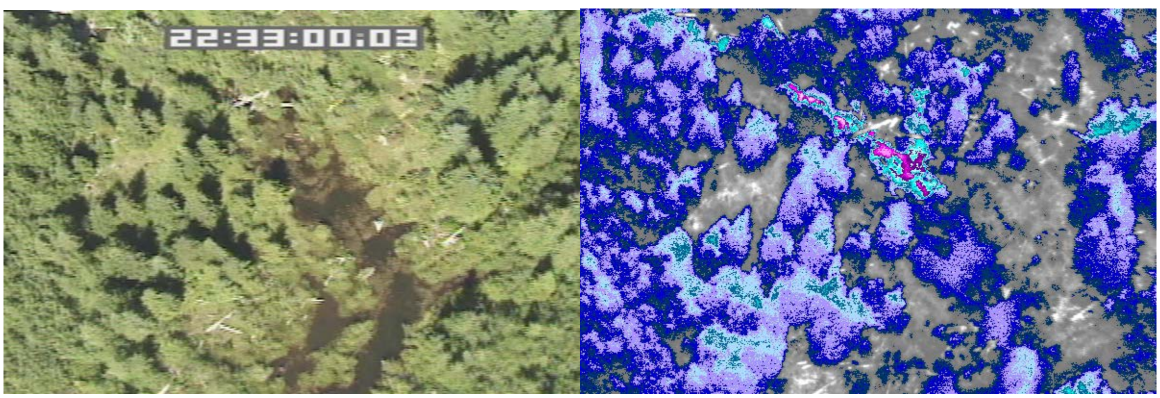
Frame: war0303-0305 – Visible band/TIR image showing Warnicke Creek (12.8^{o}C) near the headwaters at river mile 4.9. The images show channel characteristics in the low gradient meadow near the headwaters. The TIR image shows that the stream is potentially stratified behind the small impoundment.



Frame: war0315 – At river mile 5.1 of Warnicke Creek, near the headwaters, there is high variability in stream channel temperatures.

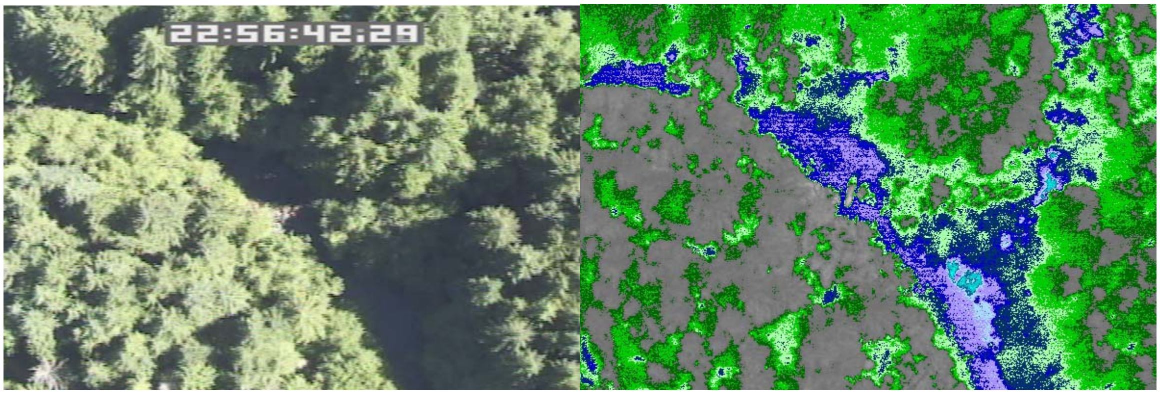


Frame: war0230–0234 – Visible band/TIR image pair showing Warnicke Creek (11.9^{o}C) at river mile 3.7. A waterfall is visible in the visible band image and the image illustrates the width of the channel upstream of the waterfall. A local temperature minimum was observed through this reach.

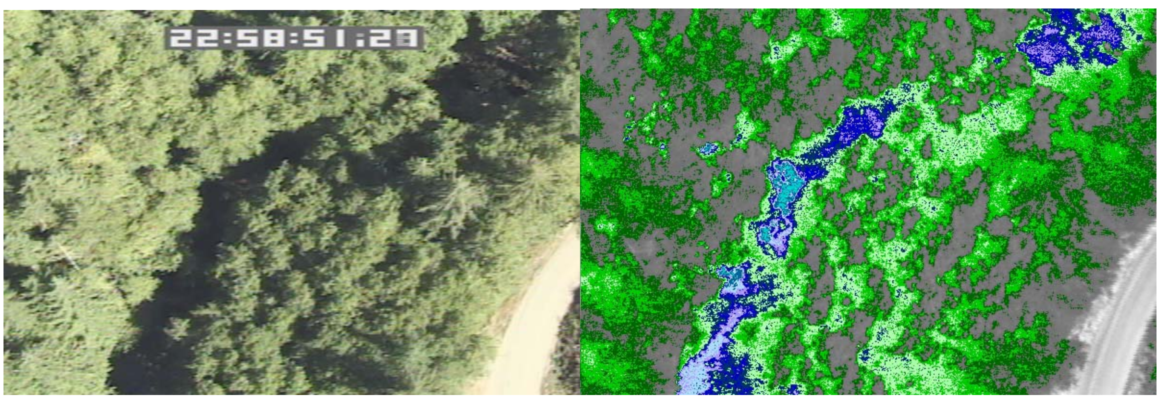


Frame: war0322 – Visible band/TIR image pair showing the apparent origin of Warnicke Creek (7.6^{o}C) at river mile 5.3. The image represents the last visible surface water detected during the survey.

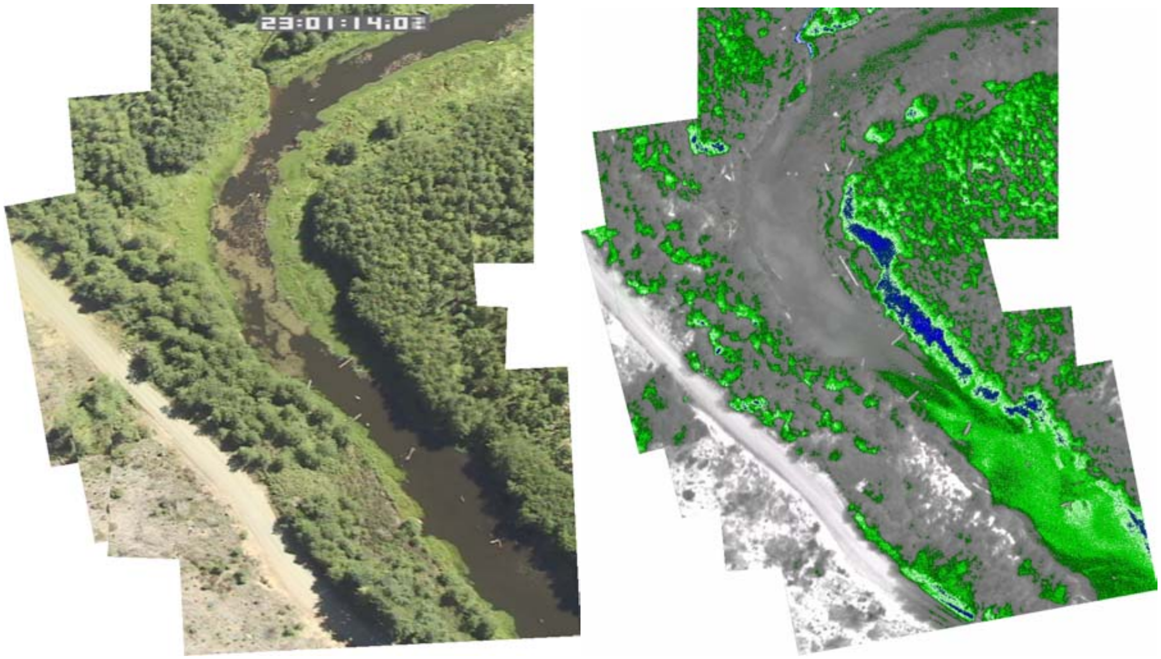
South Fork Siletz River (8/5)



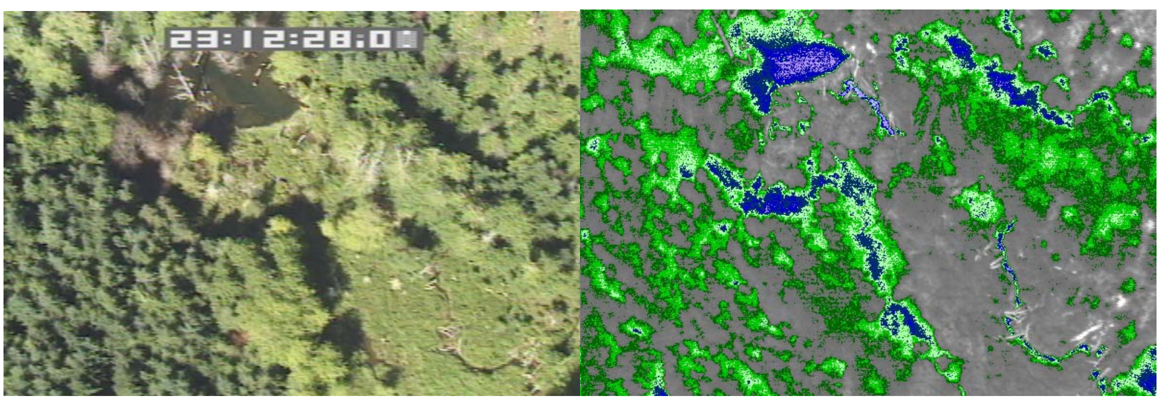
Frame: sfs0145 – These images show the confluence of Drift Creek (13.5^{o}C) to the left bank of the South Fork of the Siletz River (16.8^{o}C) at river mile 2.5.



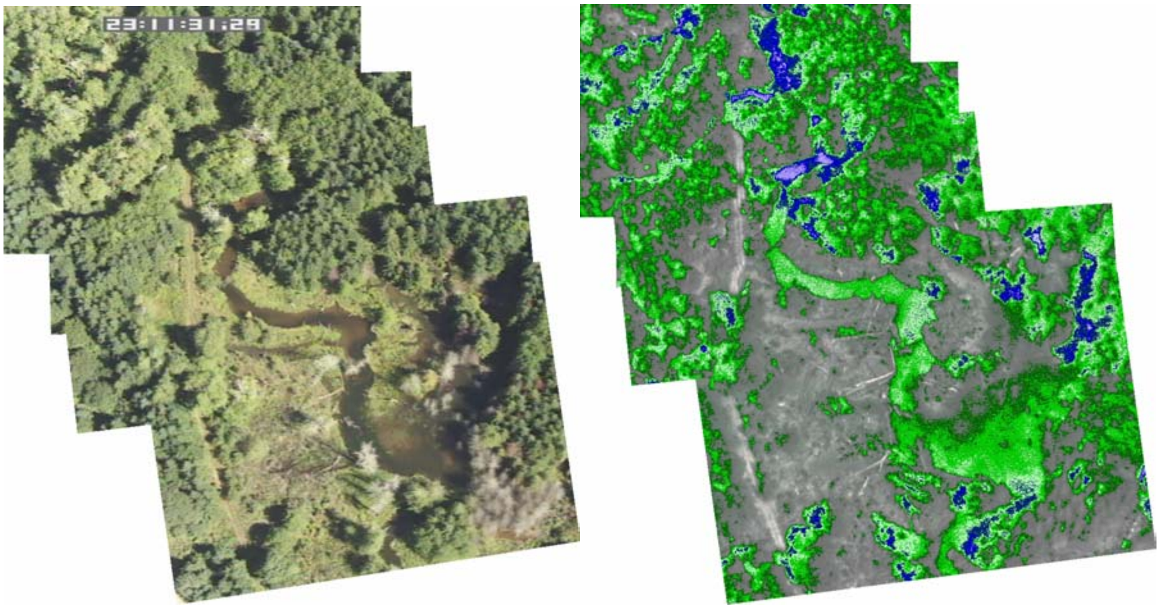
Frame: sfs0194 – At river mile 3.3, Rogers Creek (13.8^{o}C) empties into the right bank of the SF Siletz River (15.9^{o}C).



Frame: sfs0260-0265 – These mosaics show a stagnant section of Valsetz Lakebed at river mile 4.4. The mainstream measured 21.7°C while the stagnant region measured over 26°C.

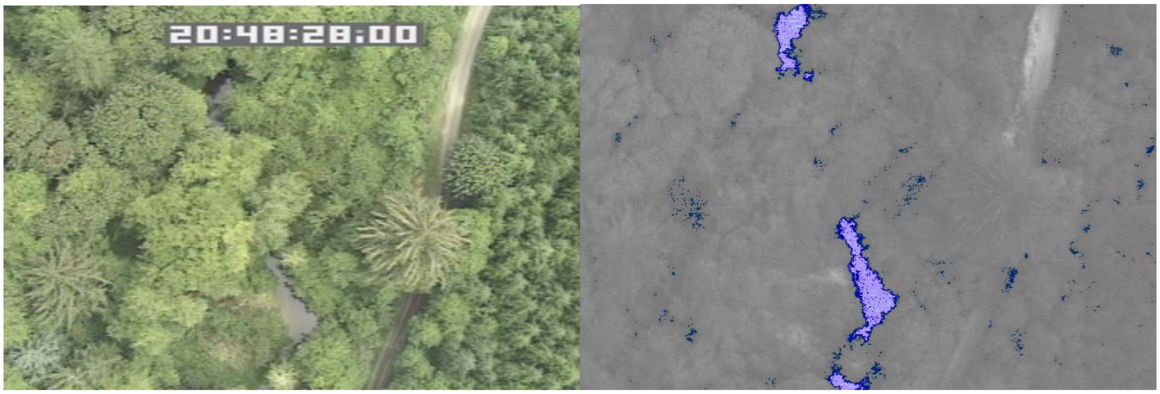


Frame: sfs0602 – Visible band/TIR image showing typical characteristics of the South Fork Siletz River at river mile10.4.

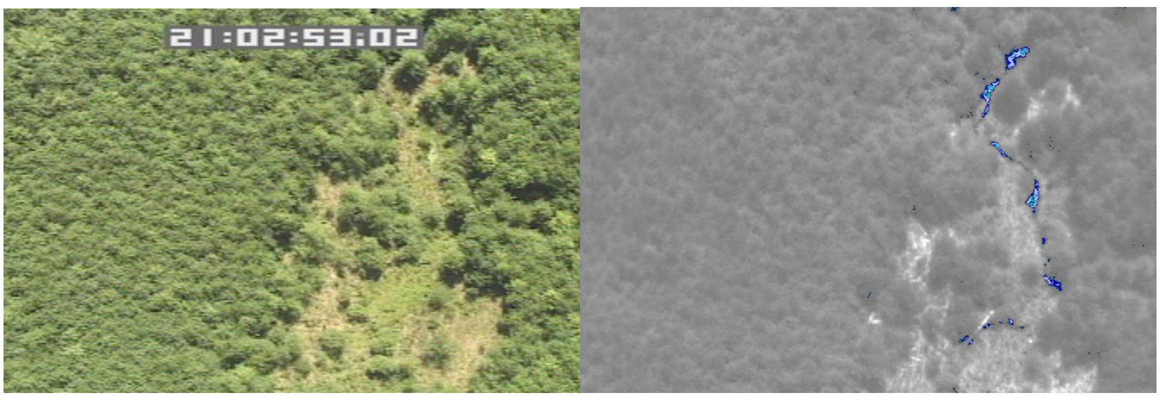


Frame: sfs0570-0574 – This pair of mosaics shows a possible side channel at river mile 9.8 measuring 20.1°C. The mainstream appears to go to the right side of the image and measures 16.7°C.

Sam Creek

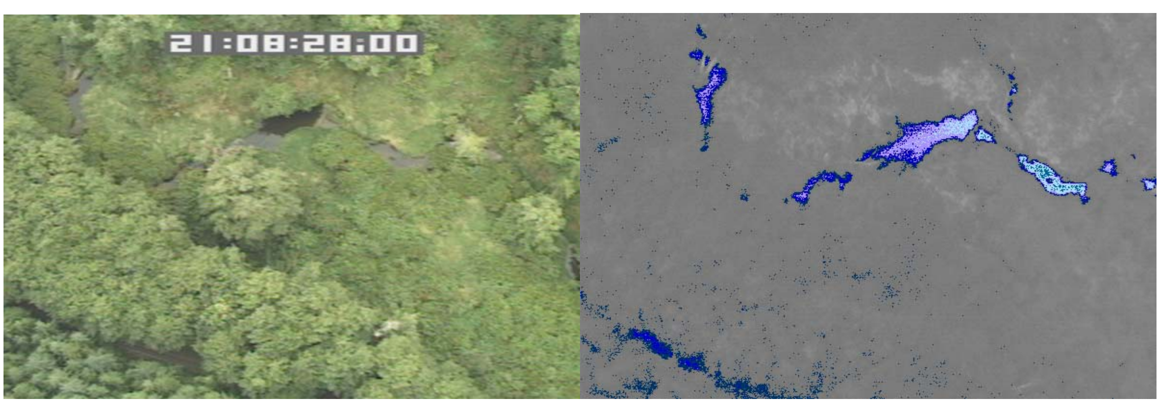


Frame: sam0141 – This images pair shows the partial canopy cover that was characteristic of Sam Creek (16.4^{o}C) in between Long Prairie Creek and the mouth. The images are from river mile 1.8

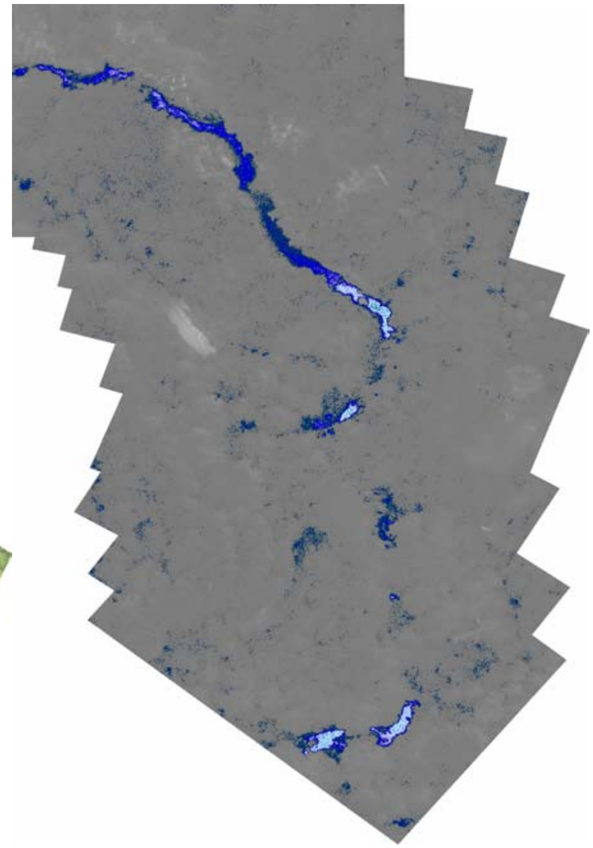


Frame: sam0574 – This image pair shows a small cool channel at the headwaters of Sam Creek, however, the channel was too small to sample.

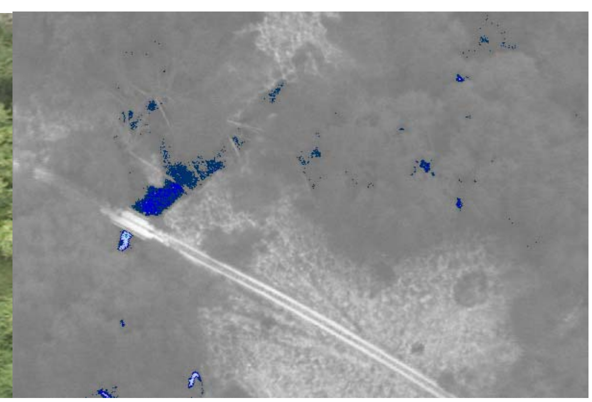
Long Prairie Creek



Frame: lp0057 – This pair of images shows a portion of Long Prairie Creek, which varies in temperature from 15.1°C downstream to 16.7°C upstream at river mile .6.

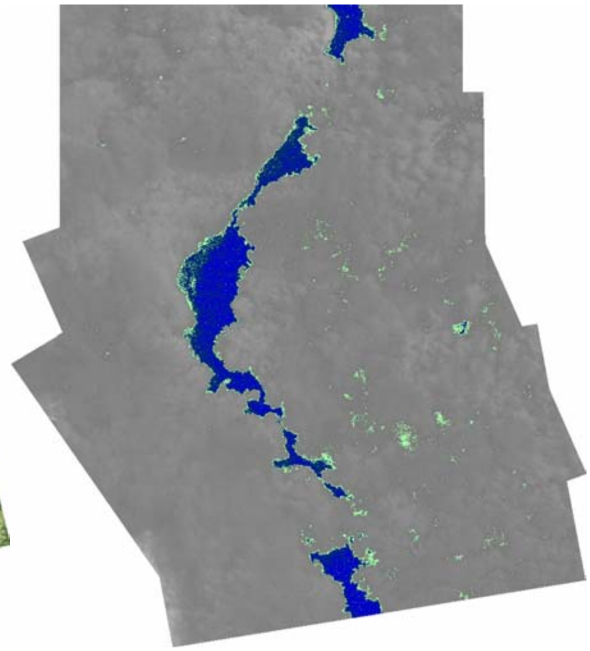


Frame: lp0130-0139 – At river mile 1.8, the temperature of Long Prairie Creek changes from 15.1°C downstream (bottom of image) to 17.8°C upstream. This temperature change suggests some level of thermal stratification.



Frame: lp0272 - Surface temperatures of 17.8°C were measured on the surface of the pool in these images at river mile 3.6. The pool was formed upstream of a road crossing and review of the image indicated that the pool surface was probably stratified.

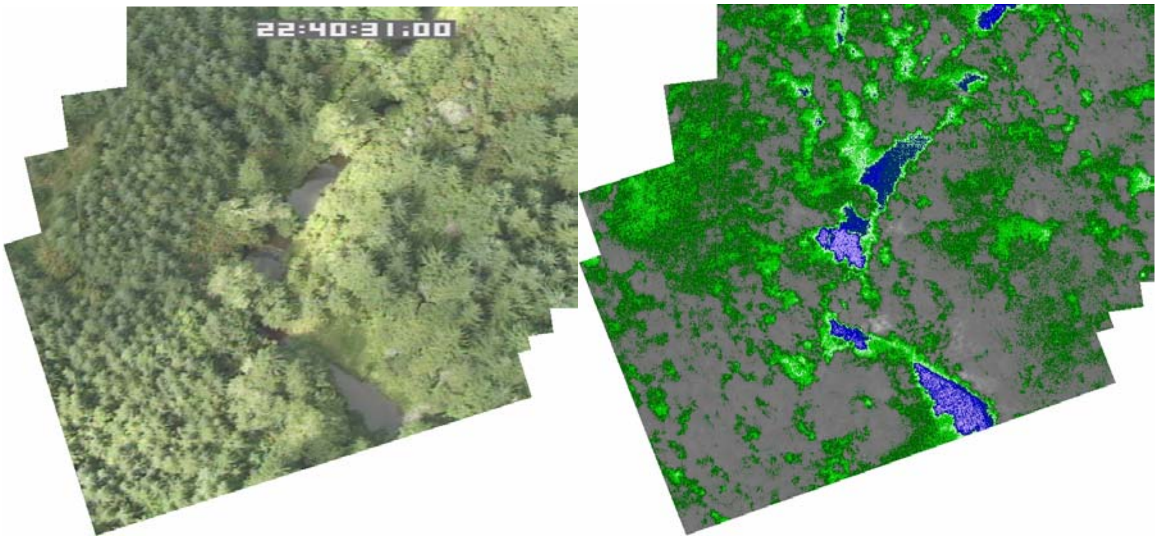
Rock Creek



Frame: rock0194-0199 – These images shows a segment of Rock Creek at river mile 2.9. A difference in temperatures was observed between the left and right bank indicating possible differential heating at the stream surface. The left bank temperature is 17.7^{o}C while the temperature on the right bank is 18.7^{o}C.

Frame: rock0351-0358 – At river mile 5.2 of Rock Creek, stream temperatures shows rapid a shift from 18.6^{o}C to 19.8^{o}C. The temperature change may represent a change from the mixed to stratified condition.

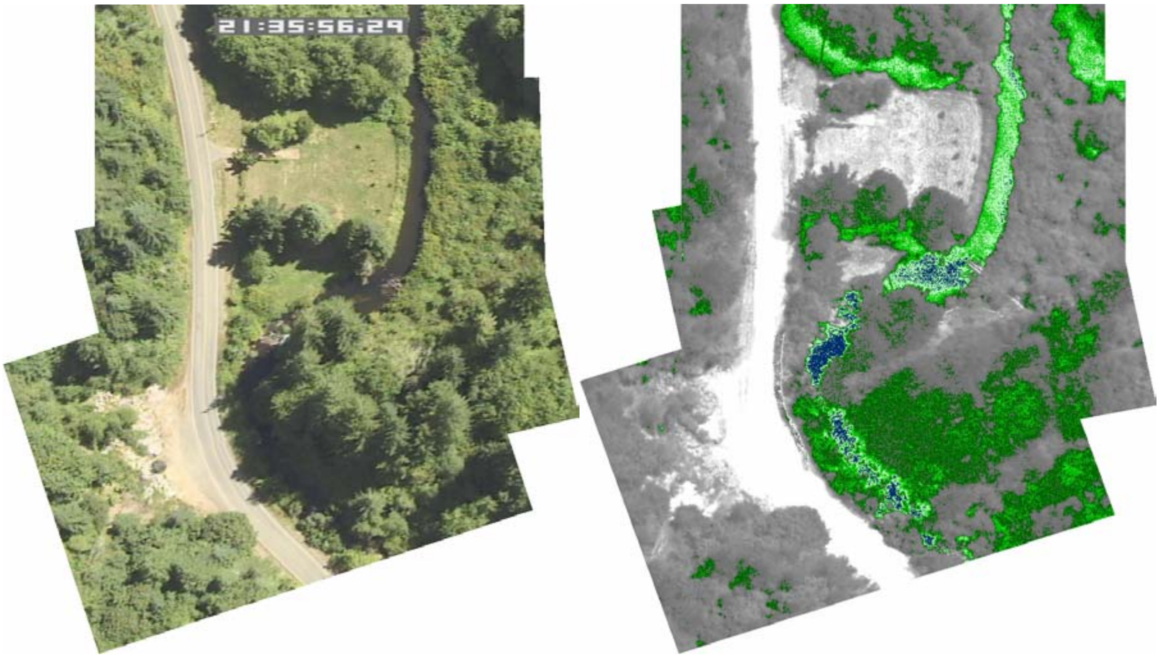
Big Rock Creek



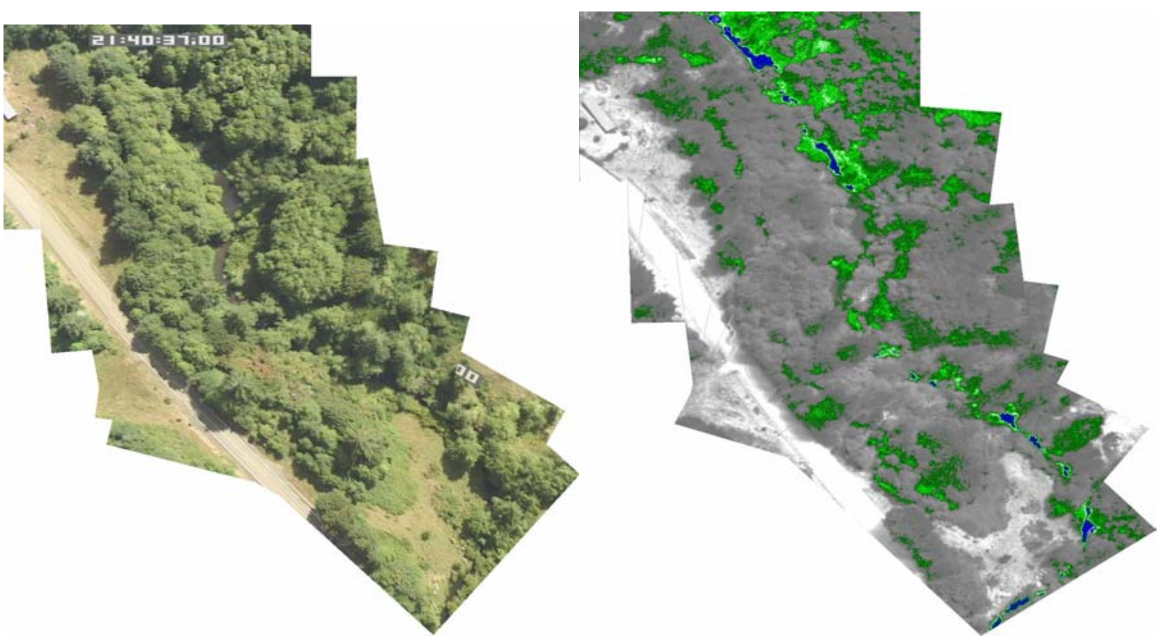
Frame: br0459-0462 – These images show a segment of Big Rock Creek at river mile 5.4, which shows differential heating of the stream's surface from 18.3°C upstream, to 16.8°C downstream. Flow direction is from the top to bottom of the image.

Frame: br0477 – This image pair shows the confluence of Youngs Creek (14.7°C) and Big Rock Creek (15.9°C) at river mile 5.7

Little Rock Creek

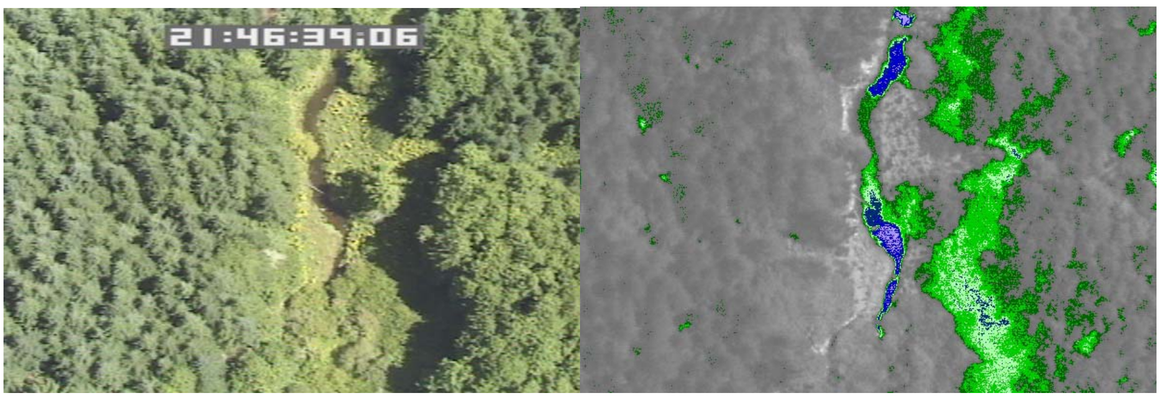


Frame: rock0401-0404 – This image mosaic of Little Rock Creek at river mile 0.7 where the decrease in apparent stream temperatures probably indicates differential heating and partial stratification at the stream's surface.



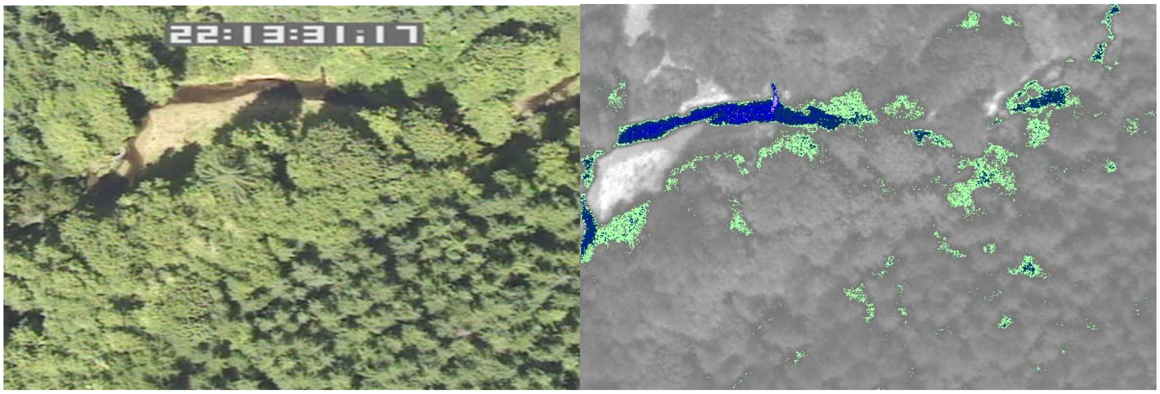
Frame: lrock0034-0041 – These images show a region of Little Rock Creek where the apparent stream temperature changes drastically from 17.8°C downstream to 22.1°C and back down to 17.1°C upstream (top of image) at river mile 2.1.

Frame: lrock0092 – This image pair illustrates channel characteristics in Little Rock Creek at river mile 2.9. Temperatures increased rapidly through this reach.

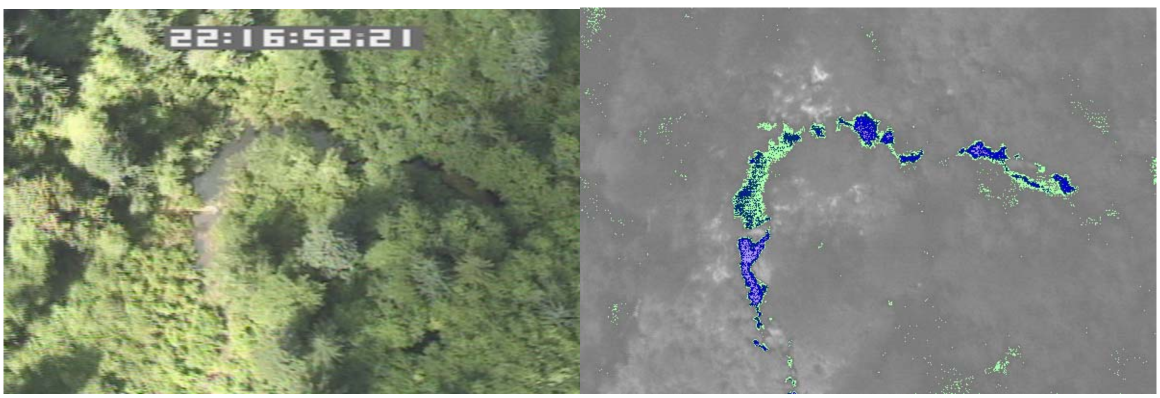


Frame: lrock0222 – This image pair of Little Rock Creek at river mile 4.9 shows intermittent stratification from the top to bottom of the image.

Steer Creek

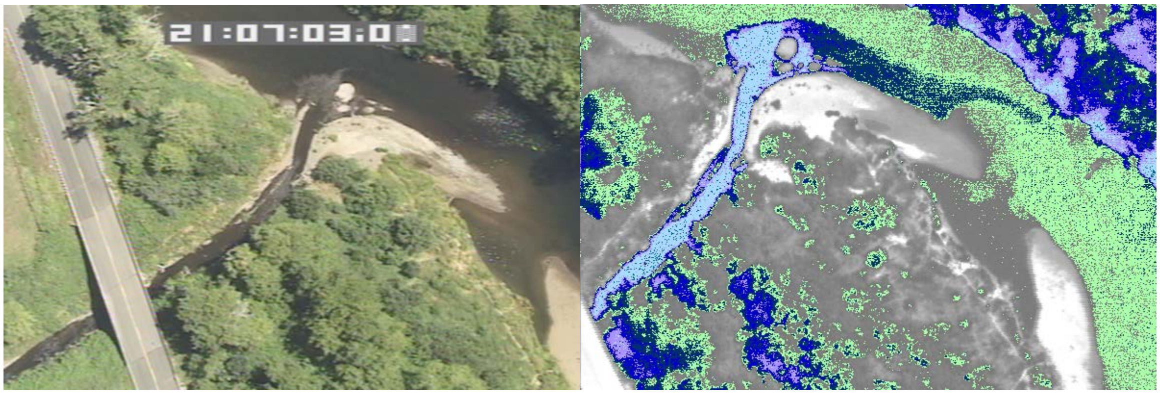


Frame: ste0130 – These images show the confluence of Beaver Creek (16.5°C) to the right bank of Steer Creek (18.2°C) at river mile 1.7.

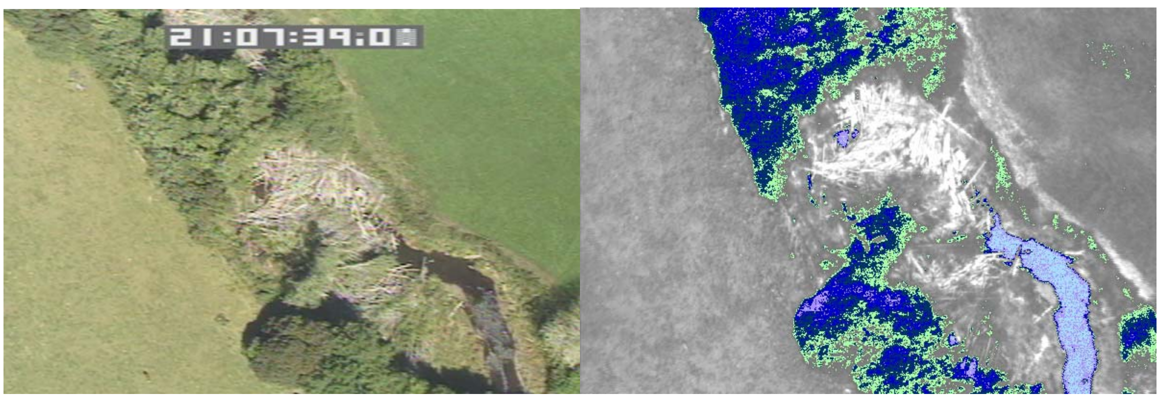


Frame: ste0230 – This image pair illustrates a segment of Steer Creek at river mile 3.1. Surface temperatures shift from 16.8°C before the bend in the stream to 18.6°C through the bend and back to 16.8°C. A temperature shift over a short spatial scale like this one often indicates some thermal stratification.

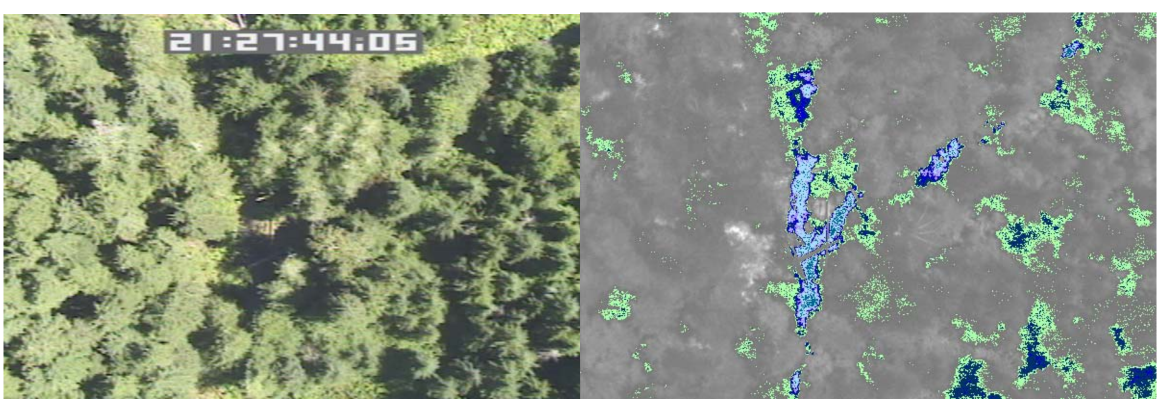
Cedar Creek



Frame: ced0039 – This image pair shows the confluence of Cedar Creek (15.4^{o}C) and the Siletz River (19.6). Flow direction is from the top to bottom of the image.

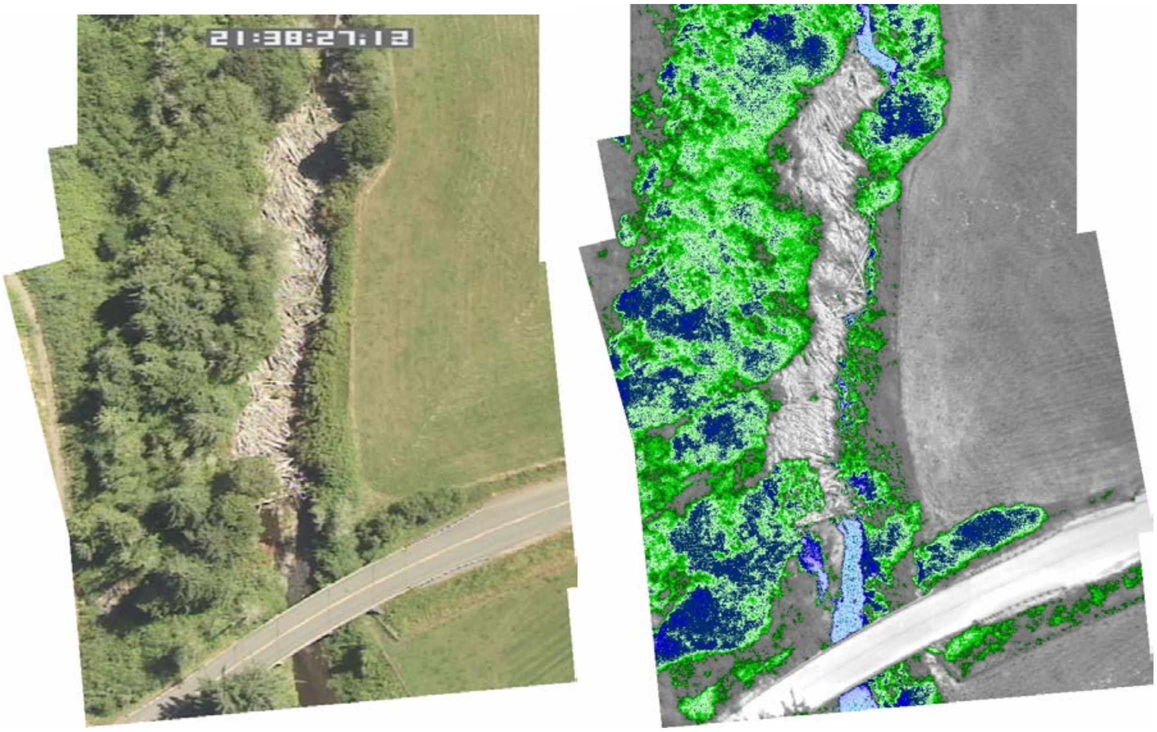


Frame: ced0057 – These images show the beginning of a quarter-mile segment of Cedar Creek where a logjam masked the stream

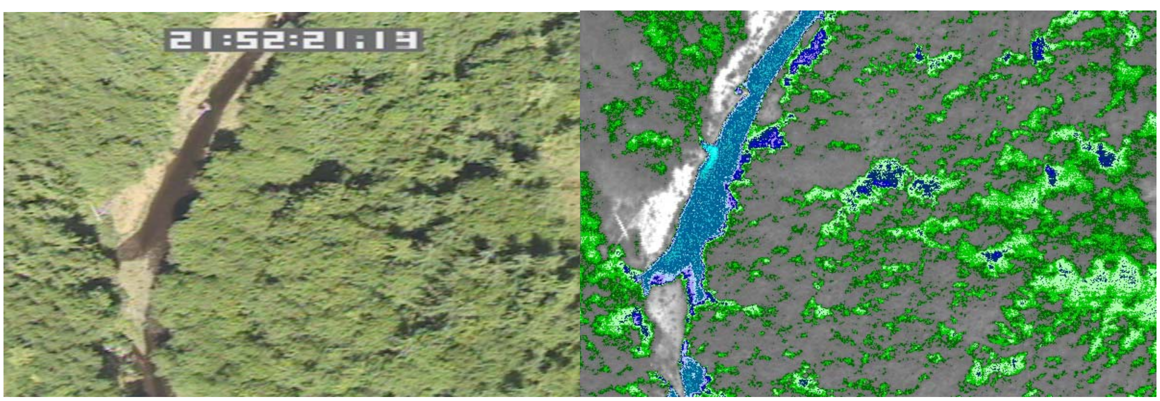


Frame: ced0584 – At river mile 8.8, there is an unnamed tributary (14.4^{o}C) enters the left bank of Cedar Creek (15.0^{o}C).

Euchre Creek

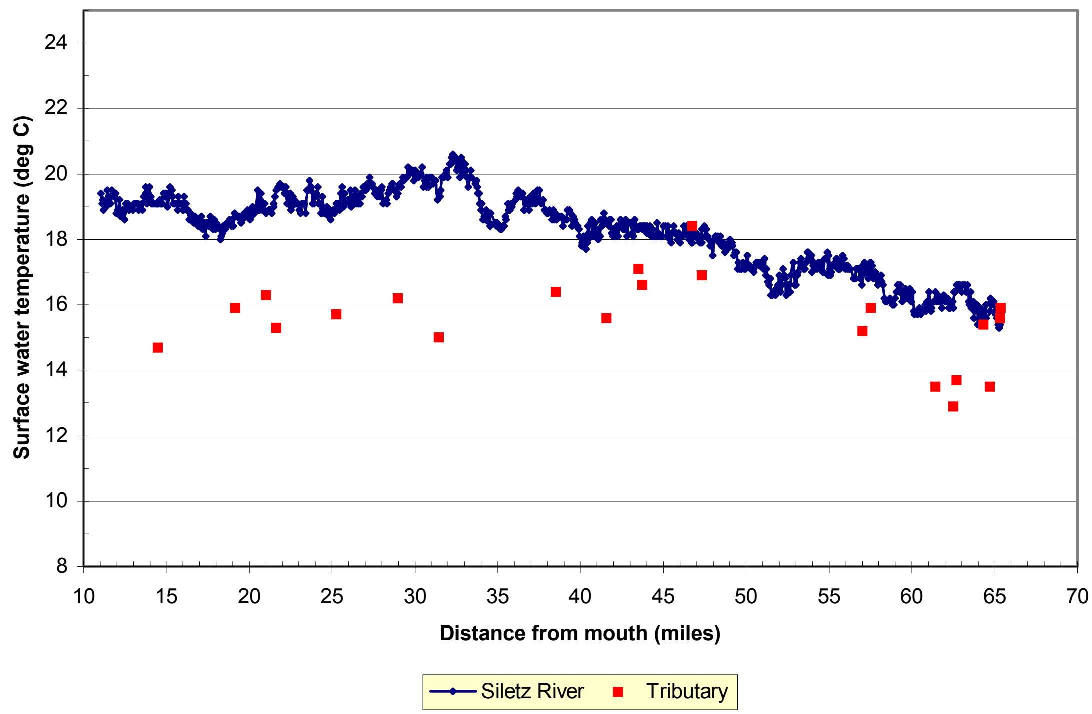


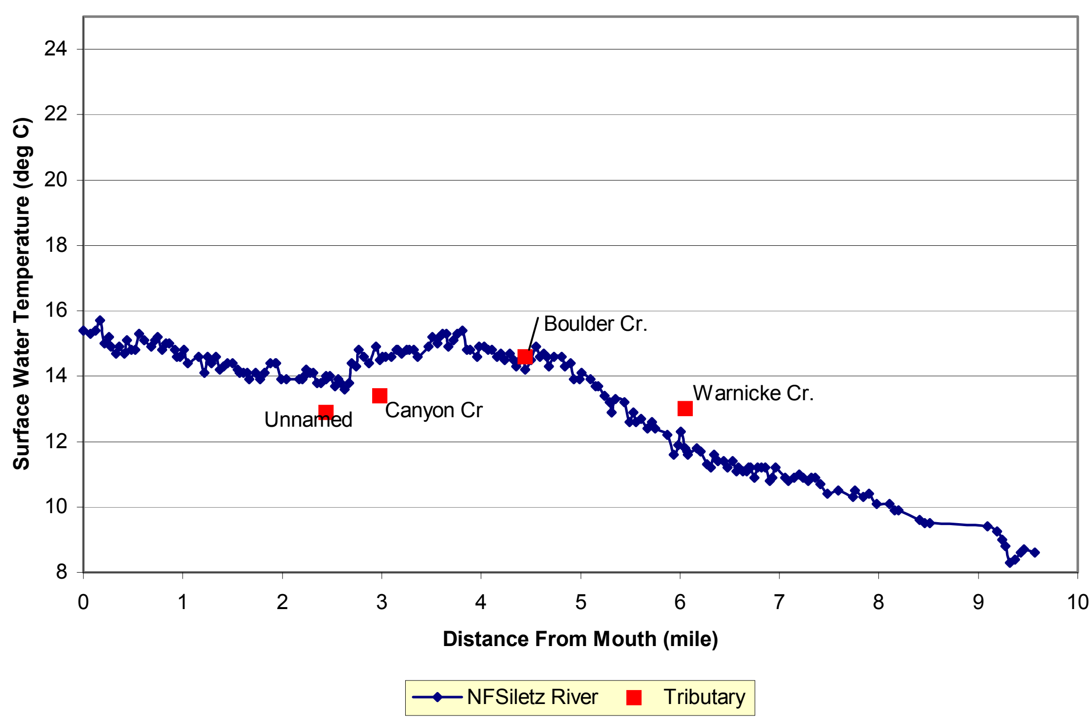
Frame: euc0025-0029 – This pair of mosaics shows a logjam near the mouth of Euchre Creek (15.6^{o}C).

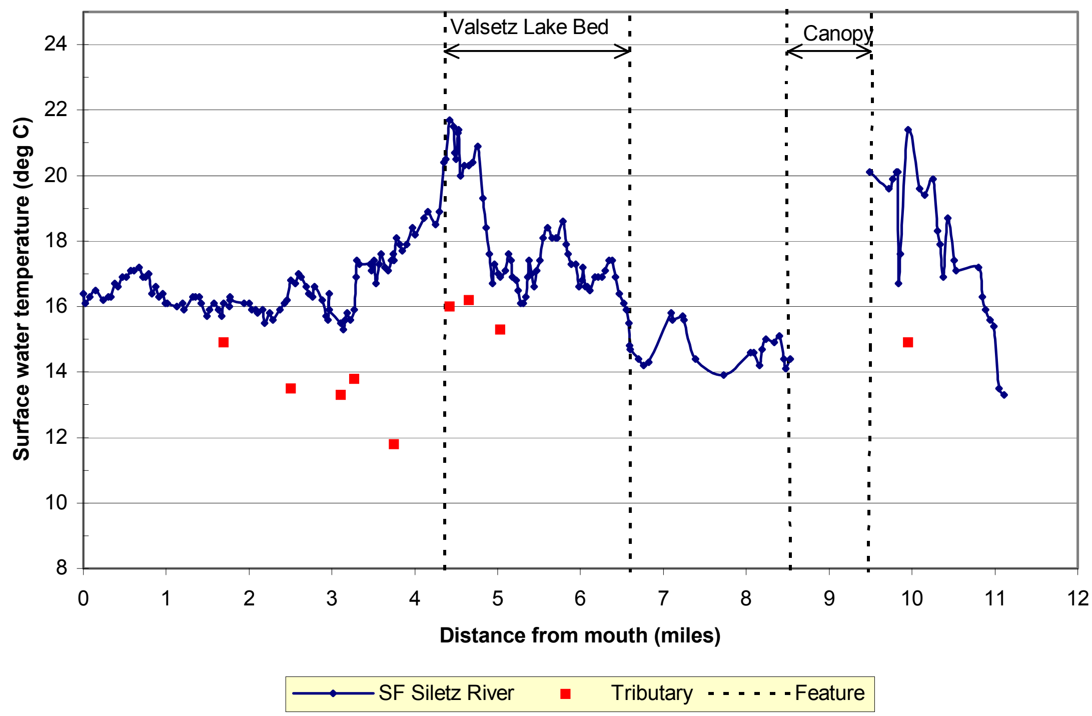


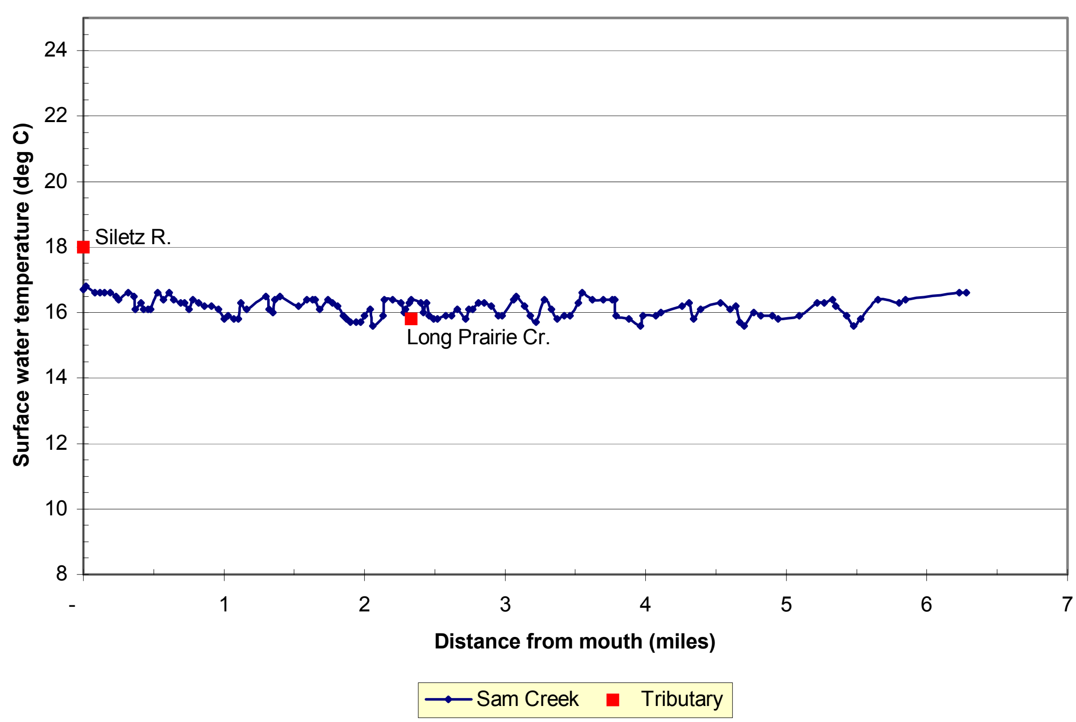
Frame: euc0446 – Visible band/TIR image pair showing the confluence of Euchre Creek (14.3^{o}C) and an unnamed tributary (12.4^{o}C).

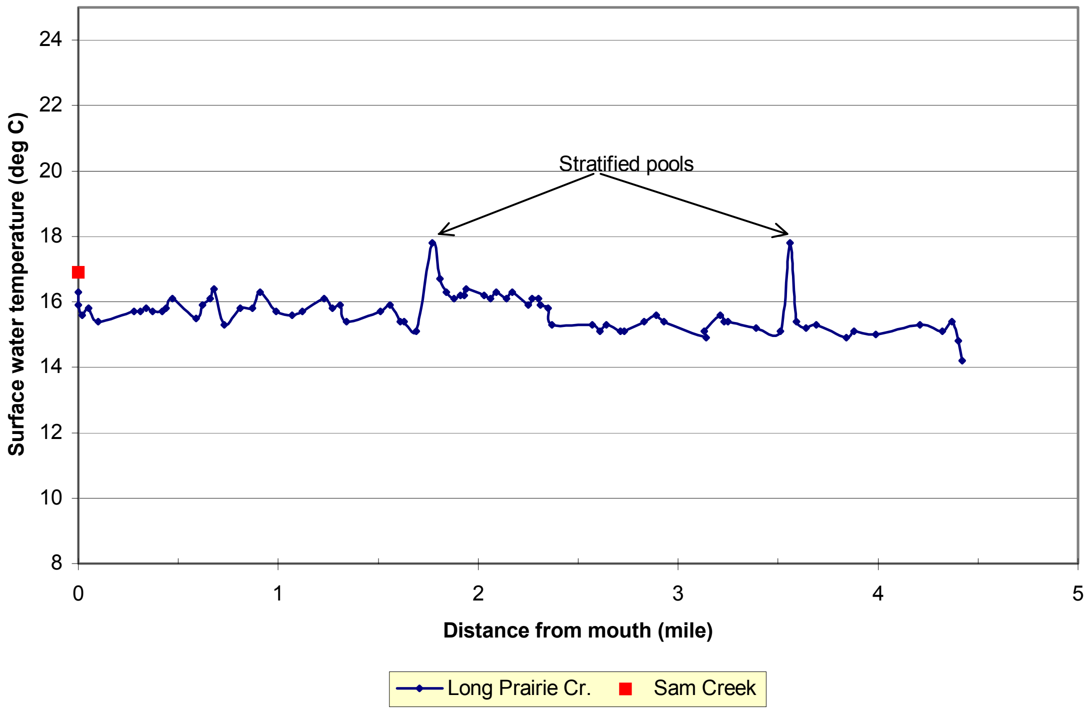
***Appendix B* –** Longitudinal Profiles of the Surveyed Streams in the Siletz River Basin. Each Profile is shown using the temperature scale of 8-25°C for relative comparisons.

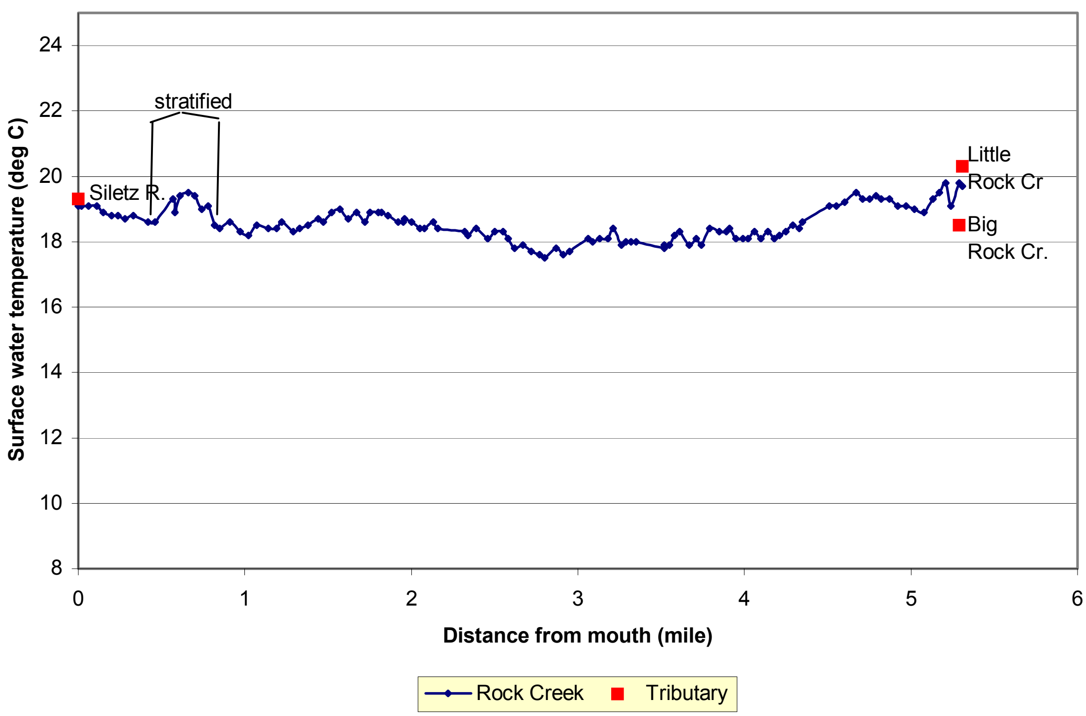


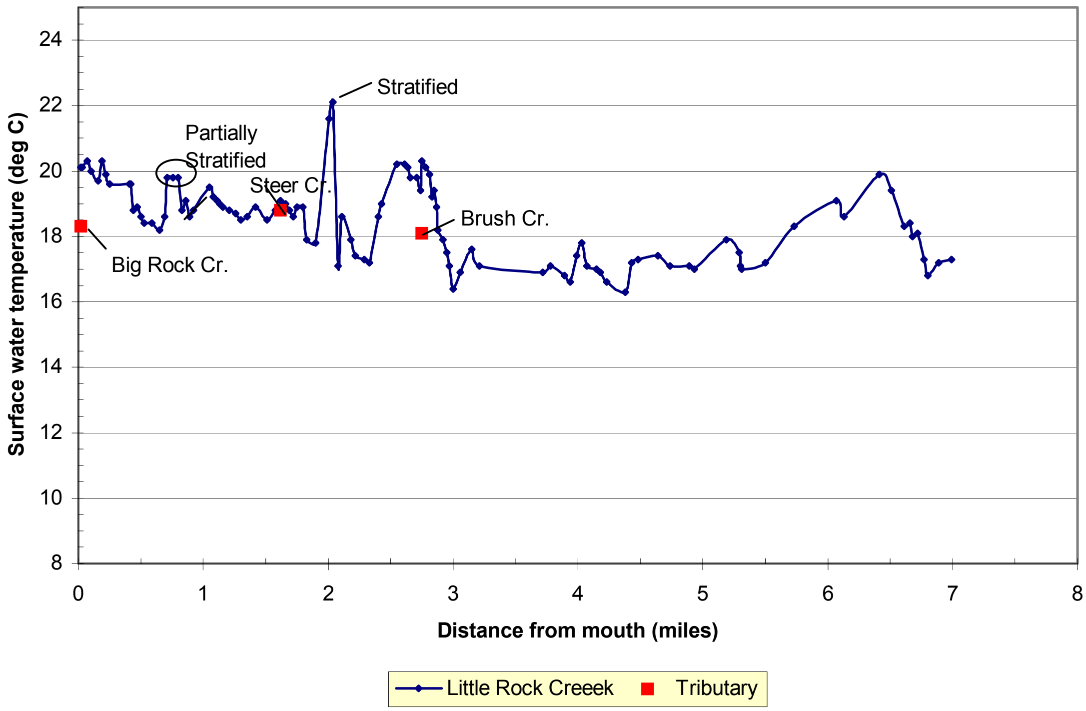


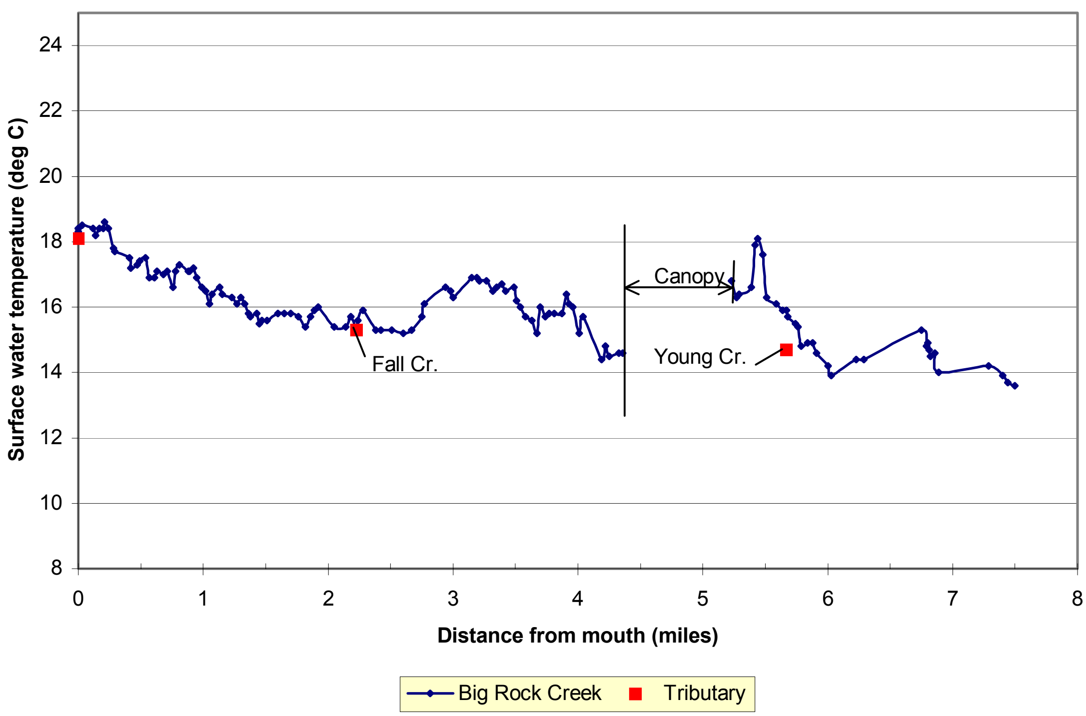

Valsetz Lake Bed
Canopy
Surface water temperature (deg C)
Distance from mouth (miles)
SF Siletz River
Tributary
Feature

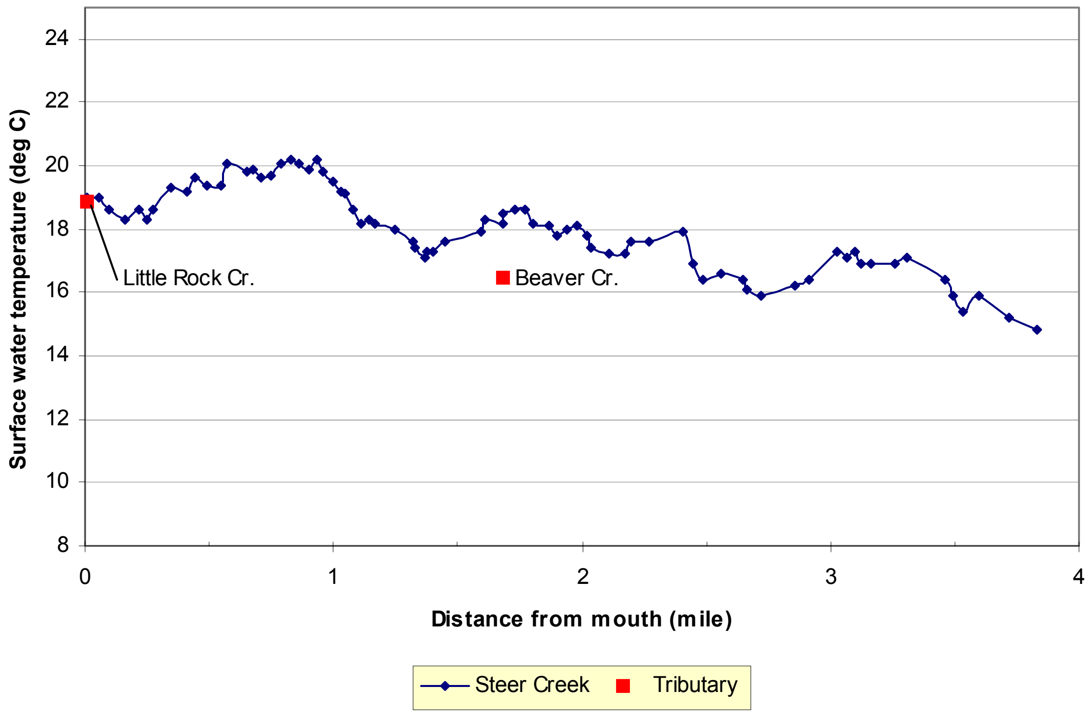

Siletz R.
Long Prairie Cr.
Surface water temperature (deg C)
Distance from mouth (miles)
Sam Creek
Tributary

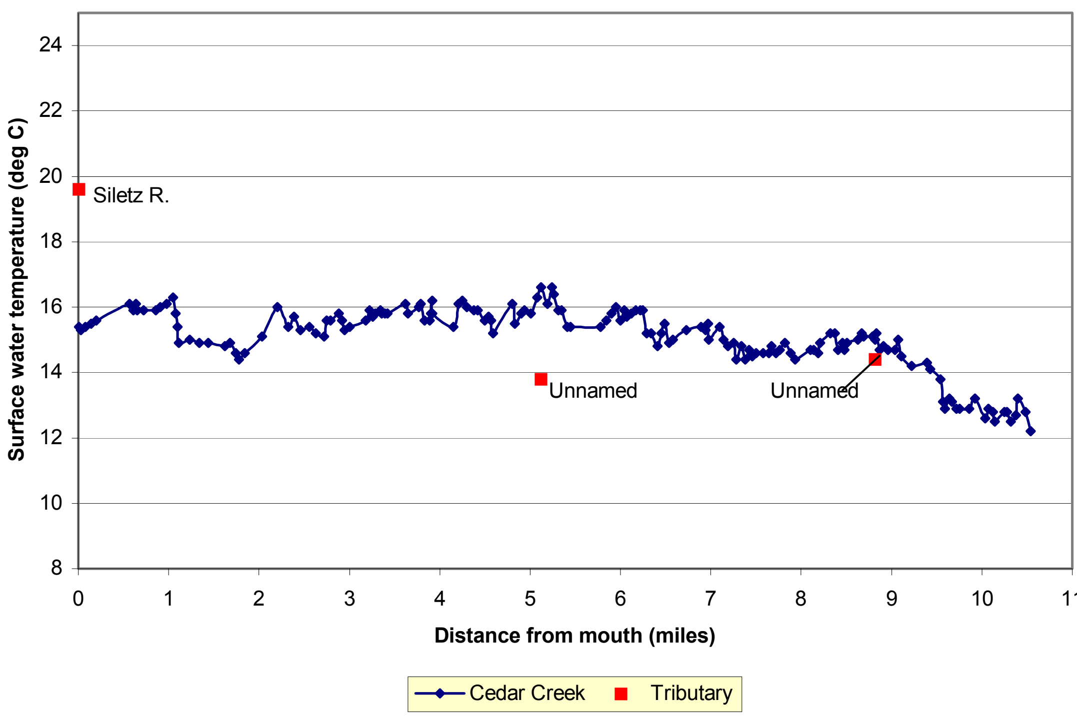

Stratified pools
Surface water temperature (deg C)
Distance from mouth (mile)
Long Prairie Cr.
Sam Creek
24
22
20
18
16
14
12
10
8
0
1
2
3
4
5

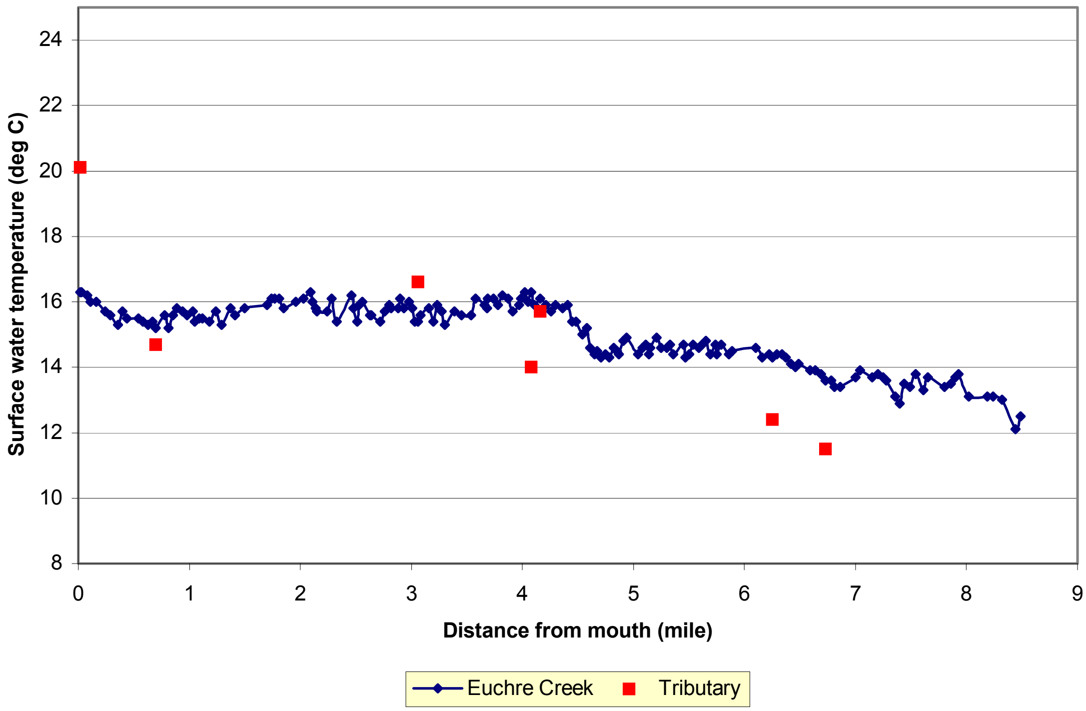

stratified
Siletz R.
Little
Rock Cr
Big
Rock Cr.
Surface water temperature (deg C)
Distance from mouth (mile)
Rock Creek
Tributary
24
22
20
18
16
14
12
10
8
0
1
2
3
4
5
6


Surface water temperature (deg C)
Distance from mouth (miles)
Stratified
Partially Stratified
Steer Cr.
Brush Cr.
Big Rock Cr.
Little Rock Creeek
Tributary

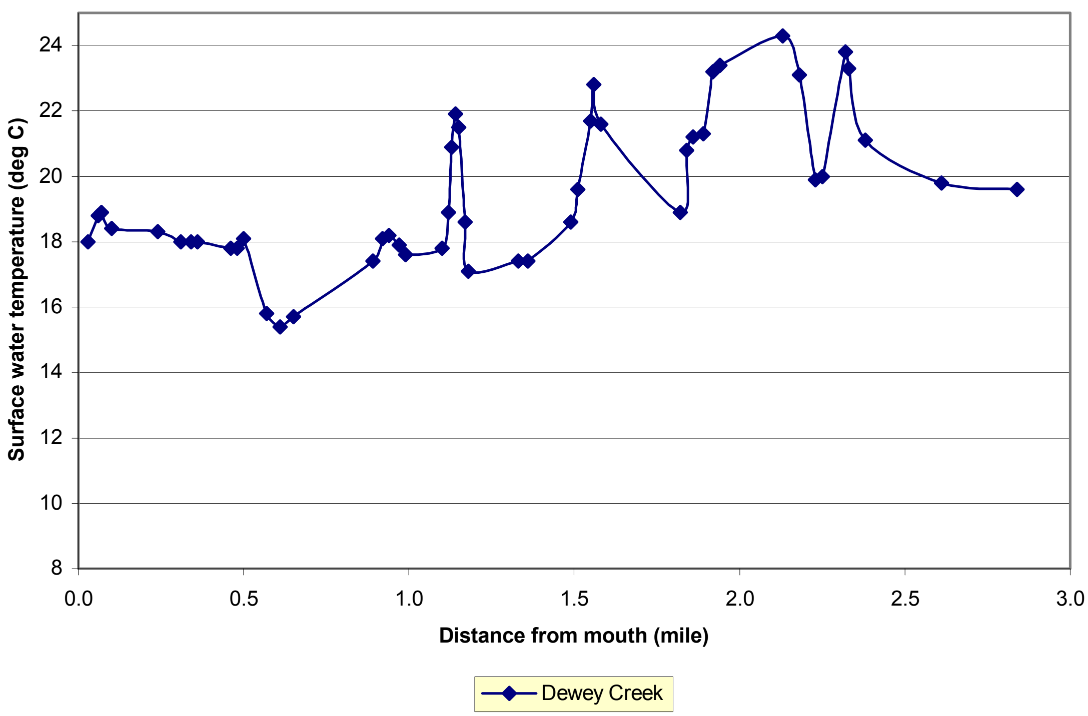

Surface water temperature (deg C)
Distance from mouth (miles)
Canopy
Young Cr.
Fall Cr.
Big Rock Creek
Tributary


Surface water temperature (deg C)
24
22
20
18
16
14
12
10
8
0
1
2
3
4
Distance from mouth (mile)
Little Rock Cr.
Beaver Cr.
Steer Creek
Tributary

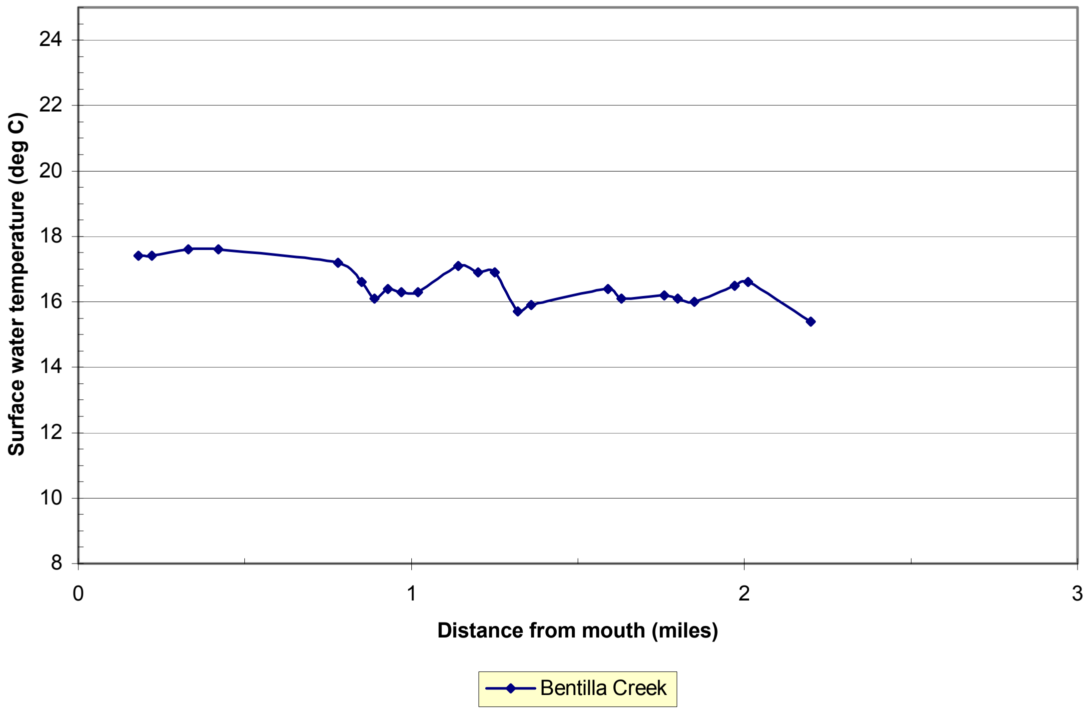

Surface water temperature (deg C)
24
22
20
18
16
14
12
10
8
0
1
2
3
4
5
6
7
8
9
10
11
Distance from mouth (miles)
Siletz R.
Unnamed
Unnamed
Cedar Creek
Tributary



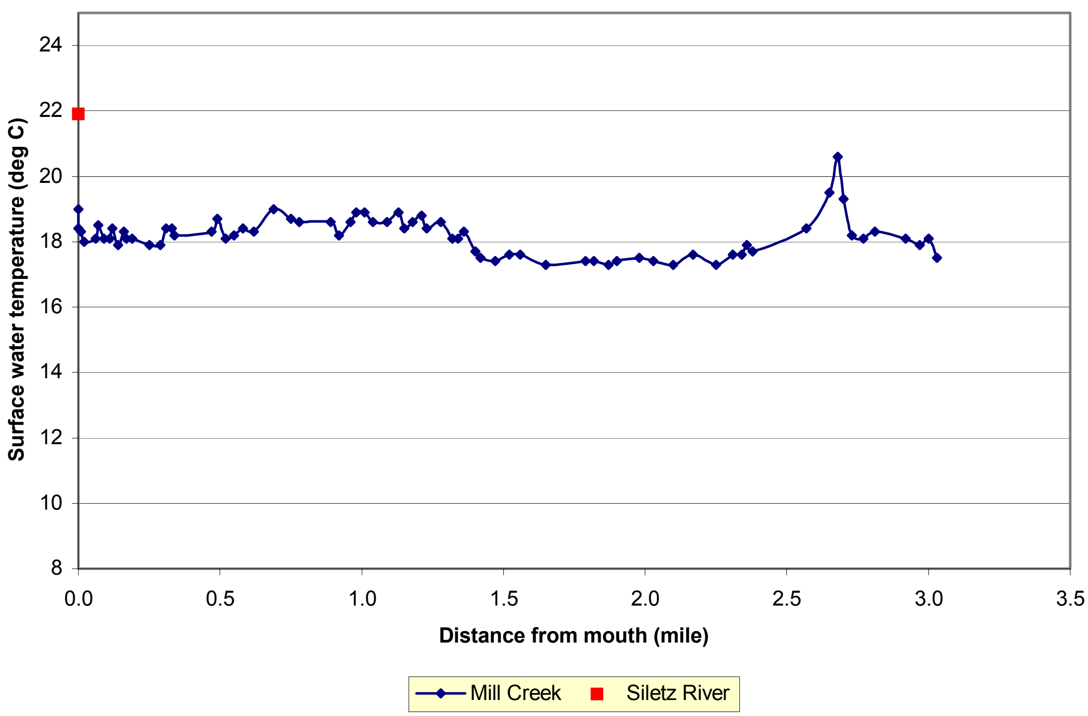
24
22
20
18
16
14
12
10
8
0
1
2
3
4
5
6
7
8
9
Surface water temperature (deg C)
Distance from mouth (mile)
Euchre Creek
Tributary



24
22
20
18
16
14
12
10
8
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Surface water temperature (deg C)
Distance from mouth (mile)
Dewey Creek



Surface water temperature (deg C)
24
22
20
18
16
14
12
10
8
0
1
2
3
Distance from mouth (miles)
Bentilla Creek



Surface water temperature (deg C)
24
22
20
18
16
14
12
10
8
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Distance from mouth (mile)
Mill Creek
Siletz River

National Water Quality Initiative
Siletz River Source Water Assessment

Prepared by Tyler Clouse and Katie Saaty

Lincoln Soil and Water Conservation District in partnership with NRCS

Siletz Source Water Protection Area

Table of Contents

Background and Purpose of the Assessment

General Overview and Location of the Assessment Area

The Siletz River Watershed is located in Western Oregon in the Coastal Mountain Range. The Source Water Protection Area (SWPA) is composed of nine 12-digit HUCS: Big Rock Creek- Rock Creek 171002040602, a portion of Dewey Creek-Siletz River 171002040703, Little Rock Creek 171002040601, Lower North Fork Siletz River 171002040402, Mill Creek-Siletz River 171002040502, Sam Creek-Siletz River 17100-2040701, South Fork Siletz River 171002040403, Sunshine Creek-Siletz River 171002040501, and Upper North Fork Siletz River 171002040401. The primary human uses are fishing, aquatic recreation, agricultural, industrial timber, and public water supplies. The outline of the 12-digit HUCS can be viewed on page 2.

The Siletz Watershed is located in Lincoln and Polk Counties, covering approximately 373 square miles. The river is just over 73 miles in length with public water intakes at approximately mile 40. The North Fork Siletz begins near the Valley of the Giants, a remnant stand of old growth forest. The South Fork Siletz begins East of the former town of Valsetz.

Threats to the Source Water Protection Area

The major threats to the SWPA are soil erosion, invasive species and improper riparian vegetation, and nonpoint source nutrient runoff and turbidity. Water extraction is at the highest peak in the Summer months when flow is at the lowest, exacerbating water quality issues.

Nonpoint sources have been identified as the primary source of pollutants in the Siletz Watershed. The impacts to water quality from adjacent agricultural properties is primarily from erosion, nutrient runoff and inputs from livestock, and improper riparian vegetation. Streambank erosion from livestock is a concern year-round with impacts most notable during the rainy season when a lack of vegetation and rising water level allow for increased sediment to enter the water. Additionally, livestock watering in-stream may introduce fecal matter into the river. High nutrient and sediment runoff leads to an increase in algal growth and low dissolved oxygen levels, which impacts fish and other aquatic organisms.

Forestry related concerns are improper riparian vegetation, lack of forestry planning, and degraded roads and culverts. Between 2000 and 2015, 42% of the Siletz watershed was clearcut (Native Fish Society, 2016). Clear Cutting practices on the Siletz's steep slopes may increase sediment loads during rain events due to a lack of soil-stabilizing vegetation. In addition, clearcutting practices increase potential temperatures by removing shade cover from streams and tributaries. While the new Private Forest Accord will mitigate some of these concerns, the legacy impacts of industrial forestry will impact the watershed for decades to come.

Drinking Water Systems, Populations Served, and Socioeconomics

Confederated Tribes of Siletz Indians (CTSI)

The Confederated Tribes of Siletz Indians (CTSI) is made up of many Indigenous tribes originating from all areas of Oregon west of the Cascades Crest. Beginning in 1856, members of these tribes were forcibly relocated to coastal reservations. Over the intervening years, Tribal land ownership has been reduced to several scattered fragments; one of these remaining pockets is largely located within the SWPA, and the City of Siletz is the present-day location of CTSI Administrative Headquarters. Tribal ownership of these parcels also constitutes a significant portion of the eligible non-industrial timber properties within the focus area.

While exact CTSI membership numbers are not available, according to the *2018-2022 EPA EJScreen Report*, 2,162 people are estimated to reside within the SWPA. Of these, 867 residents have reported to identify partially or wholly as American Indian.

Additionally, CTSI is a prominent agency in water quality monitoring efforts within the Siletz River Watershed, and much of the data discussed in this assessment are provided by the Tribe.

City of Siletz

The City of Siletz has a population of 1,242 according to the 2023 population estimated from Portland State University's Population Research Center. Per the Oregon Health Authority, the City's water system serves a total of 410 connections. According to the *2005 CTSI Comprehensive Plan*, the City of Siletz possesses a 0.25 cfs domestic use water right to the Siletz River. In 1994 this was augmented by a donation of a 0.26 cfs commercial use water right previously owned by CTSI, which was converted for domestic and municipal use, bringing the City's combined domestic and municipal water rights to 0.51 cfs.

The City's average processing rate is 83 gpm, with a Summertime maximum processing capacity of 180.5 gpm during peak demand. Winter processing capacity is lower (83-90 gpm) due to high turbidity slowing filtration.

City of Toledo

The City of Toledo has a population of 3,622 according to the 2023 population estimated from Portland State University's Population Research Center. In addition to providing water within city limits, the City's water system serves 71 residential and 6 commercial connections outside city limits and provides wholesale water to Seal Rock Water District (SRWD) and Wright Creek Water District (WCWD). The water is pumped from SRWD via the SRWD-owned and operated Toledo pump station. The maximum capacity is 1 mgd, or 700 gpm.

The City holds four water rights for use of water from the Siletz. Permit S-12553 has an authorized rate of 1.75 cfs, with the source noted as "often not available" during Winter and Spring due to high turbidity. Permit 9370 has an authorized rate of 2.66 cfs with the source noted as often not available during Winter and Spring due to high turbidity. Permit 58445 has an authorized rate of 4.0 cfs, with the source noted as "often not available" during Winter and Spring due to high turbidity. Permits 58445 and 9370 have a stipulation that "Access to water requires a final order approving the City's WMCP." (Toledo WMCP, 2017). The City primarily uses the Siletz in the Summer and Fall when their alternate source, Mill Creek, is unavailable.

City of Newport

The City of Newport has a population of 11,083 according to the 2023 population estimated from Portland State University's Population Research Center.

The city holds seven water diversion rights, but only three of the sources are utilized, with only one from the Siletz. Permit S-29213 has an authorized rate of 6.00 cfs and is primarily used in the Summer months to fill the Big Creek reservoirs. (Newport WMCP)

Seal Rock

Seal Rock is an unincorporated community, thus detailed census data is not available. Using county averages, the full-time population estimate is 4,107 persons with a seasonal increase to 5,175.

The City has a single water right on the Siletz River under Permit S40277 with an authorized rate of 2.6 cfs. The point of diversion for the permit is located at the Toledo intake near river mile 40.

County Population Data

Approximately 26,804 people rely on the Siletz River for drinking water, accounting for approximately 52 percent of the county population. Additional unincorporated areas within the Siletz watershed that rely on wells or non-public water sources are not included in this estimate.

The Median Household Income in Lincoln County is $57,794, far below the State average of $75,657. The poverty level is above State averages by approximately 2.6%, accounting for approximately 14.7% of the population. (US Census Bureau).

Identification of Goal and Objectives

The NWQI goals for the Siletz River are to address the Category 5 Impairments on the 303(d) list within the SWPA by reducing turbidity (sediment) and bacteria (E. coli) and improving native streamside vegetation.

Through the process of the NWQI, the District has worked with partners on the finalization of the Mid-Coast Water Planning Partnership (MCWPP) Water Action Plan and the subsequent early implementation plan for the continuity of the MCWPP. As part of this process the District also worked with land managers, public and private industry, conservation organizations and drinking water providers to develop the City of Toledo Drinking Water Protection Plan, and is providing technical assistance to the City of Newport Drinking Water Protection Plan development. The goals for sediment, bacteria, and temperature reduction reflect the areas the District has committed to assist partners in improving water quality in the SWPA through this process.

Sediment (Turbidity)

Sediment (Turbidity) is an impairment primarily associated in the SWPA with highly erodible soils, lack of riparian vegetation, and lack of livestock exclusion fencing. Some data exists measuring turbidity and total suspended solids; however, it is not enough to use as a baseline for monitoring improvements associated with best management practices.

The agricultural objectives for sediment reduction are livestock exclusion fencing of approximately 5400 linear feet and the conversion of bare ground and grass areas to tree shrub communities within a 50-foot riparian buffer on major waterways in the SWPA (see *Temperature* for metrics).

Objectives for the reduction of sediment from non-industrial timber operations include the coordination with woodland owners to write at least 10 forest management plans and the conversion of bare ground and grass areas to tree/shrub communities within a 50-foot riparian buffer on major waterways in the SWPA (see *Temperature* for metrics).

The priority area for implementation of forest management plans is the 1100 acres of timber conservation land within 2 miles of the drinking water intakes.

Bacteria (E. coli)

The goal is the reduction of bacteria (*E. coli*) and nutrients from livestock manure, compost, and biosolid land applications to surface waters in the SWPA.

The objectives are the development of at least 12 Nutrient Management Plans and 6 compost/manure storage facility designs, in addition to the construction of at least 6 compost/manure storage facilities.

The priority areas for treatment include 2 properties in the Dewey Creek sub watershed due to their proximity to the intake and extensive riparian frontage, 2 properties in the Big Rock Creek sub watershed with bare ground and extensive riparian frontage, and 4 properties in the Mill Creek sub watershed to address biosolid land applications.

The ability to quantify anticipated change in the water quality is unattainable with current data and lack of specific projects, however the Nutrient Management Plans will include information on current practices, soil samples and recommendations to prevent over application of manure and compost that may contribute bacteria and nutrients to surface waters.

Temperature

Data from the Siletz Streamside Vegetation Assessment (SVA) indicates a need for riparian vegetation improvements to provide shade and large woody debris recruitment. The goal to address temperature impairments is to convert areas of bare ground and grass within a 50-foot riparian buffer of major waterways in the SWPA to native tree and shrub communities.

The objective for agricultural lands is the conversion of 41 acres of bare ground and grass to tree shrub communities within a 50-foot riparian buffer on major waterways in the SWPA. The priority areas for treatment include all properties in the Mill Creek and Big Rock Creek sub watersheds to address 303(d) impairments (DEQ 2022)

The objective for non-industrial timber lands is the conversion of 18 acres of bare ground and grass to tree shrub communities within a 50-foot riparian buffer on major waterways in the SWPA. The priority areas for treatment include all properties in the Mill Creek and Big Rock Creek sub watersheds to address 303(d) impairments (DEQ 2022)

Habitat Enhancement

The goal of habitat enhancement is to improve water quality and quantity through ecological solutions that benefit ESA listed species. Within the SWPA at least four ESA listed species persist: Marbled Murrelet, Northern Spotted Owl, and Chinook and Coho Salmon.

One objective in improving water quantity and habitat for Chinook and Coho Salmon is to restore at least 5 acres of beaver pond habitat. Beavers have long been seen as a nuisance and until recently have been legally designated as a predatory species on working lands. However, they also provide the benefits of increased water storage, stream temperature reductions in beaver-dominated systems, and improved aquatic habitat for Coho and other Salmonids. Beavers can build and maintain habitat and accomplish conservation objectives faster and cheaper than engineered activities and infrastructure. Priority areas for beaver habitat improvement include the CTSI farm property and properties in Big Rock Creek, where partners are currently working on restoration efforts.

Upland forest improvement, especially in timber conservation properties not planned for harvest, could improve habitat for both the Marbled Murrelet and the Northern Spotted Owl. The objective for upland forest improvement is the development of at least 2 forest management plans on timber conservation properties within ¼ mile of critical habitat for the Marbled Murrelet. Priority areas for upland forest improvement include 20 tax lots in the Big Rock Creek sub watershed that are within ¼ mile of critical habitat for the Marbled Murrelet with a goal of 20 acres improved.

NRCS Ability to Help Partners Reach Goals

NRCS has a local District Conservationist who can assist partners in reaching conservation and land management goals. NRCS and the District have a long-standing relationship working through conservation issues together. NRCS also works with the MidCoast Watersheds Council (MCWC), McKenzie River Trust, and others to achieve conservation goals. The District supports the outreach, engagement, and project development of conservation practices on private and public lands in the watershed.

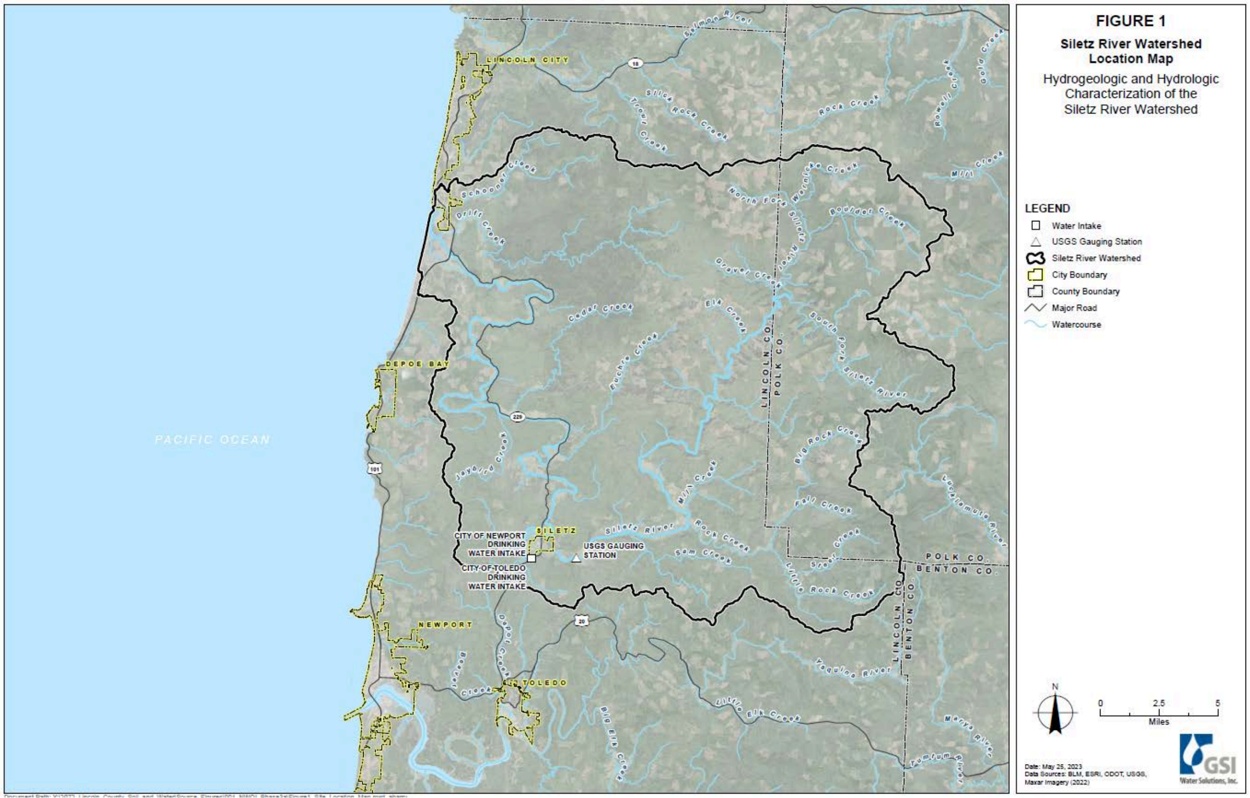
NRCS programming in the area does not currently meet the needs of this project. Additional water quality-focused funding will be required for NRCS to meet the needs of partners.

Current applicable NRCS funding in the area is primarily focused on forestry through the Forest Management Planning and Forest Resistance and Resilience Strategies. Both strategies' primary resource concerns include degraded plant conditions.

NRCS utilizes a team approach to successfully address the workload in Oregon. The local NRCS team relies on a regional Basin Engineer and summer engineering interns located in the Tangent Service Center to assist with inventory and evaluation, planning, and designs for engineering practices. Unfortunately, the high engineering workload in the Basin has necessitated the District and partners use outside engineering services for some projects. Other members of the NRCS team available to assist with planning and implementing projects in the area include the regional Forester, located in the Eugene Service Center, and the Basin Small Farms Specialist, located in the Tangent Service Center. Technical assistance on projects is also available from the State Engineering staff, State Forester, State Grazing Specialist, State Biologist, and State Agronomist, all located in the Portland State Office.

Watershed Characterization

Location of Watershed in Drainage Network and Flooding

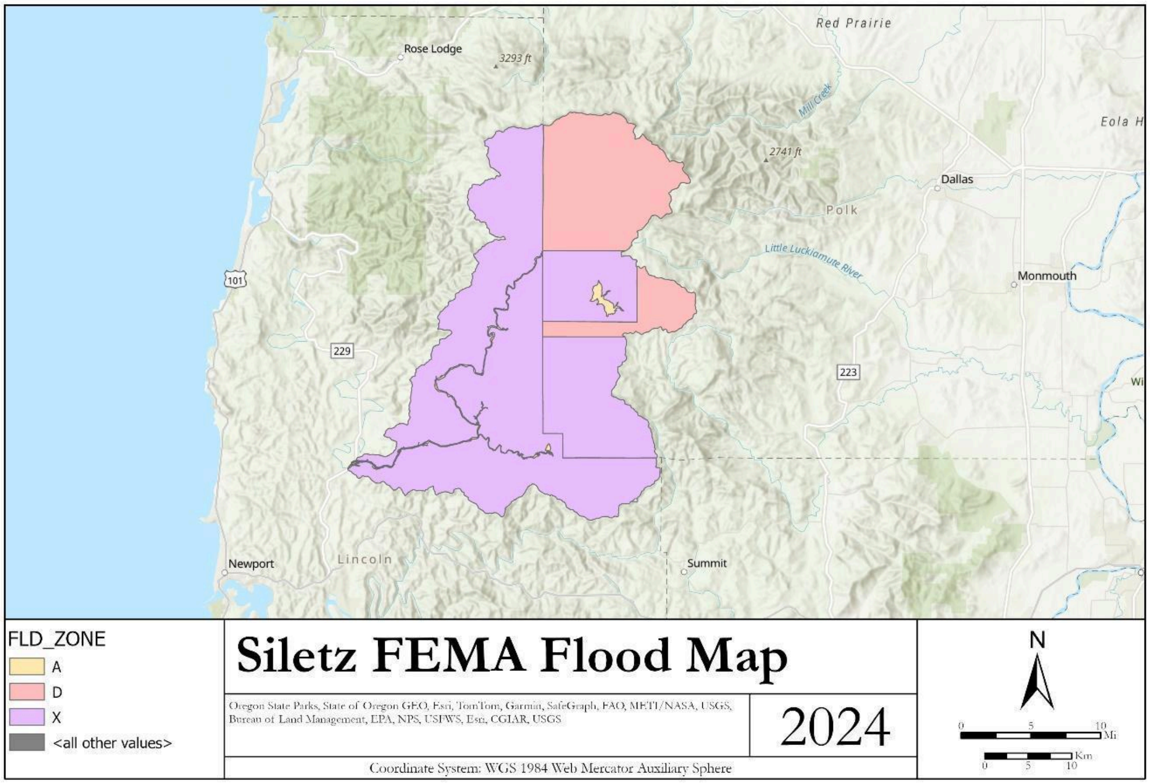


Siletz River Watershed Map

The Source Water Protection Area (SWPA) is composed of nine 12-digit HUCS: Big Rock Creek- Rock Creek 171002040602, Dewey Creek-Siletz River 171002040703, Little Rock Creek 171002040601, Lower North Fork Siletz River 171002040402, Mill Creek-Siletz River 171002040502, Sam Creek-Siletz River 171002040701, South Fork Siletz River 171002040403, Sunshine Creek-Siletz River 171002040501, and Upper North Fork Siletz River 171002040401.The SWPA begins approximately 40 miles upstream from the mouth of the river in Lincoln City, Oregon.

The river is unimpaired by major obstructions and is prone to flash flooding during seasonal rainstorms. Flooding is especially prevalent in the lowland valleys where most of the agricultural operations are located.

The FEMA Flood Hazard is also overlaid onto the SWPA in the map to display the potential flood hazard in the drainage area.

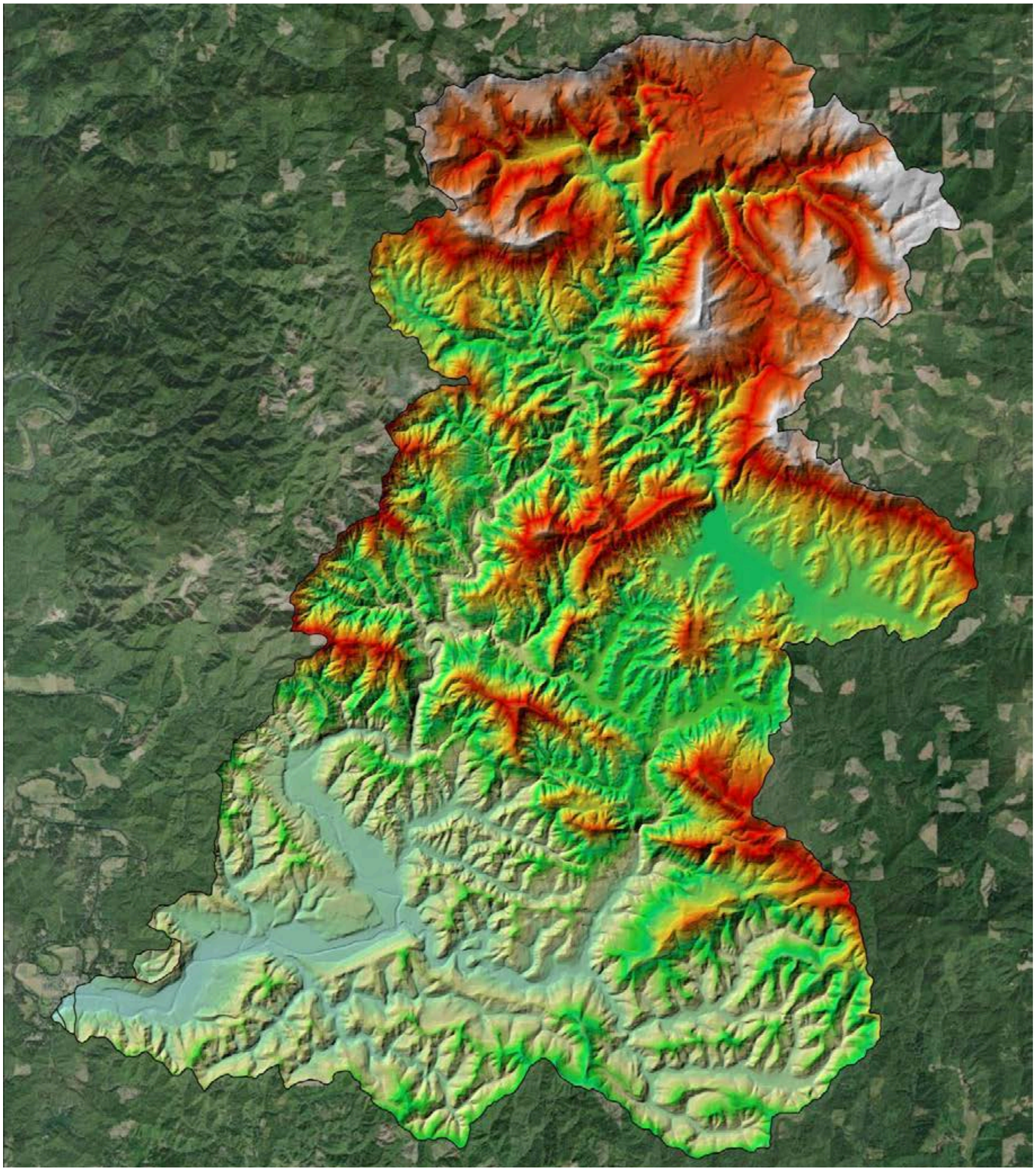


A: 100-year floodplain

D: Areas with possible but undetermined flood hazards.

X: Areas of minimal flood hazard

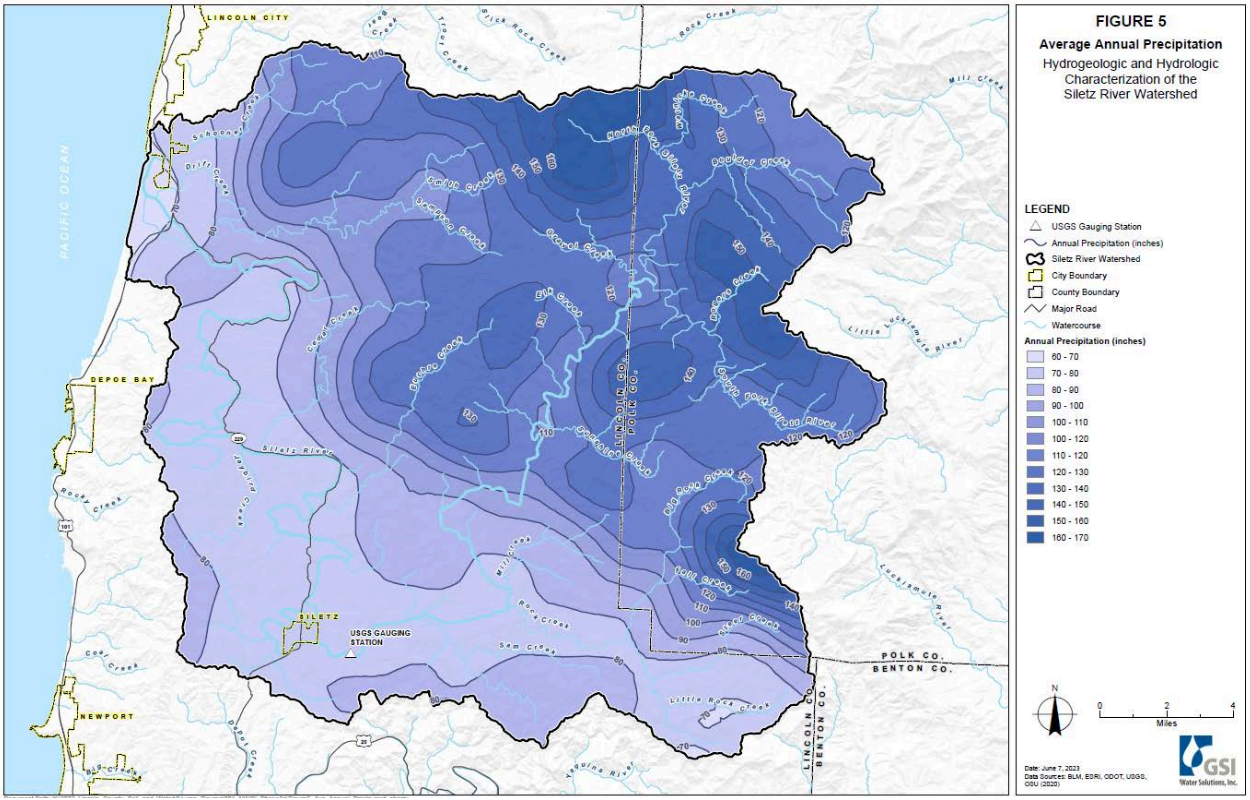
Topography



Topographic Map of SWPA

The Siletz SWPA is located completely in the Siletz River watershed within the Oregon Coastal Mountain Range. The North Fork Siletz headwaters are located at the base of Stott Mountain at approximately 2600 feet in elevation. The South Fork Siletz headwaters are located at the Southeastern end of Fanno Ridge at approximately 1600 feet. The topography of the watershed is contrasted by steep basalt cliffs with deep ravines and relatively low gradient valleys. The river drops to approximately 130 feet in elevation in Siletz, Oregon, the location of the drinking water intakes.

Climate



Average Annual Precipitation Map

The area has a temperate climate with extended wet Winters and warm, dry Summers. Average temperature lows in the Winter range from 30-40 F with Summer highs between 70-80 F. The topography and proximity to the ocean makes the climate variable within the Siletz watershed.

Average annual precipitation in the watershed is variable, with areas with over 150 inches a year in the upper watershed, and averages of 70-80 inches in Siletz near the public intakes. Climate data for the Valsetz area below highlights the temperate climate of the area. Some locations in the lower watershed receive less precipitation and higher average maximum temperatures.

Valsetz, Oregon

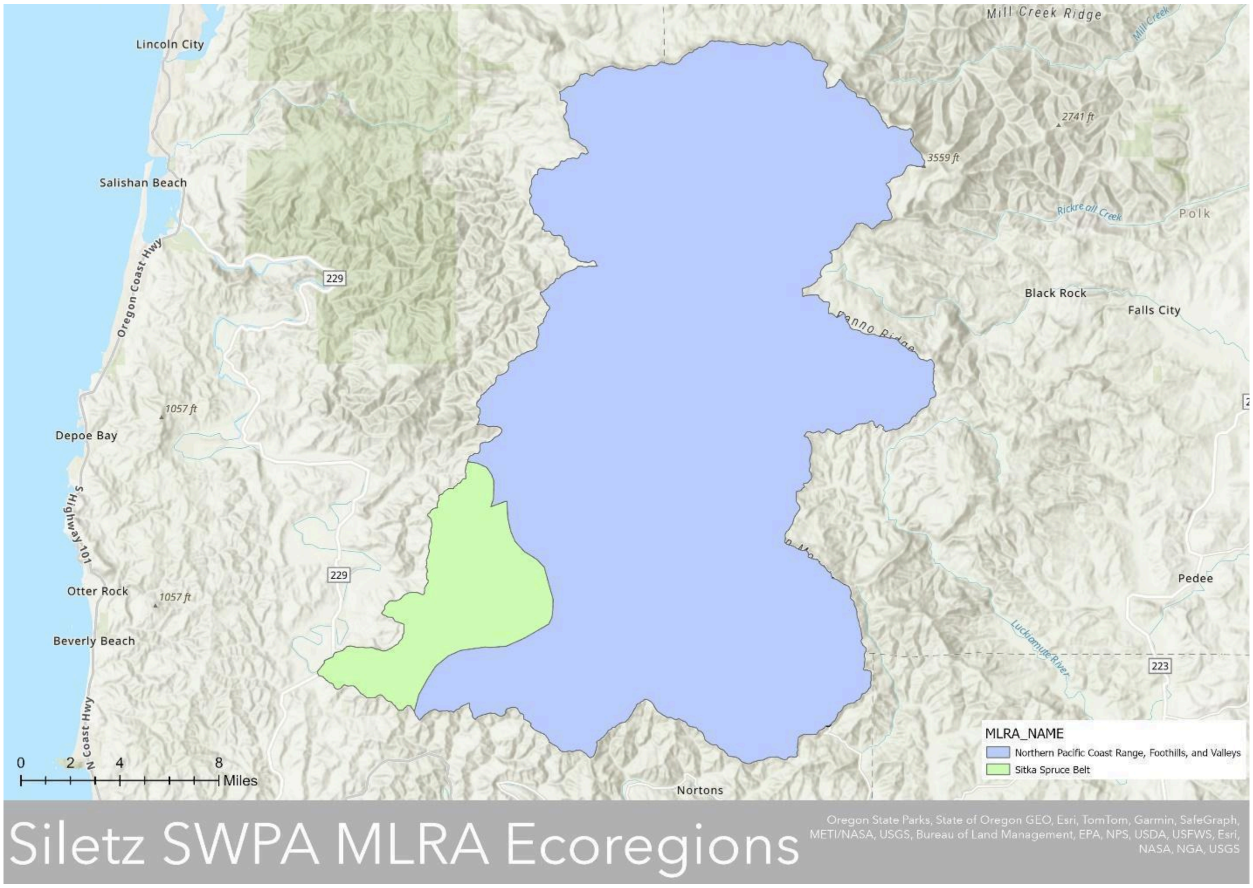
Period of Record Monthly Climate Summary

Period of Record: 10/25/1936 to 10/12/1986

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	45.3	49.7	52.5	57.7	65.3	71.4	77.6	77.5	72.9	63.5	52.4	46.7	61.0
Average Min. Temperature (F)	31.4	33.7	33.9	35.7	39.6	44.5	46.6	47.5	44.4	40.0	35.9	33.6	38.9
Average Total Precipitation (in.)	20.97	17.18	15.07	8.42	4.64	3.28	1.16	1.95	4.54	10.69	19.53	23.14	130.56
Average Total Snowfall (in.)	8.6	2.9	4.1	0.8	0.0	0.0	0.0	0.0	0.0	0.1	1.4	4.4	22.2
Average Snow Depth (in.)	2	1	0	0	0	0	0	0	0	0	0	0	0

Over the last several years measurable precipitation during the Summer months has declined, with an overall trend of longer dryer Summers and overall air temperatures increasing. The impacts of longer dryer Summers include increased risk of wildfire, decreased water availability, irrigation shut offs, decreased yields of current crops, and aquatic species population stress.

MLRA Ecoregion



Siletz SWPA MLRA Ecoregions

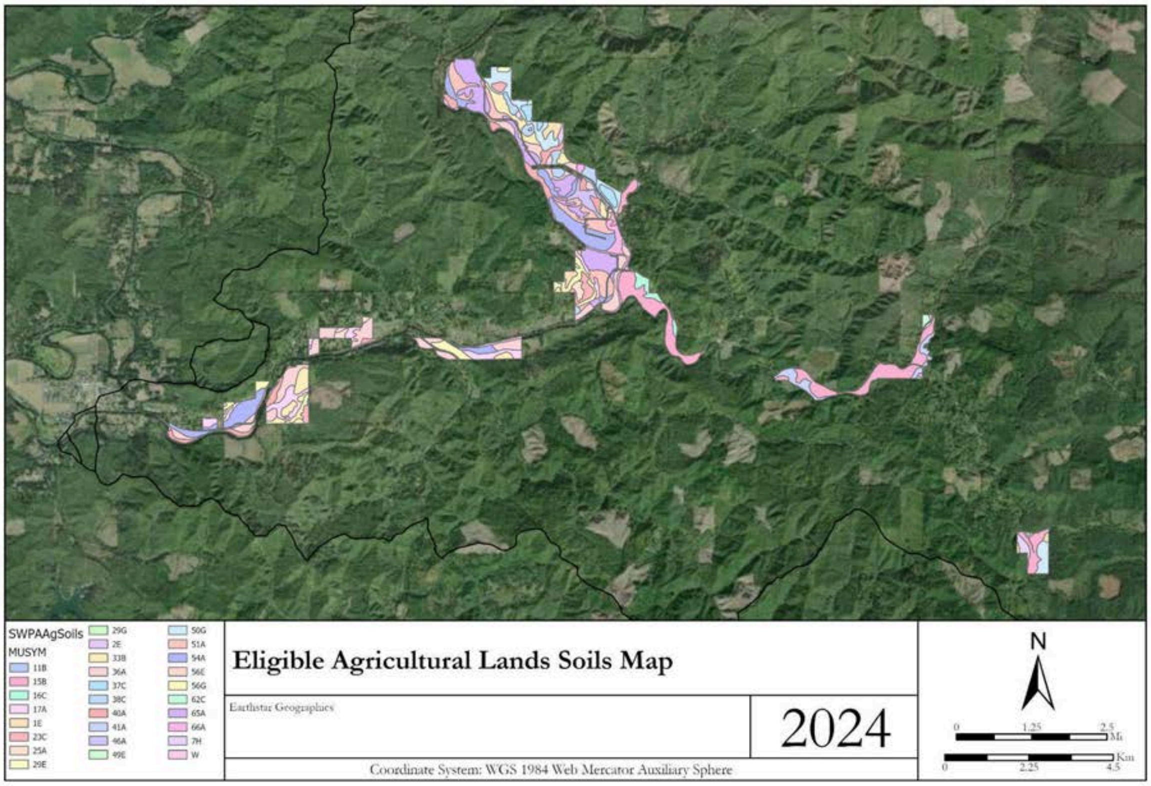
A majority of the SWPA is located within the Northern Pacific Coast Range, Foothills, and Valleys MLRA with the lower portion of the area located in the Sitka Spruce Belt. The MLRA ecoregions impact the vegetation communities present and will be used to determine suitable plant communities for tree and shrub planting and conservation cover.

Geology, Geomorphology, Soils and Hydrologic Characteristics

Soils

There are 93 unique soils in the SWPA according to the USDA Gridded National Soil Geographic Database (gNATSGO).

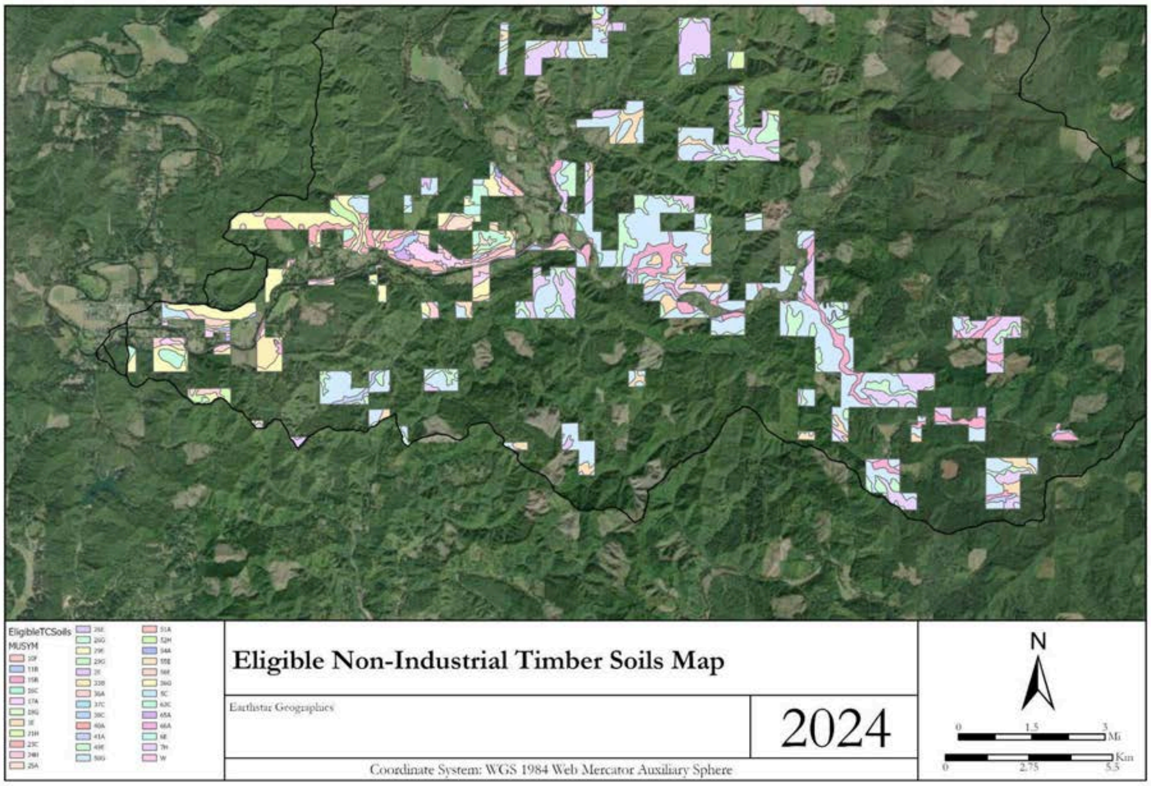
Agricultural Lands



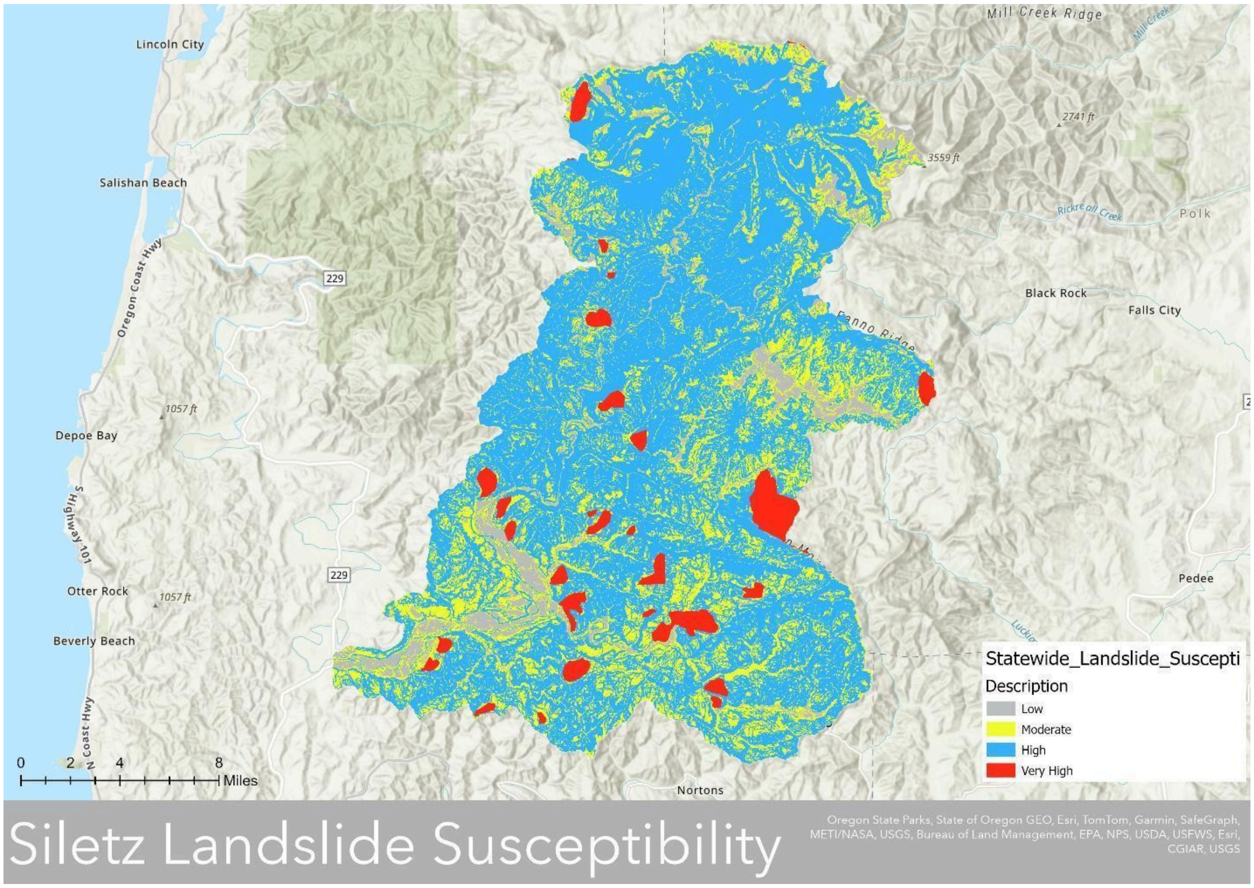
On eligible agricultural lands 28 unique soils are present. The dominant soil type in the area is silty loam with varying degrees of sand and slope. The primary soil type in the area is 36A Logsden Silt Loam. A deep, nearly level, well drained, low ph soil. This soil formed in silty and stratified, loamy alluvium derived from mixed sources. The soil is characterized by moderate permeability and a high-water capacity.

Logsden Silt Loam used for hay and pasture are limited by the susceptibility of the surface layer to compaction and low fertility. Compaction can lead to sheet flow of nutrients, manure, and soil into surface waters. Grazing during wet periods results in compaction of the surface layer and excessive runoff.

Eligible Non-Industrial Timber Lands



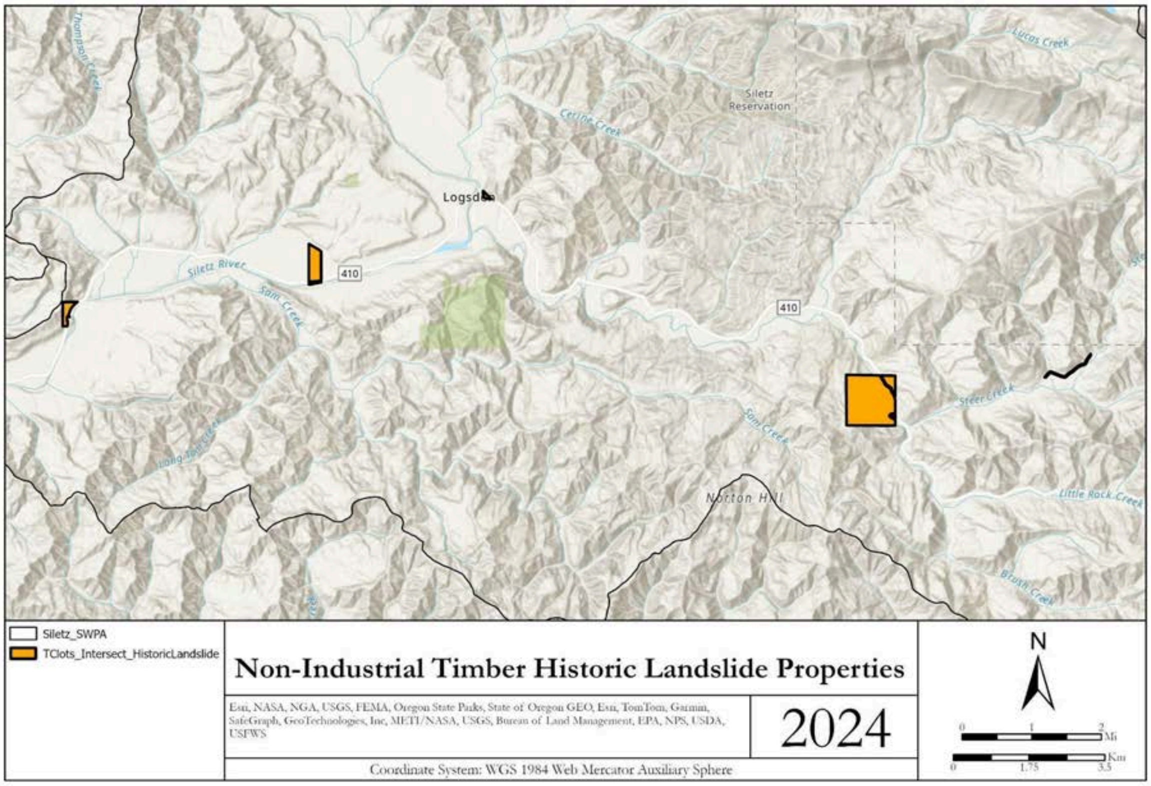
On eligible non-industrial timber lands 38 unique soils are present. The dominant soil type in the area is silty loam with varying degrees of sand and slope. The primary soil type in the area is 49E Preacher-Bohannon. This soil type is found on ridge tops and benches in mountainous areas. A deep and well-drained soil formed by colluvium weathered from sedimentary rock. The soil is characterized by moderate permeability and a moderate water capacity. This soil is highly erodible land.



Siletz Landslide Susceptibility

The statewide landslide susceptibility map indicates the majority of the watershed being in high and very high landslide susceptibility. This is consistent with the topography and soil characteristics of the SWPA.

Historic Landslide Areas



In the SWPA there are five known historic landslide areas that intersect with eligible non-industrial timber properties. These areas are in close proximity to the river and represent an opportunity for forest management planning to prevent mass wasting events that can deposit large amounts of sediment to surface waters.

Major and Minor Aquifers

Geology in the Siletz River Watershed consists of volcanic rocks, marine sedimentary rocks, and alluvium, shown on the geologic map in Figure 2 and the geologic cross section in Figure 3. All of these units are used for domestic water supply purposes, but the productivity of the units varies significantly. The following bullets summarize the primary geologic units in the Siletz River Watershed and their permeability. The geologic units are organized from youngest to oldest (Frank and Laenen, 1977):

- The **Alluvium (Qal)** is a thin (15 to 25 feet thick) and narrow deposit found in the relatively flat areas along the main stem of the Siletz River, and consists of clay, silt, sand and gravel deposited on the river's floodplain. The Alluvium is sufficiently permeable to produce groundwater for domestic purposes, although most domestic wells appear to be completed in the underlying sedimentary rock units.

- The **Siltstone and Sandstone (Tss)** is comprised of several tuffaceous (i.e., ash-rich) siltstone and sandstone formations[1] and collectively ranges from 200 feet thick to 5,000 feet thick. The Siltstone and Sandstone are characterized by a low permeability, with well yields reported to be less than 5 gpm, and many wells being reported to produce no usable water.

- The **Tyee Formation (Tet)** is a 6,000 feet thick deposit of marine sandstones and siltstones. The Tyee Formation is characterized by a low permeability, with well yields reported to range between 1 gpm and 5 gpm.

- The **Siletz River Volcanics (Tsr)** are a 10,000 feet thick deposit of basalt (including basalt flows, pillow basalt, tuff breccia, and lapilli tuff) with interbedded tuffaceous marine siltstone and sandstone. The Siletz River Volcanics exhibit a variable permeability. Well yields generally range from 5 gpm to 10 gpm, although yields of up to 120 gpm have been reported.

Based on a review of depth-to-water measurements at wells in the watershed (OWRD, 2023), the groundwater depths generally range from about 5 feet below ground surface in alluvial material adjacent to the Siletz River or Siletz Bay to over 100 feet below ground surface in the sandstones and siltstones in the upper reaches of the watershed.[2] The sandstones and siltstones are under confining pressure, and after drilling the static water levels in water wells rise to a level that is above the depth at which groundwater was first encountered. The groundwater levels represented by white-filled triangles in Figure 3 represent the depth at which groundwater was encountered, while the blue-filled triangles in Figure 3 represent the static water levels after a well is drilled. Inferred groundwater flow directions, based on topography and the fact that groundwater discharges to surface water, are provided in Figure 4. Groundwater flows towards the west, from the highlands of the Coast Range to the Pacific Ocean.

Aquifer Recharge and Discharge Processes

Aquifers in the watershed are recharged seasonally by precipitation during the late Fall and Winter, which ranges from about 70 inches per year in the southwestern part of the watershed to over 200 inches per year in the mountains of the Coast Range in the eastern part of the watershed. A rainfall distribution map based on 800 meter 30-year annual normal for precipitation from 1991 to 2020 is provided in Figure 5 (PRISM, 2023). Because rainfall amounts are significantly higher at higher elevations in the mountains of the Coast Range, most of the recharge to the aquifer likely occurs at these higher elevations. In addition, because the Siletz River Volcanics that comprise most of the higher elevations are more permeable than the marine sedimentary rocks, more recharge occurs in the areas where the Siletz River Volcanics are present at ground surface. Groundwater discharges from the aquifers at springs, seeps, and surface water bodies (i.e., the Pacific Ocean, rivers, and creeks); groundwater wells; and by evapotranspiration.

The top panel of Figure 6 is a map showing surface water withdrawals in the Siletz River Watershed. There are about 690 surface water rights on the Siletz River or its tributaries. The surface water rights are for irrigation, stock watering, instream use (to protect stream flows for migration, spawning, egg

---

[1] Sandstone of Whale Cove, Astoria Formation, Yaquina Formation, Nye Mudstone, Siltstone of Alsea, Nestucca Formation, and Yamhill Formation.

[2] See LINC 1906 and LINC 53000

incubation, fry emergence, and juvenile rearing), municipal water supply, industrial, domestic, forest management, etc.

The bottom panel of Figure 6 is a map showing groundwater withdrawals (water wells) in the Siletz River Watershed. Water wells were downloaded from the Oregon Water Resources Department (OWRD) online Well Report Query (OWRD, 2023a). Note that some of the water wells in remote sections of the watershed are probably mis-located on the OWRD records. There are a little over 450 groundwater wells in the watershed. About 98% of the wells are domestic wells, with the remaining wells being irrigation or community wells. Based on a search of the OWRD water rights mapping tool (OWRD, 2023b), there are no permitted groundwater rights in the Siletz River Watershed, meaning that all groundwater wells are classified as "exempt".

Surface Water – Groundwater Interaction

During dry periods with no surface water runoff, rivers in the Siletz Watershed continue to flow. This river flow is maintained by groundwater that discharges to the rivers by seeps and/or springs and is often referred to as "baseflow." Based on base flow measurements of streams in Lincoln County, the Siletz River Volcanics contribute significantly more groundwater to rivers than the Tyee Formation (i.e., about 0.6 $ft^3/s/mi^2$ for the Siletz River Volcanics as compared to 0.125 $ft^3/s/mi^2$ for the Tyee Formation). Overall, because of the low permeability geologic deposits within the Siletz Watershed (see discussion of well yields in Section 2.1.1), rivers in the Siletz River Watershed are characterized by relatively low base flows in the Summer (although they are higher than in the Alsea Basin) (Frank and Laenen, 1977).

Groundwater Chemistry

Table 1 summarizes raw groundwater quality data from Frank and Laenen (1977) (a water resources investigation study prepared by the United States Geological Survey)[3] and the Oregon Health Authority (OHA) database (a compilation of water quality data collected by public water supply systems as part of Safe Drinking Water Act Compliance)[4].

[3] Water quality data are only included if the aquifer in which the well is completed is known.

[4] Water quality data are only included if the aquifer in which the well is completed is known. In addition, because water quality samples in OHA's database are collected downstream of treatment, data from OHA were excluded if treatment beyond chlorination is occurring.

Table 1. Groundwater Chemistry.

Well ID	Date	Iron (mg/L)	Manganese (mg/L)	Fluoride (mg/L)	Chloride (mg/L)	Nitrate/ Nitrite (mg/L)	Arsenic (mg/L)	Temperature (deg F)
Alluvium								
7S/11W-34ddd [1]	–	2.1	0.02	0.30	19	0.10	ND	–
9S/10W-7dad [1]	–	0.05	0.01	0.20	3.3	2.9	ND	–
10S/10W-4ccb [1]	–	0.01	ND	0.10	1.7	1.0	ND	–
Sandstone/Siltstone								
7S/10W-25acd [1]	6/20/73	0.02	ND	0.10	390	0.05	ND	58
8S/11W-36adc [1]	–	0.08	0.1	1.2	160	ND	–	63
10S/10W-3cbb [1]	6/20/73	0.03	0.01	0.80	530	0.02	ND	56
LINC 231/657 [2]	Varies [3]	ND	ND	0.28	–	ND	ND	–
Basalt								
8S/10W-8dcb [1]	–	0.05	ND	0.30	17	0.66	ND	58
8S/11W-36ada [1]	6/20/73	0.04	ND	0.50	9.5	0.65	0.001	57
9S/11W-8ccd [1]	3/7/76	–	–	–	35	–	–	–

Notes

ND = Not Detected

mg/L = milligrams per liter

(1) Data are from Frank and Laenen (1977)

(2) Data are from OHA (2023)

(3) Water quality samples collected on 1/15/85 (iron, manganese, fluoride), 1/1/91 (arsenic), and 12/16/22 (nitrate)

Given that groundwater discharges to surface water in the Siletz Watershed (see Section 2.1.3), it should be noted that these concentrations do not *currently* appear to pose an impairment risk to surface water because, for the constituents in Table 1, the surface water is considered by DEQ to be in attainment (DEQ, 2022). The following groundwater constituents are characterized by elevated concentrations.

- **Nitrate/Nitrite.** While nitrate is naturally occurring in groundwater, concentrations over 1 milligram per liter (mg/L) are considered to be anthropogenic (Dubrovsky et al., 2010). Nitrate/nitrite is likely related to rural homesteads with associated septic systems and/or biosolids ap. Bacteria generally do not transport far through alluvial sediments (bacteria are large relative to soil pores) but may travel far if fractures in sandstone/siltstone bedrock are encountered. Septic systems associated with rural homesteads were identified as posing a moderate to high risk to the drinking water supply in the Source Water Assessment Report for the City of Newport (DEQ and OHA, 2002).

- **Chloride.** Chloride is elevated in the marine sedimentary rocks (i.e., sandstone and siltstone) due to the occurrence of chloride salts (mostly NaCl). Elevated salinity is a naturally-occurring pollutant in marine rocks of the Coast Range in Oregon.

According to DEQ's 2022 Oregon Integrated Report, surface water in the Siletz Watershed is impaired. Specifically, the Siletz River is impaired for dissolved oxygen, turbidity, elevated temperature, and alkalinity, and Rock Creek is impaired for temperature (DEQ, 2022). Groundwater is non-turbid and low temperature (see Table 1) and, therefore, discharge of groundwater to the surface water is beneficial to mitigate impairment of the surface water system.

Hydrologic Characterization

This section contains a discussion of the average annual precipitation, an overview of the hydrologic cycle, and a discussion of a flow budget.

Average annual precipitation in inches in the Siletz River Watershed is shown in Figure 5. The Siletz River Watershed is a rain-dominated system (as opposed to a mixed rain-snow system) (Lee, et al., 2020), with a majority of the precipitation occurring during the Winter months (Frank and Laenen, 1977).

Precipitation that falls within the watershed either evaporates, is transpired to the atmosphere by vegetation, runs off to surface water, or infiltrates into the ground and becomes groundwater. Groundwater moves under the force of gravity from the recharge area to downgradient discharge points including seeps, springs, or the Pacific Ocean (see Figure 4). The groundwater discharge forms a stream's baseflow, which is the groundwater contribution to streamflow. Surface water is also removed from the Siletz River by surface water withdrawals, which are shown in the top panel of Figure 6.

Figure 7(a) and Figure 7(b) show Siletz River stage and discharge, respectively, from 2017 to 2023 measured at the USGS gage shown in Figure 1[5]. The gray highlights indicate the wet season (i.e., from November 1 to May 31 of each year). Note that the surface water elevation and discharge of the Siletz River are highly variable, reflecting the seasonal effects of the wet season. During the dry season, inputs from precipitation runoff decrease and flow is due to groundwater discharges.

A flow budget for the Siletz River Watershed is provided in Table 2. Note that this flow budget is for the watershed upstream of USGS Gaging Station 14305500, shown in Figure 1[6]

Flow Budget Component	Value	Column Heading
Average Precipitation	2,825 ft^3/s	Based on contours of normal annual precipitation from 1991 – 2020 (PRISM, 2020), and presented in Figure 5 of this TM. Specifically, rainfall volumes were determined by multiplying the area between each contour, and multiplied by the midrange precipitation value (e.g., the area between the 140-inch contour and 150-inch contour was multiplied by 145 inches).
Average Groundwater Discharge	131 ft^3/s to 860 ft^3/s (midrange=495.5 ft^3/s)	Range based on monthly mean Siletz River discharge, 1940 – 1974, May to October. Values range from 0.65 ft^3/s per mi^2 of drainage basin (August) to 4.25 ft^3/s per mi^2 of drainage basin (May), over an area of 202 mi^2 (see Figure 9 of Frank and Laenen, 1977). The groundwater discharge may be biased slightly low because it does not take into account surface water diversions upstream of the USGS gauge (see footnote 9).

[5] USGS 14305500 Siletz River at Siletz, Oregon

[6] Table 2 does not account for irrigation or other consumptive uses in the watershed above USGS Gage 14305500. However, OWRD data indicates that there are only water rights for approximately 250 acres of irrigation. OWRD estimates the consumptive use of water for irrigation in the watershed above the gage amounts to less than 0.5 cfs at peak demand in July, less than 1 percent of the 80 percent exceedance flow.

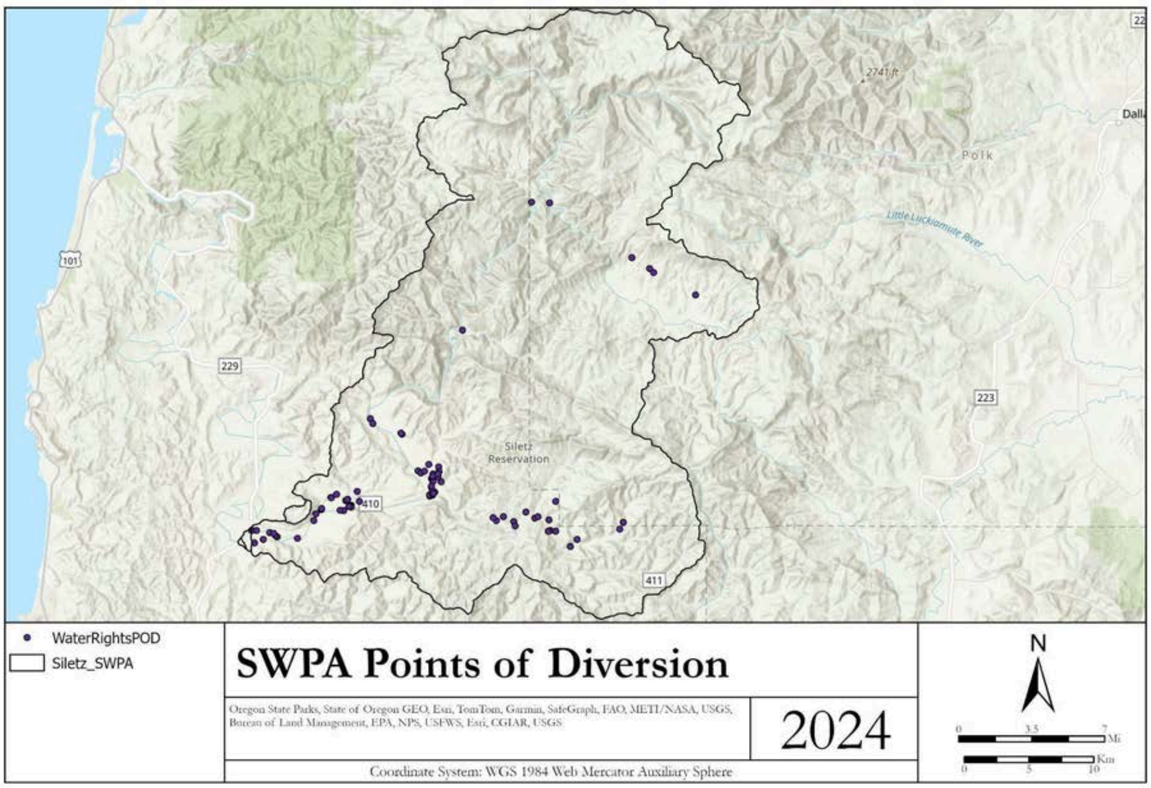
Runoff and Transpiration	2,329.5 ft^3/s	Precipitation that does not infiltrate either runs off to surface water or is transpired by vegetation. Value is calculated by subtracting the midrange groundwater discharge (495.5 ft^3/s) from the average annual precipitation (2,825 $ft^3/year$). This runoff and transpiration may be biased slightly high because groundwater discharge may be underestimated [because surface water diversions upstream of the USGS gauge are not taken into account (see footnote 9)].

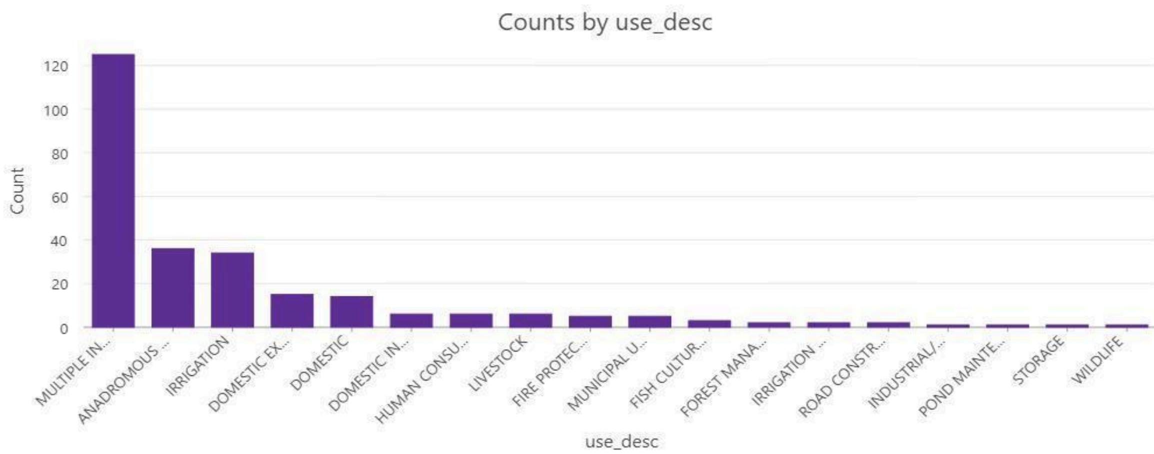
Notes

ft^3/s = cubic feet per second

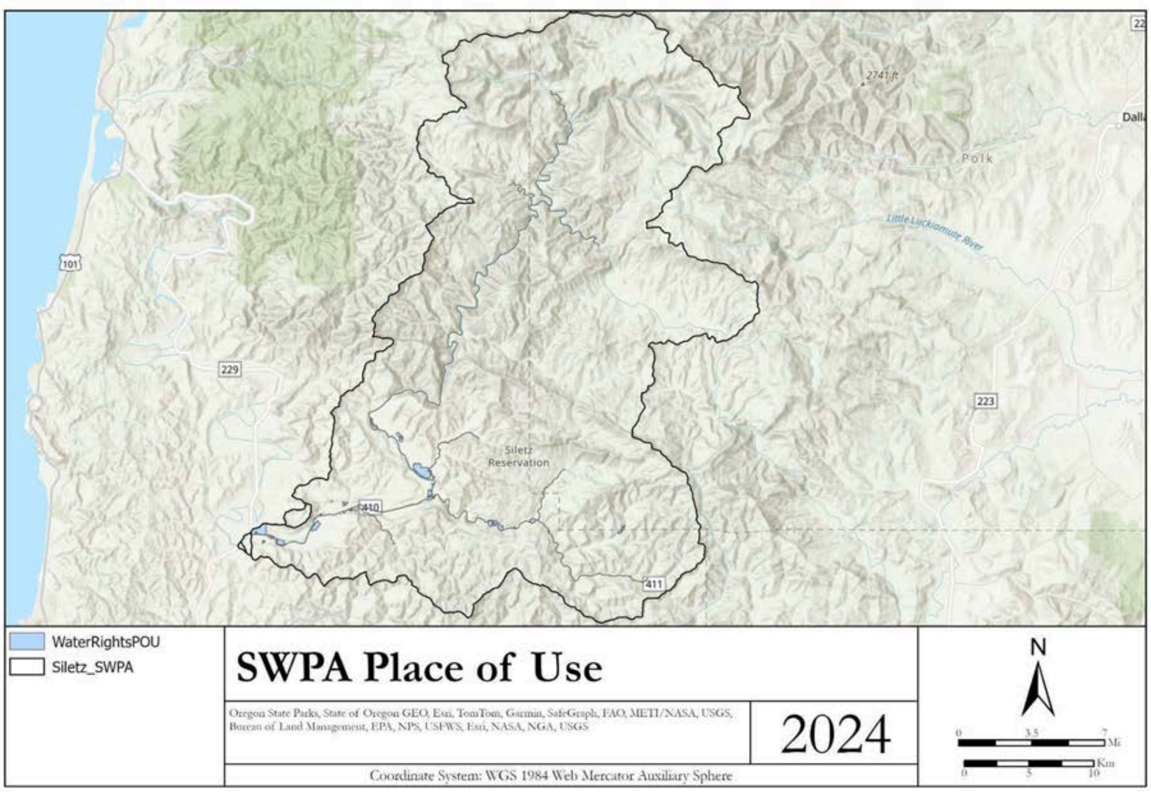
mi^2 = square miles

Water Rights





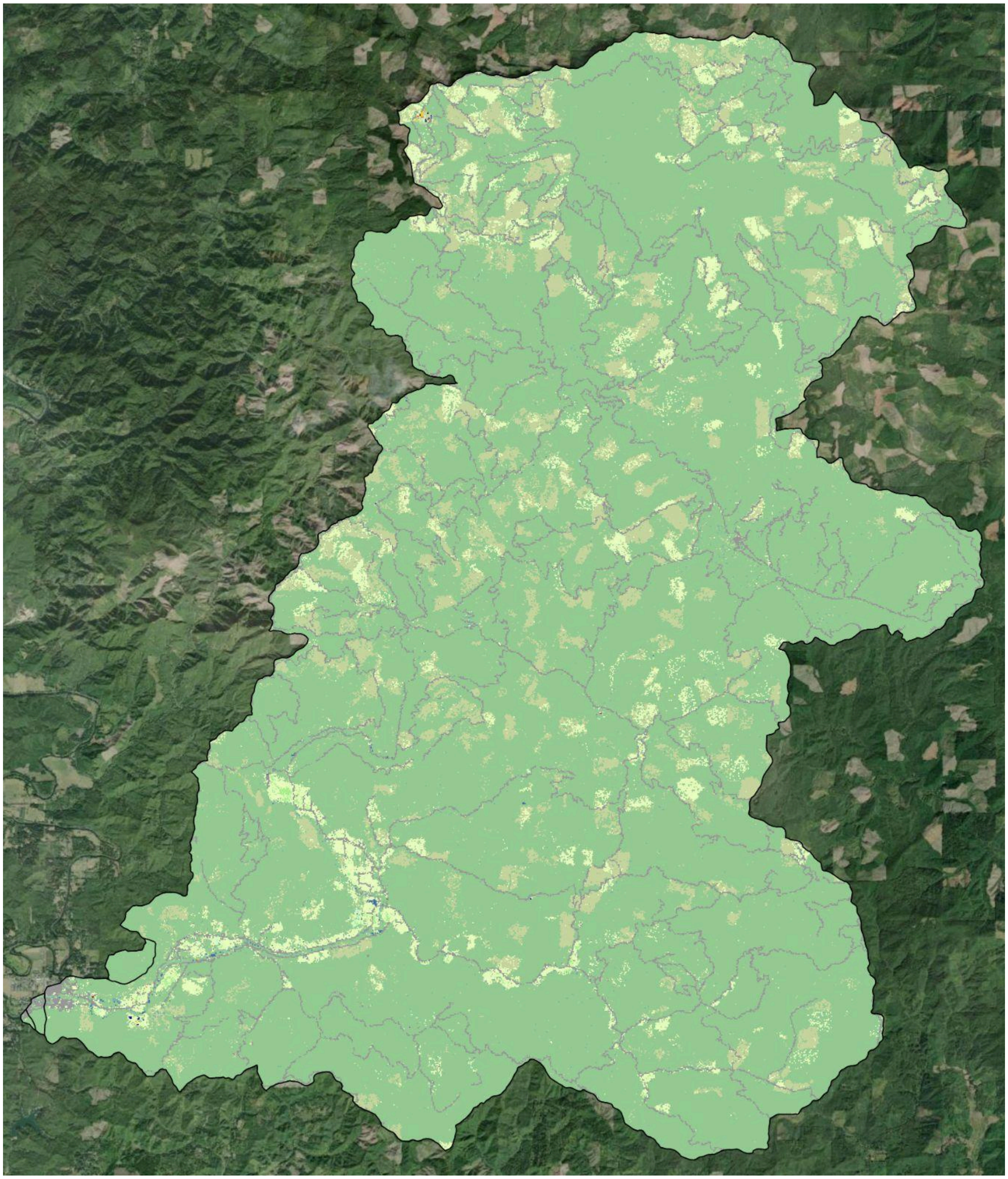
265 points of diversion exist in the SWPA for various needs including domestic, livestock, irrigation, fire protection, and habitat (instream and anadromous fish).



Within the SWPA 102 places of use have been identified from the OWRD. Of these, five have been designated as for livestock use. While this does provide an indication of producers using water for livestock, the exclusion for livestock in-stream watering makes it difficult to understand the exact amount of water being used by livestock.

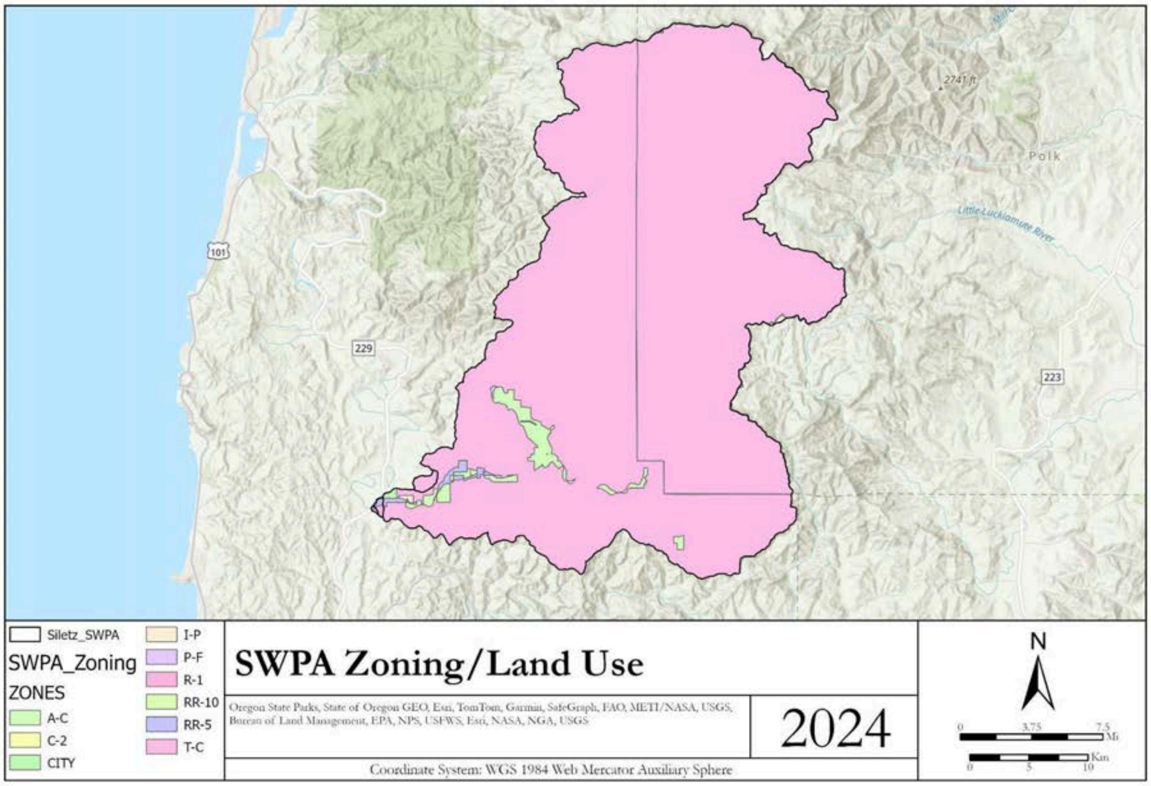
28 places of use are designated for irrigation. The total irrigated acreage is approximately 310 acres. Irrigation systems in the SWPA are limited to stand/tripod style systems.

Land Use/Land Cover



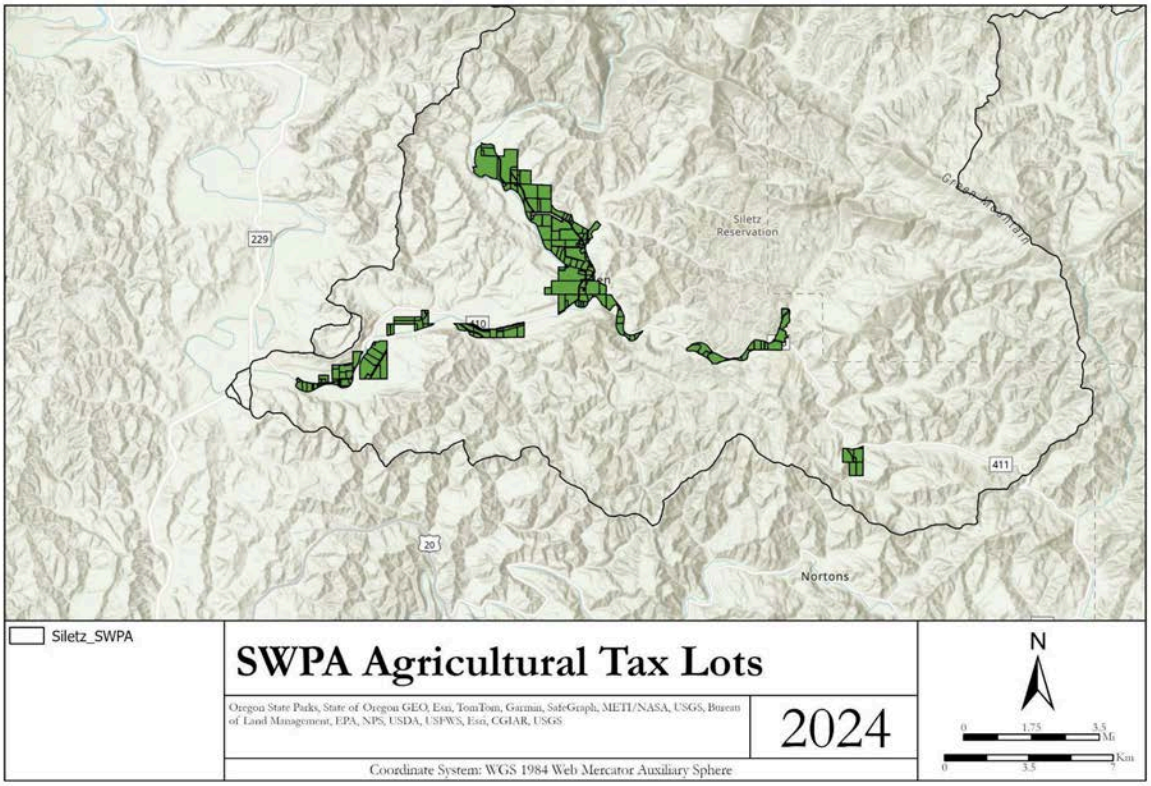
The USDA-NASS Cropland data provides some useful information on the scope of agricultural production within the SWPA. The map above highlights the expanse of timber production throughout the SWPA. For the purposes of this assessment the land use/cover has been refined to focus on eligible areas for practice implementation.

SWPA Zoning



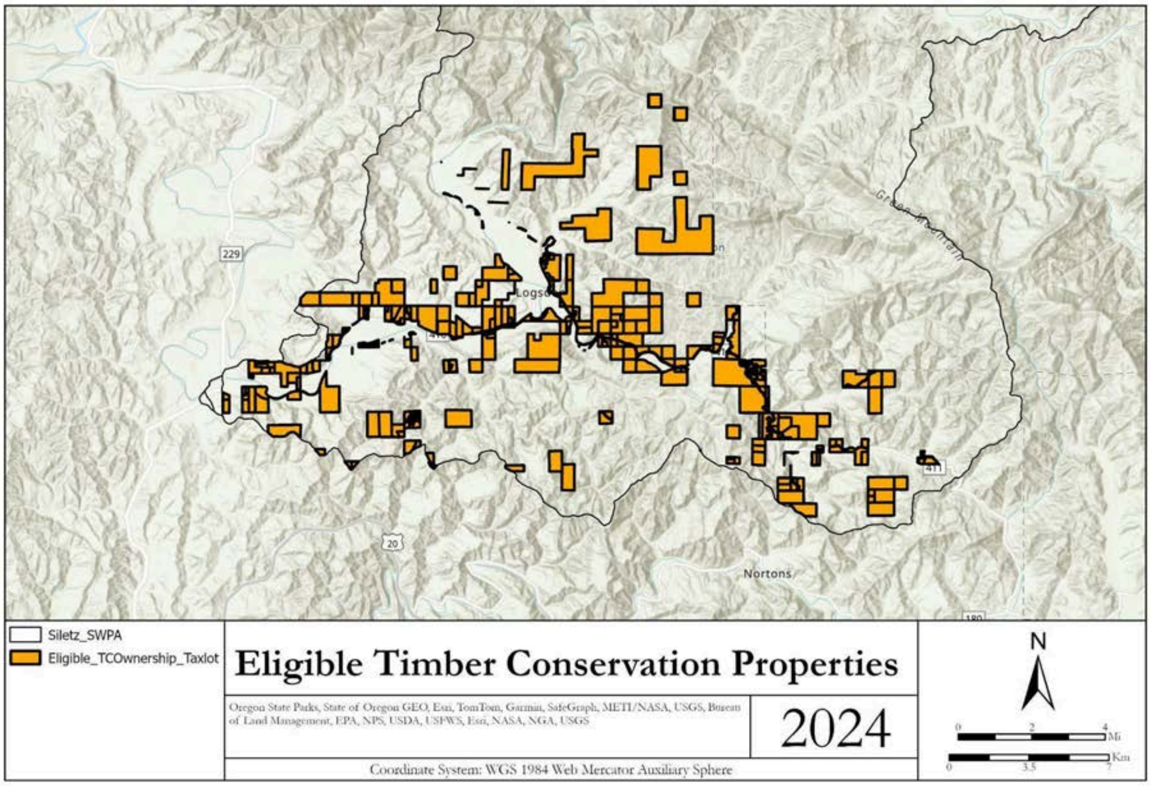
The SWPA contains approximately 37,000 acres of eligible land in ownership by private individuals, companies, and/or tribal entities. A majority of the land in the SWPA is Industrial Timber owned by a few large companies. Near the intakes there are mixed residential and City properties that may impact the SWPA minimally, these have not been included as they are outside of this project.

Agriculture Properties



There are 211 Agricultural Conservation tax lots in the SWPA totaling 4,956.09 acres. This does not represent a comprehensive assessment of rural residential properties in the SWPA that may be conducting "homestead" level agriculture for personal use. While the vast majority of agricultural properties are located in lowlands in valleys, the properties in upland areas have been included in the assessment due to potential surface water interconnections.

Non-Industrial Timber Properties



There are 295 eligible non-industrial timber conservation properties within the SWPA covering over 32,000 acres. A majority of these properties are held by tribal and small woodland landowners.

Water Quality Characterization

Water Quality Conditions in Watershed

An inventory of potential contaminants of concern based on the land uses in the watershed and discussion of the water quality conditions in the Siletz River and its tributaries was conducted by GSI Water Solutions (GSI). GSI has worked on Drinking Water Protection Plans for the City of Toledo and Newport. GSI also serves as a lead in coordinating the Mid-Coast Water Planning Partnership.

Agricultural Contaminant Sources of Concern

The contaminants of concern include excessive sediment, nutrients, and elevated water temperatures. Sources of concern include a lack of livestock exclusion fencing, off-stream watering solutions, and proximity of grazing to surface waters, land application of biosolids and unregistered soil additives including fish plant waste, unmanaged and legacy riparian forest land, low flows during peak seasonal usage, and improper or lack of riparian vegetation.

Table 1. Agricultural Sources of Concern in the Siletz River Watershed.

Agricultural Source	Potential Impacts
Grazing Animals	Animal wastes may impact the river if not managed properly. Livestock may contribute to erosion and reduced riparian vegetation, and therefore, turbidity in surface water.
Managed Forest Land	Yarding and cutting of trees increases erosion, which causes turbidity and chemistry changes in the Siletz River. Improper application of pesticides and/or fertilizers can result in chemicals reaching the river. Lands with reduced tree cover have increased runoff that may reduce infiltration of precipitation into groundwater, which could lower base flows in streams during prior periods.
Agricultural Operations	Improper handling or over-application of pesticides and fertilizers may impact drinking water. Biosolid spreading has the potential to impair groundwater and surface water when not applied in accordance with state and federal guidelines and regulations.

GSI, 2023

Biosolids continue to be a community concern in the watershed. Based on studies by the Environmental Protection Agency (EPA), biosolids pose a small risk to the environment when applied in accordance with state and federal guidelines and regulations (MDEQ, 2014). However, biosolids are considered to pose a potential contamination risk to the watershed due to the potential for application in a manner that is not consistent with state and federal guidelines. There is a growing concern for the potential presence of emerging contaminants as a constituent in biosolids. Table 2 summarizes pollutant concentrations in biosolids from the City of Siletz Wastewater Treatment Plant, which are locally used in the Siletz River Watershed. At the time of the report, there is little to no oversight in the application of biosolids on agricultural lands.

Table 2. Pollutant Concentrations in Biosolids, City of Siletz WWTP (4/30/2008 Samples).

Constituent	Concentration [1]	Units
Arsenic	< 5.0	mg/kg
Cadmium	2.9	mg/kg
Chromium	38.3	mg/kg
Copper	52.3	mg/kg
Lead	36.7	mg/kg
Mercury	4.1	mg/kg
Molybdenum	7.7	mg/kg
Nickel	28.6	mg/kg
Selenium	< 5.0	mg/kg
Zinc	800	mg/kg
Total Kjeldahl Nitrogen (TKN)	6.07	Percent
Nitrate as Nitrogen	< 0.01	Percent
Ammonia	1.14	Percent
Phosphorus	2.60	Percent
Potassium	0.24	Percent
pH	7.0	Standard units

NOTES:

(1) Source: DEQ (2008)

mg/kg = milligrams per kilogram

WWTP = wastewater treatment plant

GSI, 2023

Four biosolid application sites were provided by DEQ in 2023, all of which were in close proximity to the river, and pose a risk of surface water contamination if proper application measures are not taken.

Commercial and Industrial Contaminant Sources of Concern

Commercial and industrial contaminant sources of concern are primarily associated with potential activities in the City of Siletz, mining operations and timber salvage and roofing shingle production operations.

The City of Siletz poses minimal concern as a source for commercial and/or industrial contaminants based on the types of businesses and proximity to the river. However, a new gas station and auto repair shop pose a moderate risk of adverse impact to water quality due to stormwater runoff, potential leaking tanks, spills, and improper disposal of waste. Based on the DEQ Facility Profiler, there are no Leaking Underground Storage Tank (LUST) sites or Environmental Cleanup Site Information (ECSI) sites in the City.

In addition to the sources of concern within the City of Siletz, the City of Toledo's Drinking Water Protection Plan identified two operations upstream of the City's surface water intake (GSI, 2023).

The Mill Creek Pit is an active basalt mine located about 200 feet off the North Fork of Mill Creek, Northeast of Logsden. Spills, leaks, and leachate from mining operations may introduce chemicals and waste products into source waters. Ground disturbance can also cause erosion and increase turbidity in nearby streams if measures are not taken to protect water quality. One of Mill Creek Pit's permit conditions requires the operator to prevent turbid water from the site from entering nearby water bodies. Aerial images available from DOGAMI show that 0.7 acres of previously mined lands had been reclaimed and vegetated by 2014. Aerial imagery from 2021 shows some mined areas and a wide vegetated buffer between the mine and Mill Creek.

Historically, the timber salvage facility was a wood and pulp processing mill, where proper handling of chemicals would be a major concern. Now that the facility operates as timber salvage/roofing shingle production, it may pose a lower risk to water quality.

Commercial and Industrial Forestry Contaminant Sources of Concern

Commercial and Industrial forestry practices are also a source of concern of contamination. The City of Toledo's Drinking Water Protection Plan Risk Assessment identified clearcuts as highly likely to occur within the watershed with a moderate impact to the source water. Since this report in 2022, the Private Forest Accord (PFA) has changed the buffer restrictions for forestry activities. These new regulations may reduce the likelihood of significant contaminant inputs into surface waters. However, as the PFA is being implemented, heavy logging in soon to be restricted areas has left riparian buffers lacking proper vegetation to reduce runoff and provide proper shade to cool surface waters.

In 2024, the Valley of the Giants, a 51-acre old growth grove near the headwaters, experienced a massive debris flow destroying roads and depositing sediment into surface waters. While this incident was large, events such as this are not uncommon in areas of high intensity industrial and commercial forestry in the Coastal Range. Clearcutting in the upper reaches of the watershed is still a major concern due to the increased risk of landslides and sedimentation on steep slopes.

Forestry road maintenance is also a concern of contamination from sedimentation. Historically, access roads were built in the valley floor to allow flat access for machinery. Some of these roads have been decommissioned or moved as forestry practices have improved and new technology allows for machinery on ridgelines. These legacy roads in tributary valleys pose a risk of adding dust and sediment to surface waters during the Summer and during use in the rainy season.

Residential Contaminant Sources of Concern

The City of Siletz wastewater is managed at a wastewater treatment plant that discharges treated wastewater to the Siletz River under a National Pollutant Discharge Elimination System (NPDES) permit. The dry season flow was 0.0993 million gallons per day (MGD) and the wet season flow was 0.276 MGD (1989 data). Formerly a lagoon system, the plant was recently upgraded to include a sequencing batch reactor (SBR), ultraviolet disinfection, aerobic digesters, and facultative sludge lagoon (Dyer Partnership, 2023).

Outside of the City of Siletz city limits, domestic wastewater from rural homesteads is managed using septic systems. Septic systems were identified as posing a moderate to high risk to the drinking water supply in the Source Water Assessment Report for the City of Newport (DEQ and OHA, 2002).

No landfills are listed in the Oregon Solid Waste Active Permitted Facilities Database in the Siletz Watershed (GSI, 2023).

No records of underground storage tanks or leaking underground storage tanks were found in the Siletz using the Oregon Records Management Solution website (GSI, 2023).

A single chemical release in the town of Siletz is documented on DEQ's Environmental Cleanup Site Information (ECSI) database. The release (ECSI Site No. 5605) involved pesticide and fuel contamination related to destruction of a Swanson's Pest Management truck during a garage fire in 2011. Soil and groundwater samples were collected to evaluate the extent of the release, and DEQ issued a No Further Action letter in 2013, although low levels of contamination remain in the subsurface soil and groundwater (GSI, 2023).

Rural development and property management are sources of concern of contamination. In particular, removal of riparian vegetation can result in streambank erosion depositing sediment and nutrients into surface waters. The removal of riparian vegetation can also result in increased stream temperatures.

Property management practices for new and existing rural development may also affect water quality. Overuse and improper storage and disposal of household and landscaping chemicals may allow contaminants to enter surface waters. Domestic animals, such as chickens and horses, require proper waste management to avoid impacting water quality. Installation of impervious surfaces, such as rooftops, patios, and driveways can increase runoff of contaminants.

Recreation in the SWPA is common and popular throughout the year. Motorized boat recreation is allowed on most reaches of the Siletz but is only viable during higher flows outside of the Summer months. There are two boat launches upstream of the City of Toledo's water intake in the SWPA. Water quality may be affected by chipping paint, leaks or spills of gasoline and oil from boats, household waste, and fishing waste including lead weights and plastic fishing line.

Aging and new transportation infrastructure is a concern of contamination. Transportation including road building, maintenance, and usage may increase erosion and stream turbidity. Attention to proper siting and construction techniques can reduce these risks.

Water Quality Monitoring

In 2023 Lincoln Soil and Water Conservation District ("the District"), in collaboration with Oregon Department of Environmental Quality (DEQ) and Oregon Department of Agriculture (ODA), established a watershed-monitoring program to assess long-term trends in water quality and evaluate stream reaches to focus implementation of best management practices (BMP). The selected locations have been used in the past by the District and Partners to assess water quality. The current locations include the Confluence of Rock Creek-Siletz, Confluence of Big Rock Creek-Rock Creek, the CTSI hatchery (Rock Creek), Siletz mainstem (Moonshine Park).

Water quality data in the SWPA is fragmented with large gaps in testing. This makes the efficacy of practices difficult to measure using water quality parameters. In 2026 the District will begin the process of the ODA Strategic Implementation Area. This will provide additional monitoring funds to expand the current sampling to include Mill Creek and technical assistance funding for design of BMPs.

Ambient Water Quality Conditions

Several surface water bodies in the Siletz River Watershed are identified as impaired in DEQ's 2022 Integrated Report. The integrated report, which DEQ is required to prepare for the Environmental Protection Agency (EPA) by the Clean Water Act, is a report on surface water quality in the State of Oregon. Impaired parameters for individual stream reaches are shown in Table 2, and the streams are shown in Figure 1. Impaired parameters include temperature, dissolved oxygen, turbidity, alkalinity, and biological criteria (DEQ, 2022). All of the impairments constitute a Category 5 impairments, meaning that data indicate a water quality standard is not attained and a Total Maximum Daily Load (TMDL) is needed.

Table 2. Impaired Water Quality Parameters in the Siletz River Watershed.

Name	Description	Impaired Parameters [2]	Year Last Assessed
Siletz River	Roy Creek to Rock Creek	Dissolved Oxygen, year round Dissolved Oxygen, spawn Turbidity Temperature, year round Temperature, spawn Alkalinity	2022
Siletz River	Rock Creek to Confluence of North and South Forks of the Siletz River	Dissolved Oxygen, spawn Turbidity Temperature, year round Temperature, spawn Alkalinity	2022
South Fork Siletz River	Rogers Creek to Siletz River	Bio Criteria	2010
South Fork Siletz River	Sand Creek to Rogers Creek	Bio Criteria Temperature, year round	2010
Rock Creek	Siletz River to Confluence of Big Rock and Little Rock Creek	Temperature, year round Temperature, spawn	2022

NOTES:

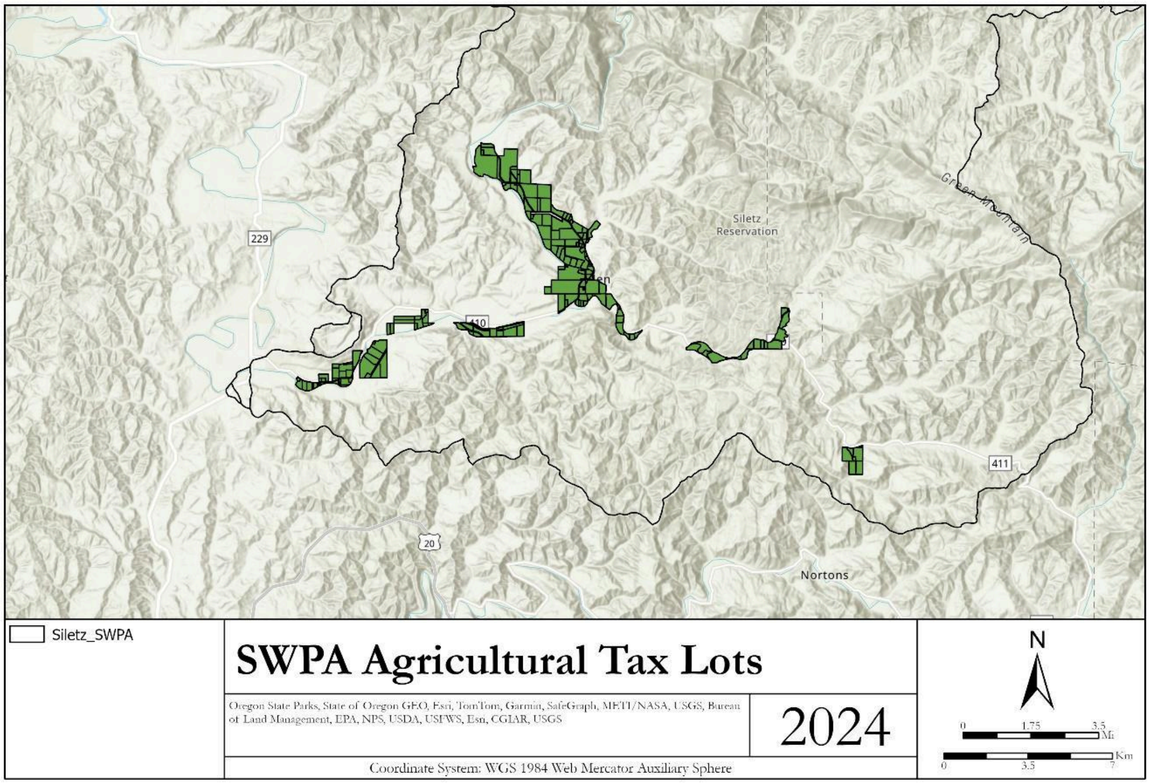
(1) Source: DEQ (2022)

(2) "Year round" indicates that the surface water body is impaired for the parameter all year. "Spawn" indicates that the surface water body is impaired during the spawning date range for active salmon and steelhead spawning, or any additional assumed spawning by resident trout species. Violation of the spawning criteria is in effect only during the applicable spawning date range (DEQ, 2020).

The impairments listed in Table 2 affect beneficial uses of the Siletz River, including fish and aquatic life and private/public domestic water supply. Specifically, drinking water intakes are potentially impacted by elevated turbidity. Fish and aquatic life are potentially impacted by temperature, dissolved oxygen, and turbidity. (GSI, 2023).

Resource Analysis and Source Assessment

Extent of Agricultural Commodities in Project Area



The majority of farms in the county are considered small by standards of the region. Farmers in Lincoln County largely have a diversified production system where they manage livestock and crops. County assessor data indicated that 25% of farms in Lincoln County are in the Siletz Watershed.

The 2017 USDA Census of Agriculture for Lincoln County highlighted the top crops by acres as Forage (hay/haylage) with over 2500 acres followed by Cultivated Christmas Trees. The livestock inventory calculated 2,993 cattle and calves with the second most livestock being goats at 621. Exact numbers for the SWPA are difficult to ascertain, however the primary crop and livestock species of the county are representative of the SWPA.

Within the project area agricultural commodities primarily include timber, livestock (cattle), and hay. Fruit production is primarily located below the SWPA, however at the time of this assessment several producers have begun installing orchards. As new farmers from other regions move into the area the commodities may change.

Current Level of Treatment and Producer Participation

Implementation of conservation practices in the MidCoast are largely based on relationships with landowners and with the understanding of the geographic constraints that put practices in conflict with producer needs. Each of the bundles of treatment options below provide current treatment and the balance of treatment with producer participation.

Riparian Tree and Shrub Planting

Current treatment in the SWPA is limited primarily to public (local and state), private industrial, and tribal owned properties. Agricultural and small woodland properties in the SWPA are receiving relatively little treatment due primarily to a lack of funding and gap in outreach for several years.

Outreach and implementation of projects by The District over the last year has increased participation significantly although implementation has been slow due to a lack of funding. The District currently has a Focus Area in the Siletz Watershed that will be transitioning to a Strategic Implementation Area (SIA) in 2026. This shift will provide the District with $120,000 of Technical Assistance and Outreach funding. The SIA will also provide additional funding opportunities for conservation practices that improve water quality on agricultural lands to match future EQIP contracts.

Current treatment in Little Rock Creek watershed includes 17.9 ac of Tree/Shrub Establishment (612), 16 ac of Brush Management (314), and 1.9 ac of Herbaceous Weed Treatment (315) along a section of stream restoration on Big and Little Rock Creek near the Tribal Fish Hatchery.

A community farm in Sam Creek - Siletz River sub watershed completed installation of a High Tunnel (325) through an NRCS EQIP contract in 2023 and are working on a conservation plan for EQIP or CSP funding to help with planned Cover Crop (340), Mulching (484), and Conservation Crop Rotation (328) on the 5-ac farmed part of the property, as well as Tree/Shrub Establishment (612), Wildlife Habitat Planting (420), beaver dam analogs (643), and Upland Wildlife Habitat Management (645) on the forested/wetland parts of the property that aren't in agricultural production.

One agricultural landowner in the Big Rock Creek - Rock Creek sub watershed has worked with NRCS through EQIP in the last couple years to implement a High Tunnel (325) to help produce more food for local markets. They also have streamside property (pasture/hayland) with degraded riparian areas and may be open to future riparian planting projects.

The District and partners continue restoration activities on state and private lands following large woody debris installations on Long Prairie and Sam Creek. Riparian tree and shrub planting in reed canary grass meadows continues with over 15 acres of restoration to be completed over the next several years.

Producers are reluctant to implement riparian revegetation due to a historic placement of agricultural land on the valley bottom between deeply sloped forested upland that would eliminate a significant portion of the productive acres. While the desired riparian buffer is between 50 and 100 ft., it has been the experience of the District and partners that by allowing as small as a 35 ft. buffer can provide water quality benefit while meeting producer's needs.

Livestock Exclusion Fencing

Currently, the District is requesting funding from the OWEB Small Grant Program to install approximately 2000 linear feet of livestock exclusion fencing that would expand the current exclusion area from 5 feet away from the creek to an average of 30 feet distance.

Producers in the SWPA are familiar with large amounts of seasonal precipitation that provides ample water for livestock watering. Due to the lack of deep wells and consistent groundwater, surface waters are typically used for livestock watering year-round or between the months of June and October when wells and groundwater springs have dried up and not yet been recharged. To allow for the exclusion of livestock from surface waters, to meet desired water quality standards, additional assistance in the form of Spring Enhancement and off-channel watering will be needed as an accompanying practice to fencing.

Nutrient Management Planning and Manure Storage Facilities

Currently, one Nutrient Management Plan is being developed in the SWPA in the Sam Creek sub watershed. Once that plan has been completed the development of a manure storage facility design will be completed by the District.

One agricultural landowner in the Dewey Creek - Siletz River sub watershed has worked with NRCS over the last 20 years on conservation plans through several EQIP and CSP contracts to implement a Comprehensive Nutrient Management Plan (100) and Composting Facilities (317), as well as Roof Runoff Structures (558), Underground Outlet (620), Pumping Plant (533), Watering Facilities (614), Livestock Pipeline (516), Heavy Use Area Protection (561), Fence (382), Prescribed Grazing (528), Pasture and Hay Planting (512), and Tree/Shrub Establishment (612).

Three small agricultural landowners in the Mill Creek - Siletz River sub watershed have worked with NRCS through EQIP in the last couple years to implement High Tunnels (325), Cover Crop (340), Mulching (484), Conservation Cover (327), and/or Hedgerow (422) to help improve soil health, pollinator habitat, and produce more food for local markets.

The desire by other producers to understand and properly manage nutrients is strong. There is little resistance to these practices, however the high cost of plans, designs, and eventual implementation keeps most from moving ahead.

Forest Resiliency and Health

CTSI has 2 active and 3 completed EQIP contracts in the Siletz Basin from the last 11 years, which include a total of 2,787 acres of pre-commercial thinning (666) on Tribal Forest lands.

One priority timber conservation property within 2 miles of the intakes is currently working with NRCS for the development of a Forest Management Plan (106) and Forest Management Practice Design (165) on 70 acres through EQIP.

One timber conservation property in the Little Rock Creek sub watershed is currently working with NRCS on the development of a Forest Management Plan (106) and Forest Management Practice Design (165) on 287 acres through EQIP.

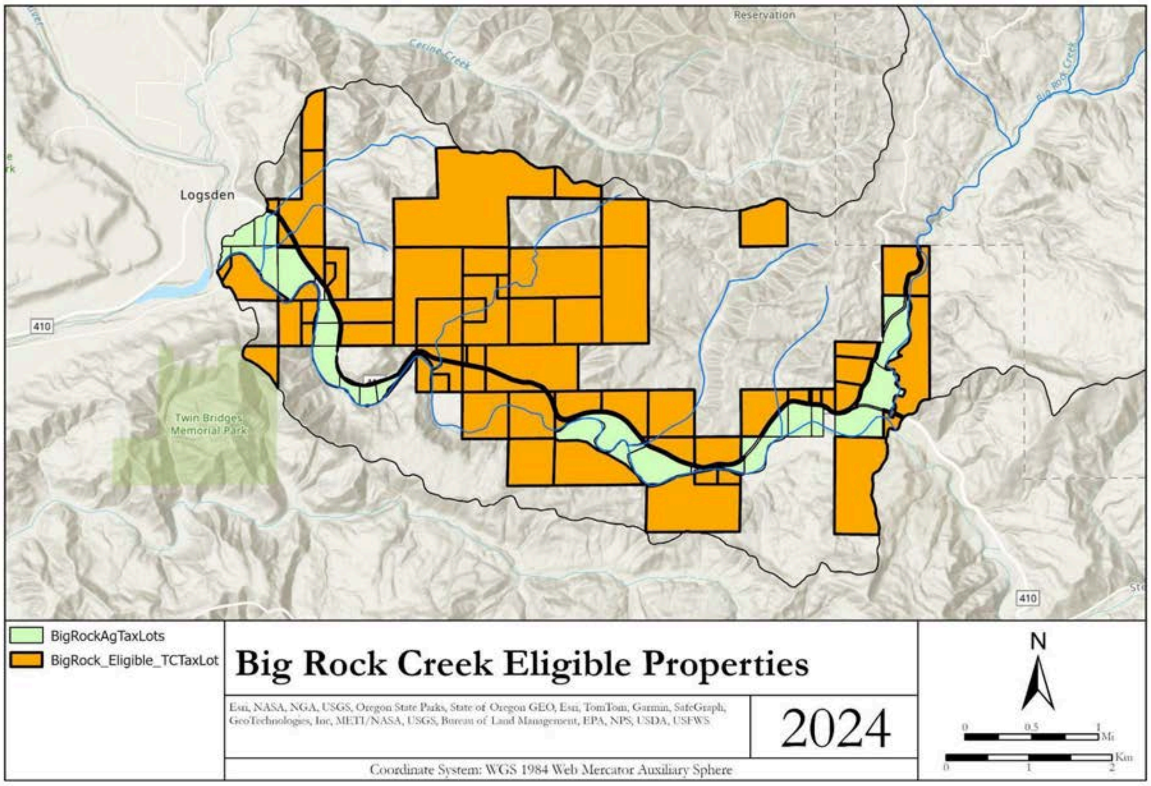
One agricultural landowner in the Mill Creek sub watershed is developing a conservation plan for a hedgerow and conservation cover for habitat improvement through EQIP.

Critical Areas of Concern

AU_Name	HUC_12	HU_12_NAME	Pollutant	Assessment	Period
Rock Creek	171002040602	Big Rock Creek-Rock Creek	Temperature	Temperature - Numeric	year-round
Rock Creek	171002040602	Big Rock Creek-Rock Creek	Temperature	Temperature - Numeric	spawn
Siletz River	171002040502	Mill Creek-Siletz River	Dissolved Oxygen	Dissolved Oxygen	spawn
Siletz River	171002040502	Mill Creek-Siletz River	Turbidity	Narrative Criteria for Turbidity	
Siletz River	171002040502	Mill Creek-Siletz River	Temperature	Temperature - Numeric	year-round
Siletz River	171002040502	Mill Creek-Siletz River	Temperature	Temperature - Numeric	spawn
Siletz River	171002040502	Mill Creek-Siletz River	Alkalinity	Toxic Substances - Aquatic Life	

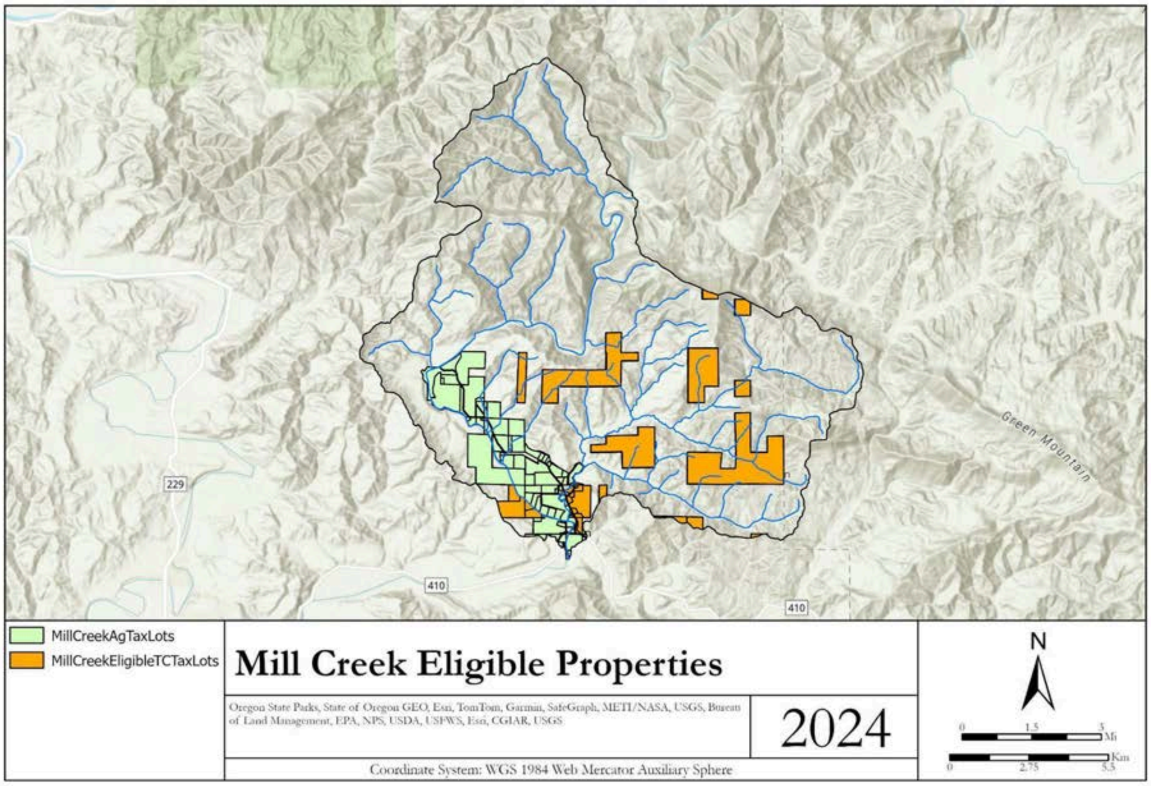
The primary Critical Areas of Concern include the Big Rock Creek-Rock Creek sub watershed and the Mill Creek-Siletz sub watershed. Additional areas of concern include the known biosolids application sites and non-industrial timber properties within 2 miles of the drinking water intakes.

Big Rock Creek-Rock Creek



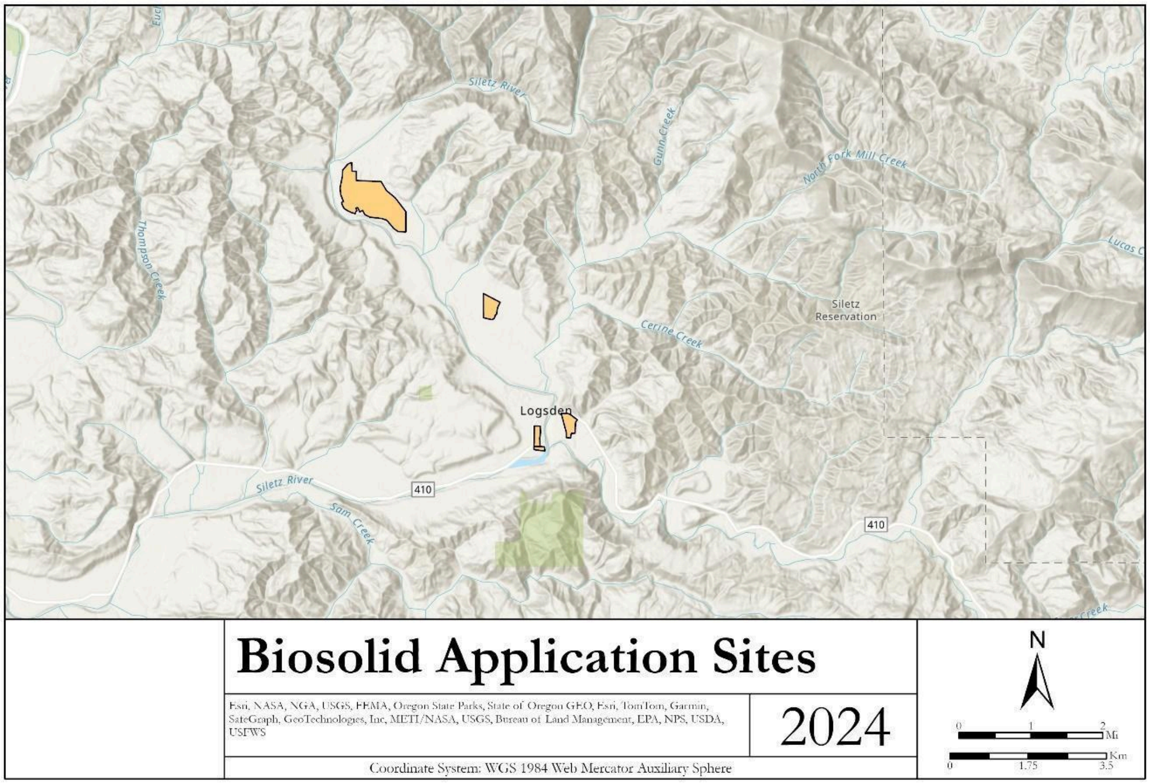
All of the agricultural tax lots within Big Rock Creek have surface water interconnections where conservation practice implementation may improve water quality. The upper watershed is held by industrial timber ownership and is ineligible for this project. In the lower watershed many non-industrial timber properties are eligible for conservation practices.

Mill Creek-Siletz River



The mainstem Mill Creek contains many eligible agricultural properties with riparian frontage. Non-industrial timber properties are more sporadic and have not been individually assessed for potential conservation practice implementation.

Biosolids Application Sites



According to information provided by DEQ, there are four known biosolid application sites within the SWPA, covered by four different permits.

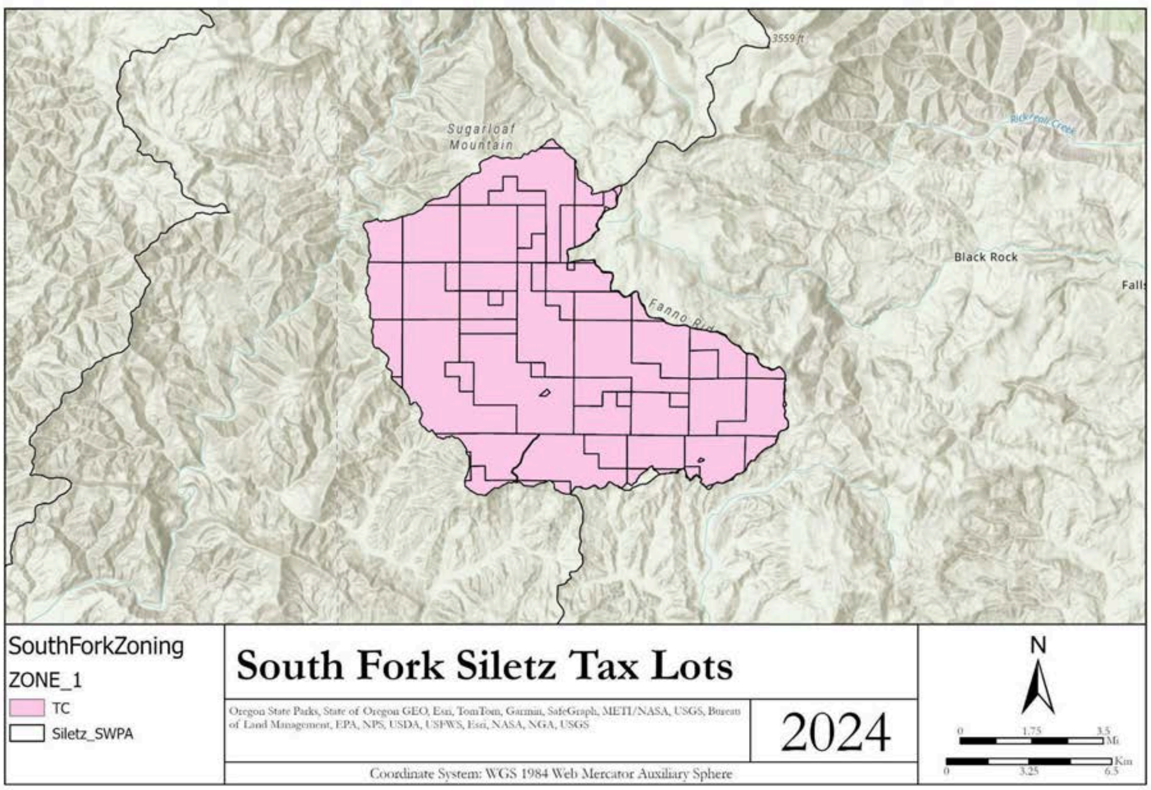
NPDES Permit No. 102497 lists 33 total dry tons applied over 11.9 acres at one site which lies between Baker Creek and an unnamed tributary. Aerial imagery and observations from the road show that Baker Creek, while somewhat lacking in vegetative cover, is not suffering significant erosion based on aerial imagery and is located on the edge of the property. The unnamed tributary has very little vegetative cover, runs approximately 640 feet through the center of the property, and appears to be experiencing heavy erosion. Recommendations for this property include the implementation of a Nutrient Management Plan and planting of erosion-controlling native vegetation along any riparian areas within the property.

NPDES Permit No. 101383 lists 40.55 total dry tons applied over 35 acres. This property borders the Siletz River for approximately 3,500 feet. Approximately 550 feet of this length appears to be suffering from heavy erosion and lack of vegetation. Recommendations for this property include the implementation of a Nutrient Management Plan and planting of erosion-controlling native vegetation along the 550-foot stretch of streambank suffering from excessive erosion.

NPDES Permit No. 101713 lists 8.84 total dry tons applied over 7.1 acres. The application area borders an unnamed tributary of Rock Creek, which enters into the river 1,480 feet upstream of its confluence with the Siletz. Based on aerial imagery and observations from the road, the 950-foot stretch of this tributary which runs through the application area is marked by Himalayan blackberry-dominated understory and at least two highly eroded cattle crossings. Recommendations for this property include the implementation of a Nutrient Management Plan, installation of hardened cattle crossings, and riparian restoration along the Rock Creek tributary to replace Himalayan blackberry with erosion-controlling native vegetation.

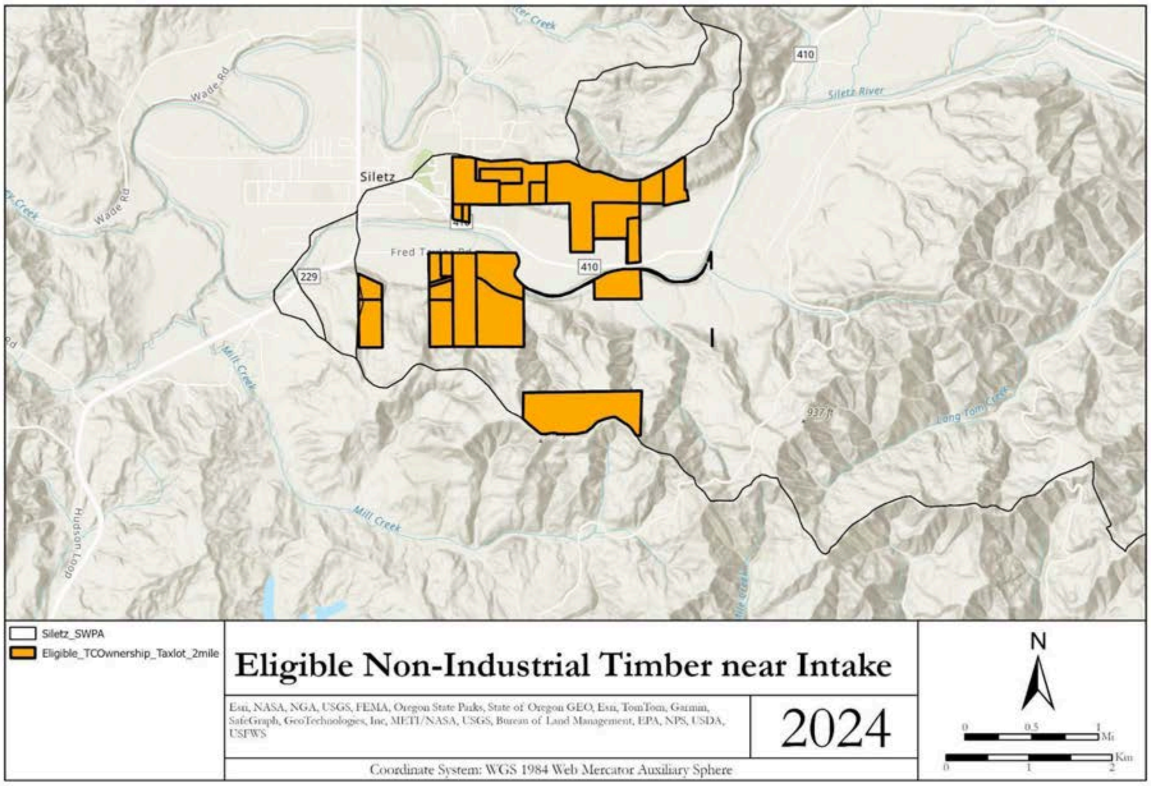
NPDES Permit No. 101269 lists 1.56 total dry tons applied over 1.74 acres. This application site is located on the opposite side of Logsden Road from the Siletz River and it is unclear if there is direct surface water drainage from the property to the river. However, several retention ponds exist on the property, one of which lies within 230 feet of the Siletz River. Aerial imagery suggests that while the retention pond in closest proximity to the river may be sufficiently vegetated, other ponds on the property appear to lack vegetation buffers. Recommendations for this property include the implementation of a Nutrient Management Plan and ensuring that sufficient vegetation buffers are present around bodies of water on the property to allow for filtration of biosolid runoff.

South Fork Siletz River



A brief assessment of the South Fork Siletz tax lots revealed no non-industrial timber operations. While this area is of critical concern due to water quality impairments outlined in the 2022 DEQ Integrated Report, there are currently no eligible properties for NRCS funding.

Non-Industrial Timber Properties near Intakes



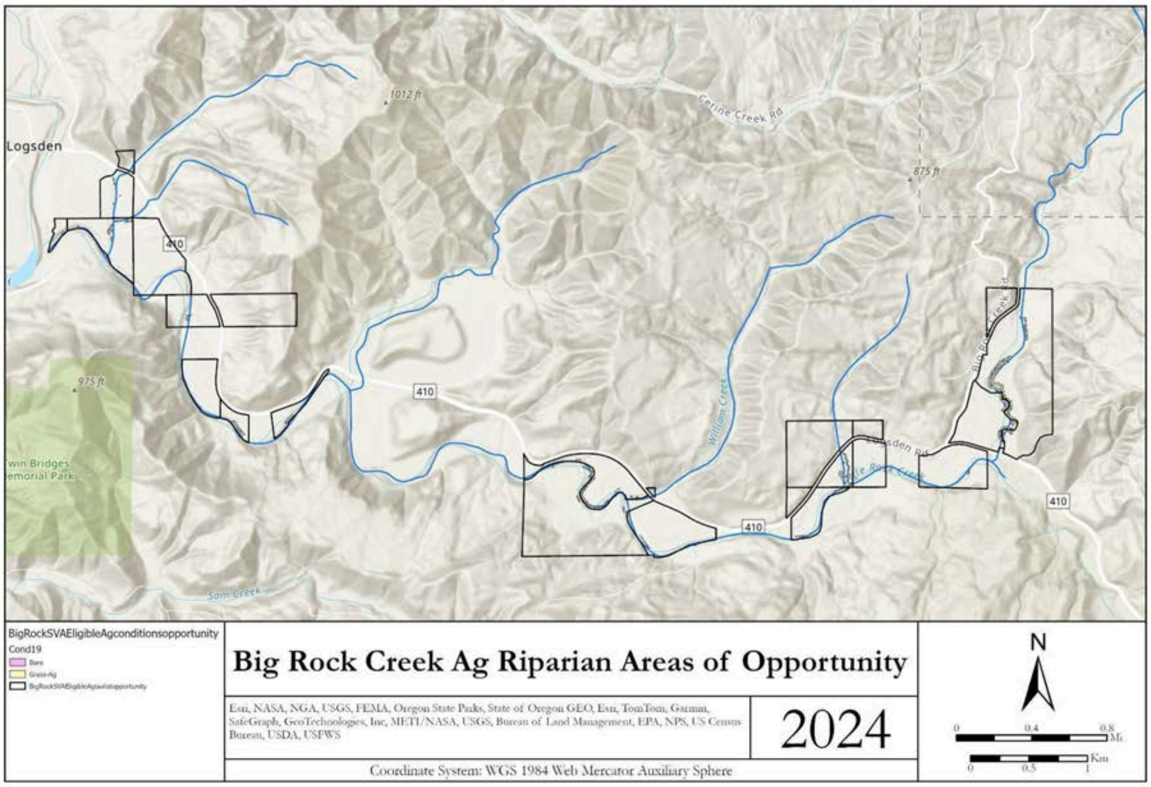
Non-industrial timber conservation properties in close proximity to drinking water intakes are a critical area of concern for forest management planning, riparian buffer planting, and upland habitat management to decrease sediment inputs to surface waters. The proximity of these properties to the intake decreases the available time for the treatment facilities to shut off equipment during high sediment events.

Analysis of Treatment Opportunities

In determining treatment opportunities in the Critical Areas of Concern, the District used a Streamside Vegetation Assessment of riparian conditions completed in 2021. The geospatial analysis of streamside vegetation focused on identifying areas with bare ground, grass, agricultural grass, and tree/shrub within 50 feet of major waterways within the Siletz. Compiled as part of the District's Siletz Focus Area, the assessment primarily targeted agricultural areas of opportunity. Through the use of geospatial analysis of eligible timber conservation properties within the SWPA select timber conservation properties have been identified for forestry related conservation opportunities.

Big Rock Creek-Rock Creek

Agricultural Property Treatment Opportunities

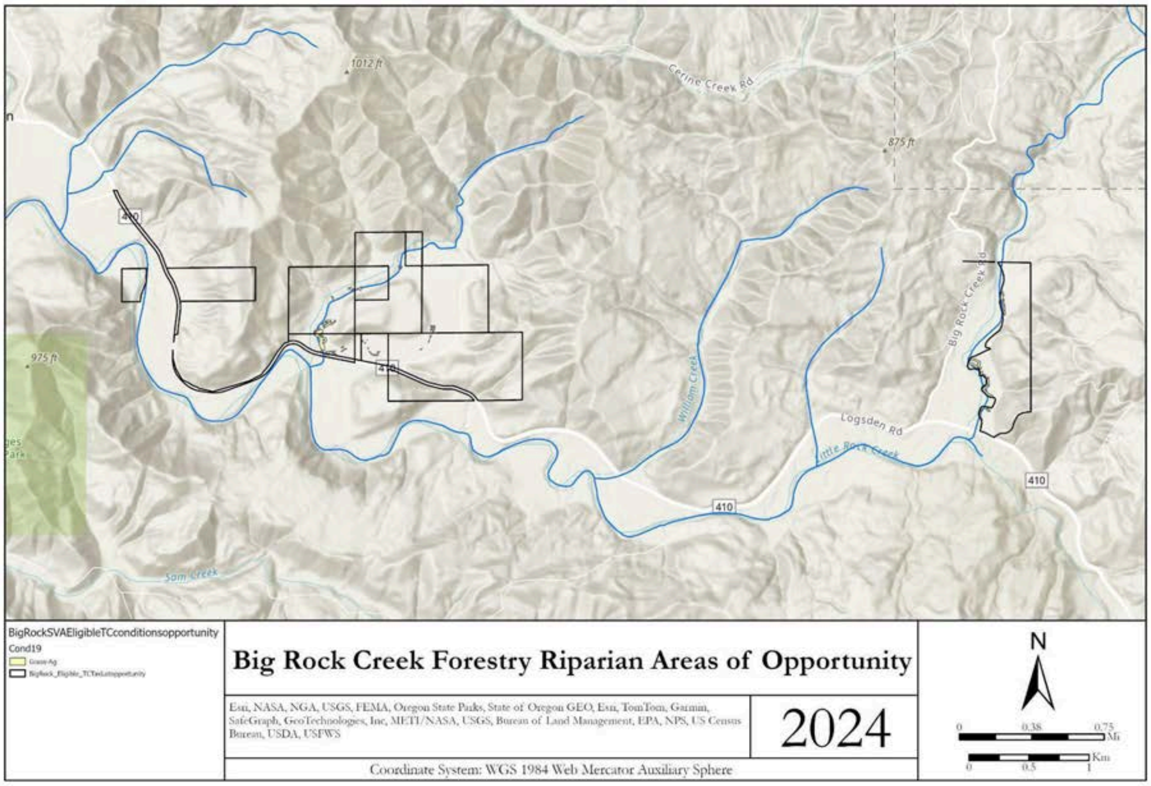


The Big Rock Creek agricultural areas of treatment opportunity for riparian restoration were determined by identifying bare ground, grass, and agricultural grass vegetation cover on eligible agricultural tax lots within the SWPA (SVA, 2021). The 50 ft. riparian buffer utilized in this analysis is consistent in meeting the needs of source water protection while also accommodating producer needs.

Riparian tree and shrub planting on approximately 14.1 acres in Big Rock Creek would be needed to meet the goals of this assessment and partner's needs. The treatment of these areas would provide approximately 2 miles of streamside shade on 17 individual tax lots.

Areas of bare agriculture were used to identify potential locations for livestock exclusion fencing. These areas were then field verified to determine livestock use. Based on geospatial and field site visits approximately 500 linear feet of livestock exclusion fencing would be needed to meet the sediment and bacteria reduction goals for livestock exclusion.

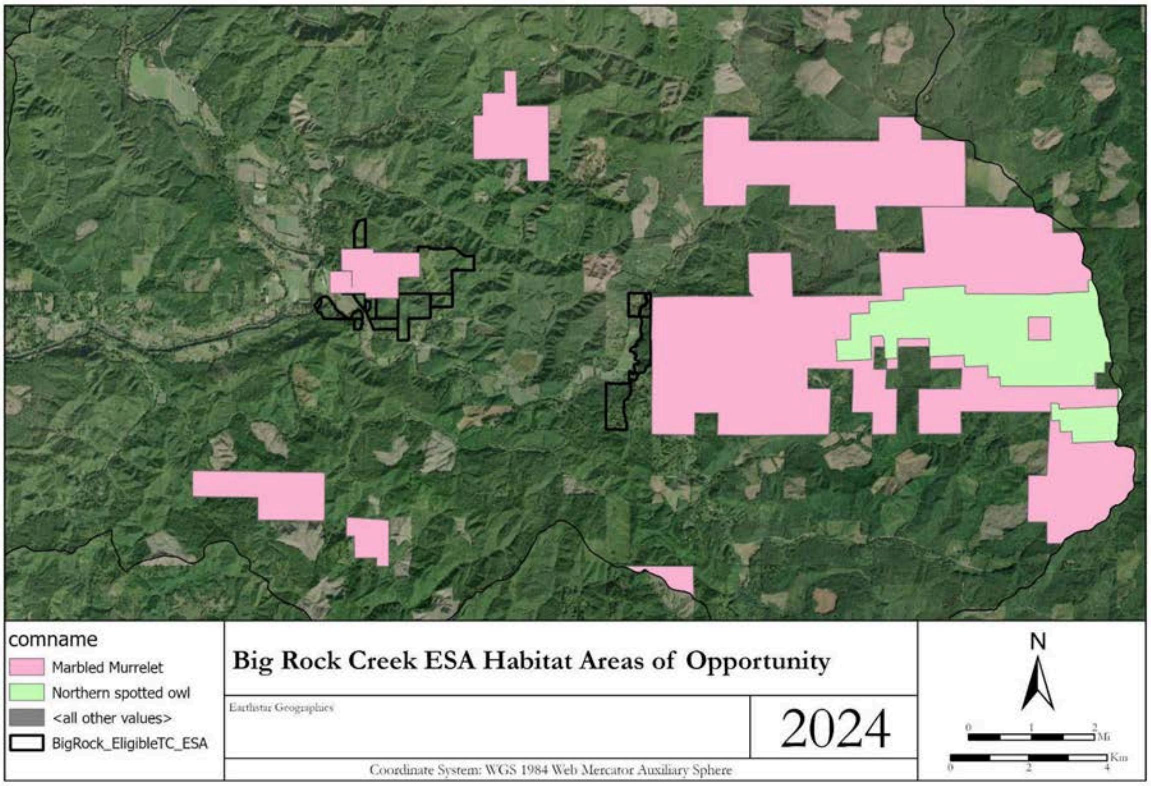
Non-Industrial Timber Property Treatment Opportunities



The Big Rock Creek non-industrial timber areas of treatment opportunity for riparian restoration were determined by identifying bare ground, grass, and agricultural grass vegetation cover on eligible agricultural tax lots within the SWPA (SVA, 2021). The 50 ft. riparian buffer utilized in this analysis may provide low estimates for potential acreage of opportunity. This is in part due to the ongoing implementation of the Private Forest Accord, which will require large riparian buffers and harvesting exclusion zones to improve aquatic habitat.

Riparian tree and shrub planting on approximately 7.5 acres in Big Rock Creek would be needed to meet the goals of this assessment and partner's needs. The treatment of these areas would provide approximately 1.2 miles of streamside shade on 11 individual tax lots.

Upland Forest Improvement Opportunities

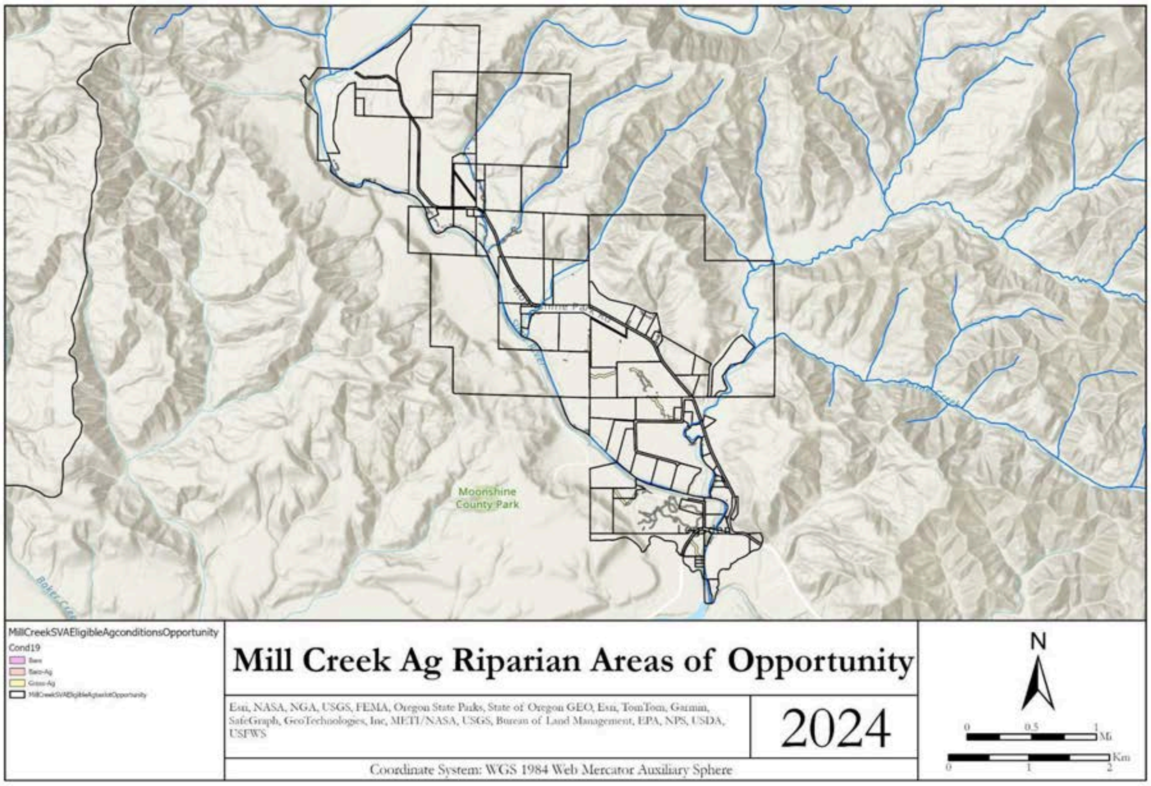


The Big Rock Creek non-industrial timber areas of treatment opportunity for upland forest improvement were determined by selecting eligible timber conservation properties within ¼ mile of known critical habitat for ESA listed species (marbled murrelet and northern spotted owl) in the SWPA.

A total of 21 tax lots were identified as potential locations for treatment. The tax lots total approximately 1190 acres.

Mill Creek-Siletz River

Agricultural Property Treatment Opportunities

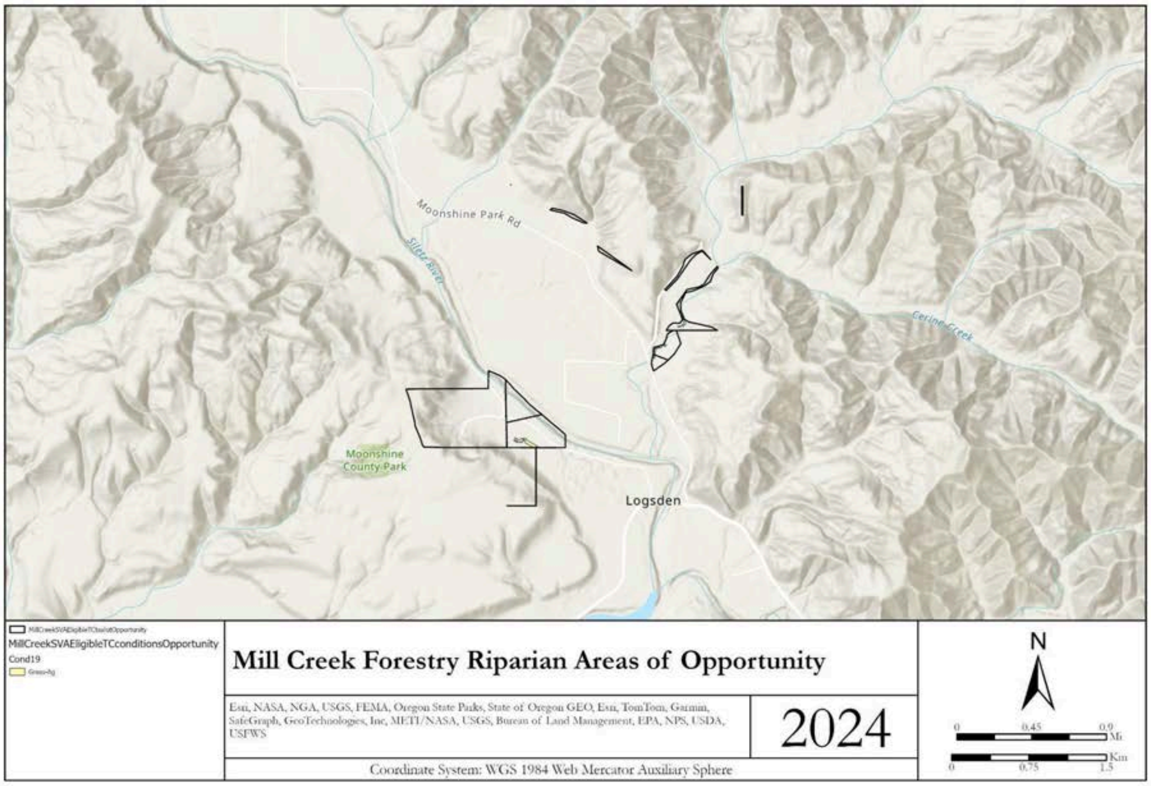


The Mill Creek agricultural areas of treatment opportunity for riparian restoration were determined by identifying bare ground, grass, and agricultural grass vegetation cover on eligible agricultural tax lots within the SWPA (SVA, 2021). The 50 ft. riparian buffer utilized in this analysis is consistent in meeting the needs of source water protection while also accommodating producer needs.

Riparian tree and shrub planting on approximately 22.7 acres in Mill Creek would be needed to meet the goals of this assessment and partner's needs. Approximately 1.5 acres were identified as having bare ground in the riparian buffer. These areas will be the priority for treatment within the CAC. The treatment of these areas would provide approximately 2.4 miles of streamside shade on 51 individual tax lots.

Areas of bare agriculture were used to identify potential locations for livestock exclusion fencing. These areas were then field verified to determine livestock use. Based on geospatial and field site visits approximately 3600 linear feet of livestock exclusion fencing would be needed to meet the sediment and bacteria reduction goals for livestock exclusion.

Non-Industrial Timber Property Treatment Opportunities



The Mill Creek non-industrial timber areas of treatment opportunity for riparian restoration were determined by identifying bare ground, grass, and agricultural grass vegetation cover on eligible agricultural tax lots within the SWPA (SVA, 2021). The 50 ft. riparian buffer utilized in this analysis may provide low estimates for potential acreage of opportunity. This is in part due to the ongoing implementation of the Private Forest Accord, which will require large riparian buffers and harvesting exclusion zones to improve aquatic habitat.

Riparian tree and shrub planting on approximately 3.4 acres in Mill Creek would be needed to meet the goals of this assessment and partner's needs. The treatment of these areas would provide approximately 0.5 miles of streamside shade on 6 individual tax lots.

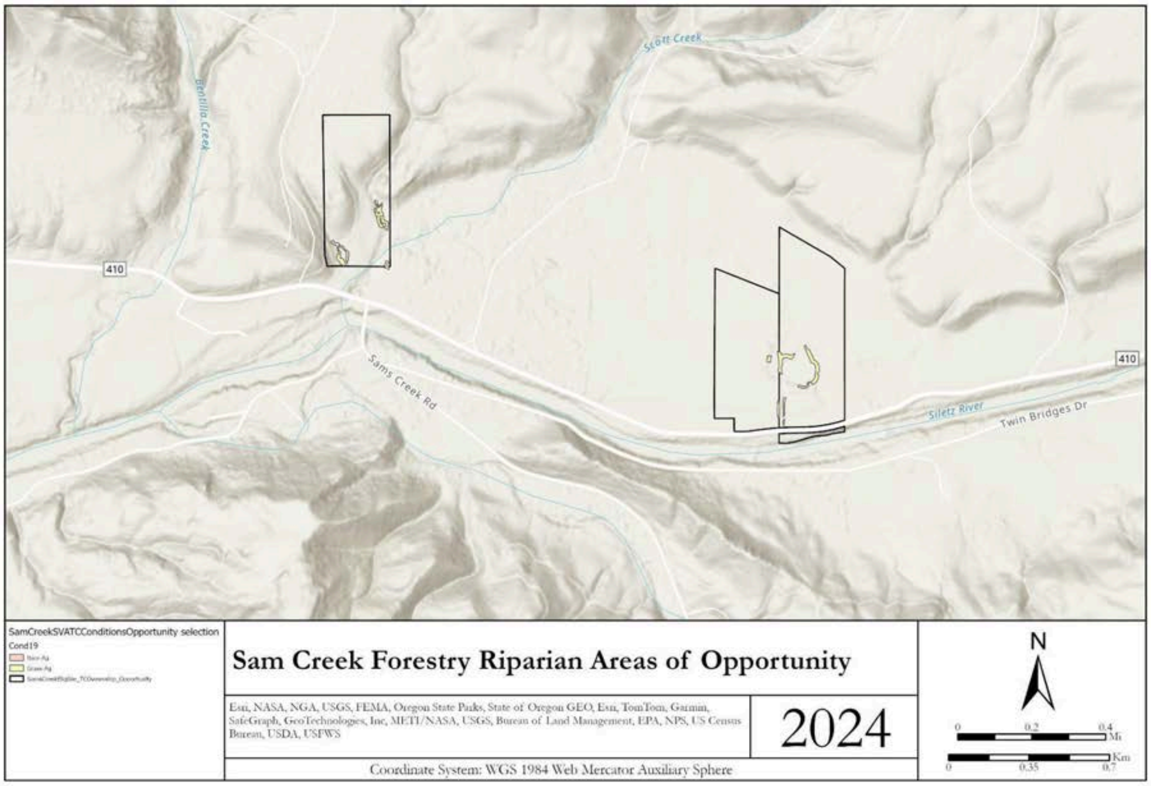
Sam Creek Siletz

Agricultural Property Treatment Opportunities

The Sam Creek agricultural areas of treatment opportunity for riparian restoration were determined by identifying bare ground, grass, and agricultural grass vegetation cover on eligible agricultural tax lots within the SWPA (SVA, 2021). The 50 ft. riparian buffer utilized in this analysis is consistent in meeting the needs of source water protection while also accommodating producer needs.

Within the eligible agricultural areas in Sam Creek Siletz no areas of bare ground, grass, or agricultural grass vegetation cover were identified. Opportunities for improving riparian vegetation cover through diversification of land species and expansion of the buffer size may increase the needs for treatment.

Non-Industrial Timber Property Treatment Opportunities



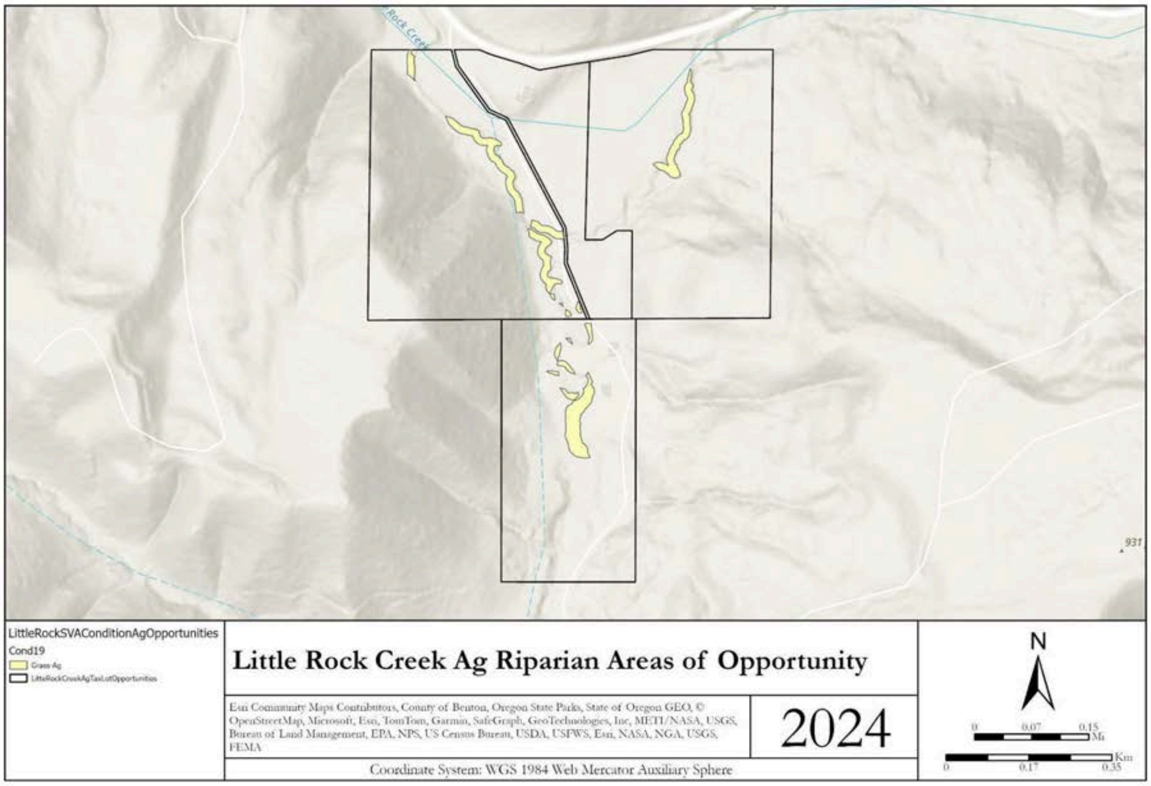
The Sam Creek sub watershed non-industrial timber areas of treatment opportunity for riparian restoration were determined by identifying bare ground, grass, and agricultural grass vegetation cover on eligible agricultural tax lots within the SWPA (SVA, 2021). The 50 ft. riparian buffer utilized in this analysis may provide low estimates for potential acreage of opportunity. This is in part due to the ongoing implementation of the Private Forest Accord, which will require large riparian buffers and harvesting exclusion zones to improve aquatic habitat.

Riparian tree and shrub planting on approximately 3.76 acres in Sam Creek sub watershed would be needed to meet the goals of this assessment and partner's needs. The treatment of these areas would provide approximately 0.5 miles of streamside shade on 3 individual tax lots.

Areas of bare agriculture were used to identify potential locations for livestock exclusion fencing. These areas were then field verified to determine livestock use. Based on geospatial and field site visits approximately 700 linear feet of livestock exclusion fencing would be needed to meet the sediment and bacteria reduction goals for livestock exclusion.

Little Rock Creek

Agricultural Property Treatment Opportunities

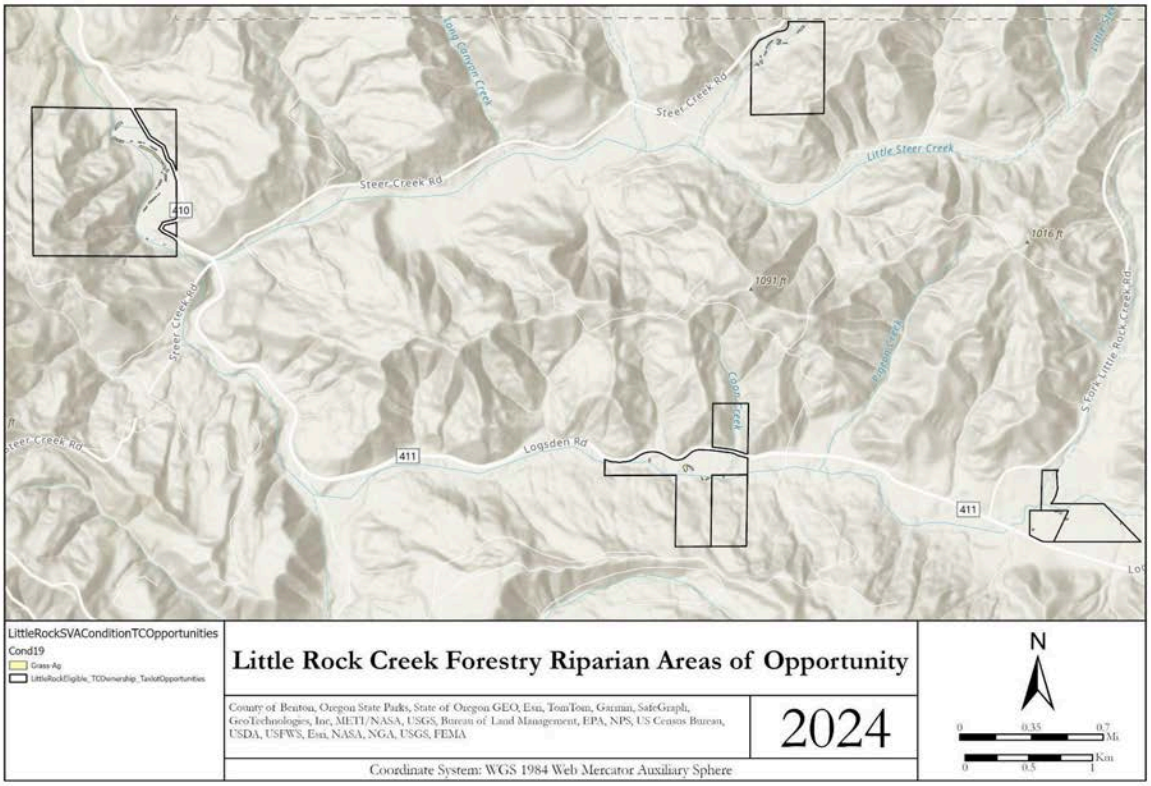


The Little Rock Creek sub watershed agricultural areas of treatment opportunity for riparian restoration were determined by identifying bare ground, grass, and agricultural grass vegetation cover on eligible agricultural tax lots within the SWPA (SVA, 2021). The 50 ft. riparian buffer utilized in this analysis is consistent in meeting the needs of source water protection while also accommodating producer needs.

Riparian tree and shrub planting on approximately 2.7 acres in Little Rock Creek sub watershed would be needed to meet the goals of this assessment and partner's needs. Approximately 0.5 acres were identified as having bare ground in the riparian buffer. These areas will be the priority for treatment within the CAC. The treatment of these areas would provide approximately 0.94 miles of streamside shade on 3 individual tax lots.

No areas of bare agriculture were used to identify potential locations for livestock exclusion fencing. However, based on geospatial and field site visits, approximately 600 linear feet of livestock exclusion fencing would be needed to meet the sediment and bacteria reduction goals for livestock exclusion.

Non-Industrial Timber Property Treatment Opportunities



The Little Rock Creek sub watershed non-industrial timber areas of treatment opportunity for riparian restoration were determined by identifying bare ground, grass, and agricultural grass vegetation cover on eligible agricultural tax lots within the SWPA (SVA, 2021). The 50 ft. riparian buffer utilized in this analysis may provide low estimates for potential acreage of opportunity. This is in part due to the ongoing implementation of the Private Forest Accord, which will require large riparian buffers and harvesting exclusion zones to improve aquatic habitat.

Riparian tree and shrub planting on approximately 2.9 acres in Little Rock Creek sub watershed would be needed to meet the goals of this assessment and partner's needs. The treatment of these areas would provide approximately 0.8 miles of streamside shade on 6 individual tax lots.

Dewey Creek

Agricultural Property Treatment Opportunities

The Dewey Creek sub watershed agricultural areas of treatment opportunity for riparian restoration were determined by identifying bare ground, grass, and agricultural grass vegetation cover on eligible agricultural tax lots within the SWPA (SVA, 2021). The 50 ft. riparian buffer utilized in this analysis is consistent in meeting the needs of source water protection while also accommodating producer needs.

Riparian tree and shrub planting on approximately 1.9 acres in Dewey Creek sub watershed would be needed to meet the goals of this assessment and partner's needs. Approximately .1 acres were identified as having bare ground in the riparian buffer. These areas will be the priority for treatment within the CAC. The treatment of these areas would provide approximately 0.81 miles of streamside shade on 7 individual tax lots.

Areas of bare agriculture were used to identify potential locations for livestock exclusion fencing. These areas were then field verified to determine livestock use. Based on geospatial and field site visits no livestock are crossing in the bare ground areas.

Non-Industrial Timber Property Treatment Opportunities

The Dewey Creek sub watershed non-industrial timber areas of treatment opportunity for riparian restoration were determined by identifying bare ground, grass, and agricultural grass vegetation cover on eligible agricultural tax lots within the SWPA (SVA, 2021). The 50 ft. riparian buffer utilized in this analysis may provide low estimates for potential acreage of opportunity. This is in part due to the ongoing implementation of the Private Forest Accord, which will require large riparian buffers and harvesting exclusion zones to improve aquatic habitat.

No non-industrial timber properties were identified for riparian restoration treatment based on the SVA.

Within the Dewey Creek sub watershed there are 32 individual non-industrial timber tax lots within 2 miles of the source water intakes. These properties total 1105 acres that could impact the source water intakes due to proximity. Available treatment in these locations should include forest management planning and implementation of riparian and upland restoration.

A geospatial analysis of tributaries within the tax lots near the intakes indicates that over 4400 linear feet of stream run through 6 individual tax lots. Riparian restoration and improvement to stabilize soils with proper vegetation will help to meet the goals of the assessment.

Preferred Practices, Locations, Responsible Parties, Costs, Timelines

An evaluation of project goals and objectives was completed with the District Conservationist to determine the preferred practices. Locations for these practices have been identified in the assessment with priority given to producers and lands within identified Critical Areas of Concern.

Practice Name	Practice Number	No/Ac/Ft	SWPA	Average Cost	Total Need
Comprehensive Nutrient Management Plan	102	Number	12	$5,008.75	$60,105.00
Forest Management Plan	106	Number	10	$1,966.65	$19,666.50
Forest Management Practice Design	165	Number	10	$609.03	$6,090.30
Brush Management	314	Acre	29	$207.50	$6,017.50
Herbaceous Weed Treatment	315	Acre	29	$176.82	$5,127.78
Composting Facility	317	Cubic Feet	42000	$8.18	$343,560.00
Riparian Herbaceous Cover	390	Acre	29	$813.93	$23,603.97
Roofs and Covers	367	Square Feet	7000	$13.14	$91,980.00
Fence (Woven Wire)	382	Linear Feet	5400	$5.58	$30,132.00
Woody Residue Treatment	384	Acres	20	$91.80	$1,836.00
Riparian Forest Buffer	391	Acre	59	$4,453.58	$262,761.22
Tree/Shrub Site Preparation	490	Acre	58	$1,251.03	$72,559.74
Livestock Pipeline	516	Feet	10000	$3.89	$38,900.00
Roof Runoff Structure	558	Linear Feet	12000	$11.28	$135,360.00
Heavy Use Area Protection	561	Square Feet	10000	$2.22	$22,200.00
Nutrient Management	590	Acre	40	$38.14	$1,525.60
Watering Facility	614	Gallons	1800	$9.41	$16,938.00
Underground Outlet	620	Feet	1000	$9.82	$9,820.00
Upland Wildlife Habitat Management	645	Acre	20	$12.44	$248.80
Forest Stand Improvement	666	Acre	20	$496.38	$9,927.60
Beaver	643	Linear Feet	200	$39.12	$7,824.00
Stream Crossings	578	Square Feet	1500	$22.14	$33,210.00

Summary and Recommendation

Summary of Resource Concerns and Impairments

Sediment and nutrient inputs to surface waters of the SWPA from agricultural activities provide opportunities for improvement of water quality. Sediment and bacteria (E. coli) inputs from agricultural activities are linked to livestock access to surface waters for drinking and passage. A lack of off stream watering infrastructure and fencing is present across the watershed allowing free passage of livestock.

With over 75% of the total acreage of the SWPA under industrial timber, the acreage of eligible non-industrial timber properties is located toward the lower portion of the watershed. Timber operations in the SWPA are characterized by steep slopes with erodible soils. These areas are susceptible to mass wasting and soil loss from clear cutting practices, improper BMPs, and lack of forest management planning that are common.

The land use of the SWPA provides limited habitat for wildlife such as beaver, Coho Salmon, the Marbled Murrelet, and the Northern Spotted Owl. The aquatic habitat for beaver and Coho Salmon is important ecologically and can provide both economic and water quality benefits. Marbled Murrelet and Northern Spotted Owl require old growth tree habitat. Old growth trees provide shade and decrease the overall loss of water through evapotranspiration.

As listed in the DEQ 2022 Integrated Report, there are several 303(d) Listed Waters in the SWPA impaired for temperature, sediment, and dissolved oxygen. This information frames the critical areas of concern of this report and priority areas for treatment to address impairments. The South Fork Siletz, while on the 303(d) List, does not have eligible properties for NRCS practice implementation at this time.

Description of Project Goals, Practice Efficiencies, and Metrics

Priority for implementation and goals will be in the Mill-Creek and Big-Rock Creek sub watersheds and within 2 miles of the intake. Effectively accomplishing these goals through District and partner outreach such as NGO meetings, conservation field days, community events, and participation in the Siletz Strategic Implementation Area will be critically important in the success of the project. Goals will be tracked through ArcGIS to spatially evaluate successes and continued opportunities. Practices implemented within the SWPA will be tracked and captured through continued District participation in the Mid-Coast Water Planning Partnership Source Water Protection subcommittee. Additional areas of opportunity identified by the Oregon Department of Agriculture through the Strategic Implementation area will be added to the geospatial database.

Goal: Work to implement conservation practices on at least half, 16, of the non-industrial timber properties within 2 miles of the drinking water intake.

Unit of Measure: Number of forestry conservation contracts funded.

Baseline Condition: There are 32 forestry properties within 2 miles of the drinking water intakes. As of the time of this report one of those properties was proceeding with a forest management plan.

How will the goal be assessed? Assessed at the end of the NWQI funding period as the total number of forestry contracts funded.

Goal: Fund and implement twenty forest management plans outside of the two mile radius of the drinking water intakes.

Unit of Measure: Number of forestry conservation contracts funded.

Baseline Condition: There are over 400 forestry properties within the SWPA. As of the time of this report several have or are working with NRCS on forest management plans.

How will the goal be assessed? Assessed at the end of the NWQI funding period as the total number of forestry management plan contracts funded.

Temperature changes in the watershed will likely not be measurable in the short term, however as part of this process the NRCS District Conservationist will conduct the Streamside Visual Assessment Protocol (SVAP2) to determine the change in riparian function over the course of each project. Continuous temperature monitoring at the confluence of Rock Creek and the Siletz, Mill Creek and the Siletz and Moonshine Park will continue from May through October for the foreseeable future to address temperature impairments for Coho salmon spawning.

Sediment reduction efficacy will be determined by the conversion from bare ground and grass in the 50ft. buffer in the 2027-2029 biennium using the same Streamside Vegetation Assessment protocol used to determine vegetation cover in this assessment. Total Suspended Solids (TSS) and Turbidity monitoring at the confluence of Rock Creek and the Siletz, Mill Creek and the Siletz and Moonshine Park monthly from May through October will help assess sediment reduction goals.

Goal: Work with landowners to implement riparian planting contracts to provide shade and streambank stabilization to reduce stream temperatures and sediment inputs from agricultural and forestry lands on 20 acres.

Unit of Measure: Number of acres of riparian planting.

Baseline Condition: There are approximately 40 acres designated as having bare ground based on the SVA on agricultural lands.

How will the goal be assessed? Assessed at the end of the NWQI funding period as the total number of riparian acres planted.

Bacteria (E. coli) reduction goals and practice efficiencies will be determined through bacteria grab sampling at the confluence of Rock Creek and the Siletz, Mill Creek and the Siletz and Moonshine Park will continue from May through October. Nutrient reduction goals and efficiencies will be determined by soil testing for nutrient levels (N-P-K) as part of the Comprehensive Nutrient Management practice to avoid application of excess nutrients.

Goal: Work with at least 10 livestock producers to implement conservation practices that reduce nutrients runoff to surface waters.

Unit of Measure: Number of contracts implemented

Baseline Condition: Currently, the District is unaware of any producers in the SWPA that have a Comprehensive Nutrient Management plan and are aware of the ability of the District to assist with conservation practices that address nutrient management.

How will the goal be assessed? Assessed at the end of the NWQI funding period as the total number of contracts funded that directly contribute to nutrient management reduction to surface waters.

Metrics used to track progress will require a large number of working hours to effectively and continuously track progress of the project. The District and partners participation in the Midcoast Water Planning Partnership will be vital to understanding progress across organizations. The continued monitoring of water quality parameters will be vital in understanding efficacy of installed conservation practices over time.

Evaluation of Practice Scenarios and Alternative to Meeting Water Quality Objectives

Implementation of avoiding, controlling and trapping practices will be vital in the success of meeting goals.

Core practice scenarios and components that will be especially important during the project implementation will include all cover and tree/shrub scenarios that control invasive weeds, reduce erosion, improve plant species diversity, and improve habitat.

Important practices in regard to livestock will be practices such as Comprehensive Nutrient Management Plan, Composting Facility, Roof Runoff Structure, Heavy Use Area Protection, Stream Crossing, and Underground outlet. Providing a plan of manure and nutrients produced with a facility to contain and compost materials will be vital in preventing nutrients from entering surface waters of the SWPA. Fencing, livestock pipeline, and watering facility practices will be necessary to mitigate livestock in-stream watering and passage. These practices will reduce bacteria and sediment inputs.

Forestry practices of importance include Forest Management Plan and Forest Management Practice Design to improve forest stand diversity and health, improve upland habitat, and reduce erosion. Forestry implementation practices of importance include Upland Wildlife Habitat Management, Forest Stand Improvement, Woody Residue Treatment, and Beaver Dam Analogs to increase water storage and build ecological resilience and health.

Refer to Siletz NWQI Budget for estimation of treatment cost.

Documentation of NEPA Concerns

Clean Air Act

The proposed conservation actions are not expected to increase the emission rate of any regulated air pollutants.

Clean Water Act

The proposed conservation actions are not likely to result in the discharge or placement of dredged or fill material or other pollutants into waters of the US. However, if a client is conducting an activity that requires a 404 permit, then the client must obtain a section 404 permit or determination of exemption from the appropriate Corps office need to be obtained.

Actions are consistent with existing water quality or associated watershed action plans that have been established for the stream segments. The aim is to improve water quality of impaired streams with conservation practices, but temporary harmful impacts caused during implementation of conservation practices should be considered.

Cultural Resources

The SWPA is within the traditional lands of member groups of the Confederated Tribes of Siletz Indians (CTSI). The potential to find archaeological resources is higher in this area. Project design will be finalized only after a response from the NRCS Cultural Resource Specialist has responded and appropriate tribal consultation has been completed.

ESA Listed Species and Essential Fish Habitat

Marbled Murrelet

The Marbled Murrelet is listed as Threatened under the Federal Endangered Species Act (ESA). Because of this, in areas that are designated as close to the nest or known habitat (within ¼ mile) noisy mechanical equipment cannot be used during the breeding period. The nesting season for the Marbled Murrelet is from April 1 to September 15. It is unlikely that the proposed conservation practices will negatively impact this species, however a thorough review of each project will be necessary to evaluate the potential for suitable nesting habitat, designated critical habitat, and known nesting locations. Consultation with USFWS may be necessary. Oregon NRCS is in the process of completing a programmatic consultation that would include this species.

Northern Spotted Owl

The Northern Spotted Owl is listed as Threatened under the Federal ESA. Because of this, in areas that are designated as close to known nest sites, or designated Critical Habitat (within ¼ mile), noisy mechanical equipment cannot be used during the breeding period. The nesting season for the Northern Spotted Owl is from March 1 to September 30. It is unlikely that the proposed conservation practices will negatively impact this species, however a thorough review of each project will be necessary to evaluate the potential for suitable nesting, roosting, foraging habitat, designated critical habitat, and known nesting locations. Consultation with USFWS may be necessary. Oregon NRCS is in the process of completing a programmatic consultation that would include this species.

Coho and Chinook Salmon and Essential Fish Habitat

The Siletz River Basin is designated Critical Habitat under the ESA and Essential Fish Habitat under the Magnuson-Stevens Act for federally Threatened Coho Salmon, Oregon Coast Evolutionarily Significant Unit (ESU), and Chinook Salmon, Oregon Coast ESU. The spawning season for the Oregon Coast Coho ESU is from mid-October to late January. It is unlikely that the proposed conservation practices will negatively impact these species. For projects that include vegetation management near water (including weed management and riparian planting), stream crossings, or livestock water withdrawals from streams, the actions "May Affect" listed salmon, Critical Habitat, and EFH and will likely be covered under NRCS's programmatic biological opinion, the Oregon and Washington NRCS Aquatic Habitat Conservation Programmatic Consultation (ORWAC). All applicable ORWAC Conservation

Measures will be followed. A Project Notification Form will be submitted to NOAA prior to commencement of activities and a Project Completion Form will be submitted at the conclusion of each project.

Environmental Justice

Planned projects will not have disproportionately high or adverse human health or environmental effects on minority populations, low-income populations, and Indian Tribes.

Invasive Species

Invasive species are known and present. Available conservation practices in the project area such as Brush Management and Herbaceous Weed Control will reduce the occurrence of invasive species. Equipment will be cleaned of invasive species upon entering and leaving project areas. Seed and plant mixtures used will be free of invasive species.

Scenic Beauty

The action(s) will not adversely affect the scenic quality of the general landscape or any specifically designated unique or valuable scenic landscape.

Wetlands

Landowners will be guided to choose other measures that will minimize adverse effects to wetlands, including obtaining all necessary permits. Activities will not result in reduction of wetland areas. If a landowner refuses to implement an alternative that avoids adverse impacts, all assistance will be terminated.

Appendix A: Outreach Plan

Goal: Conduct stakeholder engagement and technical assistance, using NRCS and other funding, to connect with 80 landowners over four years. Stakeholder engagement events include quarterly Siletz Watershed Council meetings, (2) annual Siletz River Floats, (1) Living on the Land Educational Series, Fencing workshop, and two workshops on agricultural infrastructure for conservation.

The table below highlights the outreach plan activities, leads, partners, and years the activity will be implemented.

Lead	Partners	Activity	2025	2026	2027	2028
Lincoln SWCD	ODA, OWRD, Lincoln County, OSU Extension Small Farms	Event (2): Siletz River floats will engage landowners on the water with technical assistance providers. Highlights of the float include water quality, invasive species, and conservation programming in the area.	x	x	x	x
MCWC	Lincoln SWCD	Provide technical assistance to the Siletz Watershed Council run by the MidCoast Watersheds Council quarterly.	x	x	x	x
Lincoln SWCD	ODA, NRCS, MCWC	Provide technical assistance to agricultural and rural residential landowners on agriculture conservation practices including project development and grant writing.	X	X	X	X
Lincoln SWCD	ODA, OSU Extension	Fencing Workshop		X		X
OSU Extension	Lincoln SWCD, ODA, ODF, MCWC, MRT, NRCS	Living on the Land Series			X	
Lincoln SWCD	Lincoln SWCD, ODA, ODF, MCWC, MRT	Quarterly Newsletter	X	X	X	X
Lincoln SWCD		Mailers to biosolid land applicators and ag/timber properties within 2 miles of the intakes	X	X	X	X

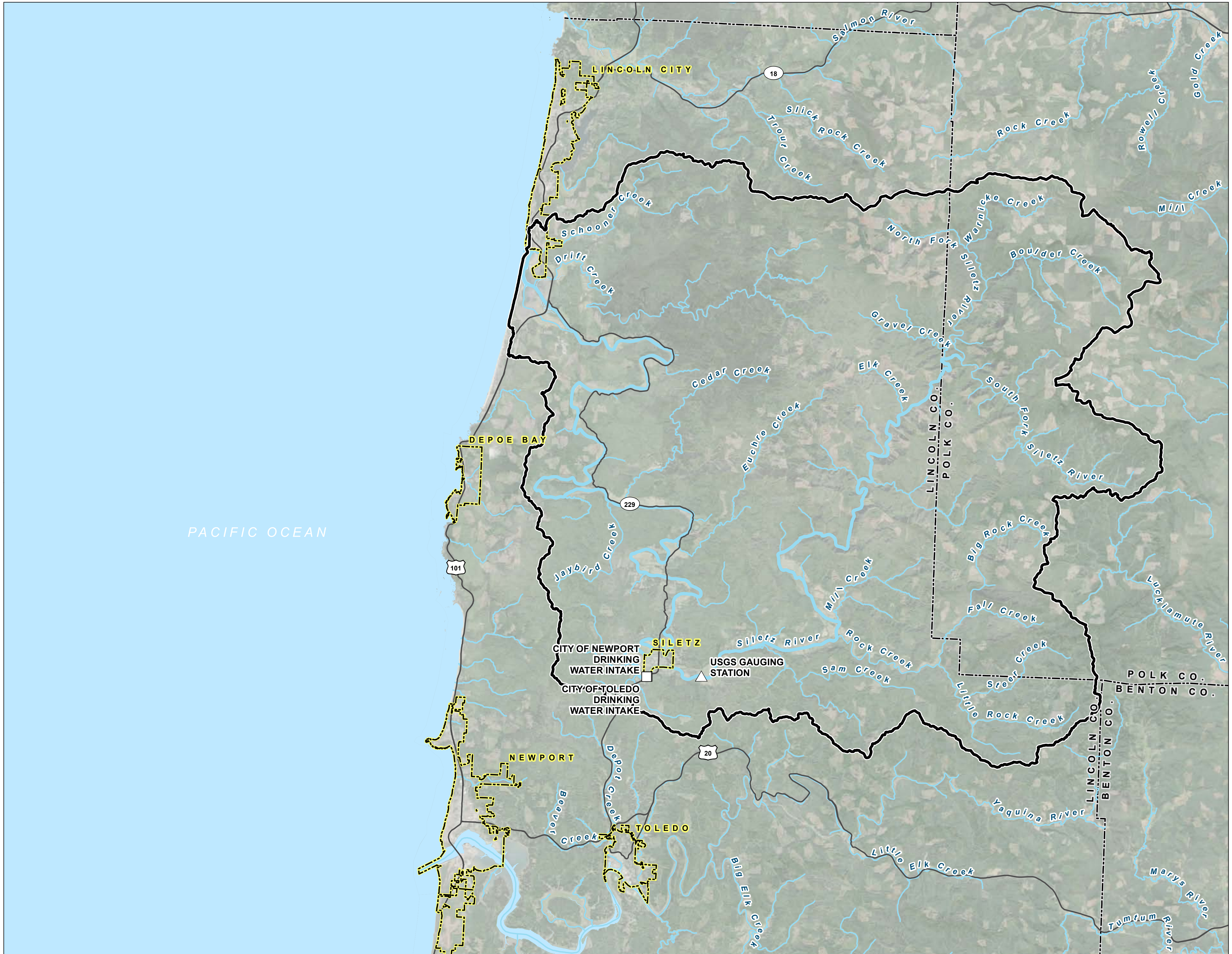
Appendix B: Figures

Appendix C: References

FIGURE 1

Siletz River Watershed Location Map

Hydrogeologic and Hydrologic Characterization of the Siletz River Watershed



LEGEND

- Water Intake
- USGS Gauging Station
- Siletz River Watershed
- City Boundary
- County Boundary
- Major Road
- Watercourse

N

0 2.5 5
Miles

Date: May 25, 2023
Data Sources: BLM, ESRI, ODOT, USGS, Maxar Imagery (2022)

GSI Water Solutions, Inc.

Document Path: Y:\2072_Lincoln_County_Soil_and_Water\Source_Figures\001_NWQI_Phase3a\Figure1_Site_Location_Map.mxd, abarry

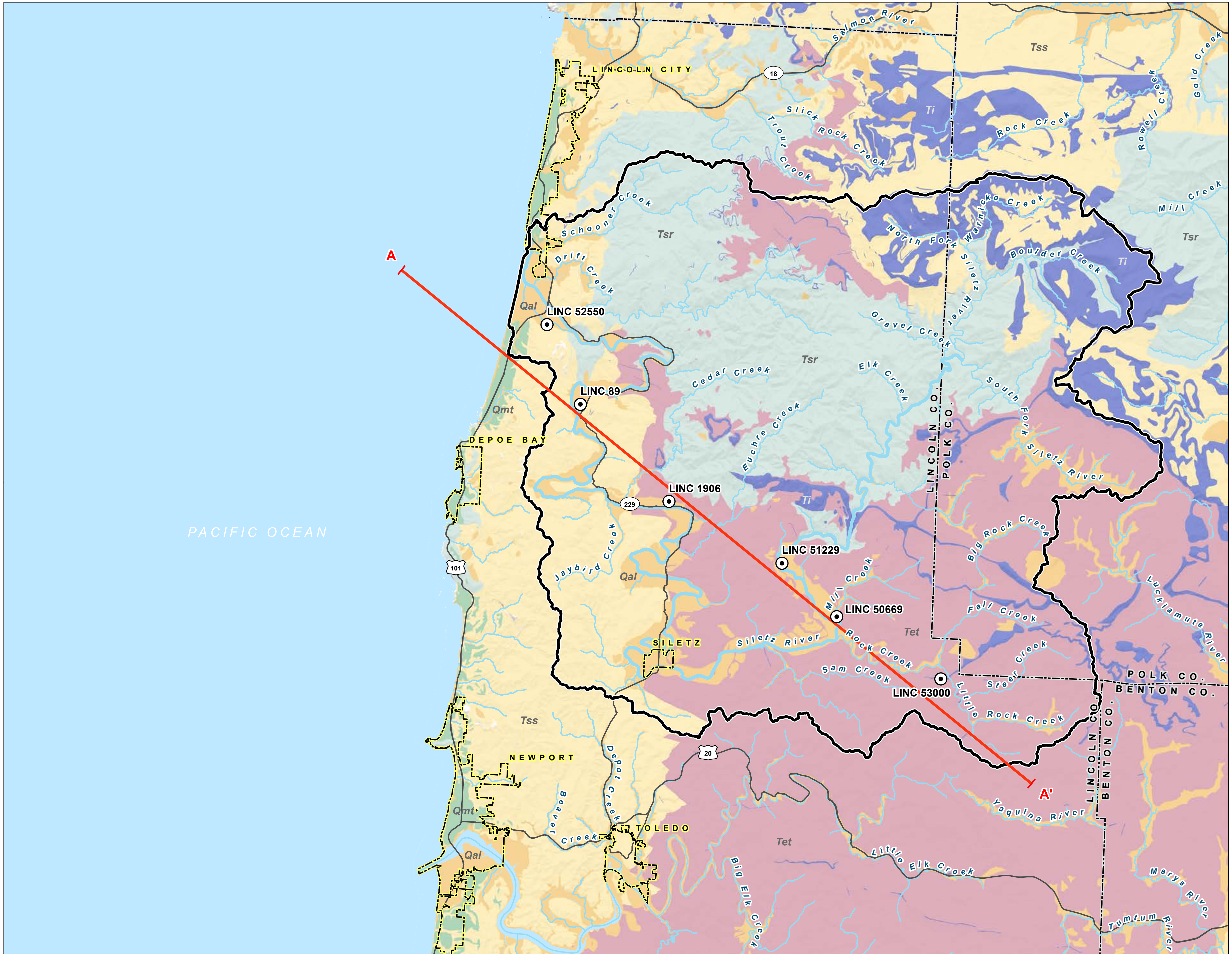


FIGURE 2

Surficial Geology Map

Hydrogeologic and Hydrologic Characterization of the Siletz River Watershed

LEGEND

- Water Well
- Cross Section Line
- Siletz River Watershed

Surficial Geology

Alluvium

- Alluvium (Qal)
- Marine Terrace Deposits (Qmt)

Marine Sedimentary Rocks

- Siltstone and Sandstone (Tss)
- Tyee Formation (Tet)

Volcanic Rocks

- Siletz River Volcanics (Tsr)
- Intrusive Rocks (Ti)

All Other Features

- City Boundary
- County Boundary
- Major Road
- Watercourse

N

0 2.5 5
Miles

Date: May 30, 2023
Data Sources: BLM, ESRI, ODOT, USGS, DOGAMI (2022)

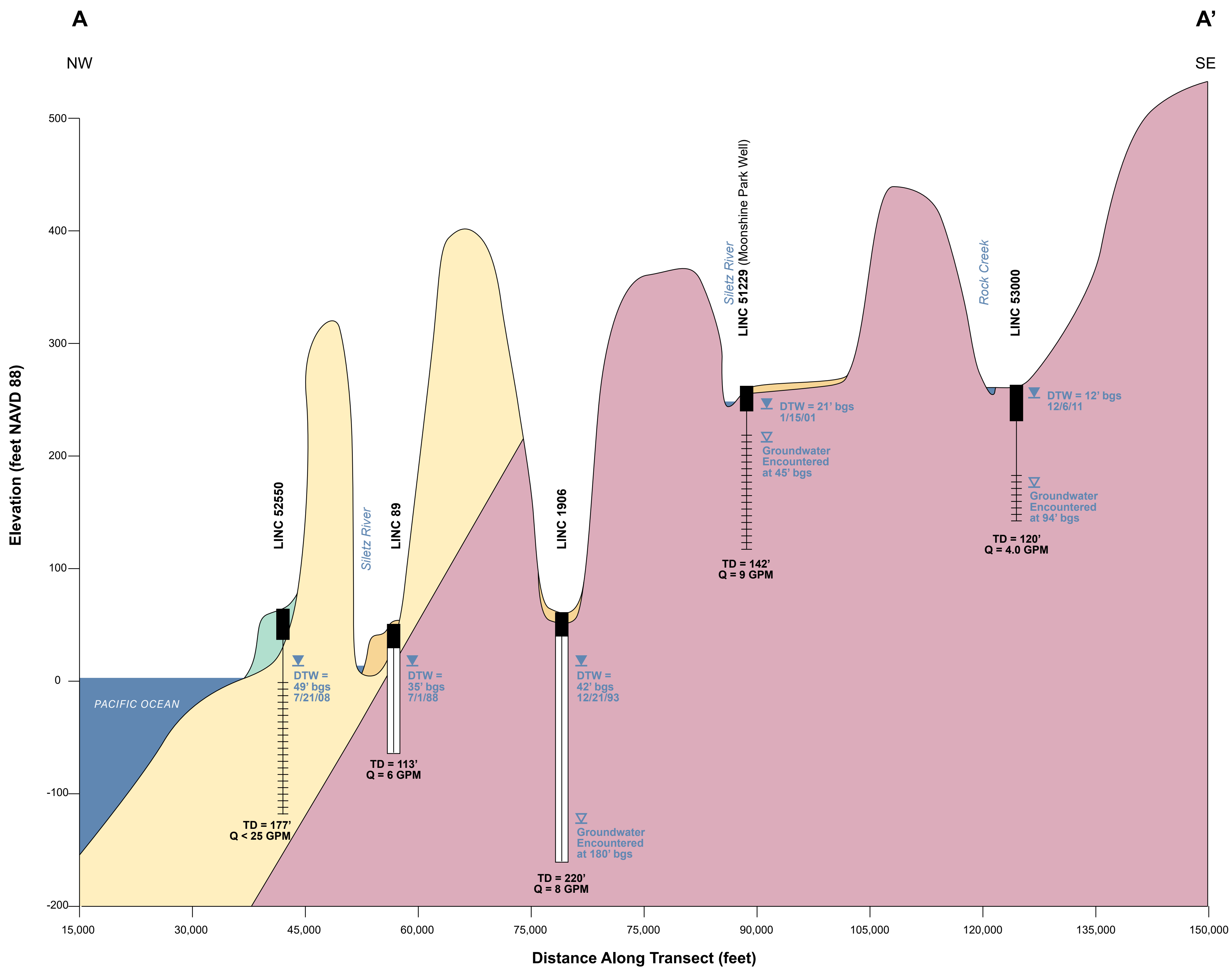
GSI Water Solutions, Inc.

Document Path: Y:\2072_Lincoln_County_Soil_and_Water\Source_Figures\001_NWQI_Phase3a\Figure2_Geology.mxd, abarry

FIGURE 3

Conceptual Geologic Cross Section of the Siletz River Watershed

Hydrogeologic and Hydrologic Characterization of the Siletz River Watershed



LEGEND

Unconsolidated Sediments

- Alluvium (Qal)
- Marine Terrace Deposits

Marine Sedimentary Rocks

- Siltstone and Sandstone (Tss)
- Tyee Formation (Tet)

Water Well

- Well Seal
- Depth at which Groundwater was Encountered
- Open Hole
- Depth at which Groundwater was Encountered
- Screened or Perforated Section

NOTES

1. Geology from Frank and Laenen (1977).
2. Faults and folds are not shown.
3. Cross section is conceptual in nature.

150x vertical exaggeration

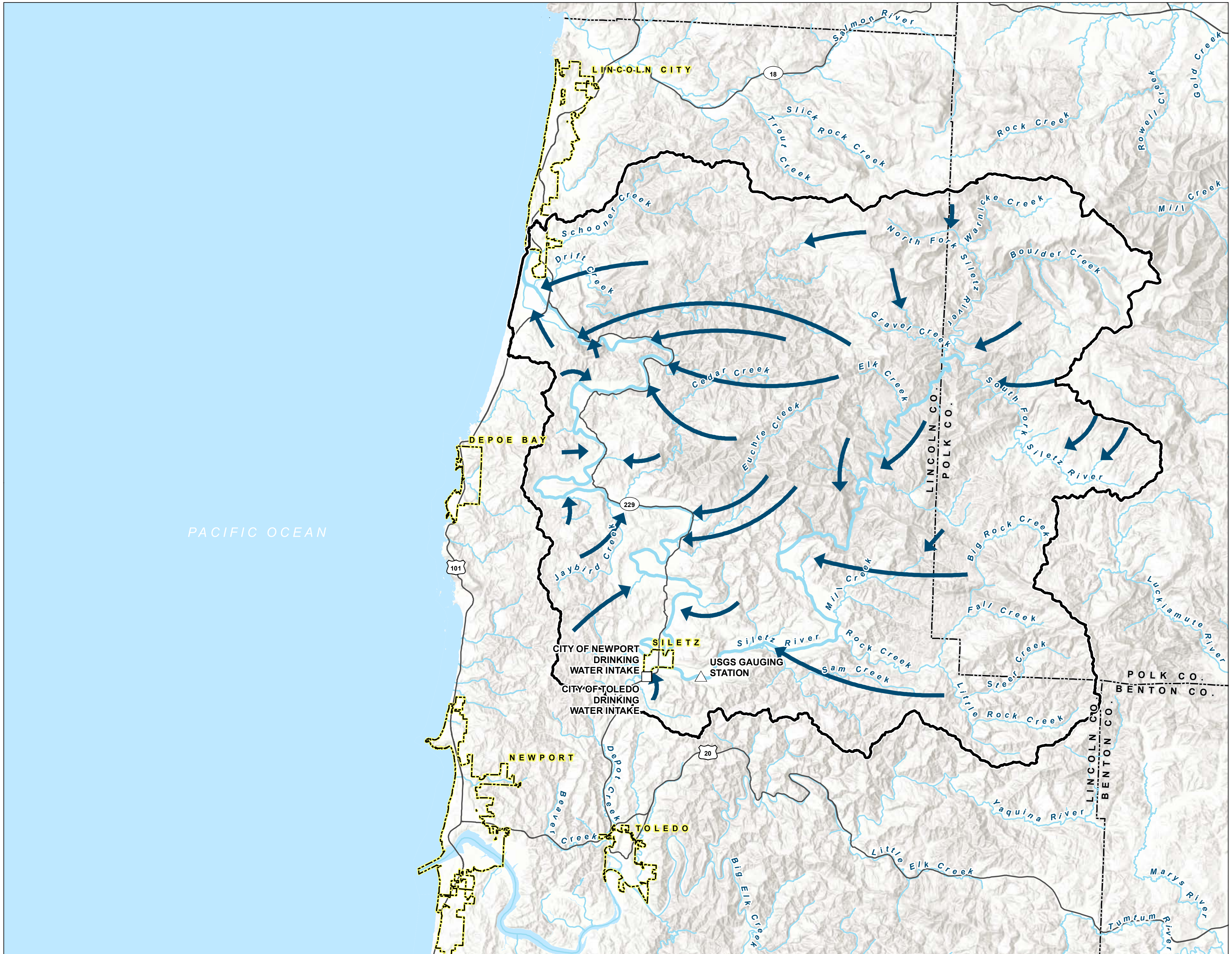
BGS: below ground surface
DTW: depth to groundwater
GPM: gallons per minute
Q: pumping rate
TD: total depth

GSI Water Solutions, Inc.

FIGURE 4

Groundwater Flow Map

Hydrogeologic and Hydrologic
Characterization of the
Siletz River Watershed



LEGEND

- Water Intake
- USGS Gauging Station
- Groundwater Flow Direction
- Siletz River Watershed
- City Boundary
- County Boundary
- Major Road
- Watercourse

N

0 2.5 5
Miles

Date: June 7, 2023
Data Sources: BLM, ESRI, ODOT, USGS

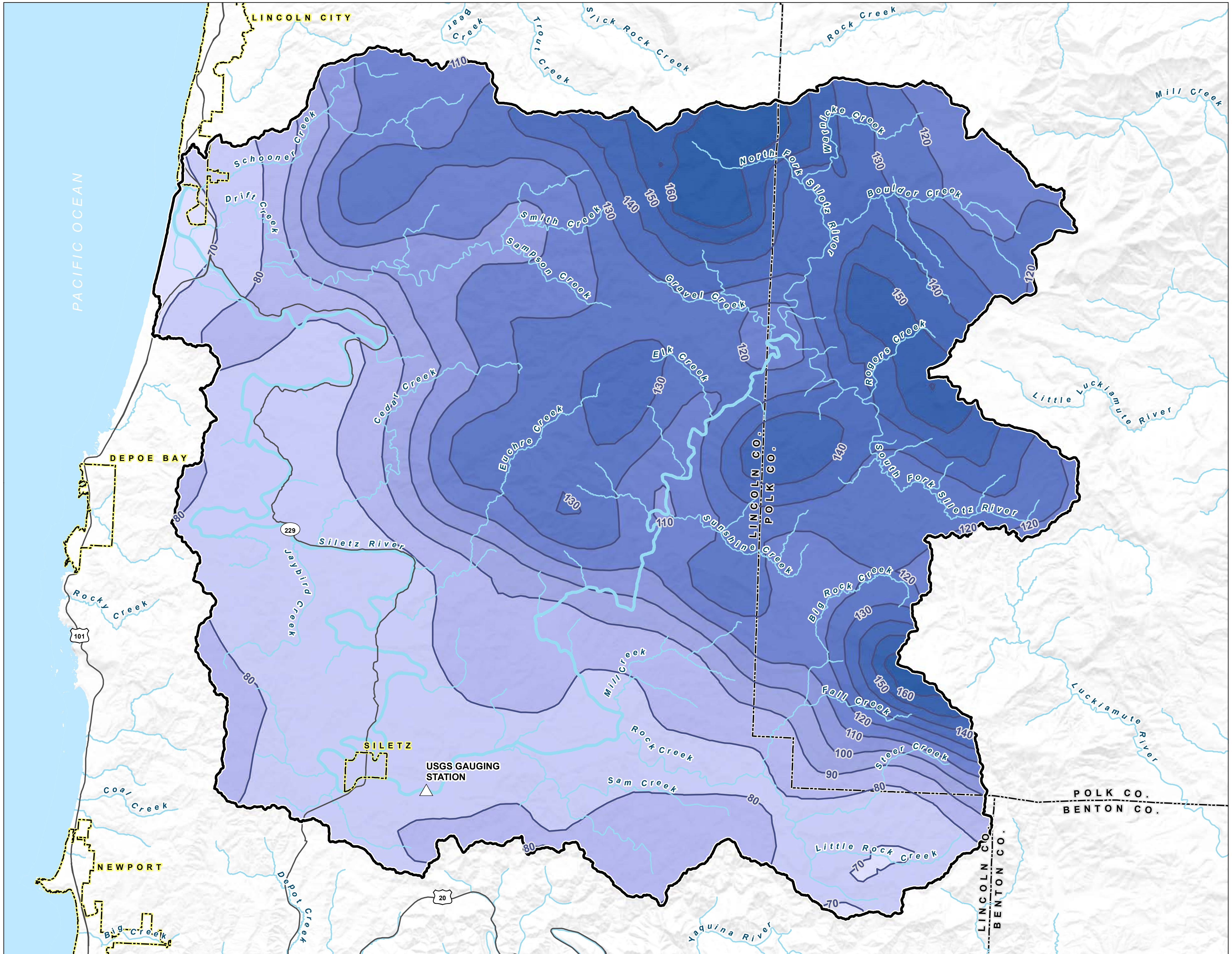
GSI Water Solutions, Inc.

Document Path: Y:\2072_Lincoln_County_Soil_and_Water\Source_Figures\001_NWQI_Phase3a\Figure4_Groundwater_Flow_Map.mxd, abarry

FIGURE 5

Average Annual Precipitation

Hydrogeologic and Hydrologic Characterization of the Siletz River Watershed



LEGEND

- USGS Gauging Station
- Annual Precipitation (inches)
- Siletz River Watershed
- City Boundary
- County Boundary
- Major Road
- Watercourse

Annual Precipitation (inches)

- 60 - 70
- 70 - 80
- 80 - 90
- 90 - 100
- 100 - 110
- 100 - 120
- 110 - 120
- 120 - 130
- 130 - 140
- 140 - 150
- 150 - 160
- 160 - 170

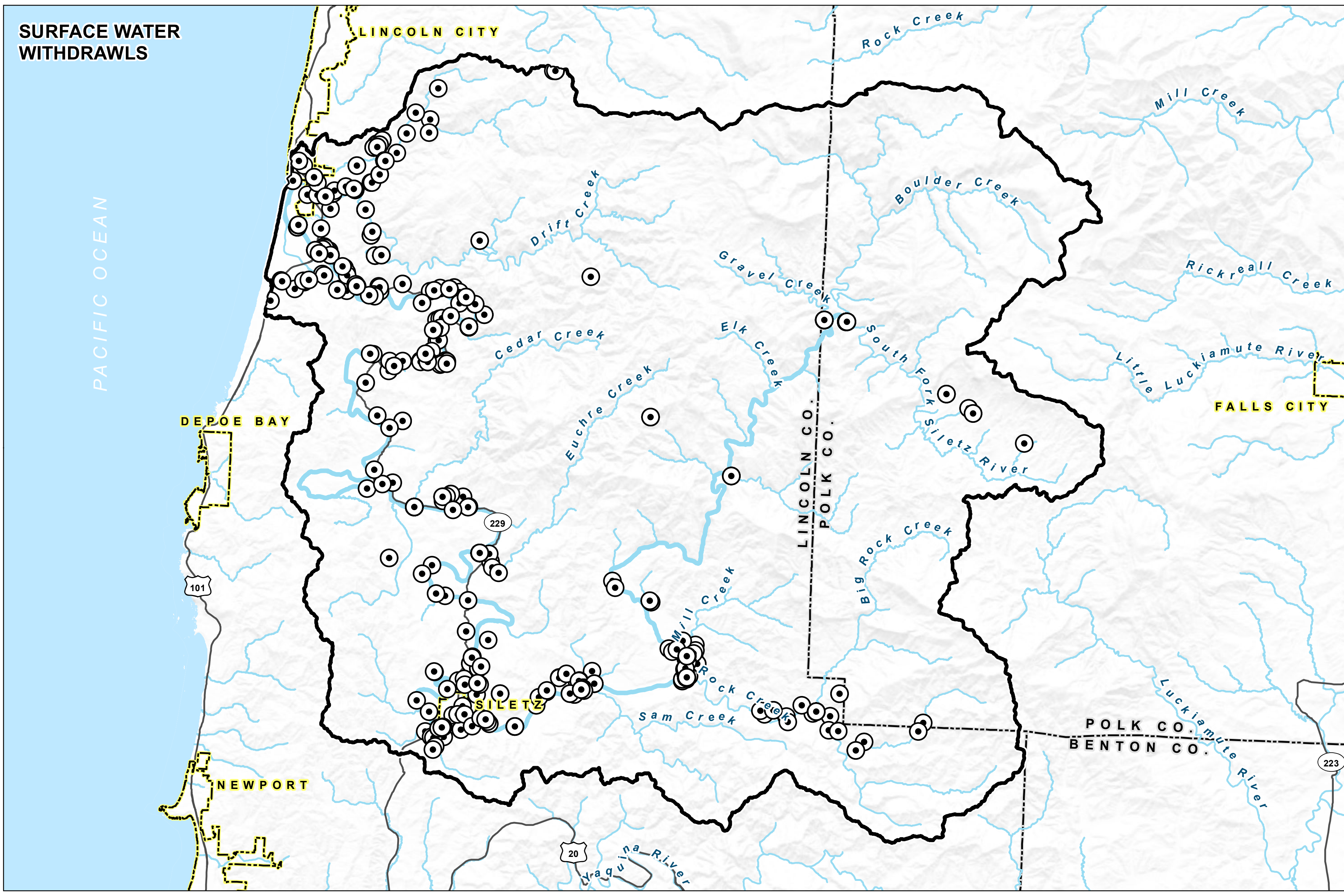
N

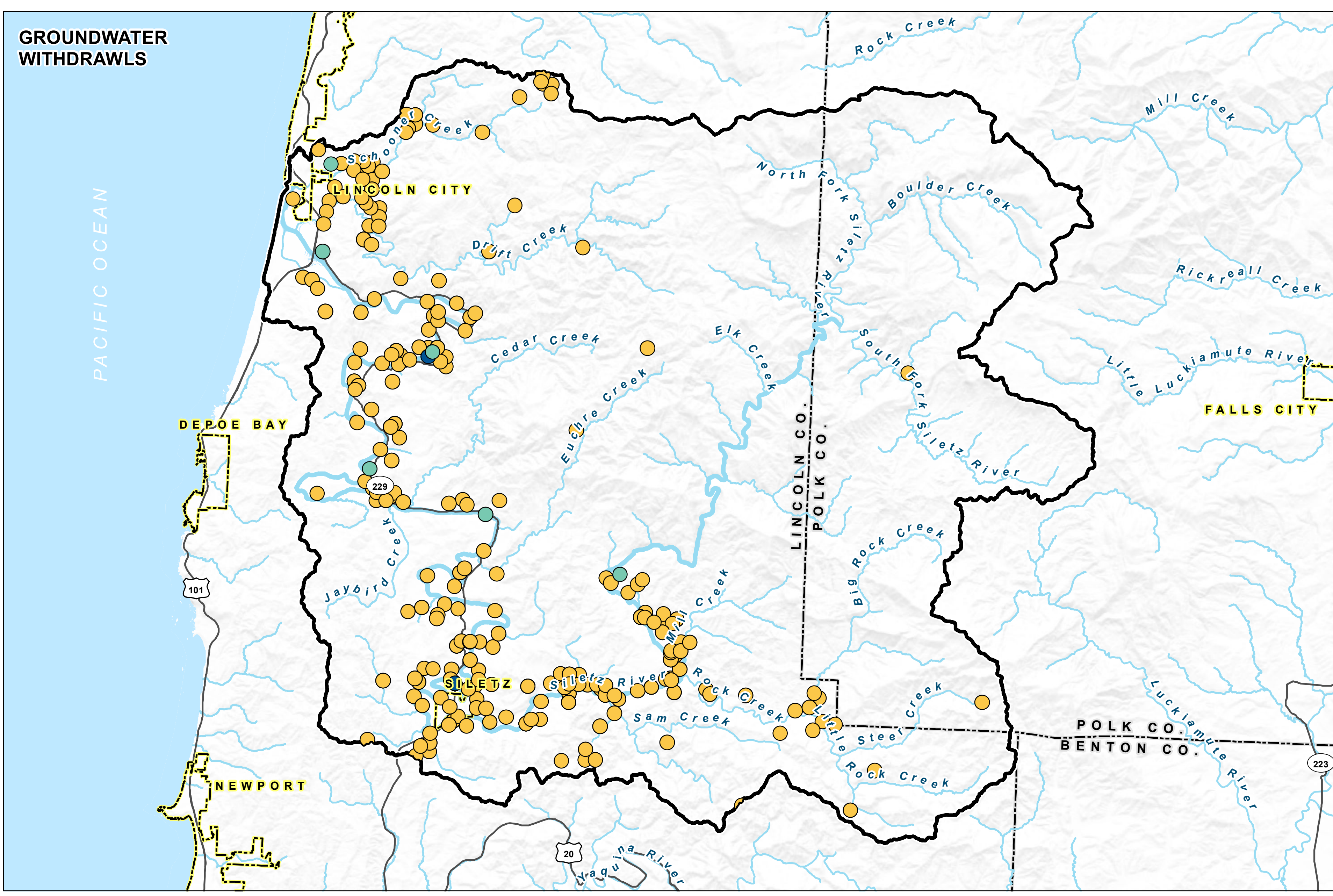
0 2 4
Miles

Date: June 7, 2023
Data Sources: BLM, ESRI, ODOT, USGS, OSU (2020)

GSI Water Solutions, Inc.

Document Path: Y:\2072_Lincoln_County_Soil_and_Water\Source_Figures\001_NWQI_Phase3a\Figure5_Avg_Annual_Precip.mxd, abarry





LEGEND

- Point of Diversion (POD)

Water Well Use Type

- Community
- Domestic
- Industrial
- Irrigation

- Siletz River Watershed
- City Boundary
- Watercourse
- Waterbody

Date: June 7, 2023
Data Sources: BLM, ESRI, ODOT, USGS, OWRD

FIGURE 6

Groundwater and Surface Water Withdrawls

Hydrogeologic and Hydrologic Characterization of the Siletz River Watershed

N

0 2 4 6
Miles

GSI Water Solutions, Inc.

Document Path: Y:\2072_Lincoln_County_Soil_and_Water\Source_Figures\001_NWQI_Phase3a\Figure6_SW_GW_Withdrawls.mxd, abarry

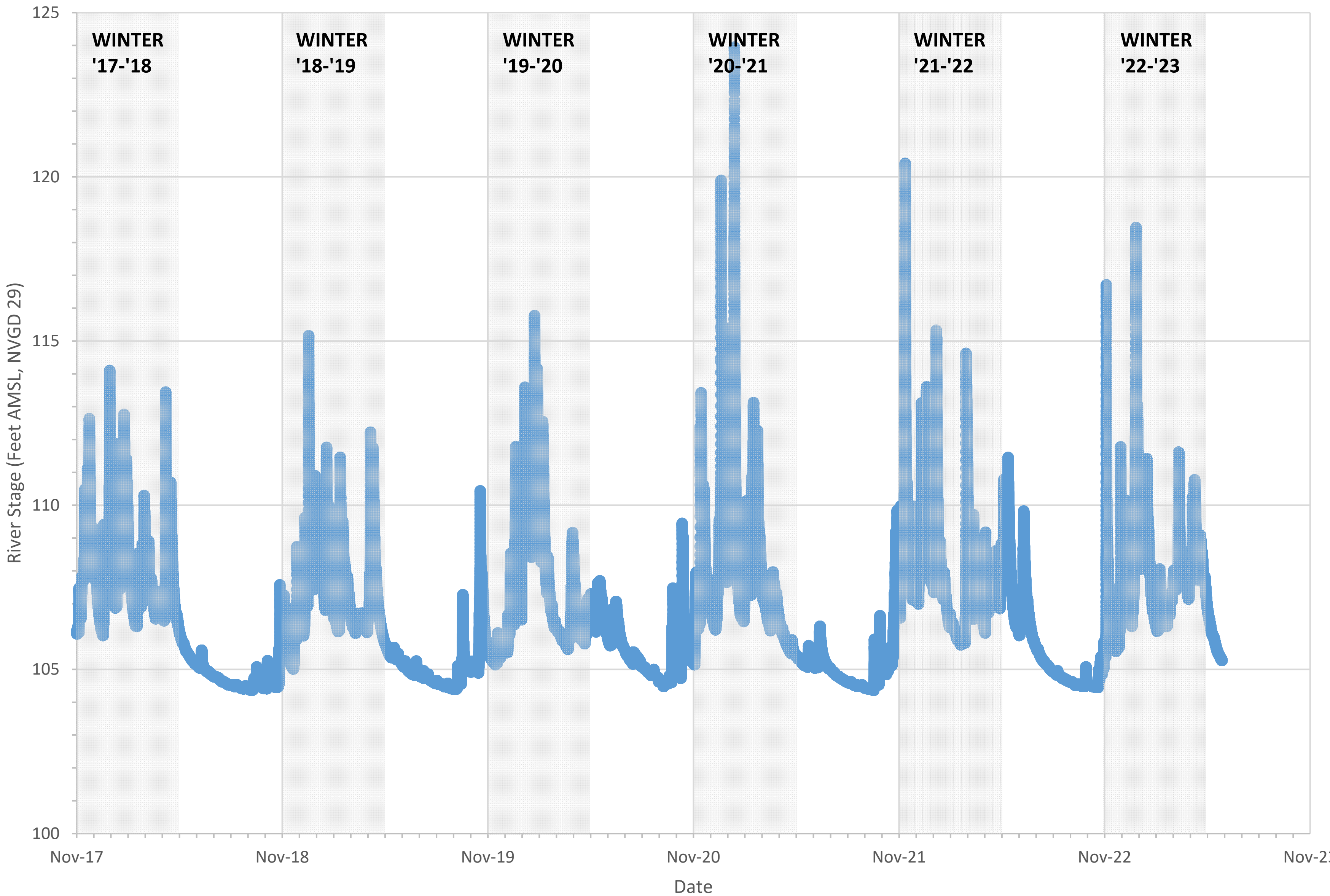


FIGURE 7(a)
Siletz River Stage, 2017 - 2023
Hydrogeologic and Hydrologic Characterization of the Siletz River Watershed

GSI Water Solutions, Inc.

P:\Portland\2072 - Lincoln County-Soil &Water\001- NWQI-Phase 3a\005 - Streamflow hydrology\Siletz River Stage and Discharge

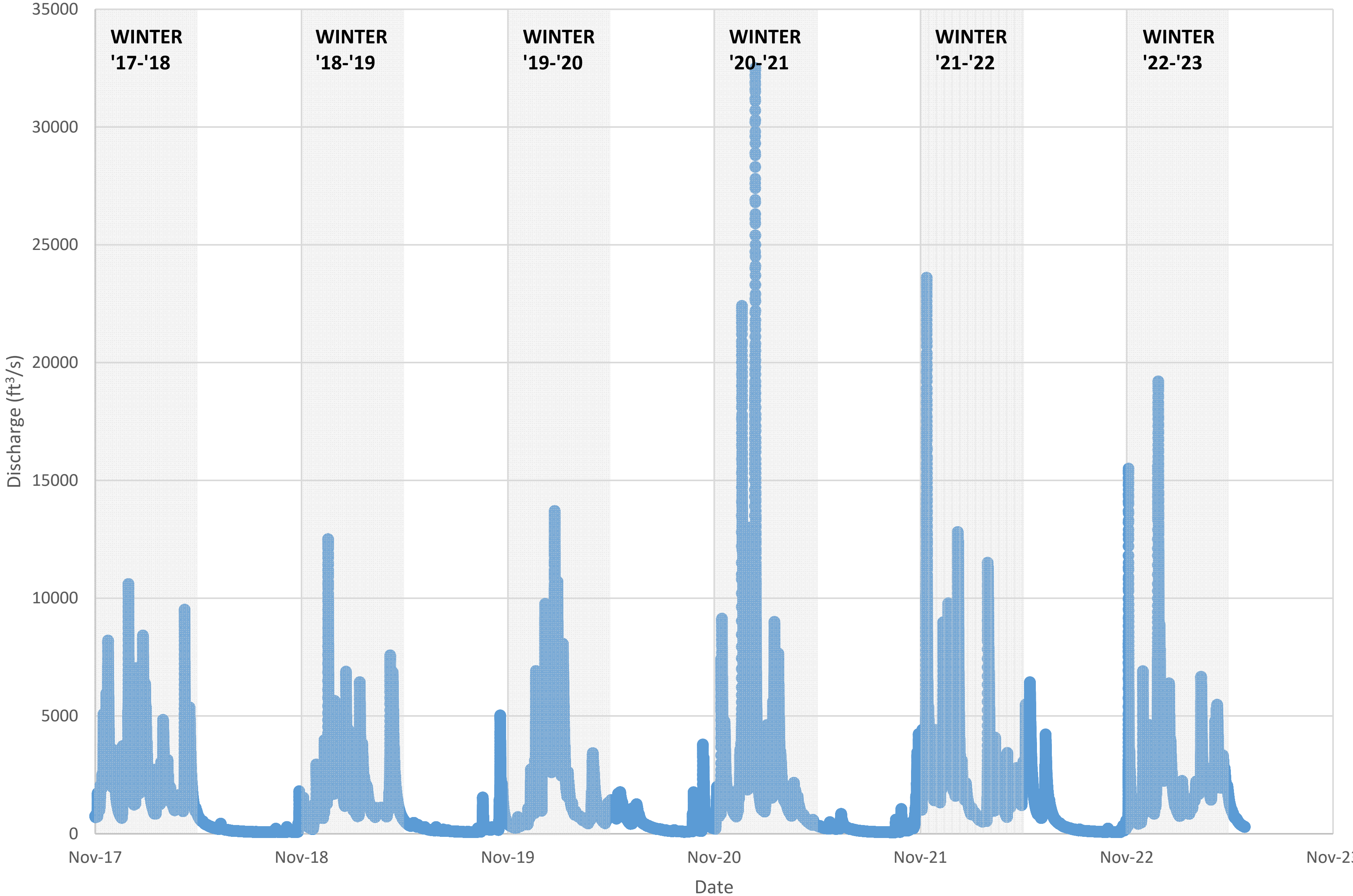


FIGURE 7(b)

Siletz River Discharge, 2017 - 2023

Hydrogeologic and Hydrologic Characterization of the Siletz River Watershed

GSI Water Solutions, Inc.

P:\Portland\2072 - Lincoln County-Soil &Water\001- NWQI-Phase 3a\005 - Streamflow hydrology\Siletz River Discharge

1. Overview of the SWPA and At-Risk Public Water Supply

a. General Characteristics

i. Contamination Level Violations

City of Siletz. (2020). Siletz Water Quality Report 2020. http://cityofsiletz.org/2021/04/siletz-water-quality-report-2020/

City of Newport Department of Water Utilities Division. (2022) 2022 Annual Water Quality Report. https://www.cityofnewport.com/en-us/files/utilities/ccr-2022-final-june2023#:~:text=For%20the%20year%202022%20the,table%20under%20Unregulated%20Contaminant%20monitoring

City of Toledo. (2021) City of Toledo 2021 Water Quality Report. https://www.cityoftoledo.org/sites/default/files/fileattachments/public_works/page/2231/water_quality_report_2021.pdf

ii. Drinking Water Systems

Oregon Health Authority. (2023) *00821 Inventory Detail: City of Siletz.* Retrieved February 27, 2024. https://yourwater.oregon.gov/inventory.php?pwsno=00821

Oregon Health Authority. (2023) *00899 Inventory Detail: Toledo Water Utilities.* Retrieved February 27, 2024. https://yourwater.oregon.gov/inventory.php?pwsno=00899

Oregon Health Authority. (2023) *00566 Inventory Detail: City of Newport.* Retrieved February 27, 2024. https://yourwater.oregon.gov/inventory.php?pwsno=00566

Oregon Health Authority. (2023) *00798 Inventory Detail: Seal Rock Water District.* Retrieved February 27, 2024. https://yourwater.oregon.gov/inventory.php?pwsno=00798

iii. Plans

Mucken, A., & Bateman, B. (Eds.). (2017) *Oregon's 2017 Integrated Water Resources Strategy.* Oregon Water Resources Department. Salem, OR https://www.oregon.gov/owrd/WRDPublications1/2017_IWRS_Final.pdf

Bacho et al. (1996) *Upper Siletz Watershed Analysis.* U.S. Department of the Interior Bureau of Land Management. https://siletz.library.oregonstate.edu/node/37856

iv. **Source Water Facilities**

State of Oregon Department of Environmental Quality. (2016) *Updated Source Water Assessment, City of Newport.* https://www.deq.state.or.us/wq/dwp/docs/uswareports/USWA_00566Newport.pdf

State of Oregon Department of Environmental Quality. (2016) *Updated Source Water Assessment, Toledo Water Utilities.* https://www.deq.state.or.us/wq/dwp/docs/uswareports/USWA_00899Toledo.pdf

State of Oregon Department of Environmental Quality. (2016) *Updated Source Water Assessment, City of Siletz.* https://www.deq.state.or.us/wq/dwp/docs/uswareports/USWA_00821Siletz.pdf

v. **Surface and Groundwater Systems**

Oregon Health Authority. (2023) *92053 Inventory Detail: LINCOLN CO PKS-MOONSHINE PARK.* Retrieved February 27, 2024. https://yourwater.oregon.gov/inventory.php?pwsno=92053

Burright, H., & LovellFord, R. (2021) (rep.) *Technical Memorandum: Water Use Summary for the Mid-Coast Place-Based Planning Area.* Oregon Water Resources Department.

b. Population

i. **Tribal**

Smith et al. (2005) *2005-2015 Comprehensive Plan: History of the Siletz.* Confederated Tribes of Siletz Indians. https://www.ctsi.nsn.us/wp-content/uploads/2020/12/CTSI-Comprehensive-Plan-2005-2015-History-Pt1.pdf

Environmental Protection Agency (2024) *EJSCREEN ACS Summary Report.* *https://ejscreen.epa.gov/mapper/demogreportpdf.aspx?report=acs2022*

c. **Contamination and Condition Concerns**

GSI Water Solutions, Inc. (2018) (rep.) *Mid-Coast Water Resources Characteristics: Water Quality* (Version 2) Mid-Coast Water Planning Partnership

Shojinaga, R. (2019) *Siletz River Dissolved Oxygen TMDL Development.* [PowerPoint Presentation] Oregon Department of Environmental Quality.

Seeds, J. (2010) (rep.) *Turbidity Analysis for Oregon Public Water Systems: Water Quality in Coast Range Drinking Water Source Areas.* Oregon Department of Environmental Quality. https://digital.osl.state.or.us/islandora/object/osl:105844

Lincoln County LUST contamination sites

2. **Characterization of the Area**
   a. **Landscape Setting**

Hobson, D. & Thomas, F. (1958) *The Valsetz Star* [Newspaper] Valsetz, OR. https://sos.oregon.gov/archives/exhibits/ghost/Documents/logging-valsetz-OHS_MSS_1441.pdf

   b. **Geology**
      i. **Siletz River Volcanics and Related Rocks**
      (ArcGIS)

      ii. **Soils**

Natural Resources Conservation Service. (2023) *Gridded National Soil Geographic Database (gNATSGO): NRCS Complete Coverage Soils Database.* U.S. Department of Agriculture.

Natural Resources Conservation Service. (2020) *Gridded Soil Survey Geographic (gSSURGO) Database: User Guide.* U.S. Department of Agriculture.

   c. **Climate**

Mote, P.W., J. Abatzoglou, K.D. Dello, K. Hegewisch, D.E. Rupp. (2019) (rep.) *Fourth Oregon Climate Assessment Report*. Oregon Climate Change Research Institute. occri.net/ocar4.

Leibowitz et al. (2014) *Hydrologic landscape classification evaluates streamflow* *vulnerability to climate change in Oregon, USA.* Hydrology and Earth System Sciences, 18(3367–3392), https://doi.org/10.5194/hess-18-3367-2014

d. Topography and Drainage System

e. Land Cover and Water Uses

i. Forestry

Stednick, J. (2008) *Hydrological and Biological Responses to Forest Practices: The Alsea Watershed Study.* Fort Collins, CO: Springer. DOI:10.1007/978-0-387-69036-0 https://www.researchgate.net/publication/321619686_Hydrological_and_Biological_Responses_to_Forest_Practices_The_Alsea_Watershed_Study

Benda, L. (1990) *The Influence of Debris Flows on Channels and Valley Floors in the Oregon Coast Range, U.S.A.* Earth Surface Processes and Landforms Vol 15, 457-466 https://doi.org/10.1002/esp.3290150508

Olson, D. H., & Burnett, K. M. (2009). Design and management of linkage areas across headwater drainages to conserve biodiversity in forest ecosystems. Forest Ecology and Management, 258. https://doi.org/10.1016/j.foreco.2009.04.018

Richardson, K. N. D., Hatten, J. A., & Wheatcroft, R. A. (2018). 1500 years of lake sedimentation due to fire, earthquakes, floods and land clearance in the Oregon Coast range: Geomorphic sensitivity to floods during timber harvest period. Earth Surface Processes and Landforms, 43(7), 1496–1517. https://doi.org/10.1002/esp.4335

Spies et al. (2002) The Ecological Basis of Forest Ecosystem Management in the Oregon Coast Range. Academia, 19(31-67) https://www.fsl.orst.edu/rna/Documents/publications/Flynn%20Creek%20spies_etal_2002_ecological_basis.pdf

Oregon Department of Forestry. (2022) (rep.) Private Forest Accord Report. https://www.oregon.gov/odf/aboutodf/documents/2022-odf-private-forest-accord-report.pdf

ii. Misc.

Senate Bill 1602, 80th Oregon Legislative Assembly, 2020 Special Session. (Ore. 2020) https://olis.oregonlegislature.gov/liz/2020S1/Measures/Overview/SB1602

Burright, H., & LovellFord, R. (2021) *Technical Memorandum: Water Rights Summary for Mid-Coast Planning Area and Sub-Areas.* Oregon Water Resources Department.

f. Socioeconomic

Banwarth et al. (2022) *Lincoln County Community Health Assessment, 2018-2022*. Lincoln County Health and Human Services. Newport, OR. https://www.co.lincoln.or.us/786/Public-Health-Reports

Caplan et al. (2021) *Oregon by the Numbers: Key measures for Oregon and its counties.* Oregon State University Extension Service. https://www.tfff.org/oregon-numbers/

Hatfield, S. C. (2009). *Traditional ecological knowledge of Siletz tribal members.* (dissertation). Oregon State University, Corvallis. https://ir.library.oregonstate.edu/concern/graduate_thesis_or_dissertations/jq085n53x

g. Unsorted

O' Neill, S. (2022) (rep.) *Lincoln County Agriculture Climate Adaptation Survey Report.* Siletz, OR. Lincoln County Board of Commissioners.

Mid Coast Local Advisory Committee. (2019) *Mid Coast Agricultural Water Quality Management Area Plan.* Oregon Department of Agriculture. https://www.oregon.gov/oda/shared/Documents/Publications/NaturalResources/MidCoastAWQMAreaPlan.pdf

Gillette, C., Sham, C. H., Rosenberg, B. (2021) (rep.) *Source Water Protection Performance Metrics.* American Water Works Association. https://www.awwa.org/Portals/0/AWWA/ETS/Resources/Technical%20Reports/28885%20SWP%20Metrics%20Report.pdf?ver=2021-08-10-120859-970

Frank, F. J., Laenen, A. (1977) (rep.) *Water Resources of Lincoln County Coastal Area, Oregon.* U.S. Geological Survey, Oregon Water Resources Department. https://pubs.usgs.gov/wri/1976/0090/report.pdf

The Trust for Public Land. (2005) *The Source Protection Handbook: Using Land Conservation to Protect Drinking Water Supplies.* The Trust for Public Land, American Water Works Association. https://www.awwa.org/Portals/0/AWWA/ETS/Resources/Technical%20Reports/water_source_protect_hbook.pdf?ver=2021-05-21-123115-573

3. **Hydrology and Water Quality Characterization**
   a. **Available Data**
      i. **USGS- Water Supply**

Eshleman, D. (2018) *Water Management and Conservation Plan.* City of Siletz Public Works Department. Siletz, OR.

GSI Water Solutions, Inc. (2017) *Water Management and Conservation Plan.* City of Toledo, Oregon. https://www.cityoftoledo.org/sites/default/files/fileattachments/public_works/page/2981/toledo-wmcp_final_sept2017_wfo.pdf

   b. **Potential Contaminants of Concern**
      i. **Agriculture**

Census of Agriculture. (2017) *County Profile: Lincoln County, Oregon.* https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Oregon/cp41041.pdf

   c. **Unsorted**

GSI Water Solutions, Inc. (2023) *Technical Memorandum: Water Quality Characterization of the Siletz River Watershed in Support of a National Water Quality Initiative Source Water Assessment (Phase 3b).* Lincoln Soil & Water Conservation Dist., Newport, OR.

4. **Unsorted**

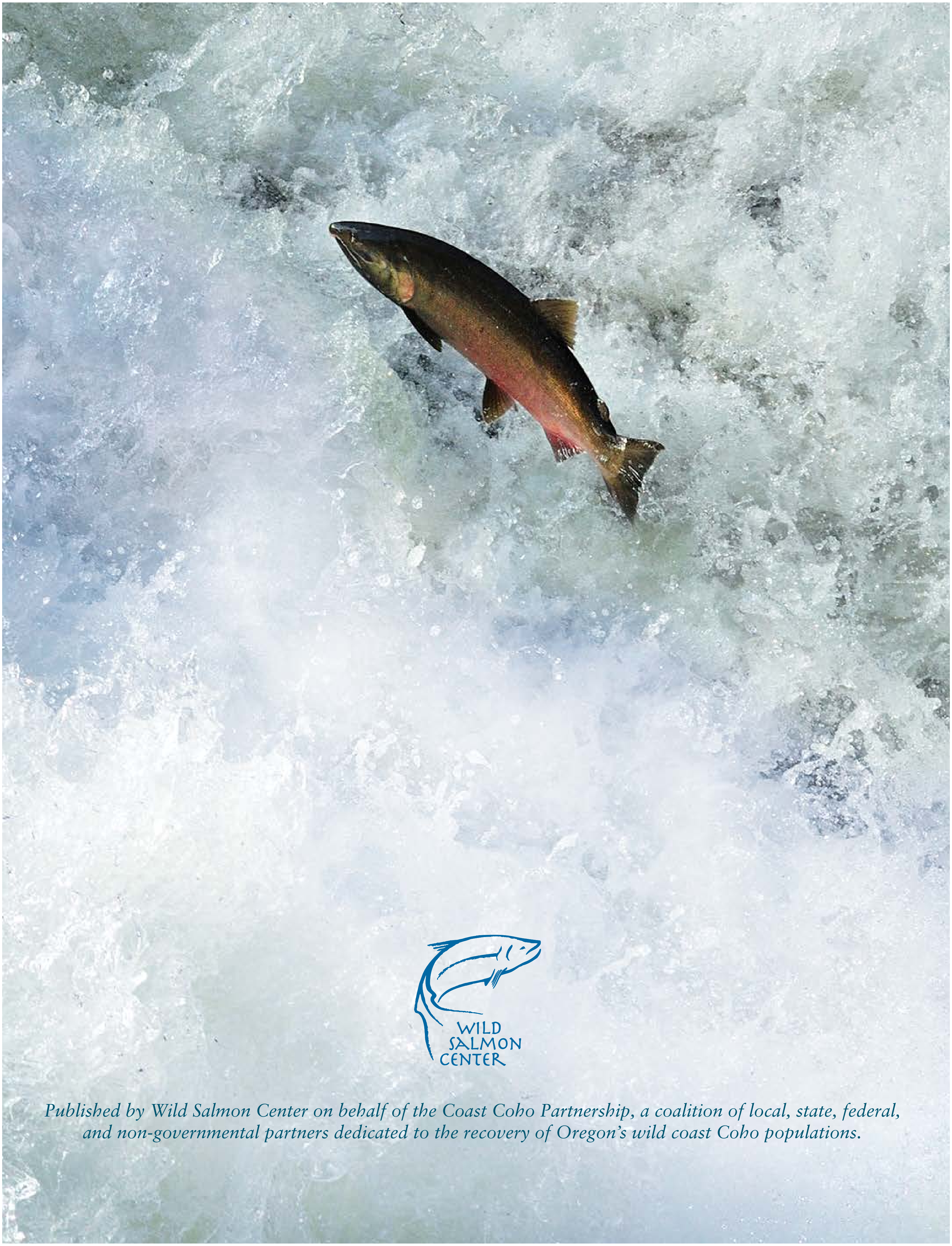
Gregory, S. V., Swanson, F. J., McKee, W. A., & Cummins, K. W. (1991). An Ecosystem Perspective of Riparian Zones. *BioScience*, *41*(8), 540–551. https://doi.org/10.2307/1311607

Neimi, E. (2009) (rep.) *An Overview of Potential Economic Costs to Oregon of a Business-As-Usual Approach to Climate Change.* The Program on Climate Economics, Climate Leadership Initiative, Institute for a Sustainable Environment, University of Oregon. https://pages.uoregon.edu/digital/uonews-archive//sites/uonews1-stage.uoregon.edu/files/uploads/OR-Fnl_Rpt.pdf

Fernandez et al. (2012) Quantifying the performance of automated GIS-based geomorphological approaches for riparian zone delineation using digital elevation models. *Hydrol. Earth Syst. Sci., 16, 3851–3862, https://doi.org/10.5194/hess-16-3851-2012*

Natural Resources Conservation Service (NRCS), U.S. Department of Agriculture (USDA). 2009. *Stream Visual Assessment Protocol Version 2*. National Biology Handbook, Subpart B – Conservation Planning, Part 614

Drift Creek. Photo: Dave Herasimtschuk



WILD
SALMON
CENTER

Published by Wild Salmon Center on behalf of the Coast Coho Partnership, a coalition of local, state, federal, and non-governmental partners dedicated to the recovery of Oregon's wild coast Coho populations.