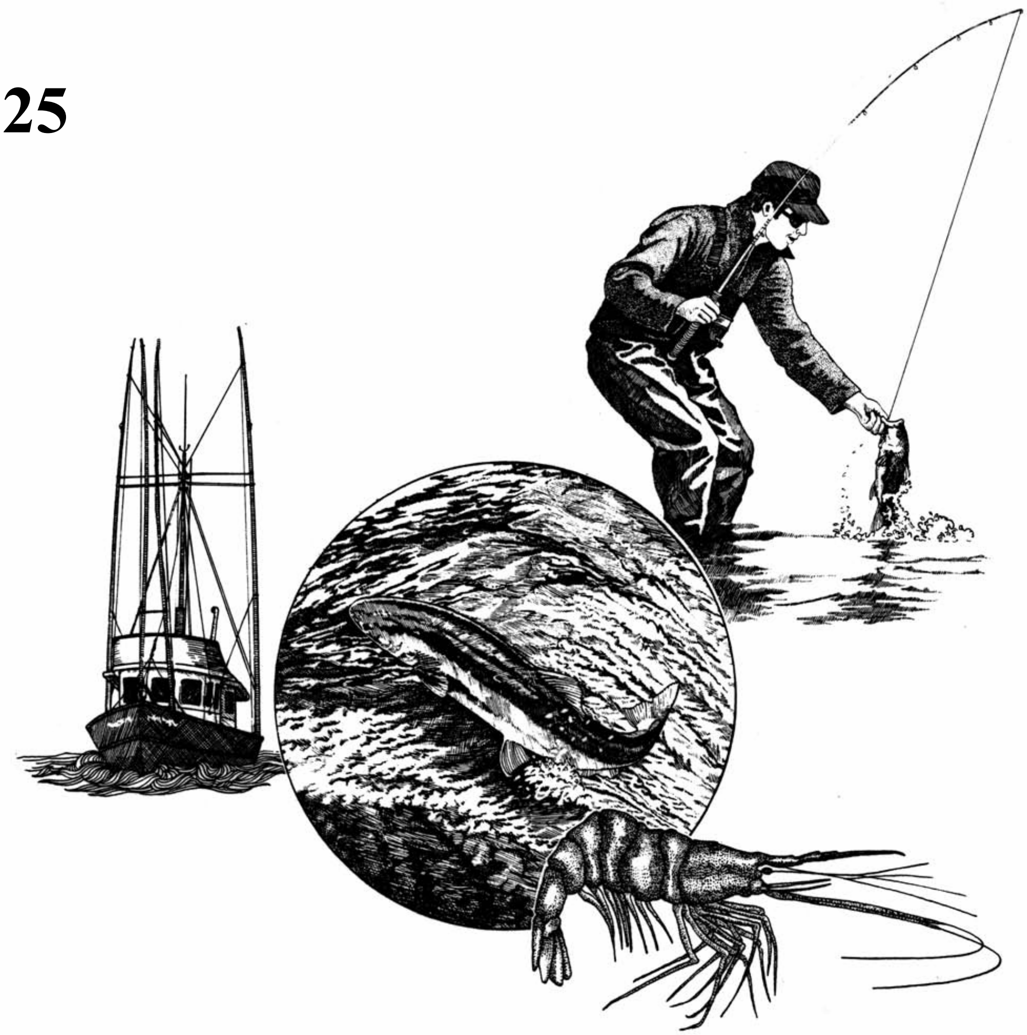
# ODFW PROGRESS REPORT Series

# 2025



## Oregon Department of Fish and Wildlife

*2024- Monitoring Report for the Clackamas Focused Investment Partnership.*

*Progress Report No. OPSW-ODFW-2025-7*

# PROGRESS REPORT FISH RESEARCH PROJECT OREGON

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Prepared by

Eric Bailey

Matt Strickland

Erik Suring

Oregon Department of Fish and Wildlife

4034 Fairview Industrial Drive SE

Salem, OR 97302



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ABSTRACT

In 2024, the Oregon Department of Fish and Wildlife's (ODFW) Aquatic Inventories Program (AQI) and Unoccupied Aerial System (UAS) operations continued their collaborative efforts with the Clackamas Focused Investment Partnership (FIP) to monitor habitat restoration in the Clackamas River basin. This initiative aligned with the goals of the Clackamas Partnership Strategic Plan to enhance river and stream habitats for native fish and wildlife. The comprehensive monitoring strategy included on-the-ground and boat habitat surveys, snorkel surveys, UAS operations, and temperature monitoring. These methods collectively assessed and documented changes in habitat and conditions, as well as the presence of juvenile salmonids at a watershed scale.

ODFW surveyed one pre-restoration site: Austin Hot Springs. Post-restoration monitoring was conducted at Kingfisher, Eagle Creek, Riverbend, Barton Natural Area, Johnson "J" Creek, and Holcomb Creek. Ongoing monitoring was conducted at three established control sites on the Lower Clackamas River: Upper, Middle, and Lower Controls. A new control site, USFS Control, was established on the Upper Clackamas to pair with Austin Hot Springs. UAS and physical habitat ground surveys were conducted from March to April, capturing winter base-flow conditions and available habitat. The UAS was also utilized in September during summer base-flow conditions, while snorkel surveys identified fish usage and assemblage in pool habitats. Additionally, year-round temperature monitoring locations were established to describe changes at the site across seasons and assess juvenile salmonid rearing suitability. Temperature loggers were deployed in March at twelve locations: Austin Hot Springs, USFS Control Main River, USFS Control Side Channel, Upper Control, Upper Clackamas River, Kingfisher, Middle Control, Middle Clackamas River, Eagle Creek, Lower Control, Lower Clackamas River, and Riverbend.

The analysis focused on data from paired sites, comparing the mean differences between pre-treatment and post-treatment periods and assessing habitat quality across salmonid life stages using the HabRate model. After restoration, all post-one-year sites showed changes; fine sediments (silt and sand) decreased, while gravel and cobble increased. There was also an increase in wood volume ($m^3$) and the number of key pieces (≥12 meters in length and 60 cm in diameter). HabRate modeling indicated that surveyed habitats were generally fair for all life history types, with minor changes compared to previous years. Snorkel surveys revealed the presence of native fish at all surveyed sites. Initial temperature results suggest more variability at the site level and across seasons, and higher summer stream temperatures at locations downstream of River Mill Dam when compared to those in the upper basin (Austin Hot Springs and USFS Control locations).

2024 marked the fifth year of AQI's seven-year commitment to monitor the Clackamas FIP. By comparing metrics collected from pre- and post-restoration sites, control sites, and the mainstem Clackamas River, we will assess habitat changes and salmonid occupancy at a spatial scale aligned with restoration efforts.

## BACKGROUND

The Aquatic Inventories Program (AQI) and Unoccupied Aircraft System (UAS) operations of the Oregon Department of Fish and Wildlife (ODFW) are integral to the Clackamas Focused Investment Partnership (FIP) by providing monitoring services to assess the effectiveness and impact of habitat restoration. This collaborative effort involves the evaluation of proposed restoration sites, control channels, and mainstem river surveys to measure the effectiveness of restoration activities at individual sites, reach, and basin scales over seven years (2020-2026).

In spring 2020, ODFW conducted habitat surveys on the mainstem Clackamas River, using ground-based methods and Side Scan Sonar (SSS) to establish a pre-restoration baseline for the Lower Clackamas River. A more detailed report outlining how sonar data are collected and analyzed can be found in Strickland et al. (2019). Simultaneously, ground-based surveys were conducted at proposed restoration sites. Additional mainstem surveys are planned for 2026 to monitor habitat changes associated with restoration efforts across specific reaches and throughout the basin.

In 2021, ODFW surveyed eight sites, including three post-restoration treatments, two locations proposed for future restoration, and three control sites. UAS and physical habitat ground surveys were carried out to capture typical high-water conditions during winter and low-flow stream conditions in summer. Snorkel surveys were performed at the end of summer to identify fish usage and assemblages.

In 2022, the habitat surveys focused on the Kingfisher restoration site and three control sites. These surveys were primarily conducted in March, following the implementation of the restoration efforts. UAS aerial surveys occurred in March, April, May, and September, while snorkel surveys took place from July to September.

In 2023, habitat surveys were expanded to include five pre-restoration sites: Johnson “J” Creek, Holcomb Creek, Barton Natural Area, Landslide Toe, and Austin Hot Springs. Post-restoration monitoring was conducted at Riverbend, Newell Creek, and Abernethy Creek. Additionally, we continued monitoring three established control sites along the Lower Clackamas River: Upper, Middle, and Lower Controls. Restoration enhancements were implemented at Holcomb Creek, Johnson “J” Creek, and Barton Natural Area during the summer of 2023. Comparisons of pre- and post-restoration conditions will be made in 2024 to document the results one year after the enhancements are implemented.

In 2024, ODFW surveyed eleven sites, including one pre-restoration location —Austin Hot Springs —and six post-restoration sites: Kingfisher, Eagle Creek, Riverbend, Barton Natural Area, Johnson “J” Creek, and Holcomb Creek. We continued monitoring three established control sites along the Lower Clackamas River: Upper, Middle, and Lower Controls. A new control site, USFS Control, was established on the Upper Clackamas to pair with Austin Hot Springs. Additionally, ODFW added stream temperature monitoring to describe seasonal variability within sites and assess juvenile salmonid rearing suitability. Temperature loggers were deployed at twelve locations: Austin Hot Springs, USFS Control Main River, USFS Control Side Channel, Upper Control, Upper Clackamas River, Kingfisher, Middle Control, Middle Clackamas River, Eagle Creek, Lower Control, Lower Clackamas River, and Riverbend. Restoration enhancements were implemented at Holcomb Creek, Johnson "J" Creek, and Barton Natural Area during the summer of 2023. Comparisons of pre- and post-restoration conditions will be made in this report to document the results one year after the enhancements were implemented. Restoration activities took place during the summer of 2024 at Austin Hot Springs, with pre- and post-restoration comparisons to be made in 2025 to document the results one year after the enhancements. Landslide Toe, which was surveyed pre-restoration in 2023 and was initially planned to be included in this report, was postponed for restoration in 2024; comparisons of pre- and post-restoration will occur upon completion of the treatments.

This report provides a comprehensive overview of habitat monitoring, outlining the methods used to evaluate various habitat types. The report includes information on reach boundaries, general habitat characteristics, channel area and depth profiles, structure complexity, and the composition and occupancy of general fish species in each surveyed area. The data presented should be viewed as baseline conditions for control channels and primary river habitats in the context of restoration activities.

## METHODS

### Study Area

In 2024, one site, Austin Hot Springs, was surveyed before restoration efforts occurred. Additionally, six sites were surveyed following restoration—Kingfisher, Eagle Creek, Riverbend, Johnson "J" Creek, Holcomb Creek, and Barton Natural Area—and four control sites —Upper, Middle, Lower, and USFS Control channels —were surveyed (Figure 1).

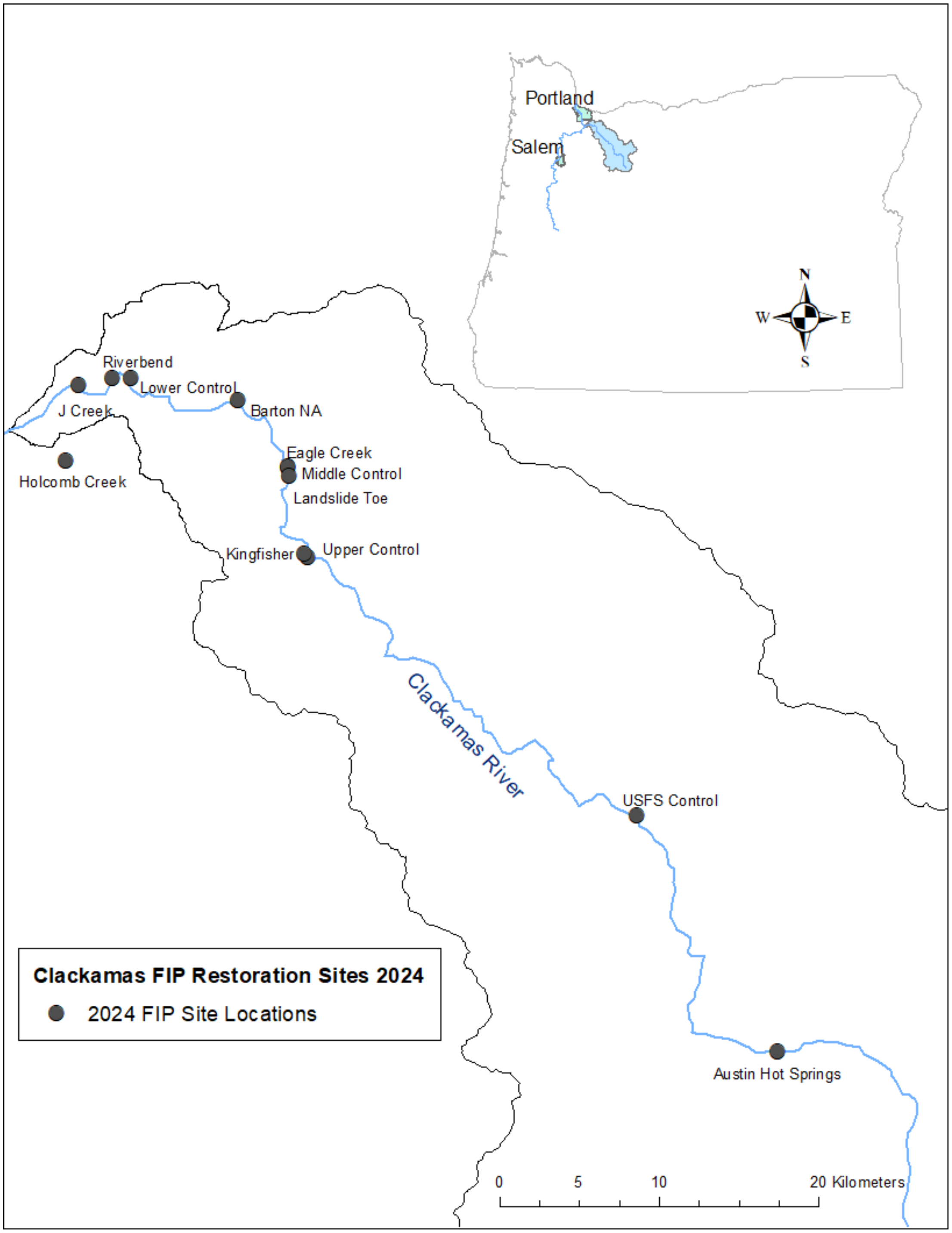


*Figure 1. 2024 Clackamas FIP Sites.*

## Barton Natural Area (NA)

The Barton Natural Area spans an expansive 95 acres, including nearly 32 acres of aquatic habitat, and is located on the east side of the main channel of the Clackamas River. It sits approximately 0.18 kilometers downstream from Barton Bridge and flows northwest for 887 meters.

In the summer of 2023, the Barton Natural Area underwent restoration enhancements to improve floodplain connectivity, alcove habitat, side channel habitat, and strategically placed large woody debris. Figure 2 depicts the Barton Natural Area during the winter and summer of 2024. UAS imagery illustrates the area's restoration efforts one year later. One significant change is that a historic secondary channel was surveyed up to Barton Bridge before restoration, featuring numerous distinct habitat units. During restoration, the side channel was excavated into a long, deep alcove unit with submerged large wood habitat structures and a defined endpoint.

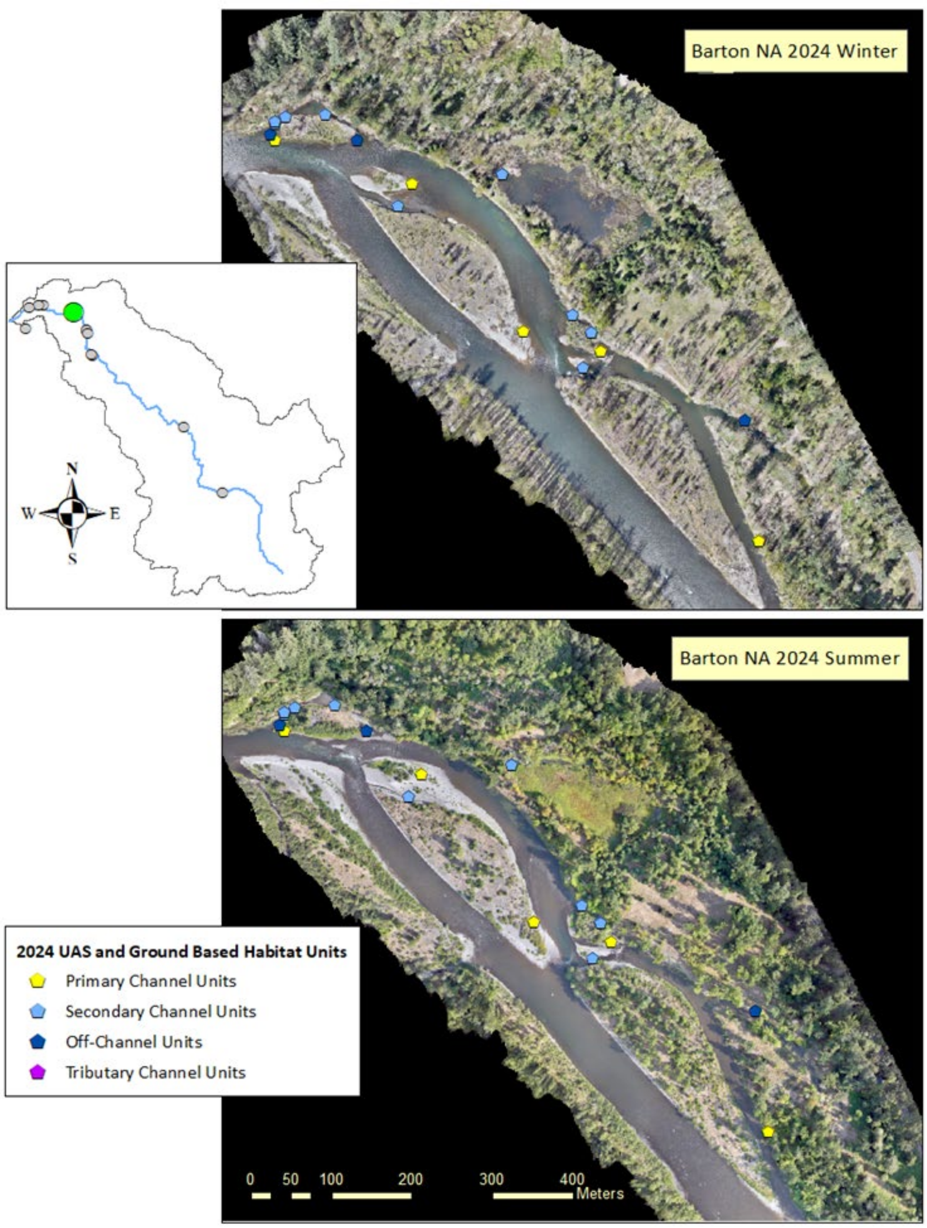


*Figure 2. Barton Natural Area. Winter and Summer 2024 UAS imagery and ground-based survey points 1 year post-restoration.*

### Holcomb Creek

Holcomb Creek, a tributary of lower Abernethy Creek, is located approximately 1.7 kilometers southeast of the North Newell restoration site, directly adjacent to South Meadow View Drive and Redland Road. The creek flows southwest for 217 meters and has the potential to shift 37 meters between constraining hillslopes.

Restoration enhancements were implemented in the summer of 2023. These improvements included placing large wood, constructing several Beaver Dam Analogs (BDAs), and addressing invasive blackberry growth along the edges of the Holcomb Creek channel. Figure 3 visually represents Holcomb Creek during the winter and summer of 2024. The UAS imagery depicts the area's restoration efforts one year after the project.

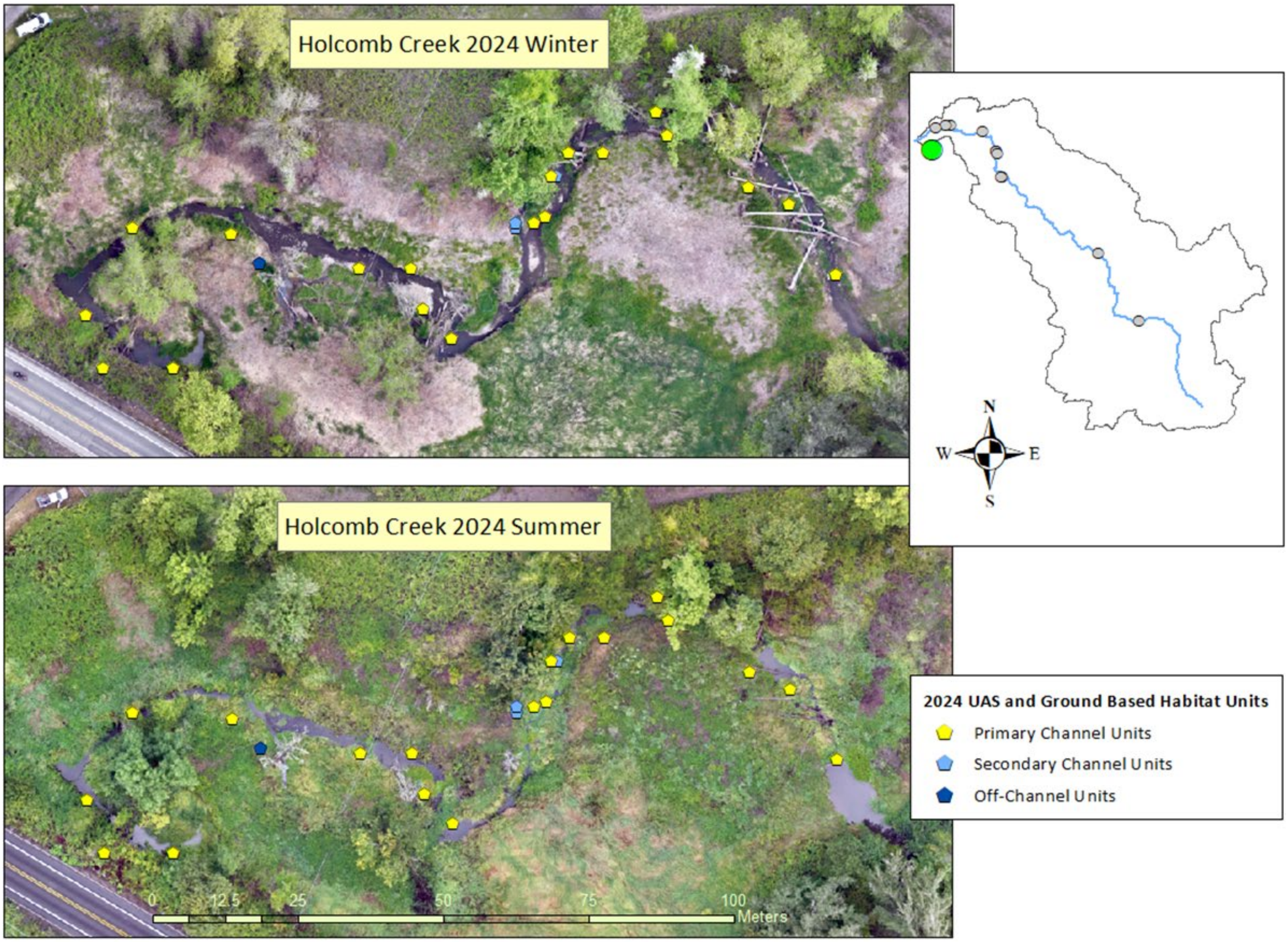


*Figure 3. Holcomb Creek. Winter and Summer 2024 UAS imagery and ground-based survey points 1 year post-restoration.*

## Johnson "J" Creek

The side channel at the confluence of Johnson "J" Creek, located approximately 1.2 kilometers upstream of Riverside Park and directly adjacent to the downstream end of BeeBee Island on the Clackamas River, extends for 511 meters and maintains a perennial connection. The creek is constrained by high terraces, and a Valley Width Index (VWI) indicates that the channel has the potential to shift up to 20 meters within the site boundaries.

In the summer of 2023, restoration efforts were initiated to enhance the habitat of the Johnson "J" Creek side channel. The focus was on re-establishing and expanding connectivity at the upper and mid inlets. The project also included the removal of an existing culvert barrier. Large wood structures were strategically placed throughout the newly constructed channel. UAS imagery was captured during the winter and summer of 2024, showing Johnson "J" Creek one year after restoration, as illustrated in Figure 4.

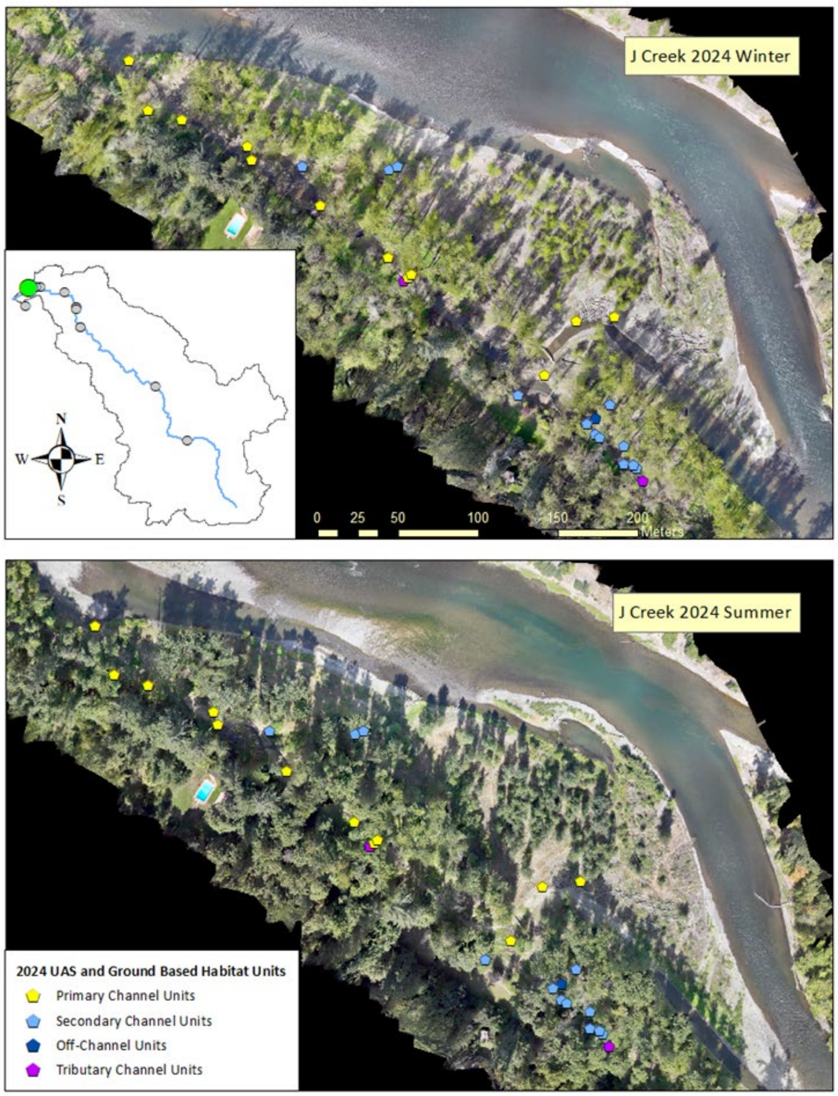


*Figure 4. Johnson "J" Creek. Winter and Summer 2024 UAS imagery and ground-based survey points 1 year post-restoration.*

## Austin Hot Springs

Austin Hot Springs, situated next to National Forest Road 46, flows northwest between Drip Creek and Switch Creek. The site spans nearly 1.3 kilometers along the mainstem Clackamas River habitat. Hillslopes constrain the Austin Hot Springs area, and a Valley Width Index (VWI) suggests that the main channel can shift up to 48 meters between the hillslopes. Figure 5 illustrates the Austin Hot Springs site in 2024 during the winter, before restoration implementation, and summer after restoration. However, it should be noted that the habitat points displayed correspond to the pre-enhancement habitat units. Due to the river's large size, the main channel was surveyed from upstream to downstream using inflatable kayaks, while the side channel habitats were surveyed on foot, moving upstream.

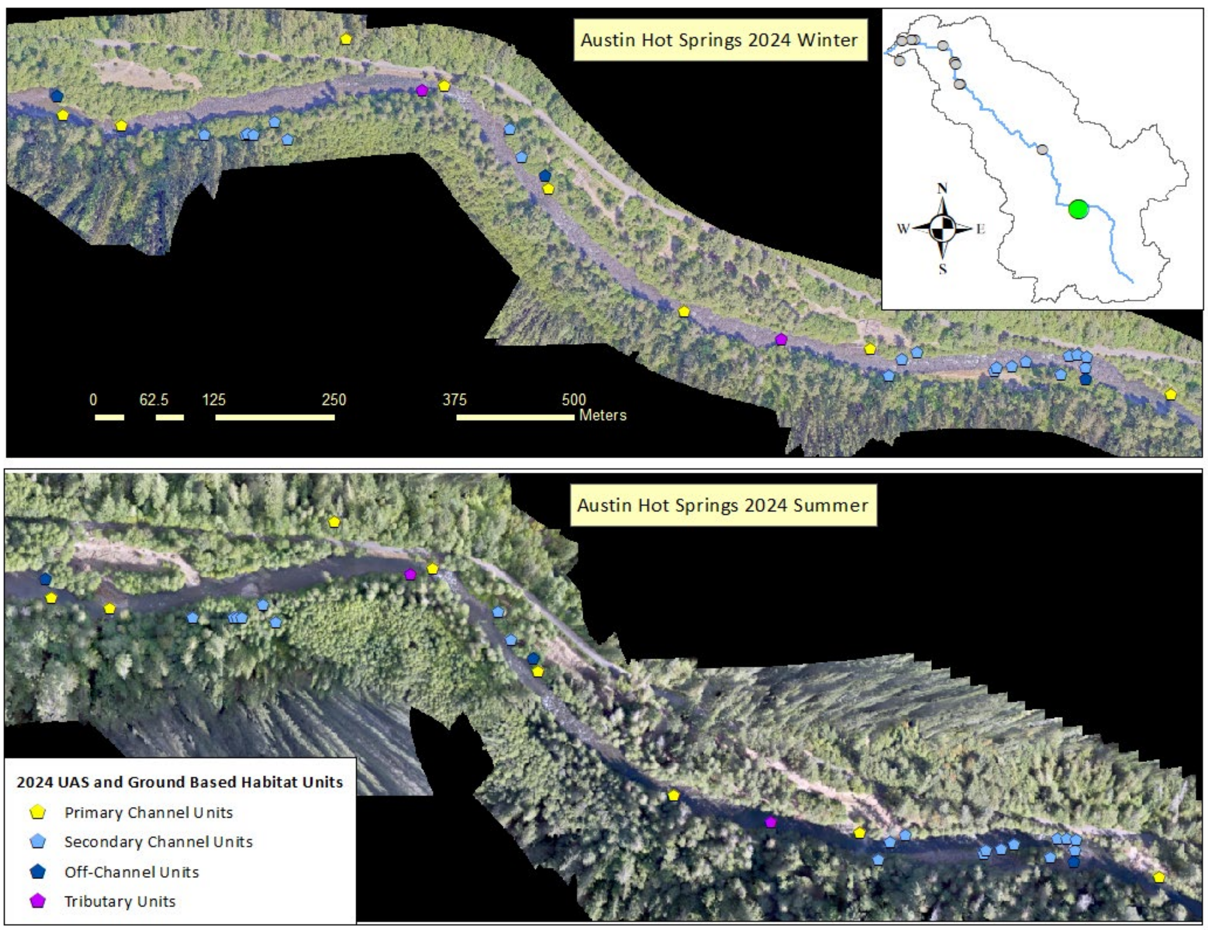


*Figure 5. Austin Hot Springs. Winter and Summer 2024 UAS imagery and ground-based survey points.*

## USFS Control

The USFS Control is located approximately 22 kilometers upstream of the North Fork Clackamas River Reservoir. Figure 6 depicts the USFS Control during the winter and summer of 2024. It encompasses a 1.24-mile (2.0 km) reach that starts at Sunstrip Campground and concludes at the Hole in the Wall boat access site. The Control Reach was surveyed downstream due to the river's large scale. It flows northwest through a series of rapid and pool units constrained by hillslopes and is bisected by one named tributary, Roaring River, along with several smaller seasonal runoff tributaries. A secondary channel at the Hole in the Wall boat access site provides refuge habitat for juvenile salmon. The potential movement of the USFS Control is limited to 54 meters due to the surrounding hillslopes and Highway 224.

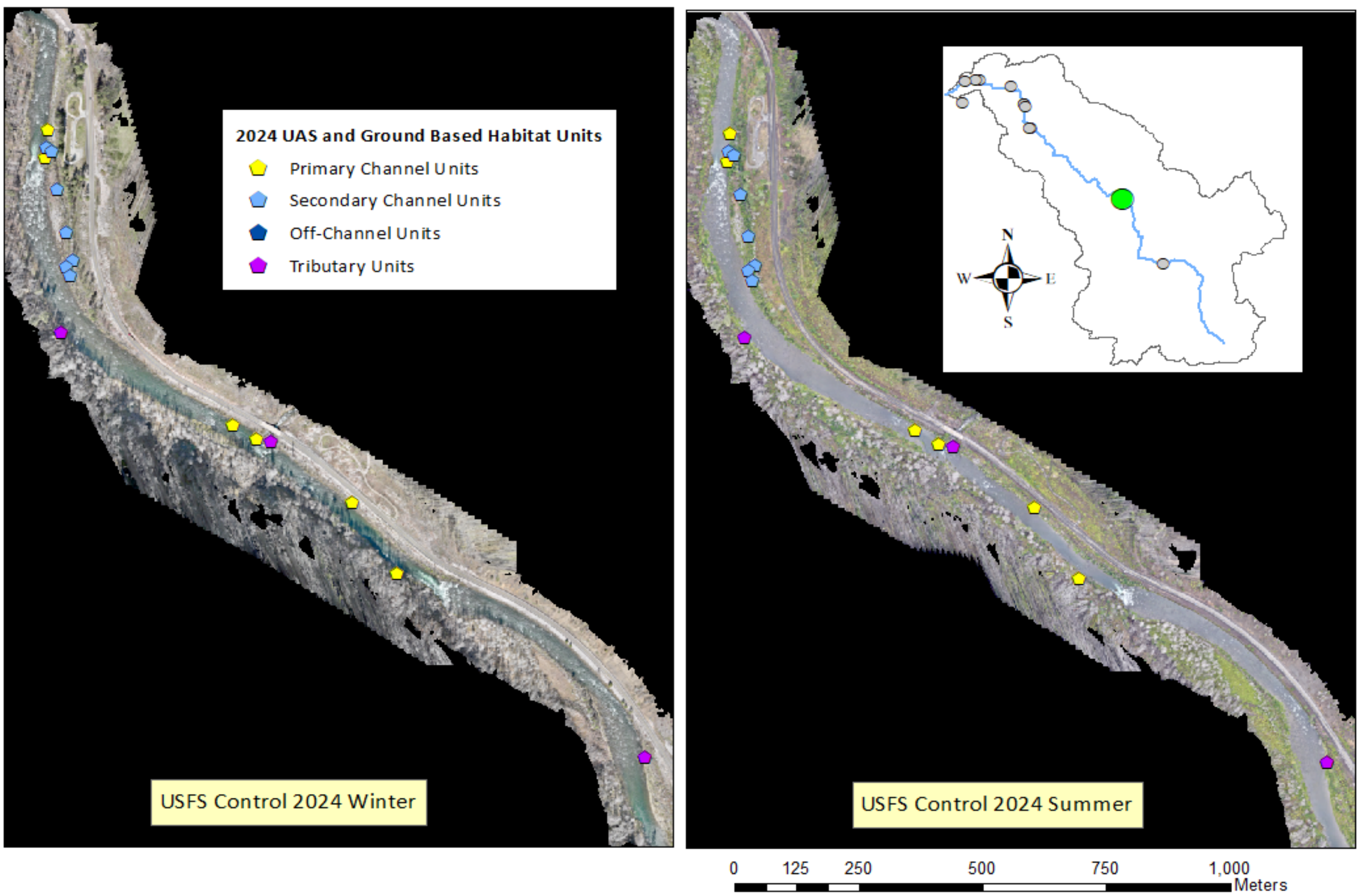


*Figure 6. USFS Control. Winter and Summer 2024 UAS imagery and ground-based survey points.*

## Kingfisher Side Channel

The Kingfisher Side Channel is situated on the west side of the Clackamas River's main channel, directly adjacent to the Upper Control Channel. This side channel is located approximately 400 meters downstream from the mouth of Dog Creek and is accessible via Milo McIver State Park. The Kingfisher Side Channel's location is constrained by terraces on both sides. A Valley Width Index (VWI) indicates that the active channel could shift 20 times between the hillslope toes.

Restoration efforts occurred on the Kingfisher Side Channel during late summer 2021. Figure 7 illustrates the Kingfisher Side Channel three years after restoration. The site flows northward for 500 meters. It was excavated into a single channel, graded, and reconnected to the Clackamas River. Large wood structures were strategically placed, and new substrates, including gravel, cobbles, and boulders, were added. The Kingfisher Side Channel now features a series of fast-water and pool habitats and a year-round connection and flow.

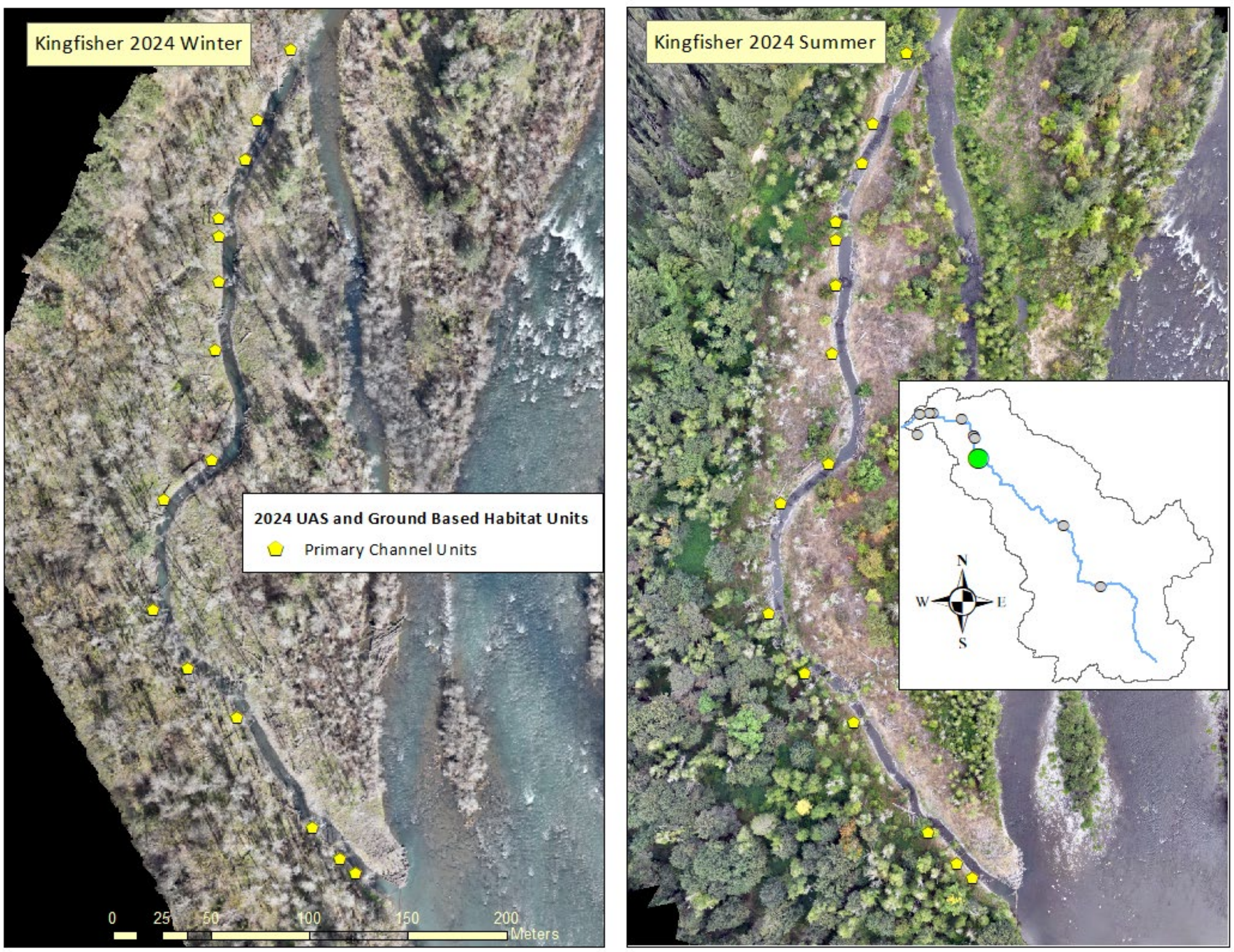


*Figure 7. Kingfisher Side Channel. Winter and Summer 2024 UAS imagery and ground-based survey points, 3 years post-restoration.*

## Upper Control Channel

The Upper Control Channel is located on the east side of the Clackamas River's main channel, directly adjacent to the Kingfisher Side Channel. The Upper Control Channel flows north for 213 meters, starting approximately 400 meters downstream from the mouth of Dog Creek, and is accessible via Milo McIver State Park. This channel is primarily confined to its current position due to a high, constraining island terrace to the west and a steep hillslope to the east. These features limit the available lateral movement of the channel to 30 meters. Figure 8 visually illustrates the Upper Control Channel during the winter and summer of 2024.

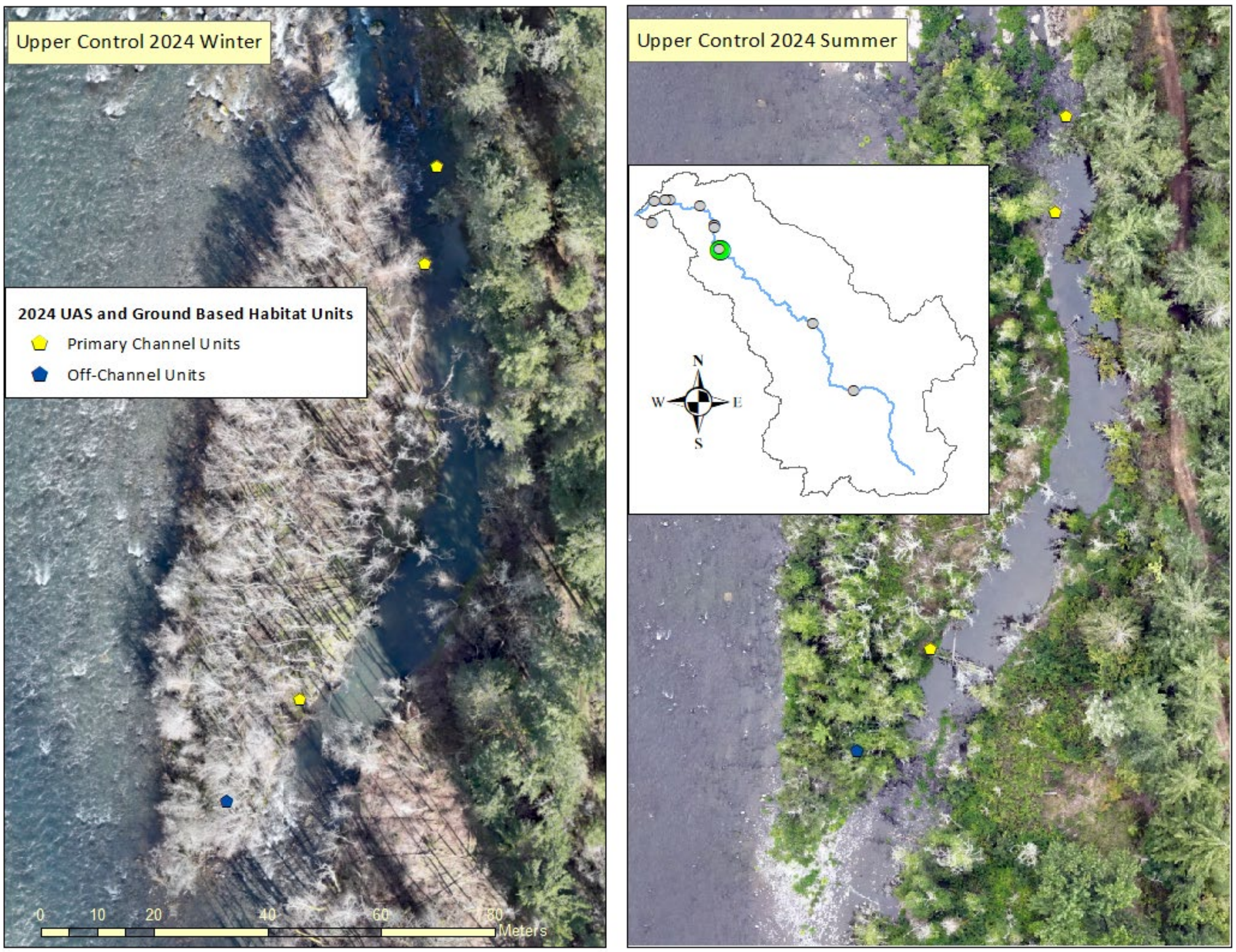


*Figure 8. Upper Control. Winter and Summer 2024 UAS imagery and ground-based survey points.*

## Eagle Creek Complex

The Eagle Creek Complex began at the confluence with the Clackamas River and extended approximately 0.5 kilometers upstream to a point just west of a bridge at SE Dowty Road. The primary channel flowed westward and entered a secondary channel of the Clackamas River in the southwest section of the study area; two secondary channels branched off and flowed primarily northwest, eventually joining the same Clackamas secondary channel further downstream in the northwest section of the study area. The entire complex is located within the Bonnie Lure State Recreation Area. The Eagle Creek Complex is mainly constrained by terraces, and the primary channel could shift approximately 200 meters across the valley floor.

Restoration efforts occurred at the Eagle Creek Complex during the summer of 2020. Figure 9 illustrates the Eagle Creek Complex four years after restoration. The site was excavated, large wood structures were strategically placed, and the main channel was redirected to flow through both the southernmost channel and the easternmost secondary channel. New substrates, including gravel, cobbles, and boulders, were introduced. During the summer, all secondary channels within the complex run dry, except for a few pools that receive hyporheic flow, which retain cool temperatures and provide cover for juvenile salmonids.

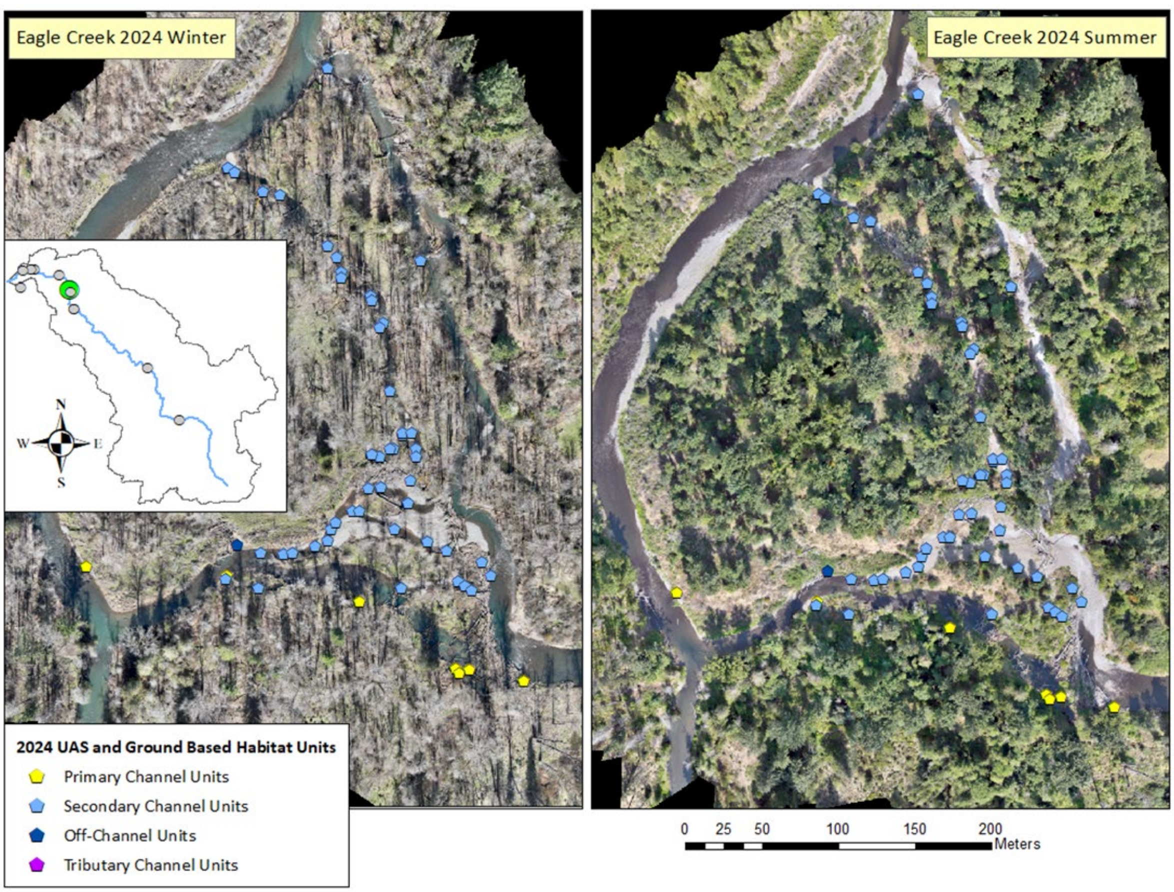


*Figure 9. Eagle Creek Complex. Winter and Summer 2024 UAS imagery and ground-based survey points, 4 years post-restoration.*

## Middle Control Channel

The Middle Control Channel, located on the east side of the Clackamas River's primary channel, flows northward for 288 meters, delineating the southwest boundary of the Eagle Creek complex. The entire reach of the Middle Control Channel is contained within the Bonnie Lure State Recreation Area. Figure 10 visually represents the Middle Control Channel in the winter and summer of 2024. The potential movement of the Middle Control Channel is limited to 220 meters between the main channel of the Clackamas River to the west and the hillslope to the east.

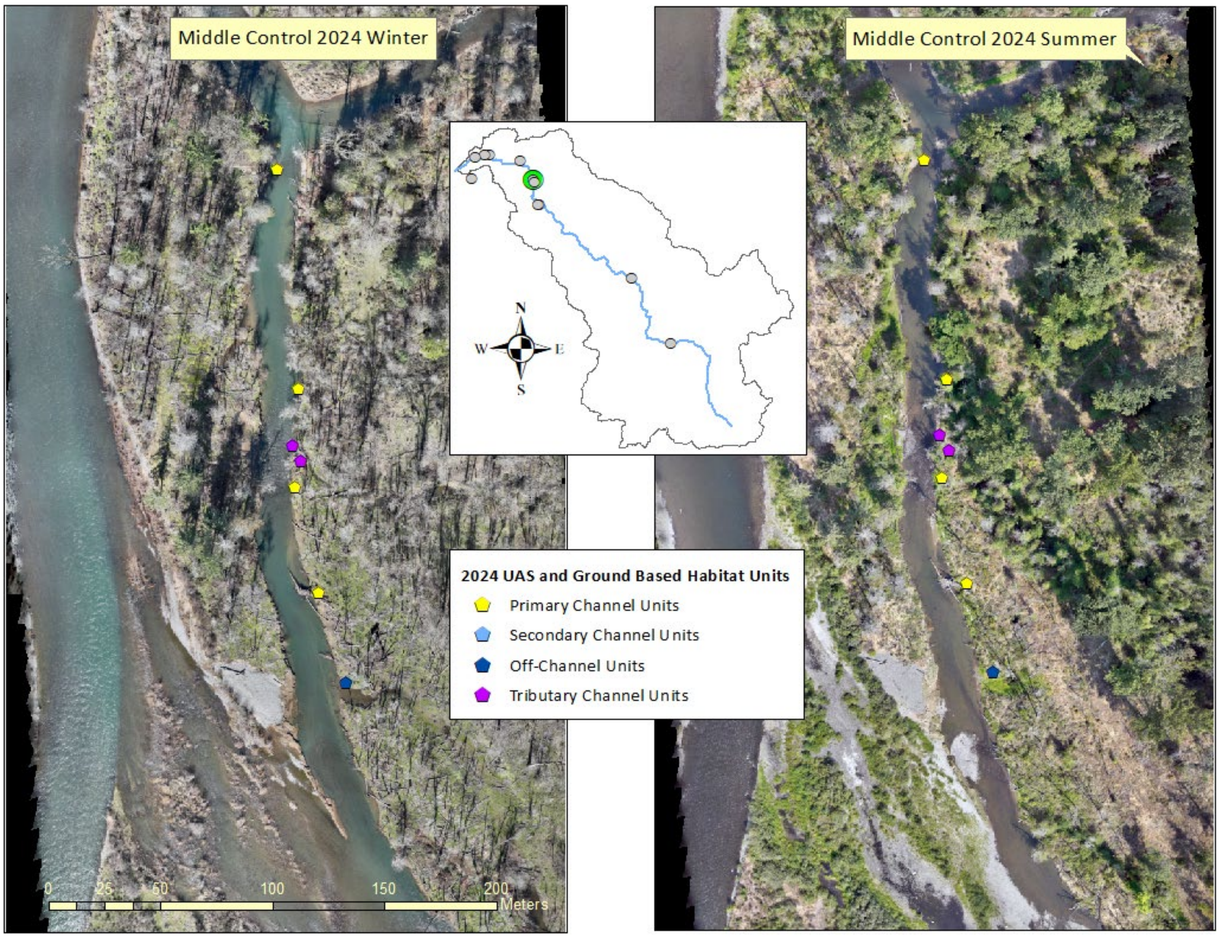


*Figure 10. Middle Control Channel. Winter and Summer 2024 UAS imagery and ground-based survey points.*

## Riverbend

Riverbend, fed by Sieben Creek, is located on the west bank of the Clackamas River between Carver Park and Riverside Park, upstream of Sah-Hah-Lee Golf Course and downstream of the confluence with Rock Creek. The top end of the Riverbend Side Channel is approximately 1.5 kilometers downstream from the Lower Control Channel. The primary channel flows southwest for 616 meters. Riverbend is characterized by its expansive floodplain, which remains largely unconstrained and is prone to inundation during high-flow events. A Valley Width Index (VWI) indicates that the active channel can shift its position up to 20 times between the toes of the hillslopes.

Riverbend underwent restoration enhancements in the summer of 2022, which included measures to increase channel complexity and connectivity. This involved introducing an apex jam to collect materials and installing large wood habitat structures throughout the channel to provide cover and initiate scour pools. Figure 11 depicts the Riverbend side channel two years after restoration. The site was excavated, large wood structures were strategically placed, and the upper end of the main channel was reconnected to the Clackamas River. New substrates, such as gravel, cobbles, and boulders, were added. Most of the restored primary channel and Seiben Creek dried completely during the summer.

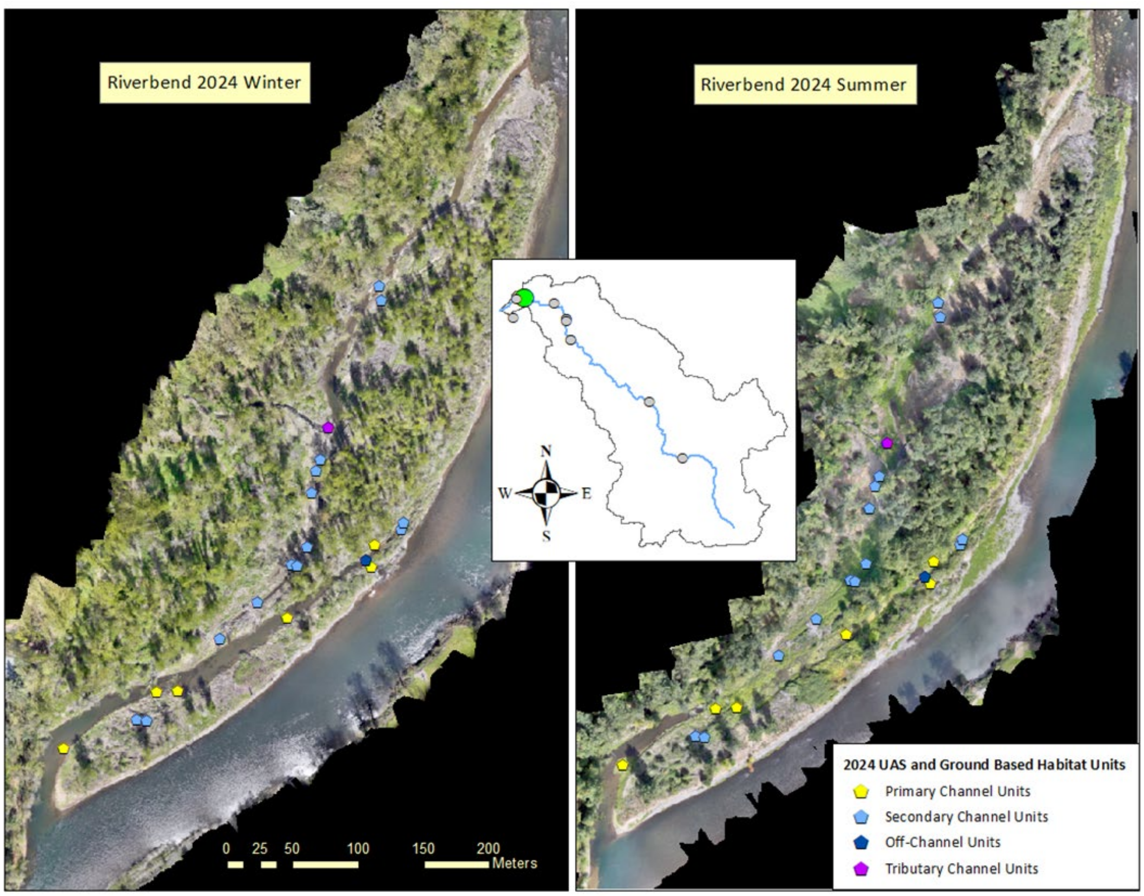


*Figure 11. Riverbend. Winter and Summer 2024 UAS imagery and ground-based survey points, 2 years post-restoration.*

### Lower Control Channel

The Lower Control Channel is located approximately 1 kilometer downstream from Carver Bridge, on the southwest side of the main Clackamas River channel. It predominantly flows northwest into a large alcove. A smaller secondary channel also diverges to the northeast, reconnecting with the mainstem of the Clackamas. Figure 12 illustrates the Lower Control Channel during the winter and summer of 2024. The potential movement of the Lower Control Channel is constrained to 80 meters between a high terrace on the west bank and the mainstem of the Clackamas River.

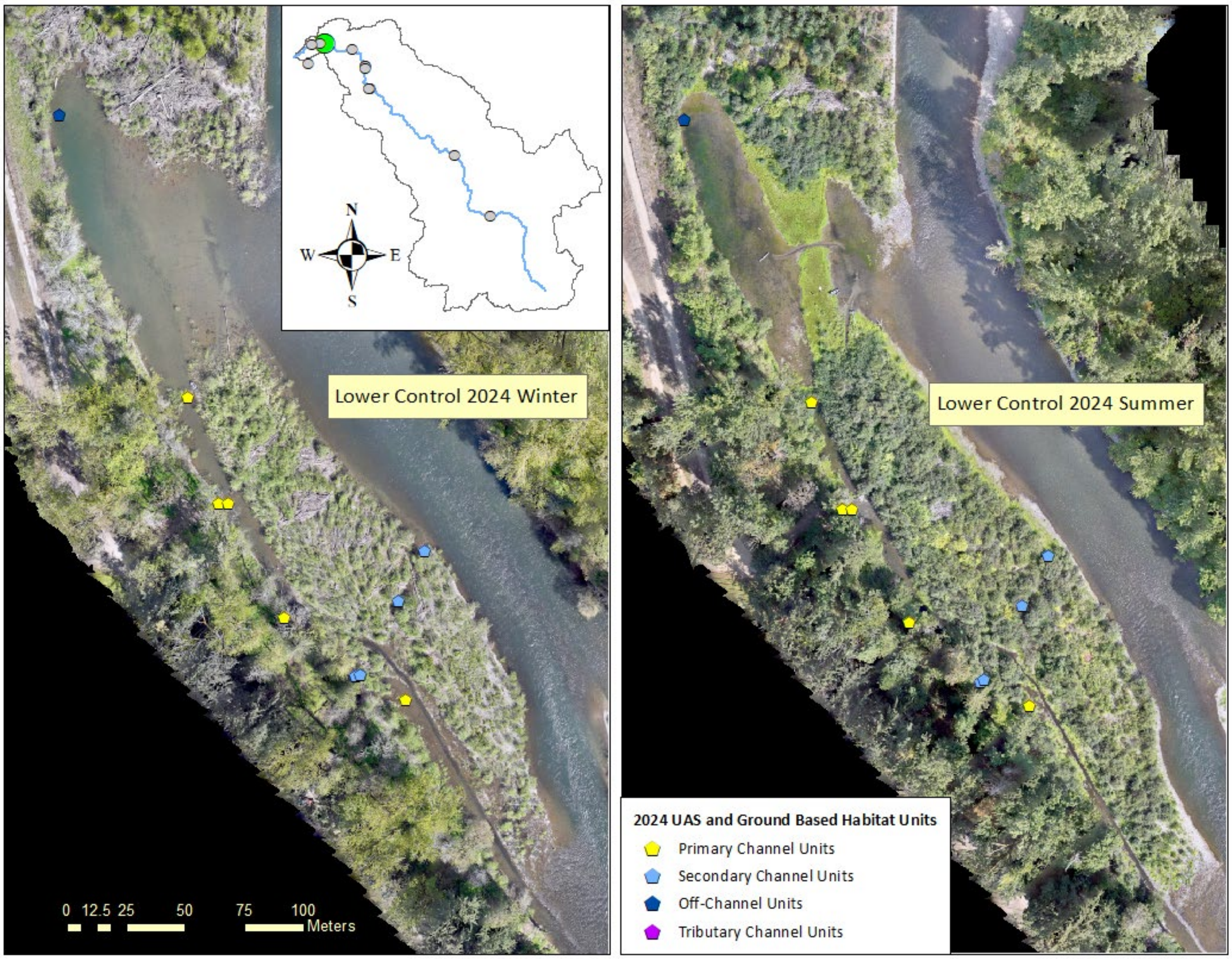


*Figure 12. Lower Control Channel. Winter and Summer 2024 UAS imagery and ground-based survey points.*

*Ground Survey*

This report discusses findings from a survey design developed for both wadeable and non-wadeable habitat types (Bailey et al. 2025, in review). Due to the nature and size of the channels and habitat characteristics, AQI adhered to methods for wadeable areas (Moore et al. 2007). Attributes collected and summarized at the reach level included channel morphology, substrate composition (including fine sediment such as silt and sand), instream wood (including wood volume and key wood pieces measuring ≥ 12 m in length and ≥ 60 cm in diameter), and fish species. The ground survey results outlined habitat quality using the HabRate model (Burke et al, 2010). This model generates habitat ratings (1-poor, 2-fair, or 3-good) for each life stage of anadromous salmonids present in the Clackamas River basin, including coho salmon, steelhead, cutthroat trout, and Chinook salmon. Snorkel surveys evaluated fish presence and adhered to the methods described in Constable and Suring (2024) (Table 1).

*Table 1. Habitat Attributes collected and assessed in report analysis.*

| Habitat Category | Habitat Attribute |
|---|---|
| Channel and Valley Form | Valley Width Index (VWI) |
| Channel Morphology | Primary Channel Length* |
| | Primary Channel Area ($m^2$)* |
| | Secondary Channel Length* |
| | Secondary Channel Area ($m^2$)* |
| | Pool Habitat (%)* |
| | Off-Channel Area ($m^2$)* |
| | Residual Pool Depth (m)* |
| | Riffle Depth (m)* |
| | Number of Pools |
| | Surface Area (%)* |
| Substrate Composition | % Fines (weighted by habitat unit area)* |
| | % Gravel (weighted by habitat unit area)* |
| | % Cobble (weighted by habitat unit area)* |
| | % Boulder (weighted by habitat unit area)* |
| | % Bedrock (weighted by habitat unit area)* |
| Instream Wood | Number of Wood Pieces* |
| | Wood Volume ($m^3$)* |
| | Number of Large Wood Key Pieces* |
| Fish Species | Presence/Absence |
| | Habitat Quality (HabRate) |

*Habitat attributes with LMER results

*UAS Survey*

UAS surveys supplemented ground surveys. Structure from Motion with Multi-View Stereo (SfM-MVS) reconstruction in Agisoft Metashape was employed to generate point clouds, Digital Elevation Models (DEMs), and orthorectified photo mosaics. DEMs were made from a dense point cloud filtered to only ground points, which could sometimes provide topographic information when obscuring vegetation was present in the orthomosaic. Measurements and counts were made using Agisoft Metashape and ESRI ArcGIS Pro.

*Temperature Monitoring*

Water temperature data were collected using HOBO TidbiT MX Temp 400 (MX2203) temperature loggers deployed at multiple locations across the Clackamas River basin. One logger was installed at each restoration site (Kingfisher, Eagle Creek, Riverbend, and Austin Hot Springs) and their corresponding control sites (Upper Control, Middle Control, Lower Control, and USFS Control). In addition, a temperature logger was placed on the mainstem of the Clackamas River, directly adjacent to each restoration and control site, to capture broader river conditions. All loggers were deployed in April 2024 and operated continuously, recording water temperature every 30 minutes. These data were downloaded during site visits in July, September, and December 2024.

*Methods Comparison*

Wood volume ($m^3$) was estimated using both ground-based surveys and UAS imagery. We conducted simple linear regression analyses to assess whether discrepancies existed between the two approaches. All data were log-transformed to stabilize variance and improve normality. Measurements of individual wood pieces were collected at all sites within each habitat unit where both ground and UAS data were available (R Development Core Team, 2006).

*Restoration Comparison*

Paired t-tests evaluated differences across all habitat metrics across the Barton Natural Area, Holcomb Creek, and Johnson “J” Creek sites between pre- and post-restoration treatments (2023, 2024). We used a linear mixed-effect regression model (LMER) on a Before-After-Control-Impact (BACI) study design to assess changes in stream morphology at the Kingfisher Side Channel (Impact) and the Upper Control Channel (Control). Eagle Creek Complex (Impact) and the Middle Control Channel (Control). Riverbend (Impact) and the Lower Control Channel (Control). Comparing the conditions before (Pre) and after (Post) the restoration period (2020-2024). We analyzed the mean difference between treatment years to test each hypothesis at a two-sided P-value of 0.05. All analyses were conducted using R software (R Development Core Team 2006).

RESULTS

*Results of Ground and UAS Surveys*

## Barton Natural Area (NA)

A UAS and a physical habitat survey captured a one-year post-restoration stream habitat during average winter flow conditions on April 9, 2024 (Figure 2). The total wetted winter surface area of the Barton Natural Area was 49,760.8 m². The total wetted summer surface area of the Barton Natural Area was 24,700.17 m². The Barton Natural Area contained 41,587 m² of primary channel habitat and 17,863.6 m² of secondary channel habitat (Table 2).

*Table 2. Channel measurements from ground-based surveys in the Barton Natural Area.*

| Site Location | Winter Surface Area (m²) | Summer Surface Area (m²) | Primary Channel Length (m) | Secondary Channel Length (m) | Primary Channel Area (m²) | Secondary Channel Area (m²) | Off-Channel Area (m²)* |
|---|---|---|---|---|---|---|---|
| Barton NA (2024) Post Restoration | 49,760.8 | 24,700.17 | 889 | 652 | 41,587.0 | 17,864.1 | 13,447.0 |

*Alcoves, Backwaters, Isolated pools.

Pool habitat comprised 51% of the primary channel (Table 3). The total large wood volume throughout the channel was 124.98 m³, which is equivalent to 14.05 m³ per 100 meters of primary channel length. Four key pieces of wood were measured, resulting in an average of 0.44 pieces per 100 meters of primary length. (Table 3).

*Table 3. Physical habitat summary from ground-based surveys in the Barton Natural Area.*

| Site Location | Pool Habitat (%) | Residual Pool Depth (m) | Riffle Depth (m) | Wood Volume (m³)* | # Of Key Wood Pieces |
|---|---|---|---|---|---|
| Barton NA (2024) Post Restoration | 51 | 0.81 | 0.41 | 14 | 4 |

*Total/100m primary channel.

The substrate types observed in the Barton Natural Area included cobble (32%), fine sediment (31%), and gravel (28%) (Table 4).

*Table 4. Summary of streambed substrate in the Barton Natural Area.*

| Site Location | % Fines* | % Gravel | % Cobble | % Boulder | % Bedrock |
|---|---|---|---|---|---|
| Barton NA (2024) Post Restoration | 31 | 28 | 32 | 8.6 | 0.06 |

*Silt and Sand.

On September 5, 2024, a UAS and snorkel survey were conducted.  We snorkeled 13 pools, which comprised 93% of the available pool area during the survey. Chinook salmon, coho salmon, cutthroat trout, steelhead, dace, red-side shiners, northern pike minnow, large-scale sucker, sculpin, and mosquitofish were observed (Table 5).

*Table 5. Results of summer snorkel surveys conducted within pool habitats in the Barton Natural Area.*

| Site Location | Pool Area ($m^2$) | Snorkel Area ($m^2$) | Sum of Coho | Sum of Cutthroat | Sum of Steelhead | Sum of Chinook | Other fish observed |
|---|---|---|---|---|---|---|---|
| Barton NA* (2024) Post Restoration | 13,838.7 | 12,877.7 | 1 | 1 | 1 | 2 | Dace, shiner, NPM**, Large Scale Sucker, Sculpin, Mosquitofish |

*Snorkeled an Alcove habitat unit type, **Northern Pikeminnow.

Prior to restoration activities, results from the HabRate model (Burke et al. 2010) suggested stream habitat quality within Barton Natural Area was poor to fair across salmonid life history types. Species-specific averages for these life history types ranged from 1.4 (steelhead) to 2.0 (coho salmon). Following the restoration efforts, the habitat rating improved for Chinook salmon, coho salmon, and steelhead, while it remained unchanged for cutthroat trout (Table 6).

*Table 6. Habrate (Burke et al. 2010) provides pre- and post-restoration life history ratings for Chinook salmon, steelhead, coho salmon, and cutthroat trout habitat for Barton NA.*

| **Chinook Salmon Habitat** | | | | | |
|---|---|---|---|---|---|
| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | Chinook Average |
| Barton NA | 2023 | 1 | 2 | 2 | 1.6 |
| Barton NA | 2024 | 1 | 3 | 3 | 2.3 |

| **Steelhead Habitat** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | 1+ Summer | 1+ Winter | Steelhead Average |
| Barton NA | 2023 | 1 | 2 | 1 | 2 | 1 | 1.4 |
| Barton NA | 2024 | 1 | 3 | 3 | 2 | 3 | 2.4 |

| **Coho Habitat** | | | | | |
|---|---|---|---|---|---|
| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | Coho Average |
| Barton NA | 2023 | 1 | 2 | 3 | 2 |
| Barton NA | 2024 | 2 | 3 | 3 | 2.6 |

| **Cutthroat Habitat** | | | | | | |
|---|---|---|---|---|---|---|
| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | 1+ Summer | Cutthroat Average |
| Barton NA | 2023 | 1 | 2 | 2 | 2 | 1.75 |
| Barton NA | 2024 | 1 | 2 | 2 | 2 | 1.75 |

### Restoration Comparison: Barton Natural Area (NA)

Following the restoration treatment of Barton Natural Area between 2023 and 2024, changes in habitat metrics were observed. The primary channel area decreased from 44,616.0 $m^2$ to 41,587.0 $m^2$, and the secondary channel area decreased from 18,166.1 $m^2$ to 17,863.6 $m^2$. The percentage of pool habitat increased from 46% to 51%. However, there were reductions in the residual pool depth and riffle depth. The wood volume increased significantly (4.45 $m^3$ to 14.05 $m^3$), and the number of individual key wood pieces increased from 1 to 4. Differences in bedload composition were observed between years, with the percentage of fine substrates increasing (30.5% to 31%), gravel increasing, and cobble and boulder decreasing after restoration (Table 7).

*Table 7. Differences between pre- and post-restoration treatments in Barton NA (2023-2024).*

| Barton Natural Area Habitat Metrics | 2023 Pre-Restoration | 2024 Post-Restoration |
|---|---|---|
| River Level (CFS)*** | 2,315 | 2,960 |
| Primary Channel Area ($m^2$) | 44,616.0 | 41,587.0 |
| Secondary Channel Area ($m^2$) | 18,166.1 | 17,863.6 |
| Off-Channel Area ($m^2$) | 15,249.0 | 13,447.0 |
| % Pool Habitat | 46 | 51 |
| Residual Pool Depth (m) | 1.2 | 0.81 |
| Riffle Depth (m) | 0.7 | 0.41 |
| Wood Volume ($m^3$)** | 4.45 | 14.05 |
| # Of Key Wood Pieces | 1 | 4 |
| % Fines* | 30.5 | 31 |
| % Gravel | 17.4 | 28 |
| % Cobble | 34.6 | 32 |
| % Boulder | 14.1 | 8.6 |
| % Bedrock | 3.1 | 0.06 |

*Silt and Sand, **Total/100m primary channel, ***Estacada gauge station.

### Holcomb Creek

A UAS and a physical habitat survey were conducted to capture the one-year post-restoration stream habitat during average winter flow conditions on March 24, 2024 (Figure 3). The total wetted winter surface area of Holcomb Creek was 737.2 m². The total wetted summer surface area of Holcomb Creek was 408.6 m². Holcomb Creek contained 734.8 m² of primary channel habitat and 54.4 m² of secondary channel habitat (Table 8).

*Table 8. Channel measurements from ground-based surveys in Holcomb Creek.*

| Site Location | Winter Surface Area ($m^2$) | Summer Surface Area ($m^2$) | Primary Channel Length (m) | Secondary Channel Length (m) | Primary Channel Area ($m^2$) | Secondary Channel Area ($m^2$) | Off-Channel Area ($m^2$)* |
|---|---|---|---|---|---|---|---|
| Holcomb Creek (2024) Post Restoration | 737.2 | 408.6 | 220.4 | 34 | 734.8 | 54.4 | 31.2 |

*Alcoves, Backwaters, Isolated pools.

Pool habitat comprised 61% of the primary channel (Table 9). The total large wood volume throughout the channel was 54 m³, which equates to 24.5 m³ per 100 meters of primary channel length. One key piece of large wood was measured (Table 9).

*Table 9. Physical habitat summary from ground-based surveys in Holcomb Creek.*

| Site Location | Pool Habitat (%) | Residual Pool Depth (m) | Riffle Depth (m) | Wood Volume ($m^3$)* | # Of Key Wood Pieces |
|---|---|---|---|---|---|
| Holcomb Creek (2024) Post Restoration | 60.6 | 0.47 | 0.15 | 24.5 | 1 |

*Total/100m primary channel.

The most frequently observed substrate types throughout Holcomb Creek included fine sediment (39%), gravel (37%), and cobble (20%) (Table 10). During the habitat survey, we observed Pacific lamprey constructing redds.

*Table 10. Summary of streambed substrate in Holcomb Creek.*

| Site Location | % Fines* | % Gravel | % Cobble | % Boulder | % Bedrock |
|---|---|---|---|---|---|
| Holcomb Creek (2024) Post Restoration | 38.6 | 36.9 | 19.9 | 1.2 | 3.1 |

*Silt and Sand.

On September 11, 2024, a UAS and snorkel survey were conducted. We snorkeled 100% of the available pool habitat (14 individual pool units). Coho salmon, red-side shiners, and dace were observed (Table 11).

*Table 11. Results of summer snorkel surveys conducted within pool habitats in Holcomb Creek.*

| Site Location | Pool Area ($m^2$) | Snorkel Area ($m^2$) | Sum of Coho | Sum of Cutthroat | Sum of steelhead | Sum of Chinook | Other fish observed |
|---|---|---|---|---|---|---|---|
| Holcomb | 545.2 | 545.2 | 91 | 0 | 0 | 0 | Dace, shiner |

Prior to restoration activities, results from the HabRate model (Burke et al. 2010) suggested stream habitat quality within Holcomb Creek was poor to fair across salmonid life history types. Average ratings for individual species within these life history types ranged from 1.2 for steelhead to 2.0 for coho salmon. Following the restoration efforts, the habitat rating showed slight improvements for steelhead and cutthroat trout, remained unchanged for Chinook salmon, and decreased slightly for coho salmon (Table 12).

*Table 12. Habrate (Burke et al. 2010) provides pre- and post-restoration life history ratings for Chinook salmon, steelhead, coho salmon, and cutthroat trout habitat for Holcomb Creek.*

| **Chinook Salmon Habitat** | | | | | |
|---|---|---|---|---|---|
| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | Chinook Average |
| Holcomb | 2023 | 1 | 2 | 2 | 1.6 |
| Holcomb | 2024 | 1 | 2 | 2 | 1.6 |

| **Steelhead Habitat** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | 1+ Summer | 1+ Winter | Steelhead Average |
| Holcomb | 2023 | 1 | 2 | 1 | 1 | 1 | 1.2 |
| Holcomb | 2024 | 1 | 2 | 2 | 2 | 2 | 1.8 |

| **Coho Habitat** | | | | | |
|---|---|---|---|---|---|
| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | Coho Average |
| Holcomb | 2023 | 1 | 2 | 3 | 2 |
| Holcomb | 2024 | 1 | 1 | 2 | 1.3 |

| **Cutthroat Habitat** | | | | | |
|---|---|---|---|---|---|
| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | 1+ Summer | Cutthroat Average |
| Holcomb | 2023 | 1 | 1 | 1 | 2 | 1.25 |
| Holcomb | 2024 | 2 | 2 | 2 | 2 | 2 |

## Restoration Comparison: Holcomb Creek

Following the restoration treatment of Holcomb Creek between 2023 and 2024, changes in habitat metrics were observed. The primary channel area decreased from 913.3 $m^2$ to 734.8 $m^2$, while the secondary channel area increased from 28 $m^2$ to 54.4 $m^2$. The percentage of pool habitat decreased from 73.1% to 60.6%. The residual pool depth increased slightly while the riffle depth decreased. The wood volume increased significantly (1.23 $m^3$ to 24.5 $m^3$), and the number of individual key wood pieces increased from 0 to 1. Differences in bedload composition were observed between years, with a decrease in the percentage of fine substrates (49.3% to 38.6%). In contrast, the percentage of gravel decreased, while cobble increased significantly, along with increases in boulders and bedrock (Table 13).

*Table 13. Differences between pre- and post-restoration treatments in Holcomb Creek (2023-2024).*

| Holcomb Creek Habitat Metrics | 2023 Pre-Restoration | 2024 Post-Restoration |
|---|---|---|
| River Level (CFS) | NA | NA |
| Primary Channel Area ($m^2$) | 913.3 | 734.8 |
| Secondary Channel Area ($m^2$) | 28 | 54.4 |
| Off-Channel Area ($m^2$) | 516.8 | 31.2 |
| % Pool Habitat | 73.1 | 60.6 |
| Residual Pool Depth (m) | 0.40 | 0.47 |
| Riffle Depth (m) | 0.25 | 0.15 |
| Wood Volume ($m^3$)** | 1.23 | 24.5 |
| # Of Key Wood Pieces | 0 | 1 |
| % Fines* | 49.3 | 38.6 |
| % Gravel | 45.5 | 36.9 |
| % Cobble | 5.14 | 19.9 |
| % Boulder | 0 | 1.2 |
| % Bedrock | 0 | 3.1 |

*Silt and Sand, **Total/100m primary channel.

### Johnson “J” Creek

On April 10, 2024, a UAS and a physical habitat survey were conducted to assess post-restoration stream habitat under average winter flow conditions (Figure 4). New channels were constructed, large wood habitat structures were added, and gravel and cobble substrates were incorporated. The total wetted winter surface area of Johnson “J” Creek was 4,869 m². The overall wetted summer surface area of Johnson "J” Creek was not available, since much of the habitat was either dry or hidden by canopy cover. Johnson “J” Creek contained 4,647.5 m² of primary channel habitat and 898 m² of secondary channel habitat (Table 14).

*Table 14. Channel measurements from ground-based surveys in Johnson “J” Creek.*

| Site Location | Winter Surface Area (m²) | Summer Surface Area (m²) | Primary Channel Length (m) | Secondary Channel Length (m) | Primary Channel Area (m²) | Secondary Channel Area (m²) | Off-Channel Area (m²)* |
|---|---|---|---|---|---|---|---|
| Johnson “J” Cr. (2024) Post Restoration | 4,869 | NA | 511 | 374 | 4,647.5 | 898 | 85 |

*Alcoves, Backwaters, Isolated pools.

Pool habitat made up 66.4% of the primary channel (Table 15). The total large wood volume throughout the channel was 103 m³, which equals 20.2 m³ per 100 meters of primary channel length. One key piece of wood was measured, translating to an average of 0.19 pieces per 100 meters of primary channel length (Table 15).

*Table 15. Physical habitat summary from ground-based surveys in Johnson “J” Creek.*

| Site Location | Pool Habitat (%) | Residual Pool Depth (m) | Riffle Depth (m) | Wood Volume (m³)* | # Of Key Wood Pieces |
|---|---|---|---|---|---|
| Johnson “J” Cr. (2024) Post Restoration | 66.4 | 0.48 | 0.21 | 20.2 | 1 |

*Total/100m primary channel.

The observed substrate types throughout Johnson “J” Creek included fine sediment (56%), gravel (24%), cobble (19%), and boulder (0.33%) (Table 16).

*Table 16. Summary of streambed substrate in Johnson “J” Creek.*

| Site Location | % Fines* | % Gravel | % Cobble | % Boulder | % Bedrock |
|---|---|---|---|---|---|
| Johnson “J” Cr. (2024) Post Restoration | 56 | 24 | 19 | 0.33 | 0 |

*Silt and Sand.

A UAS and snorkel survey was conducted on September 10, 2024, to capture summer conditions. During the survey, six pool units were snorkeled, representing 77% of the available pool habitat, and mosquitofish were the only species observed (Table 17).

*Table 17. Results of summer snorkel surveys conducted within pool habitats in Johnson "J" Creek.*

| Site Location | Pool Area ($m^2$) | Snorkel Area ($m^2$) | Sum of Coho | Sum of Cutthroat | Sum of Steelhead | Sum of Chinook | Other fish observed |
|---|---|---|---|---|---|---|---|
| Johnson "J" Creek | 1,555.2 | 1,201.0 | 0 | 0 | 0 | 0 | Mosquitofish |

Prior to restoration activities, results from the HabRate model (Burke et al. 2010) suggested stream habitat quality within Johnson "J" Creek were poor to fair across salmonid life history types. Species-specific averages for these life history types ranged from 1.0 for steelhead to 1.6 for Chinook salmon and coho salmon. Following restoration efforts, the habitat rating improved for steelhead and cutthroat trout but remained unchanged for coho salmon and Chinook salmon (Table 18).

*Table 18. Habrate (Burke et al. 2010) provides pre- and post-restoration life history ratings for Chinook salmon, steelhead, coho salmon, and cutthroat trout habitat for Johnson "J" Creek.*

**Chinook Salmon Habitat**

| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | Chinook Average |
|---|---|---|---|---|---|
| Johnson "J" Creek | 2023 | 1 | 2 | 2 | 1.6 |
| Johnson "J" Creek | 2024 | 1 | 2 | 2 | 1.6 |

**Steelhead Habitat**

| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | 1+ Summer | 1+ Winter | Steelhead Average |
|---|---|---|---|---|---|---|---|
| Johnson "J" Creek | 2023 | 1 | 1 | 1 | 1 | 1 | 1 |
| Johnson "J" Creek | 2024 | 1 | 2 | 2 | 2 | 2 | 1.8 |

**Coho Habitat**

| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | Coho Average |
|---|---|---|---|---|---|
| Johnson "J" Creek | 2023 | 1 | 2 | 2 | 1.6 |
| Johnson "J" Creek | 2024 | 1 | 2 | 2 | 1.6 |

**Cutthroat Habitat**

| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | 1+ Summer | Cutthroat Average |
|---|---|---|---|---|---|---|
| Johnson "J" Creek | 2023 | 1 | 2 | 1 | 2 | 1.5 |
| Johnson "J" Creek | 2024 | 2 | 2 | 1 | 2 | 1.75 |

### Restoration Comparison: Johnson "J" Creek

Following the restoration treatment of Johnson "J" Creek between 2023 and 2024, changes in habitat metrics were observed. The primary channel area increased from 2,205.3 $m^2$ to 4,647.5 $m^2$, and the secondary channel area increased from 147.2 $m^2$ to 898.0 $m^2$. The percentage of pool habitat decreased from 86.3% to 66.4%. However, there were no changes in the residual pool depth and riffle depth. The wood volume increased slightly (14.6 $m^3$ to 20.1 $m^3$), and the number of individual key wood pieces decreased from 4 to 1. Differences in bedload composition were observed over the years, with a decrease in the percentage of fine substrates (75.8% to 56.3%). In contrast, the gravel, cobble, and boulder percentages increased after restoration (Table 19).

*Table 19. Differences between pre- and post-restoration treatments in Johnson "J" Creek (2023-2024).*

| Johnson "J" Creek Habitat Metrics | 2023 Pre-Restoration | 2024 Post-Restoration |
|---|---|---|
| River Level (CFS)*** | 2,140 | 2,980 |
| Primary Channel Area ($m^2$) | 2,205.3 | 4,647.5 |
| Secondary Channel Area ($m^2$) | 147.2 | 898 |
| Off-Channel Area ($m^2$) | 1,671 | 319.4 |
| % Pool Habitat | 86.3 | 66.4 |
| Residual Pool Depth (m) | 0.46 | 0.48 |
| Riffle Depth (m) | 0.21 | 0.21 |
| Wood Volume ($m^3$)** | 14.6 | 20.1 |
| # Of Key Wood Pieces | 4 | 1 |
| % Fines* | 75.8 | 56.3 |
| % Gravel | 23.0 | 23.9 |
| % Cobble | 1.11 | 19.3 |
| % Boulder | 0 | 0.33 |
| % Bedrock | 0 | 0 |

*Silt and Sand, **Total/100m primary channel, ***Estacada gauge station.

## Restoration Assessment: Barton Natural Area (NA), Holcomb, and Johnson “J” Creek

The primary channel area decreased in Barton NA and Holcomb Creek and increased slightly in Johnson “J” Creek. The percentage of pool habitat increased post-treatment in the Barton NA and decreased in Holcomb Creek and Johnson “J” Creek. Residual Pool Depths increased in Holcomb Creek and Johnson “J” Creek and declined sharply in Barton NA (Figure 13). Wood volume increased across Barton NA, Holcomb, and Johnson “J” Creek following restoration treatment, and the number of key pieces of wood increased within Barton NA and Holcomb Creek (Figure 14). Within stream bedload types, we observed a decrease in the percentage of fines (silt and sand) and an increase in gravel at Barton NA and Johnson “J” Creek, as well as an increase in cobbles and boulders at Holcomb Creek and Johnson “J” Creek (Figure 15).

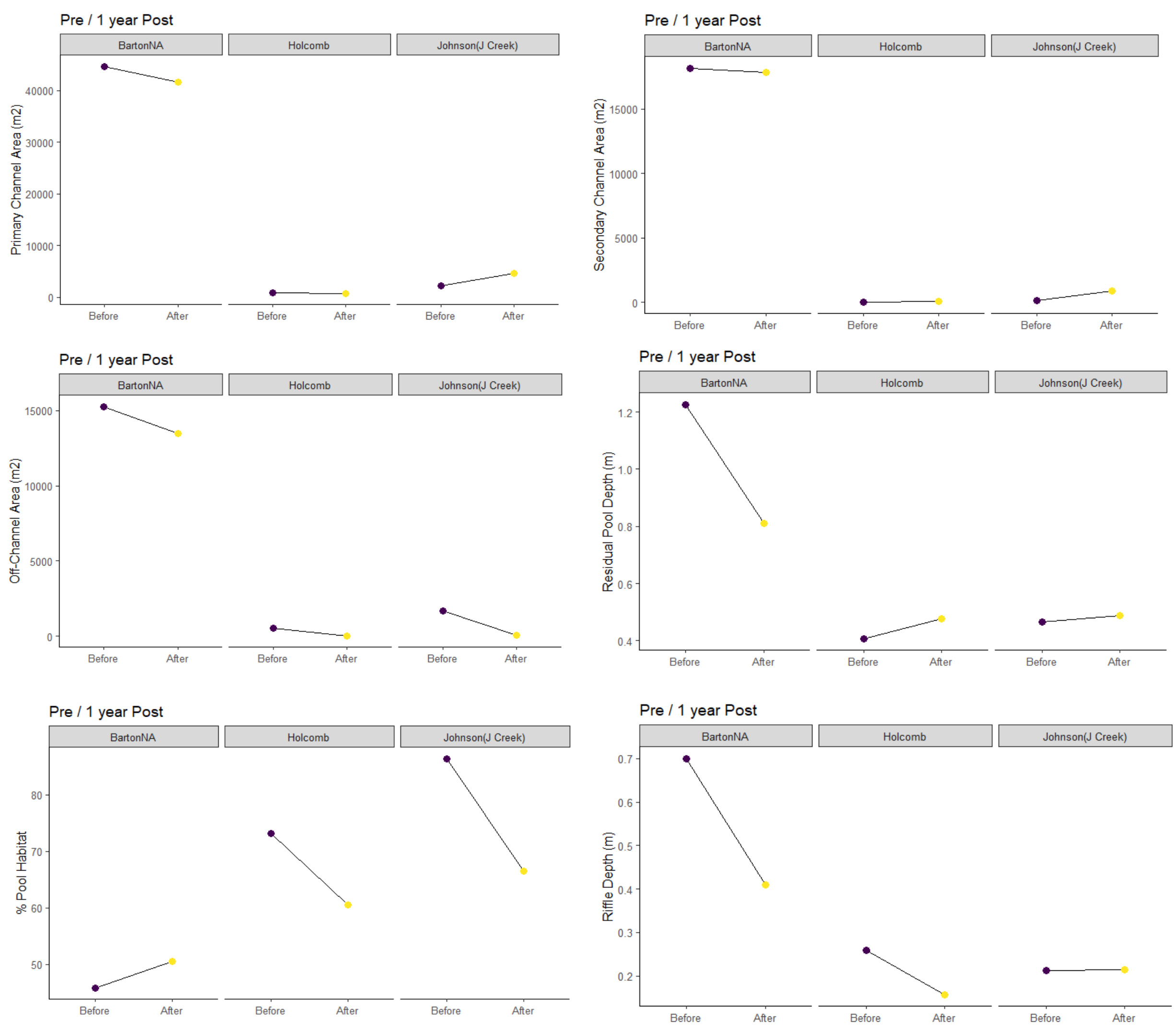


*Figure 13. Connected scatter plots illustrate the differences between pre- and post-restoration treatments across channel, pool, and riffle features of pre- and post-1-year FIP sites, Barton NA, Holcomb Creek, and Johnson ”J” Creek.*

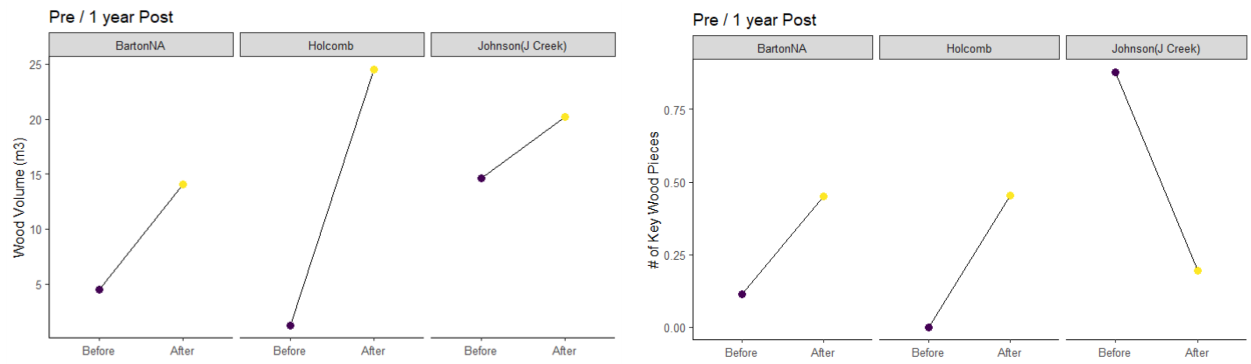


*Figure 14. Connected scatter plots illustrating the differences between pre-restoration treatment and post-restoration treatment for wood volume ($m^3$) and the number of key pieces of wood per 100m of primary channel.*

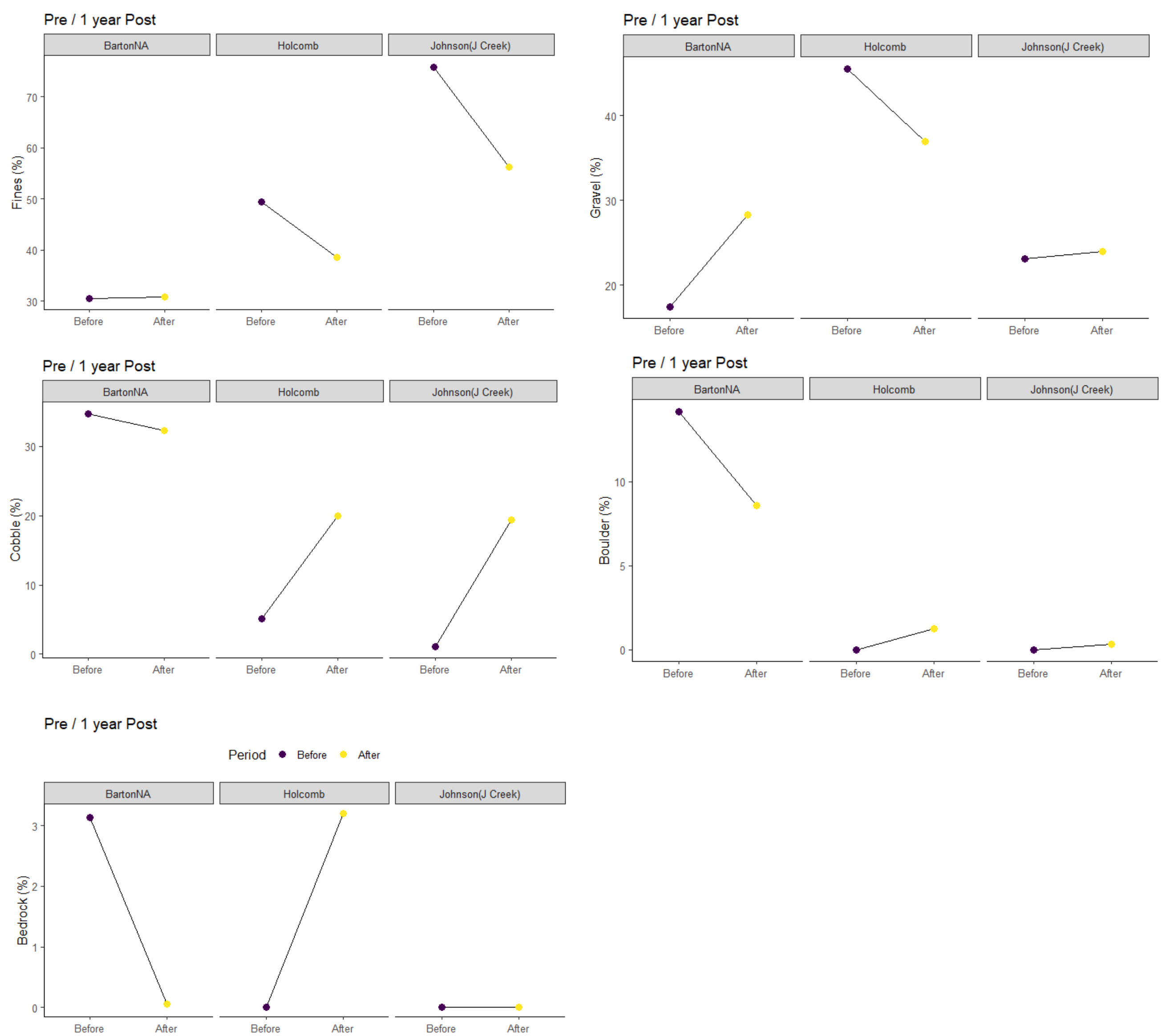


*Figure 15. Connected scatter plots illustrate the differences between pre- and post-restoration treatments across bedload types in Barton NA, Holcomb Creek. and Johnson "J" Creek.*

Paired t-tests evaluated differences across all habitat metrics at the Barton Natural Area, Holcomb Creek, and Johnson "J" Creek sites between pre- and post-restoration treatments (2023, 2024) (Table 20).

*Table 20. Paired t-tests assessed differences in habitat metrics at the Barton NA, Holcomb Creek, and Johnson "J" Creek sites between 2023 and 2024. Habitat Metric = Ecological variable, t = Difference between paired observations, Alpha = 0.05.*

| Habitat Metric | t | df | Mean of Differences | P-value |
|---|---|---|---|---|
| Primary Channel Area ($m^2$) | 0.16148 | 2 | 255.1133 | 0.8866 |
| Secondary Channel Area ($m^2$) | -0.5086 | 2 | -158.2367 | 0.6616 |
| Off-Channel Area ($m^2$)* | 3.1678 | 2 | 1291.2 | 0.08686 |
| % Pool Habitat | 1.2694 | 2 | 9.239067 | 0.332 |
| Residual Pool Depth (m) | 0.6953 | 2 | 0.1076234 | 0.5588 |
| Riffle Depth (m) | 1.5132 | 2 | 0.1295635 | 0.2694 |
| Wood Volume ($m^3$) | -2.3897 | 2 | -12.81787 | 0.1394 |
| # Of Key Wood Pieces | -0.10018 | 2 | -0.03615451 | 0.9293 |
| % Fines** | 1.7399 | 2 | 9.973731 | 0.224 |
| % Gravel | -0.18841 | 2 | -1.055734 | 0.8679 |
| % Cobble | -1.5906 | 2 | -10.21336 | 0.2527 |
| % Boulder | 0.62286 | 2 | 1.336302 | 0.5969 |
| % Bedrock | -0.022606 | 2 | -0.04093929 | 0.984 |

*Alcoves, Backwaters, and Isolated Pools. **Combined observed values of silt and sand.

These results suggest that, while some habitat metrics (like Off-Channel Area) may be trending toward change, statistical confirmation is limited due to sample size. Future monitoring with larger sample sizes could help clarify these trends.

Austin Hot Springs and USFS Control Channel.

**Austin Hot Springs**

A UAS and a physical habitat survey were conducted on April 3, 2024, to capture the available pre-restoration stream habitat under average winter flow conditions (Figure 5). The total wetted winter surface area of Austin Hot Springs was 34,492.5 m². The total wetted summer surface area was not measured due to the canopy cover. Austin Hot Springs contained 33,033.0 m² of primary channel habitat and 1,957 m² of secondary channel habitat (Table 21).

*Table 21. Channel measurements from ground-based surveys in Austin Hot Springs and the USFS Control Channel.*

| Site Location | Winter Surface Area (m²) | Summer Surface Area (m²) | Primary Channel Length (m) | Secondary Channel Length (m) | Primary Channel Area (m²) | Secondary Channel Area (m²) | Off-Channel Area (m²)* |
|---|---|---|---|---|---|---|---|
| Austin Hot Springs | 34,492.5 | NA** | 1,270.0 | 472 | 33,033.0 | 1,957.0 | 320 |
| USFS Control | 86,222.2 | 80,299.9 | 1,824.0 | 362 | 90,364.0 | 1,992.4 | 0 |

*Alcoves, Backwaters, Isolated pools, **UAS imagery obscured by canopy, unable to measure surface area.

Pool habitat comprised 7.5% of the habitat across all channel types (Table 22). The large wood volume throughout the channel was 98 m³, which is equivalent to 7.7 m³ per 100 meters of primary channel length. Three key pieces of wood were measured, translating to an average of 0.23 pieces per 100 meters of primary channel length (Table 22).

*Table 22. Physical habitat summary from ground-based surveys in Austin Hot Springs and the USFS Control Channel.*

| Site Location | Pool Habitat (%) | Residual Pool Depth (m) | Riffle Depth (m) | Wood Volume (m³)* | # Of Key Wood Pieces |
|---|---|---|---|---|---|
| Austin Hot Spring | 7.5 | 0.62 | 0.3 | 7.7 | 3 |
| USFS Control | 17 | 1.2 | 0.25 | 6.2 | 4 |

*Total/100m primary channel.

The observed substrate types across the Austin Hot Springs site included cobble (35%), gravel (25%), fine sediment (21%), and boulder (17%) (Table 23).

*Table 23. Summary of streambed substrate in Austin Hot Springs and the USFS Control Channel.*

| Site Location | % Fines* | % Gravel | % Cobble | % Boulder | % Bedrock |
|---|---|---|---|---|---|
| Austin Hot Springs | 21 | 25 | 35 | 17 | 1.8 |
| USFS Control | 15 | 21 | 39 | 24 | 0.72 |

*Silt and Sand.

On September 19, 2024, a UAS and snorkel survey were conducted. We snorkeled 11 pools, approximately 84.6% of the available pool habitat, during which adult and juvenile coho salmon, adult and juvenile Chinook salmon, adult and juvenile steelhead, and cutthroat trout were observed. Other fish observed included age-0 trout, red-side shiners, and mountain whitefish (Table 24).

*Table 24. Results of summer snorkel surveys conducted within pool habitats in Austin Hot Springs and the USFS Control Channel.*

| Site Location | Pool Area ($m^2$) | Snorkel Area ($m^2$) | Sum of Coho | Sum of Cutthroat | Sum of Steelhead | Sum of Chinook | Other fish observed |
|---|---|---|---|---|---|---|---|
| Austin Hot Springs** | 6,028.8 | 3,565.4 | 1,710 | 1 | 114 | 595 | 0+Trout*, Adult coho, adult chinook, Whitefish, Large Scale Sucker |
| USFS Control | 13,165.9 | 13,151.9 | 415 | 0 | 0 | 0 | Large Scale Sucker, Whitefish |

*Trout fry < 90 mm in fork length;  **Snorkeled a Glide habitat unit type.

The habitat rating for the USFS Control was ranked as poor to fair for salmonid use across various life history types of species based on the HabRate model from 2020 (Burke et al., 2010). Species-specific averages across life history types ranged from 1.3 (coho salmon) to 2.2 (steelhead) (Table 25).

*Table 25. Habrate (Burke et al. 2010) provides pre-restoration life history ratings for Chinook salmon, steelhead, coho salmon, and cutthroat trout habitat for Austin Hot Springs and the USFS Control Channel.*

| **Chinook Salmon Habitat** | | | | | |
|---|---|---|---|---|---|
| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | Chinook Average |
| Austin Hot Springs | 2024 | 1 | 2 | 2 | 1.6 |
| USFS Control | 2024 | 1 | 2 | 2 | 1.6 |

| **Steelhead Habitat** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | 1+ Summer | 1+ Winter | Steelhead Average |
| Austin Hot Springs | 2024 | 1 | 2 | 3 | 2 | 3 | 2.2 |
| USFS Control | 2024 | 1 | 2 | 3 | 2 | 3 | 2.2 |

| **Coho Habitat** | | | | | |
|---|---|---|---|---|---|
| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | Coho Average |
| Austin Hot Springs | 2024 | 2 | 1 | 1 | 1.3 |
| USFS Control | 2024 | 2 | 1 | 1 | 1.3 |

| **Cutthroat Habitat** | | | | | | |
|---|---|---|---|---|---|---|
| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | 1+ Summer | Cutthroat Average |
| Austin Hot Springs | 2024 | 1 | 2 | 2 | 2 | 1.75 |
| USFS Control | 2024 | 1 | 2 | 2 | 2 | 1.75 |

**USFS Control**

On April 3, 2024, a UAS and a ground-based habitat survey were conducted to assess winter flow conditions (Figure 6). The USFS control contained 90,364.0 $m^2$ of primary channel habitat and 1,992 $m^2$ of secondary channel habitat (Table 21), and pool habitat represented 17% across all channel types (Table 22). The overall large wood volume throughout the channel was 113 $m^3$, or 6.2 $m^3$ per 100 meters of primary channel length when standardized. Additionally, three key pieces of wood (≥ 12 m in length and ≥ 60 cm in diameter) were measured (Table 22). The USFS Control substrate was a mix of fine sediments (15%), cobble (39%), boulder (24%), and gravel (21%) (Table 23).

A snorkel survey was conducted on September 12, 2024, covering 99.9% of the available pool habitat. Observations included coho salmon, large scale sucker, and mountain whitefish (Table 24). The habitat rating for the USFS Control was ranked as poor to fair for salmonid use across various life history types of species based on the HabRate model from 2020 (Burke et al., 2010). Species-specific averages across life history types ranged from 1.3 for coho salmon to 2.2 for steelhead (Table 25).

## Kingfisher and Upper Control

### Kingfisher Side channel

A UAS and a physical habitat survey were conducted on March 19, 2024, to assess three years post-restoration winter conditions. The UAS imagery reveals distinct variations in habitat surface area between the winter and summer seasons following restoration efforts (Figure 7). The total wetted winter surface area of Kingfisher Side Channel was 3,191 m², while the summer surface area was 2,640 m². Kingfisher Side Channel contained 3,275 m² of primary channel habitat and no secondary channel habitat (Table 26).

*Table 26. Channel measurements from ground-based surveys in Kingfisher and the Upper Control Channel.*

| Site Location | Winter Surface Area ($m^2$) | Summer Surface Area ($m^2$) | Primary Channel Length (m) | Secondary Channel Length (m) | Primary Channel Area ($m^2$) | Secondary Channel Area ($m^2$) | Off-Channel Area ($m^2$)* |
|---|---|---|---|---|---|---|---|
| Kingfisher | 3,191 | 2,640 | 441 | 0 | 3,275.0 | 0 | 0 |
| Upper Control | 2,321 | 2,252 | 213 | 10 | 2,991.0 | 30 | 30 |

*Alcoves, Backwaters, Isolated pools.

Scour pool habitat made up 56% of the primary channel (Table 27). The overall large wood volume throughout the channel was 157 m³, which equals 36 m³ per 100 meters of primary channel length when standardized. Three key pieces of wood were measured, averaging 0.68 pieces per 100 meters of primary channel length (Table 27).

*Table 27. Physical habitat summary from ground-based surveys in Kingfisher and the Upper Control Channel.*

| Site Location | Pool Habitat (%) | Residual Pool Depth (m) | Riffle Depth (m) | Wood Volume ($m^3$)* | # Of Key Wood Pieces |
|---|---|---|---|---|---|
| Kingfisher | 56 | 0.53 | 0.5 | 36 | 3 |
| Upper Control | 59 | 1.35 | 0.3 | 0.33 | 0 |

*Total/100m primary channel.

The substrate types observed predominantly throughout the Kingfisher Side Channel were cobble (52%) and gravel (33.5%) (Table 28).

*Table 28. Summary of streambed substrate in Kingfisher and the Upper Control Channel.*

| Site Location | % Fines* | % Gravel | % Cobble | % Boulder | % Bedrock |
|---|---|---|---|---|---|
| Kingfisher | 7 | 33.5 | 52 | 8 | 0 |
| Upper Control | 19 | 25 | 42 | 9 | 5 |

*Silt and Sand.

A UAS survey was conducted on September 9, 2024, to capture post-restoration summer conditions. UAS imagery shows that the primary channel is fully inundated with water and flows freely during summer, with an expected loss of habitat surface area due to summer flow conditions. The tree canopy obscures a small portion of the visible surface area within several habitat units (Figure 7). The ground-filtered DEM layer helped establish channel boundaries, as canopy cover obscured areas on the orthomosaic. An on-the-ground habitat survey provided details about the unit boundaries, depths, and secondary verification.

On September 9, 2024, a snorkel survey was conducted. We snorkeled 100% of the available pool habitat. Coho salmon, dace, northern pike minnow, and mosquitofish were observed (Table 29).

*Table 29. Results of summer snorkel surveys conducted within pool habitats in Kingfisher and the Upper Control Channel.*

| Site Location | Pool Area ($m^2$) | Snorkel Area ($m^2$) | Sum of Coho | Sum of Cutthroat | Sum of Steelhead | Sum of Chinook | Other fish observed |
|---|---|---|---|---|---|---|---|
| Kingfisher | 1,400.0 | 1,400.0 | 1 | 0 | 0 | 0 | Dace, Mosquitofish, NPM* |
| Upper Control | 1,192.5 | 1,192.5 | 11 | 0 | 0 | 0 | Dace, Shiner, Sculpin, Mosquitofish |

*Northern Pikeminnow.

Results of the HabRate model (Burke et al. 2010) suggest habitat quality within the Kingfisher Side channel was poor to fair across salmonid life history types prior to restoration activities. The species-specific averages for life history types ranged from 1.2 (steelhead) to 1.75 (cutthroat trout). Following restoration efforts, the habitat rating improved for (Chinook salmon, steelhead, coho salmon, and cutthroat trout) (Table 30).

*Table 30. Habrate (Burke et al. 2010) provides pre-restoration life history ratings for Chinook salmon, steelhead, coho salmon, and cutthroat trout habitat.*

| Chinook Salmon Habitat | | | | | |
|---|---|---|---|---|---|
| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | Chinook Average |
| Kingfisher (Pre) | 2021 | 1 | 2 | 2 | 1.6 |
| Kingfisher (Post) | 2022 | 2 | 2 | 3 | 2.3 |
| Kingfisher (Post) | 2024 | 3 | 3 | 3 | 3 |
| Upper Control | 2021 | 2 | 2 | 2 | 2 |
| Upper Control | 2022 | 2 | 2 | 2 | 2 |
| Upper Control | 2024 | 2 | 2 | 3 | 2.3 |

| Steelhead Habitat | | | | | | | |
|---|---|---|---|---|---|---|---|
| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | 1+ Summer | 1+ Winter | Steelhead Average |
| Kingfisher (Pre) | 2021 | 1 | 2 | 1 | 1 | 1 | 1.2 |
| Kingfisher (Post) | 2022 | 2 | 3 | 3 | 3 | 3 | 2.8 |
| Kingfisher (Post) | 2024 | 3 | 3 | 3 | 3 | 3 | 3 |
| Upper Control | 2021 | 2 | 2 | 2 | 2 | 2 | 2 |
| Upper Control | 2022 | 2 | 2 | 2 | 2 | 2 | 2 |
| Upper Control | 2024 | 2 | 3 | 2 | 2 | 2 | 2.2 |

| Coho Habitat | | | | | |
|---|---|---|---|---|---|
| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | Coho Average |
| Kingfisher (Pre) | 2021 | 1 | 1 | 2 | 1.3 |
| Kingfisher (Post) | 2022 | 2 | 3 | 1 | 2 |
| Kingfisher (Post) | 2024 | 3 | 3 | 1 | 2.3 |
| Upper Control | 2021 | 3 | 1 | 1 | 1.6 |
| Upper Control | 2022 | 3 | 2 | 1 | 2 |
| Upper Control | 2024 | 3 | 2 | 1 | 2 |

| Cutthroat Habitat | | | | | | |
|---|---|---|---|---|---|---|
| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | 1+ Summer | Cutthroat Average |
| Kingfisher (Pre) | 2021 | 1 | 2 | 2 | 2 | 1.75 |
| Kingfisher (Post) | 2022 | 2 | 2 | 2 | 2 | 2 |
| Kingfisher (Post) | 2024 | 3 | 2 | 2 | 2 | 2.25 |
| Upper Control | 2021 | 1 | 1 | 1 | 2 | 1.25 |
| Upper Control | 2022 | 2 | 1 | 1 | 2 | 1.5 |
| Upper Control | 2024 | 1 | 1 | 1 | 2 | 1.25 |

## Upper Control Channel

A UAS and a physical habitat survey captured average winter flow conditions on March 19, 2024 (Figure 8). The total wetted winter surface area of the Upper Control Channel was 2,321 $m^2$, while the summer surface area was 2,252 $m^2$ (Table 26). The Upper Control Channel contained 2,991 $m^2$ of primary channel habitat and 30 $m^2$ of secondary channel habitat (Table 26). Scour pool habitat made up 59% of the primary channel (Table 27). The wood volume throughout the channel was 0.71 $m^3$, or 0.33 $m^3$ per 100 meters of primary channel length. No key pieces of large wood were measured (Table 27). The observed substrate types in the Upper Control Channel were predominantly cobble (42%), gravel (25%), and fine sediment (19%) (Table 28).

A UAS survey to capture summer flow conditions took place on September 9, 2024. The UAS imagery reveals expected variations in habitat surface area between the summer and winter seasons (Figure 8). UAS imagery indicates that the channel is completely inundated with water during average winter flows, whereas there is a reduction in habitat surface area during summer flows. The Upper Control Channel maintains consistent connectivity to the Clackamas mainstem and, as a result, experiences minimal habitat loss between the winter and summer seasons. The summer tree canopy obscures a significant portion of the observable surface area (Figure 8). When canopy cover obscured areas on the orthomosaic, the ground-filtered DEM layer helped establish channel boundaries. An on-the-ground habitat survey provided details on the unit boundaries and depths, as well as a secondary verification.

A snorkel survey was conducted on September 9, 2024. We snorkeled all available pool habitats. Observations included coho salmon, dace, red-side shiners, sculpin, and mosquitofish (Table 29).

Prior to any restoration activities associated with the Clackamas FIP, results from the HabRate model (Burke et al. 2010) suggested habitat quality within the Upper Control Channel was poor to fair across salmonid life history types. Species-specific averages across life history types ranged from 1.5 (cutthroat trout) to 2.6 (Chinook salmon). Between 2021 and 2023, habitat quality improved slightly for Chinook salmon (from 2.3 to 2.6), steelhead (from 2.0 to 2.4), and cutthroat trout (from 1.25 to 1.5). However, it decreased for coho salmon (1.6 to 1.3). In 2024, habitat quality increased for coho salmon (2.0) and declined for Chinook (2.3), steelhead (2.2), and cutthroat trout (1.25) (Table 30).

### Restoration Comparison: Kingfisher and Upper Control

We compared the Kingfisher restoration site to the Upper Control site to assess morphological change for the years 2021, 2022, and 2024. The restoration of the Kingfisher site resulted in several notable changes. The off-channel area decreased dramatically from 1,348.82 $m^2$ to 0. The percentage of pool habitat decreased by almost a third from 82% to 56%, and the residual pool depth decreased from 0.65 m to 0.53 m. The wood volume increased from 6.6 $m^3$ to 36 $m^3$, and the number of individual key wood pieces increased from 1 to 3. The percentage of fines (silt and sand) decreased from 48% to 7%, while the percentages of gravel and cobble increased from 14% to 33.5% and from 23% to 52%. (Table 31).

*Table 31. Differences between pre- and post-restoration treatments in Kingfisher and the Upper Control Channel, for 2021, 2022, and 2024.*

| **Habitat Metric** | **Upper Control Channel 2021** | **Upper Control Channel 2022** | **Upper Control Channel 2024** | **Kingfisher Side Channel 2021** | **Kingfisher Side Channel 2022** | **Kingfisher Side Channel 2024** |
|---|---|---|---|---|---|---|
| River Level (CFS)**** | 2,090 | 3,250 | 4,319 | 2,090 | 3,250 | 4,319 |
| Primary Channel Area ($m^2$) | 1,588 | 2,261 | 2,991 | 3,283.5 | 2762.6 | 3,275 |
| Secondary Channel Area ($m^2$) | 0 | 0 | 30 | 0 | 0 | 0 |
| Off-Channel Area ($m^2$)*** | 0 | 0 | 30 | 1,348.82 | 0 | 0 |
| % Pool Habitat | 61 | 29 | 59 | 82 | 31.7 | 56 |
| Residual Pool Depth (m) | 1.12 | 1.35 | 1.35 | 0.65 | 0.7 | 0.53 |
| Riffle Depth (m) | 0.3 | 0.7 | 0.3 | 0.18 | 0.63 | 0.5 |
| Wood Volume ($m^3$)** | 0.3 | 1.5 | 0.33 | 6.6 | 36.5 | 36 |
| # of Key Wood Pieces | 0 | 0 | 0 | 1 | 12 | 3 |
| % Fines* | 9 | 6 | 19 | 48 | 11 | 7 |
| % Gravel | 19 | 18 | 25 | 14 | 27 | 33.5 |
| % Cobble | 43 | 47 | 42 | 23 | 48 | 52 |
| % Boulder | 19 | 20 | 9 | 15 | 14 | 8 |
| % Bedrock | 9 | 9 | 5 | 0 | 0 | 0 |

*Silt and Sand, ** Total/100m primary channel, ***Alcoves, Backwaters, Isolated pools, ****Estacada gauge station.

We used a Linear Mixed Effects Regression (LMER) model within a Before-After, Control-Impact (BACI) framework to evaluate changes in instream habitat metrics at the Kingfisher Side Channel (Impact site) and the Upper Control site (Control) across three sampling years (2021, 2022, 2024) (Table 32).

*Table 32. Linear Mixed model results assessing differences among instream habitat attributes across Control and Impact sites. Random effect = Year and Site, Alpha = 0.05.*

| Habitat Metric | Estimate | Std. Error | t-Statistic | p-Value |
|---|---|---|---|---|
| Primary Channel Area ($m^2$) | -1,202.70 | 772.39 | -1.55 | 0.259 |
| Secondary Channel Area ($m^2$) | -15 | 25.98 | -0.57 | 0.622 |
| Off-Channel Area ($m^2$)*** | -1,363.82 | 25.98 | -52.49 | 0.0003 |
| % Pool Habitat | -21.66 | 33.30 | -0.65 | 0.582 |
| Residual Pool Depth (m) | -0.26 | 0.14 | -1.83 | 0.208 |
| Riffle Depth (m) | 0.18 | 0.36 | 0.51 | 0.660 |
| Wood Volume ($m^3$)** | 28.93 | 1.30 | 22.13 | 0.002 |
| # Of Key Wood Pieces** | 1.56 | 1.85 | 0.84 | 0.487 |
| % Fines* | -41.91 | 11.73 | -3.57 | 0.070 |
| % Gravel | 13.61 | 8.64 | 1.57 | 0.255 |
| % Cobble | 25.06 | 5.07 | 4.93 | 0.038 |
| % Boulder | 0.78 | 11.40 | 0.06 | 0.951 |
| % Bedrock | 2.45 | 3.61 | 0.67 | 0.567 |

*Silt and Sand, ** Total/100m primary channel, ***Alcoves, Backwaters, Isolated pools

Among the habitat attributes assessed, wood volume showed a statistically significant increase at the impact site relative to the control (Estimate = 28.93 $m^3$/100 m, $p = 0.002$), indicating a clear treatment effect of instream wood. Off-channel area showed a significant decrease at the treated site (Estimate = -1,363.82 $m^2$, $p = 0.0003$). Percent cobble also increased significantly (Estimate = 25.06%, $p = 0.038$). Other habitat metrics, including pool habitat, depths, substrate fines, and key wood pieces, did not show statistically significant BACI responses ($p > 0.05$) (Table 32).

## Restoration Assessment: Kingfisher and Upper Control

Minor differences were observed within the Upper Control over the years of monitoring (2021, 2022, 2024). In contrast, Kingfisher underwent observable changes associated with restoration efforts. Both riffle depth (Figure 16) and large wood metrics (Figure 17) increased within the Kingfisher site when compared to the Upper Control.

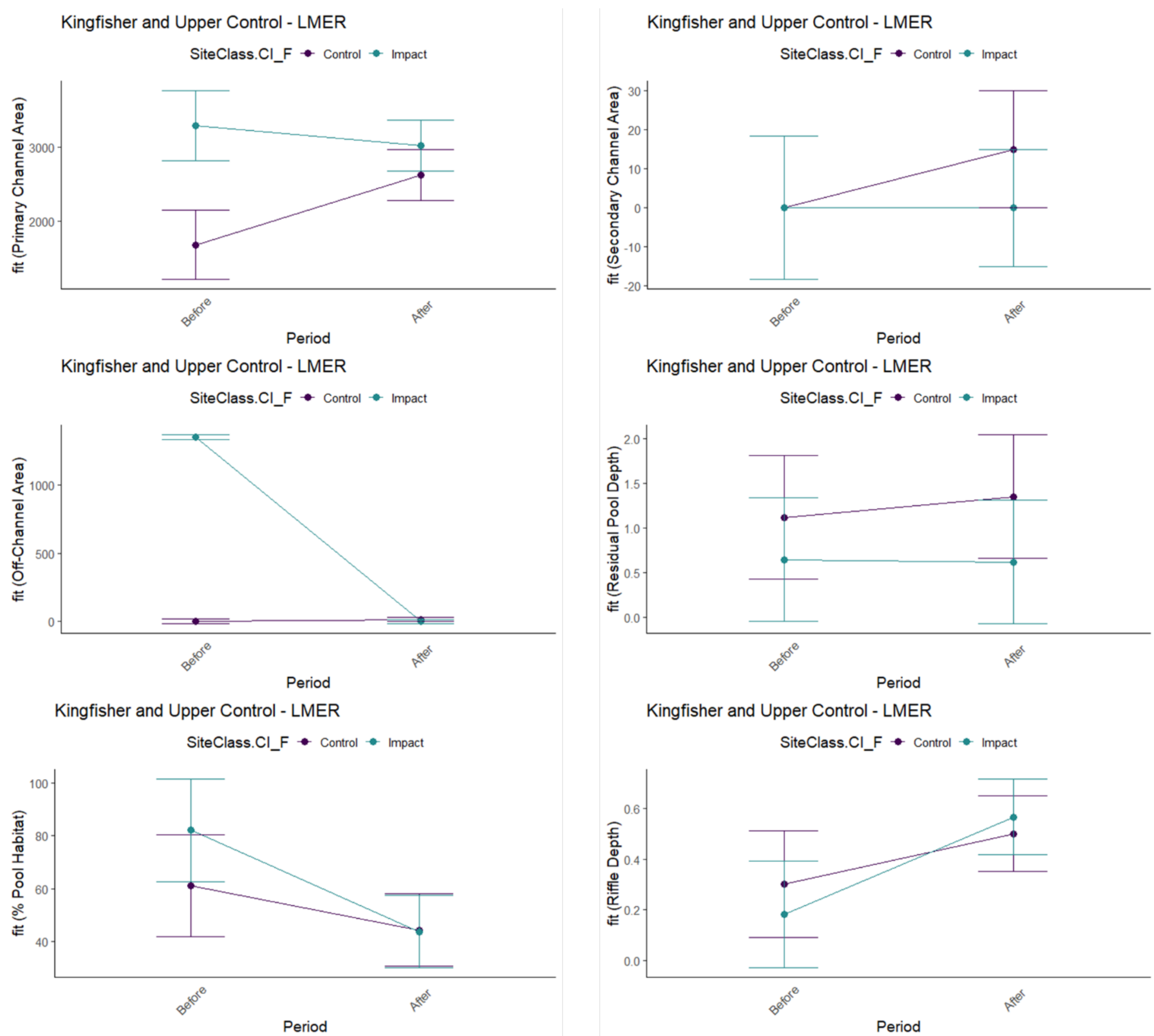


*Figure 16. Line plots illustrate the differences between pre-restoration and post-restoration treatments across channel, pool, and riffle features of Kingfisher and the Upper Control sites.*

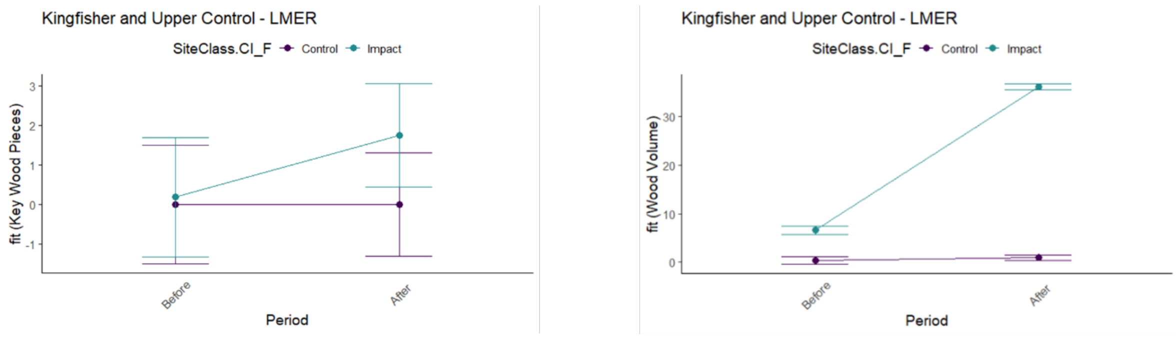


*Figure 17. Line plots illustrate the differences between pre-restoration treatment and post-restoration treatment for wood volume (m³) and the number of key pieces of wood per 100m of primary channel.*

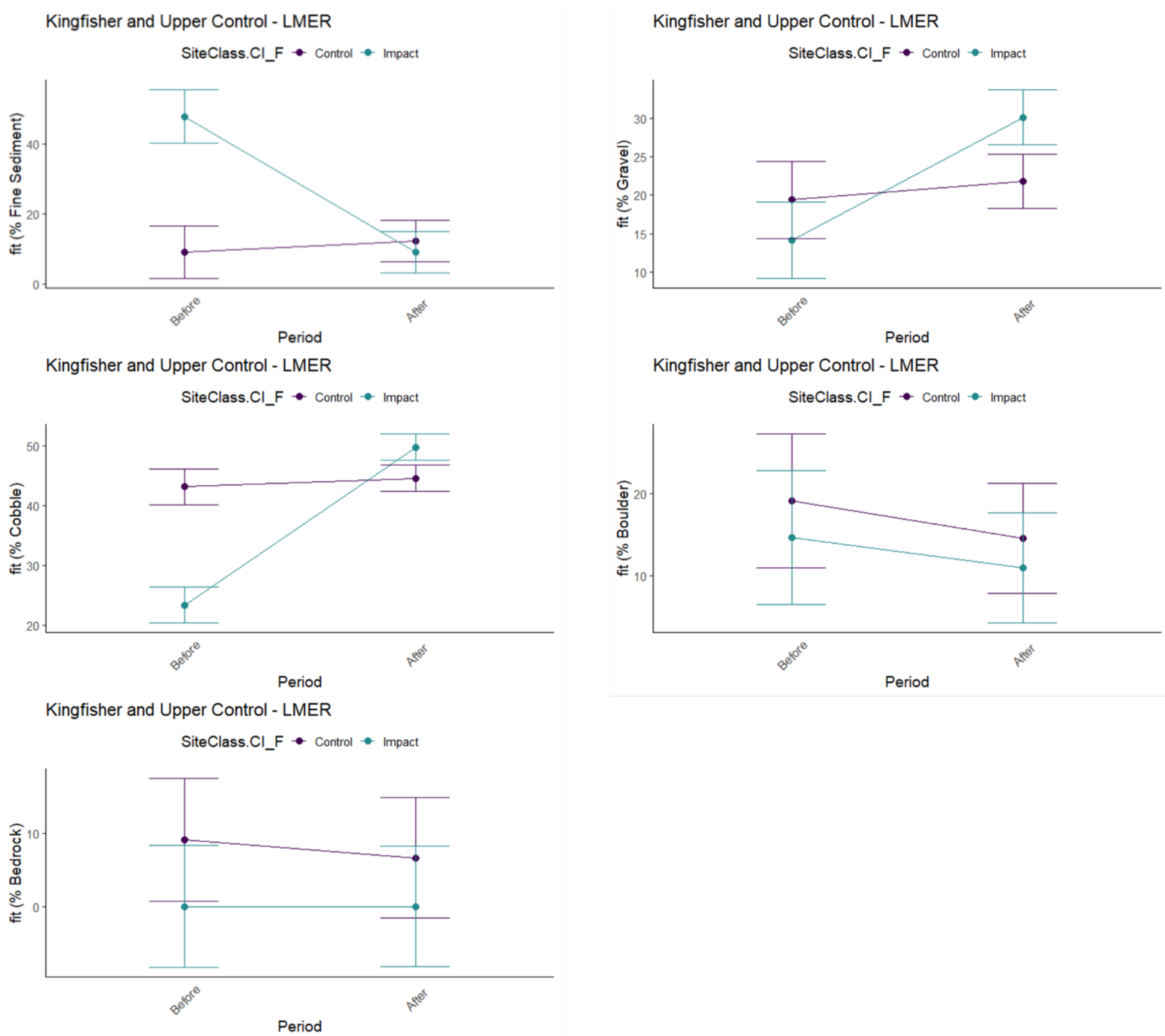


*Figure 18. Line plots illustrate the differences between pre- and post-restoration treatments across bedload types in Kingfisher and the Upper Control Channel.*

## Eagle Creek Complex and Middle Control Channel

**Eagle Creek Complex**

A UAS survey was conducted on March 7, 2024, to capture four years of post-restoration winter conditions (Figure 9). An on-the-ground physical habitat survey was conducted on March 20, 2024. The total wetted winter surface area of Eagle Creek Complex was 20,213.2m², while the summer surface area was 9,223.67m² (Table 33). The Eagle Creek Complex contained 13,537.0 m² of primary channel habitat and 11,496.0 m² of secondary channel habitat (Table 33).

*Table 33. Channel measurements from ground-based surveys in Eagle Creek and the Middle Control Channel.*

| Site Location | Winter Surface Area (m²) | Summer Surface Area (m²) | Primary Channel Length (m) | Secondary Channel Length (m) | Primary Channel Area (m²) | Secondary Channel Area (m²) | Off-Channel Area (m²)* |
|---|---|---|---|---|---|---|---|
| Eagle Creek | 20,213.2 | 9,223.67 | 543 | 988.2 | 13,537.0 | 11,496.0 | 40 |
| Middle Control | 5,897.9 | 4,450 | 288 | 107 | 4,883.0 | 461 | 416 |

*Alcoves, Backwaters, Isolated pools.

Scour pool habitat made up 40% of the primary channel (Table 34). The total large wood volume throughout the complex amounted to 555 m³ or 102.2 m³ when standardized per 100 meters of primary channel length. Additionally, 24 key pieces were measured across the surveyed area, averaging 4.4 pieces per 100 meters of primary channel length (Table 34).

*Table 34. Physical habitat summary from ground-based surveys in Eagle Creek and the Middle Control Channel.*

| Site Location | Pool Habitat (%) | Residual Pool Depth (m) | Riffle Depth (m) | Wood Volume (m³)* | # Of Key Wood Pieces |
|---|---|---|---|---|---|
| Eagle Creek | 40 | 0.64 | 0.25 | 102.2 | 24 |
| Middle Control | 21 | .6 | .45 | 11.3 | 1 |

*Total/100m primary channel.

The observed substrate types within the complex consisted of cobble (42%), gravel (37%), sand (17%), bedrock (2.5%), and boulders (1.3%) (Table 35).

*Table 35. Summary of streambed substrate in Eagle Creek and the Middle Control Channel.*

| Site Location | % Fines* | % Gravel | % Cobble | % Boulder | % Bedrock |
|---|---|---|---|---|---|
| Eagle Creek | 17 | 37 | 42 | 1 | 2.5 |
| Middle Control | 19 | 35 | 40 | 3 | 3 |

*Silt and Sand.

A UAS post-restoration summer conditions survey was conducted on September 4, 2024. The surface area of the stream habitat observed within the Eagle Creek Complex using the UAS varied dramatically between the summer and winter seasons (Figure 9). Some changes were attributed to the emergence of the tree canopy during the summer surveys, which resulted in limited visual penetration with the UAS camera (Figure 9). Utilizing image filters within the UAS DEM layer helped improve visibility through the canopy and establish channel boundaries; however, it remained challenging to delineate distinct edge boundaries and surface areas of habitat units in densely vegetated secondary side channel units due to leaf canopy obstructions. An on-the-ground habitat survey provided detailed information on the unit boundaries and depths and served as a secondary verification.

In the Eagle Creek Complex, the UAS imagery clearly indicates that seasonal flows significantly contribute to the available surface area of the stream habitat. The imagery reveals that both primary and secondary channels are completely inundated with water during the winter flows. Following restoration efforts, the flow was redirected so that while all channels remain inundated during winter, a substantial amount of the flow has been diverted into the primary and easternmost secondary channels. Additionally, the UAS imagery reveals that the primary and secondary channels are severely affected by the lack of flow during the summer months, resulting in the complete drying up of all secondary channels (Figure 9).

A snorkel survey was conducted on September 4, 2024. We snorkeled 99% of the available pool habitat (Table 36). Observations included juvenile and adult coho salmon, steelhead, cutthroat trout, dace, red-side shiner, northern pikeminnow, largemouth bass, and sculpin.

*Table 36. Results of summer snorkel surveys conducted within pool habitats in Eagle Creek and the Middle Control.*

| Site Location | Pool Area ($m^2$) | Snorkel Area ($m^2$) | Sum of Coho | Sum of Cutthroat | Sum of Steelhead | Sum of Chinook | Other fish observed |
|---|---|---|---|---|---|---|---|
| Eagle Creek | 3,965.95 | 3,952.95 | 190 | 1 | 15 | 0 | Dace, shiner, Sculpin, NPM**, Largemouth Bass, Adult coho |
| Middle Control* | 4,026 | 4,026 | 0 | 0 | 2 | 0 | Dace, shiner, NPM**, Sculpin, Largemouth bass |

*Snorkeled a Glide habitat unit type; **Northern Pikeminnow.

Prior to restoration activity, the HabRate model (Burke et al. 2010) rated the Eagle Creek Complex habitat quality as fair to good across salmonid life history types. Species-specific averages across life history types ranged from 2.0 (steelhead) to 2.6 (coho salmon). Following restoration, in 2021, the model suggested habitat quality was poor to fair across species life history types. Habitat quality decreased overall after restoration for Chinook, steelhead, and coho salmon, while it remained unchanged for cutthroat trout. In 2024, four years post-restoration, the habitat rating in the Eagle Creek complex showed improvements for all species-specific averages across life history types, ranging from 2.8 (steelhead) to 2.6 (Chinook and coho salmon) and 2.5 (cutthroat trout) (Table 37).

*Table 37. Habrate (Burke et al. 2010) provides pre-restoration life history ratings for Chinook salmon, steelhead, coho salmon, and cutthroat trout habitat.*

| **Chinook Salmon Habitat** | | | | | |
|---|---|---|---|---|---|
| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | Chinook Average |
| Eagle Creek (Pre) | 2020 | 1 | 3 | 3 | 2.3 |
| Eagle Creek (Post) | 2021 | 1 | 2 | 2 | 1.6 |
| Eagle Creek (Post) | 2024 | 3 | 2 | 3 | 2.6 |
| Middle Control | 2020 | 1 | 2 | 2 | 1.6 |
| Middle Control | 2021 | 1 | 2 | 2 | 1.6 |
| Middle Control | 2024 | 1 | 2 | 2 | 1.6 |

| **Steelhead Habitat** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | 1+ Summer | 1+ Winter | Steelhead Average |
| Eagle Creek (Pre) | 2020 | 1 | 3 | 3 | 2 | 1 | 2 |
| Eagle Creek (Post) | 2021 | 1 | 2 | 2 | 2 | 2 | 1.8 |
| Eagle Creek (Post) | 2024 | 3 | 3 | 3 | 2 | 3 | 2.8 |
| Middle Control | 2020 | 1 | 2 | 2 | 2 | 2 | 1.8 |
| Middle Control | 2021 | 1 | 2 | 2 | 2 | 2 | 1.8 |
| Middle Control | 2024 | 1 | 2 | 2 | 2 | 2 | 1.8 |

| **Coho Habitat** | | | | | |
|---|---|---|---|---|---|
| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | Coho Average |
| Eagle Creek (Pre) | 2020 | 2 | 3 | 3 | 2.6 |
| Eagle Creek (Post) | 2021 | 1 | 2 | 3 | 2 |
| Eagle Creek (Post) | 2024 | 2 | 3 | 3 | 2.6 |
| Middle Control | 2020 | 1 | 2 | 2 | 1.6 |
| Middle Control | 2021 | 1 | 2 | 2 | 1.6 |
| Middle Control | 2024 | 1 | 2 | 2 | 1.6 |

| **Cutthroat Habitat** | | | | | | |
|---|---|---|---|---|---|---|
| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | 1+ Summer | Cutthroat Average |
| Eagle Creek (Pre) | 2020 | 2 | 2 | 3 | 2 | 2.25 |
| Eagle Creek (Post) | 2021 | 2 | 3 | 2 | 2 | 2.25 |
| Eagle Creek (Post) | 2024 | 3 | 3 | 2 | 2 | 2.5 |
| Middle Control | 2020 | 2 | 2 | 2 | 2 | 2 |
| Middle Control | 2021 | 1 | 2 | 2 | 2 | 1.75 |
| Middle Control | 2024 | 1 | 2 | 2 | 2 | 1.75 |

### Middle Control Channel

A UAS and on-the-ground physical habitat survey were conducted on March 20, 2024, to capture the average winter flow conditions (Figure 10). The total wetted winter surface area of the Middle Control Channel was 5,897.9 $m^2$, while the summer surface area was 4,450 $m^2$ (Table 33). The Middle Control Channel contained 4,883.0 $m^2$ of primary channel habitat and 461 $m^2$ of secondary channel habitat (Table 33). Scour pool habitat made up 21% of the primary channel (Table 34). The wood volume throughout the channel was 32.45 $m^3$, or 11.3 $m^3$ per 100 meters of primary channel length. One key piece of large wood was measured (Table 34). The substrate types observed throughout the Middle Control Channel included cobble (40%), gravel (35%), and fine sediments (19%) (Table 35).

A UAS survey took place on September 3, 2024, to capture summer flow conditions. The UAS imagery reveals minor variations in habitat surface area between winter and summer (Figure 10). The Middle Control Channel maintains consistent connectivity to the Clackamas mainstem, resulting in minimal habitat loss across the winter and summer seasons. UAS imagery indicates the channel is inundated with water during typical winter flows. The Middle Control Channel features three alcoves, a tributary, and a long pool unit with wood structures. UAS imagery reveals a near-complete loss of off-channel habitat during summer baseflow conditions. Recent fires had diminished the tree canopy, but UAS imagery still shows that the canopy obscures some of the visible surface area and the tributary (Figure 10). An on-the-ground habitat survey confirmed the unit boundaries and the location of the tributary.

A snorkel survey was conducted on September 3, 2024. We snorkeled all available pool habitat. Fish observations included steelhead, dace, red-side shiner, northern pikeminnow, largemouth bass, and sculpin (Table 36).

Prior to any restoration activities associated with the Clackamas FIP, results from the HabRate model (Burke et al. 2010) suggested stream habitat quality within the Middle Control Channel was poor to fair for salmonids across life history types. Species-specific averages for life history types were similar: Chinook and coho salmon (1.6), cutthroat trout (1.75), and steelhead (1.8). Habitat quality ratings have remained consistent throughout the sampling years (Table 37).

#### Restoration Comparison: Eagle Creek Complex and Middle Control

We compared the Eagle Creek Complex restoration site to the Middle Control site to assess morphological change for the years 2020, 2021, and 2024. The restoration of the Eagle Creek Complex from 2020 to 2024 resulted in several notable changes. We recorded an increase in the primary channel area from 11,749.8 $m^2$ to 13,537.0 $m^2$, and the secondary channel area increased from 7,350.7 $m^2$ to 11,496.0 $m^2$. The percentage of pool habitat decreased from 48% to 40%, while both the residual pool depth and riffle depth increased from 0.57 m to 0.64 m. The wood volume increased from 59 $m^3$ to 102.2 $m^3$, and the number of individual key wood pieces decreased from 28 to 24. Minor shifts in substrate composition were recorded (Table 38).

*Table 38. Differences between pre- and post-restoration treatments in Eagle Creek and the Middle Control Channel, for 2020, 2021, and 2024.*

| **Habitat Metric** | **Middle Control Channel 2020** | **Middle Control Channel 2021** | **Middle Control Channel 2024** | **Eagle Creek Complex 2020** | **Eagle Creek Complex 2021** | **Eagle Creek Complex 2024** |
|---|---|---|---|---|---|---|
| River Level (CFS)**** | 2,380 | 2,620 | 4,490 | 2,330 | 2,200 | 4,490 |
| Primary Channel Area ($m^2$) | 4,668.0 | 4,882.0 | 4,883.0 | 11,749.8 | 10,179.5 | 13,537.0 |
| Secondary Channel Area ($m^2$) | 0 | 594 | 255.2 | 7,350.75 | 7,027.4 | 11,496.0 |
| Off-Channel Area ($m^2$)*** | 443.1 | 573.1 | 210 | 108 | 264.5 | 40 |
| % Pool Habitat | 71 | 69 | 18 | 48 | 38.5 | 40 |
| Residual Pool Depth (m) | 1.16 | 1.12 | 0.6 | 0.57 | 0.75 | 0.64 |
| Riffle Depth (m) | 0.45 | 0.37 | 0.45 | 0.23 | 0.27 | 0.25 |
| Wood Volume ($m^3$)** | 12.3 | 10.5 | 8.9 | 89 | 104.9 | 102.2 |
| # of Key Wood Pieces | 0 | 0 | 1 | 28 | 22 | 24 |
| % Fines* | 29 | 33 | 15 | 16.4 | 19.9 | 17 |
| % Gravel | 26 | 25 | 35 | 37 | 36 | 37 |
| % Cobble | 42 | 30 | 40 | 43 | 35 | 42 |
| % Boulder | 3 | 12 | 3 | 2.9 | 9.7 | 1 |
| % Bedrock | 0 | 0 | 3 | 0 | 0.2 | 2.5 |

*Silt and Sand, ** Total/100m primary channel, ***Alcoves, Backwaters, and Isolated Pools

****Estacada gauge station.

We used a Linear Mixed Effects Regression (LMER) model within a Before-After, Control-Impact (BACI) framework to evaluate changes in instream habitat metrics at the Eagle Creek Complex (Impact site) and the Middle Control site (Control) across three sampling years (2020, 2021, 2024) (Table 39).

*Table 39. Linear Mixed model results assessing differences among instream habitat attributes across Control and Impact sites. Random effect = Year and Site, Alpha = 0.05.*

| Habitat Metric | Estimate | Std. Error | t-Statistic | p-Value |
|---|---|---|---|---|
| Primary Channel Area ($m^2$) | -106.05 | 2,907.68 | -0.03 | 0.974 |
| Secondary Channel Area ($m^2$) | 1,486.21 | 3,880.66 | 0.38 | 0.738 |
| Off-Channel Area ($m^2$)*** | 95.8 | 369.70 | 0.25 | 0.819 |
| % Pool Habitat | 18.61 | 44.06 | 0.42 | 0.713 |
| Residual Pool Depth (m) | 0.42 | 0.46 | 0.91 | 0.454 |
| Riffle Depth (m) | 0.07 | 0.06 | 1.03 | 0.407 |
| Wood Volume ($m^3$)** | 17.35 | 2.74 | 6.32 | 0.024 |
| # Of Key Wood Pieces** | -1.56 | 0.46 | -3.35 | 0.078 |
| % Fines* | 6.97 | 15.79 | 0.44 | 0.701 |
| % Gravel | -5.49 | 10.34 | -0.53 | 0.648 |
| % Cobble | 0.84 | 11.93 | 0.07 | 0.949 |
| % Boulder | -2.07 | 10.39 | -0.20 | 0.859 |
| % Bedrock | -0.25 | 3.39 | -0.07 | 0.947 |

*Silt and Sand, ** Total/100m primary channel, ***Alcoves, Backwaters, Isolated pools.

Among the habitat attributes assessed, wood volume showed a statistically significant increase at the impact site relative to the control (Estimate = 17.35 $m^3$/100 m, $p = 0.024$), indicating a clear treatment effect. Other metrics, including channel area, pool habitat, residual pool depth, and substrate composition, did not show statistically significant BACI responses ($p > 0.05$) (Table 39).

Restoration Assessment: Eagle Creek Complex and Middle Control.

Minor differences were observed within the Middle Control over the years of monitoring (2020, 2021, 2024). In contrast, the Eagle Creek Complex underwent observable changes associated with restoration efforts. Both secondary channel habitat (Figure 19) and wood volume (Figure 20) increased within the Eagle Creek Complex compared to Middle Control.

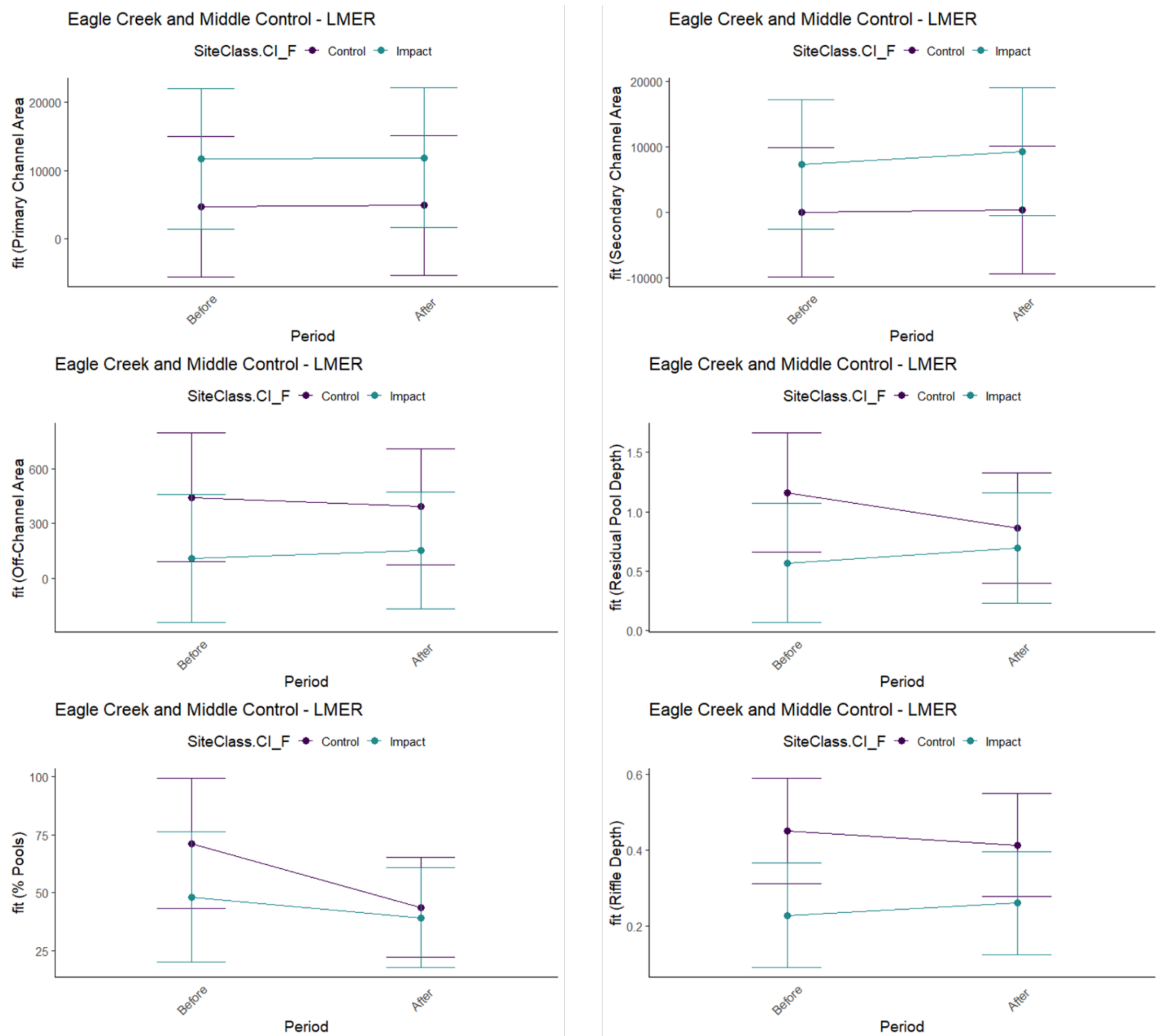


*Figure 19. Line plots illustrate the differences between pre-restoration and post-restoration treatments across channel, pool, and riffle features of Eagle Creek and the Middle Control Channel.*

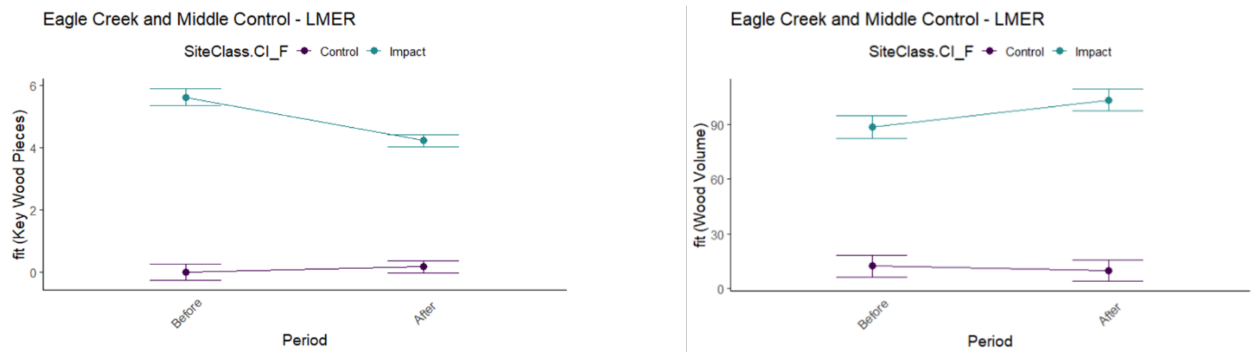


*Figure 20. Line plots illustrate the differences between pre-restoration treatment and post-restoration treatment for wood volume ($m^3$) and the number of key pieces of wood per 100m of primary channel.*

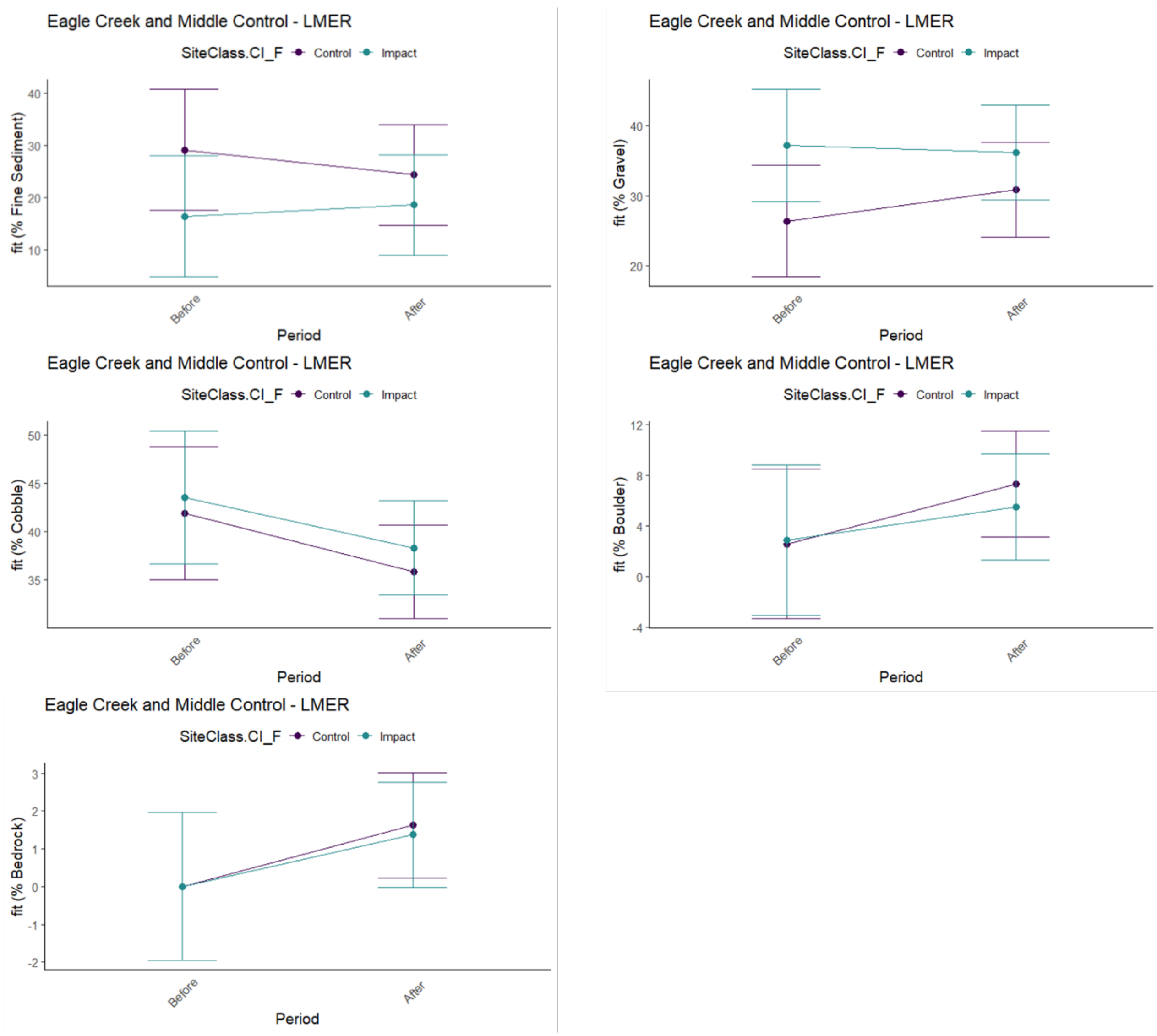


*Figure 21. Line plots illustrate the differences between pre- and post-restoration treatments across bedload types in Eagle Creek and the Middle Control Channel.*

## Riverbend and Lower Control Channel

### Riverbend

A UAS and a physical habitat survey captured two years post-restoration winter flow conditions on April 10, 2024 (Figure 11). The total wetted winter surface area of Riverbend was 6,776.9 $m^2$, while the summer surface area was 1,918.4 $m^2$ (Table 40). The Riverbend site contained 7,836.8 $m^2$ of primary channel habitat and 124 $m^2$ of secondary channel habitat (Table 40).

*Table 40. Channel measurements from ground-based surveys in Riverbend and the Lower Control Channel.*

| Site Location | Winter Surface Area ($m^2$) | Summer Surface Area ($m^2$) | Primary Channel Length (m) | Secondary Channel Length (m) | Primary Channel Area ($m^2$) | Secondary Channel Area ($m^2$) | Off-Channel Area ($m^2$)* |
|---|---|---|---|---|---|---|---|
| Riverbend | 6,776.9 | 1,918.4 | 868 | 74 | 7,836.8 | 124 | 51 |
| Lower Control | 7,610.7 | 4,190.7 | 248 | 200 | 2,319.0 | 5,299.0 | 5,130.0 |

*Alcoves, Backwaters, Isolated pools.

Scour pool habitat made up 82% of the primary channel habitat (Table 41). The total large wood volume throughout the channel was 114 $m^3$, equivalent to 37.7 $m^3$ per 100 meters of primary channel length when standardized. One key piece of wood was measured, translating to an average of 0.11 pieces per 100 meters of primary channel length (Table 41).

*Table 41. Physical habitat summary from ground-based surveys in Riverbend and the Lower Control Channel.*

| Site Location | Pool Habitat (%) | Residual Pool Depth (m) | Riffle Depth (m) | Wood Volume ($m^3$)* | # Of Key Wood Pieces |
|---|---|---|---|---|---|
| Riverbend | 82 | 0.63 | 0.22 | 37.7 | 1 |
| Lower Control | 80 | 0.13 | 0.17 | 21.4 | 2 |

*Total/100m primary channel.

The substrate types observed throughout the Riverbend site consisted of fine sediment (60%), cobble (21%), gravel (15%), and boulder (4%) (Table 42).

*Table 42. Summary of streambed substrate in Riverbend and the Lower Control channel.*

| Site Location | % Fines* | % Gravel | % Cobble | % Boulder | % Bedrock |
|---|---|---|---|---|---|
| Riverbend | 60 | 15 | 21 | 4 | 0 |
| Lower Control | 64 | 11 | 19 | 6.5 | 0 |

*Silt and Sand.

A UAS survey was conducted on September 10, 2024, to capture post-restoration summer conditions. The UAS imagery reveals distinct variations in habitat surface area between the summer and winter seasons following restoration efforts (Figure 11). The UAS imagery indicates that both the primary and secondary channels are completely inundated with water during average winter flows. Additionally, the UAS imagery shows that the primary channel and Sieben Creek, which flows into the Riverbend Channel, are entirely dry during summer flows. The tree canopy obscured a small portion of the visible surface area within several habitat units (Figure 11). The ground-filtered DEM layer assisted in establishing channel boundaries where canopy-covered areas on the orthomosaic were obscured. An on-the-ground survey provided secondary verification of the dry channel conditions.

On September 10, 2024, a snorkel survey was conducted. We snorkeled 88.5% of the available summer pool habitat, which consisted of two pools. The remaining habitat was either dry or the water quality was unsafe to snorkel for health reasons. Northern pike minnow, bluegill, and sculpin were observed (Table 43).

*Table 43. Results of summer snorkel surveys conducted within pool habitats in Riverbend and the Lower Control.*

| Site Location | Pool Area ($m^2$) | Snorkel Area ($m^2$) | Sum of Coho | Sum of Cutthroat | Sum of Steelhead | Sum of Chinook | Other fish observed |
|---|---|---|---|---|---|---|---|
| Riverbend | 1,611.5 | 1,426.0 | 0 | 0 | 0 | 0 | NPM**, Bluegill, Sculpin |
| Lower Control* | 3,486 | 3,486 | 0 | 0 | 0 | 0 | Dace, NPM** |

*Snorkeled an Alcove habitat unit type, **Northern Pikeminnow.

Prior to restoration activity, results from the HabRate model (Burke et al. 2010) suggested stream habitat quality within Riverbend was poor to fair across salmonid life history types. Species-specific averages across life history types ranged from 1.3 (coho salmon) to 2.0 (cutthroat trout). After restoration activities, the habitat rating remained unchanged for all life history types: 1.3 (coho salmon), 2.0 (cutthroat trout), 1.6 (Chinook), and 1.6 (steelhead) (Table 44).

*Table 44. Habrate (Burke et al. 2010) provides pre-restoration life history ratings for Chinook salmon, steelhead, coho salmon, and cutthroat trout habitat.*

**Chinook Salmon Habitat**

| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | Chinook Average |
|---|---|---|---|---|---|
| Riverbend (Pre) | 2021 | 1 | 2 | 2 | 1.6 |
| Riverbend (Post) | 2023 | 1 | 2 | 2 | 1.6 |
| Riverbend (Post) | 2024 | 1 | 2 | 2 | 1.6 |
| Lower Control | 2021 | 3 | 2 | 2 | 2.3 |
| Lower Control | 2023 | 1 | 2 | 2 | 1.6 |
| Lower Control | 2024 | 1 | 2 | 2 | 1.6 |

**Steelhead Habitat**

| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | 1+ Summer | 1+ Winter | Steelhead Average |
|---|---|---|---|---|---|---|---|
| Riverbend (Pre) | 2021 | 1 | 2 | 2 | 2 | 2 | 1.8 |
| Riverbend (Post) | 2023 | 1 | 2 | 2 | 2 | 2 | 1.8 |
| Riverbend (Post) | 2024 | 1 | 2 | 2 | 2 | 2 | 1.8 |
| Lower Control | 2021 | 2 | 2 | 3 | 2 | 3 | 2.4 |
| Lower Control | 2023 | 1 | 2 | 3 | 2 | 3 | 2.2 |
| Lower Control | 2024 | 1 | 2 | 2 | 2 | 2 | 1.8 |

**Coho Habitat**

| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | Coho Average |
|---|---|---|---|---|---|
| Riverbend (Pre) | 2021 | 1 | 2 | 1 | 1.3 |
| Riverbend (Post) | 2023 | 1 | 2 | 1 | 1.3 |
| Riverbend (Post) | 2024 | 1 | 2 | 1 | 1.3 |
| Lower Control | 2021 | 2 | 2 | 3 | 2.3 |
| Lower Control | 2023 | 2 | 2 | 3 | 2.3 |
| Lower Control | 2024 | 1 | 2 | 2 | 1.6 |

**Cutthroat Habitat**

| Stream | Year | Spawning to Emergence | 0+ Summer | 0+ Winter | 1+ Summer | Cutthroat Average |
|---|---|---|---|---|---|---|
| Riverbend (Pre) | 2021 | 2 | 2 | 2 | 2 | 2 |
| Riverbend (Post) | 2023 | 2 | 2 | 2 | 2 | 2 |
| Riverbend (Post) | 2024 | 2 | 2 | 2 | 2 | 2 |
| Lower Control | 2021 | 2 | 3 | 2 | 2 | 2.25 |
| Lower Control | 2023 | 1 | 2 | 2 | 2 | 1.75 |
| Lower Control | 2024 | 2 | 3 | 2 | 2 | 2.25 |

**Lower Control Channel**

A UAS and a physical habitat survey were conducted on April 10, 2024, to capture the average winter flow conditions following restoration (Figure 12). The total wetted winter surface area of the Lower Control Channel was 7,610.7 $m^2$, while the summer surface area was 4,190.7 $m^2$ (Table 40). The Lower Control contained 2,319 $m^2$ of primary channel habitat and 5,299 $m^2$ of secondary channel habitat (Table 40). Pool habitat comprised 80% of the channel habitat (Table 41). The wood volume throughout the channel measured 53.13 $m^3$, which is equivalent to 21.4 $m^3$ per 100 meters of primary channel length. Two key pieces of wood were recorded, resulting in an average of 0.8 pieces per 100 meters of primary length (Table 42). The substrate types within the Lower Control Channel included fine sediments (64%), cobble (19%), gravel (11%), and boulder (6.5%) (Table 43).

A UAS survey was conducted on September 10, 2024, to capture summer base flow conditions. The UAS imagery revealed distinct variations in habitat surface area between summer and winter (Figure 12). During average winter flows, the channel is completely inundated with water. In contrast, during summer flows, much of the mainstem flow is diverted from the control channel, which reduces habitat surface area. Additionally, the tree canopy made it challenging to observe the distinct edge boundaries of several habitat units (Figure 12). The ground-filtered DEM layer helped establish channel boundaries when the canopy cover obscured areas on the orthomosaic. An on-the-ground habitat survey provided details on the unit boundaries, depths, and a secondary verification.

On September 10, 2024, a snorkel survey was conducted, sampling 100% of the available pool habitat. The observations included dace, northern pikeminnow, mosquitofish, and a dead bluegill (Table 43).

Prior to any restoration activities associated with the Clackamas FIP, results from the HabRate model (Burke et al. 2010) suggested stream habitat quality within the Lower Control Channel was fair to good for salmonids across life history types. Species-specific averages across life history types ranged from 1.6 (coho salmon) to 2.4 (steelhead). Habitat quality remained consistent across sampling years for all salmonid life histories, with a slight decline observed for Chinook salmon, coho salmon, steelhead, and cutthroat between 2023 and 2024 (Table 44).

Restoration Comparison: Riverbend and Lower Control

We compared the Riverbend restoration site to the Lower Control site to evaluate morphological changes for the years 2021, 2023, and 2024. The restoration of the Riverbend site from 2021 to 2024 led to several notable changes. The primary channel area expanded from 3,549.3 $m^2$ to 7,837.0 $m^2$, while the secondary channel area decreased from 156 $m^2$ to 124 $m^2$. The residual pool depth and riffle depth increased. The wood volume increased from 11 $m^3$ to 37.7 $m^3$, while the number of individual key wood pieces decreased from 2 to 1. The percentage of fines (silt and sand) increased from 54.5% to 60.3%, while the percentage of gravel decreased from 24% to 15% (Table 45).

*Table 45. Differences between pre- and post-restoration treatments in Riverbend and the Lower Control Channel, for 2021, 2023, and 2024.*

| Habitat Metric | Lower Control Channel 2021 | Lower Control Channel 2023 | Lower Control Channel 2024 | Riverbend Side Channel 2021 | Riverbend Side Channel 2023 | Riverbend Side Channel 2024 |
|---|---|---|---|---|---|---|
| River Level (CFS)**** | 2,020 | 2,140 | 2,980 | 2,020 | 2,140 | 2,980 |
| Primary Channel Area ($m^2$) | 3,097.2 | 3,338.0 | 2,319.0 | 3,549 | 7,521.5 | 7,837 |
| Secondary Channel Area ($m^2$) | 8,382.0 | 4,030 | 5,299 | 156 | 333.3 | 124 |
| Off-Channel Area ($m^2$)*** | 8,768 | 4,475 | 5,130 | 0 | 0 | 51 |
| % Pool Habitat | 76 | 63 | 80.2 | 83 | 89 | 82 |
| Residual Pool Depth (m) | 0.4 | 0.21 | 0.13 | 0.43 | 0.52 | 0.63 |
| Riffle Depth (m) | 0.2 | 0.30 | 0.17 | 0.09 | 0.28 | 0.21 |
| Wood Volume ($m^3$)** | 21.0 | 20.2 | 21.4 | 11 | 28.2 | 37.7 |
| # of Key Wood Pieces | 2 | 3 | 2 | 2 | 14 | 1 |
| % Fines* | 60 | 35 | 64 | 54.5 | 49.7 | 60.3 |
| % Gravel | 17 | 19 | 11 | 24 | 31 | 15 |
| % Cobble | 20 | 43 | 19 | 19 | 17 | 21 |
| % Boulder | 3 | 4 | 6.5 | 2.1 | 1 | 3.9 |
| % Bedrock | 0 | 0 | 0 | 0 | 0 | 0 |

*Silt and Sand, ** Total/100m primary channel, ***Alcoves, Backwaters, and Isolated Pools
****Estacada gauge station.

We used a Linear Mixed Effects Regression (LMER) model within a Before-After, Control-Impact (BACI) framework to evaluate changes in instream habitat metrics at the Riverbend (Impact site) and the Lower Control site (Control) across three sampling years (2021, 2023, 2024)(Table 46).

*Table 46. Linear Mixed model results assessing differences among instream habitat attributes across Control and Impact sites. Random effect = Year and Site, Alpha = 0.05.*

| Habitat Metric | Estimate | Std. Error | t-Statistic | p-Value |
|---|---|---|---|---|
| Primary Channel Area ($m^2$) | 2,512.65 | 3,120.78 | 0.80 | 0.505 |
| Secondary Channel Area ($m^2$) | 5,676.05 | 3,275.10 | 1.73 | 0.225 |
| Off-Channel Area ($m^2$)* | 3,991 | 568.96 | 7.01 | 0.019 |
| % Pool Habitat | 7.47 | 16.10 | 0.46 | 0.688 |
| Residual Pool Depth (m) | 0.38 | 0.11 | 3.38 | 0.077 |
| Riffle Depth (m) | 0.12 | 0.12 | 1.02 | 0.413 |
| Wood Volume ($m^3$) | 22.06 | 8.28 | 2.66 | 0.116 |
| # Of Key Wood Pieces | 0.51 | 1.20 | 0.42 | 0.711 |
| % Fines** | 10.96 | 26.70 | 0.41 | 0.721 |
| % Gravel | 0.80 | 16.22 | 0.04 | 0.964 |
| % Cobble | -10.54 | 21.35 | -0.49 | 0.670 |
| % Boulder | -1.22 | 3.34 | -0.36 | 0.748 |
| % Bedrock | 0 | 0 | NA | NA |

*Alcoves, Backwaters, and Isolated Pools. **Combined observed values of silt and sand.

Among the habitat attributes assessed, Off-channel Area showed a statistically significant increase at the impact site relative to the control (Estimate = 3,991, p = 0.019), indicating a clear treatment effect. Other metrics, including channel area, pool habitat, residual pool depth, and substrate composition, did not show statistically significant BACI responses (p > 0.05).

## Restoration Assessment: Riverbend and Lower Control

Minor differences were observed within the Lower Control over the years of monitoring (2021, 2023, 2024). In contrast, the Riverbend site underwent observable changes associated with restoration efforts. Both secondary channel habitat (Figure 22) and wood volume (Figure 23) increased within the Riverbend site compared to Lower Control.

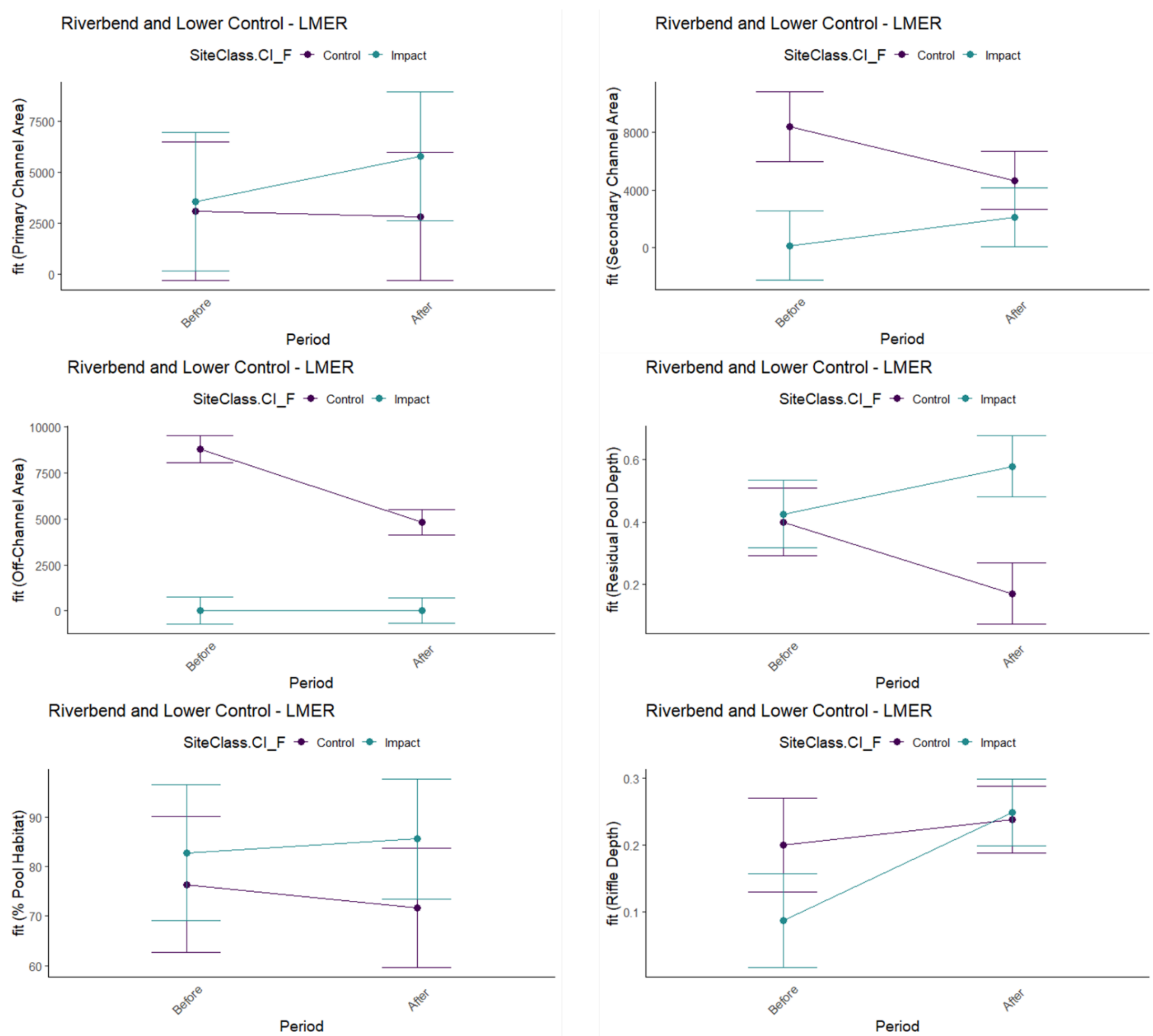


*Figure 22. Line plots illustrate the differences between pre-restoration and post-restoration treatments across channel, pool, and riffle features of Riverbend and the Lower Control Channel.*

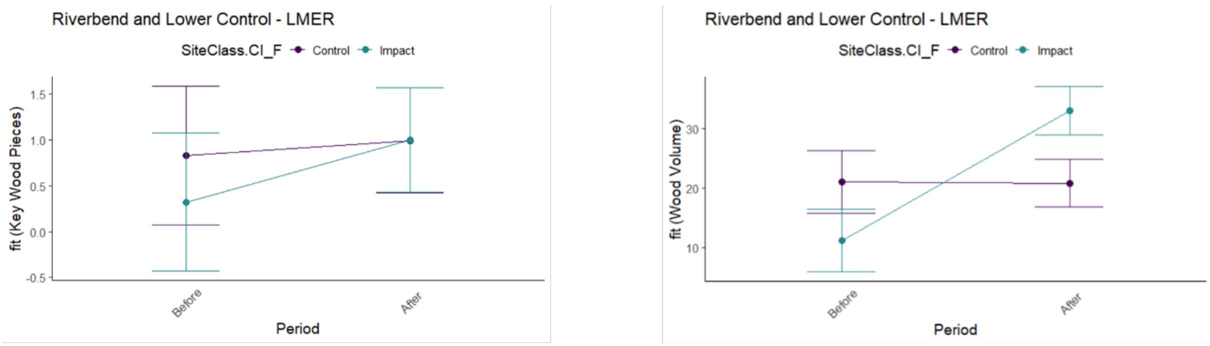


*Figure 23. Line plots illustrate the differences between pre-restoration treatment and post-restoration treatment for wood volume (m³) and the number of key pieces of wood per 100m of primary channel.*

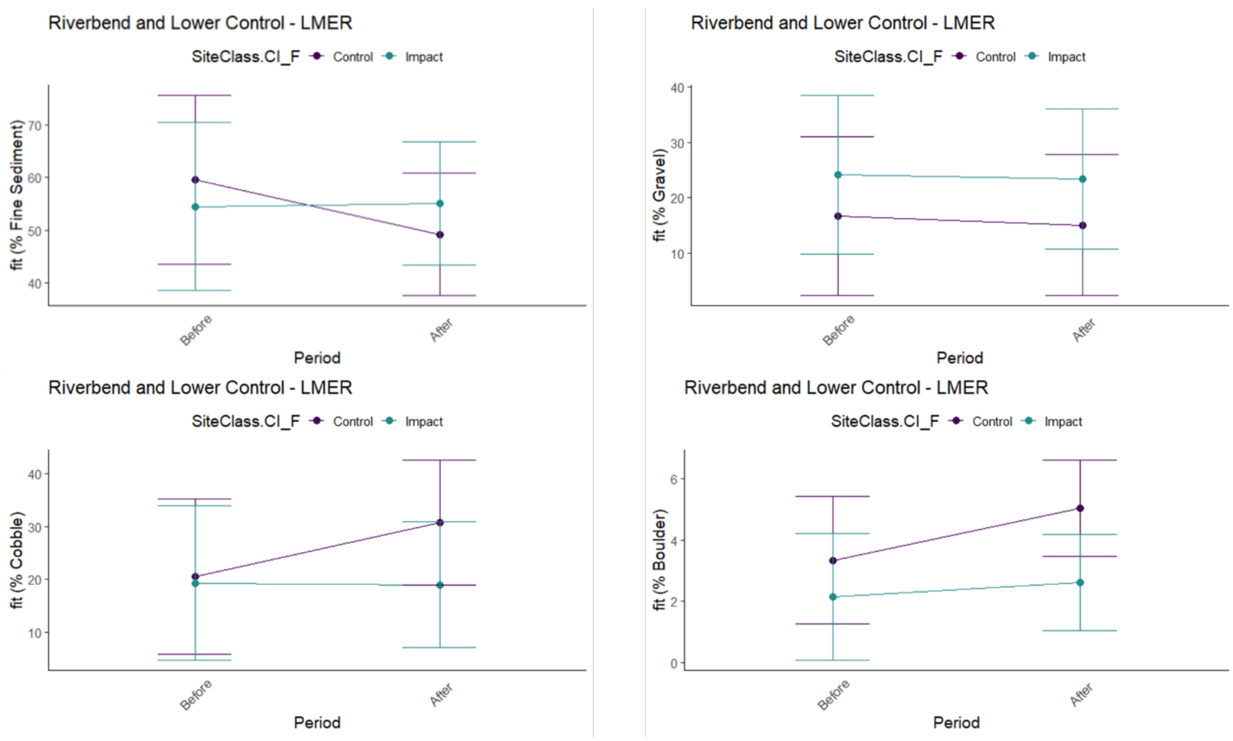


*Figure 24. Line plots illustrate the differences between pre- and post-restoration treatments across bedload types in Riverbend and the Lower Control Channel.*

## Temperature Monitoring

### Kingfisher and Upper Control

The temperature monitoring data from the Kingfisher restoration site, Upper Control site, and Clackamas Upper site reveal consistent seasonal trends, with warming during the summer and cooling into late fall (Figure 25). Kingfisher experienced slightly cooler peak temperatures compared to Clackamas Upper, suggesting a cooling effect potentially associated with restoration activities. However, a complete comparison with the nearby Upper Control site is limited due to missing data caused by a malfunctioning temperature logger during a significant portion of the summer. Clackamas Upper, as a mainstem site located near the Kingfisher and Upper Control sites, reflects slightly higher peak temperatures than Kingfisher but maintains a similar overall trend. The Clackamas River at Estacada temperature monitor, located further upstream, serves as a baseline reference and represents the coolest and most stable thermal conditions. Despite the data gap, the observed patterns indicate that restoration at Kingfisher may contribute to localized temperature moderation; however, further data would be needed to fully assess its effectiveness relative to the control.

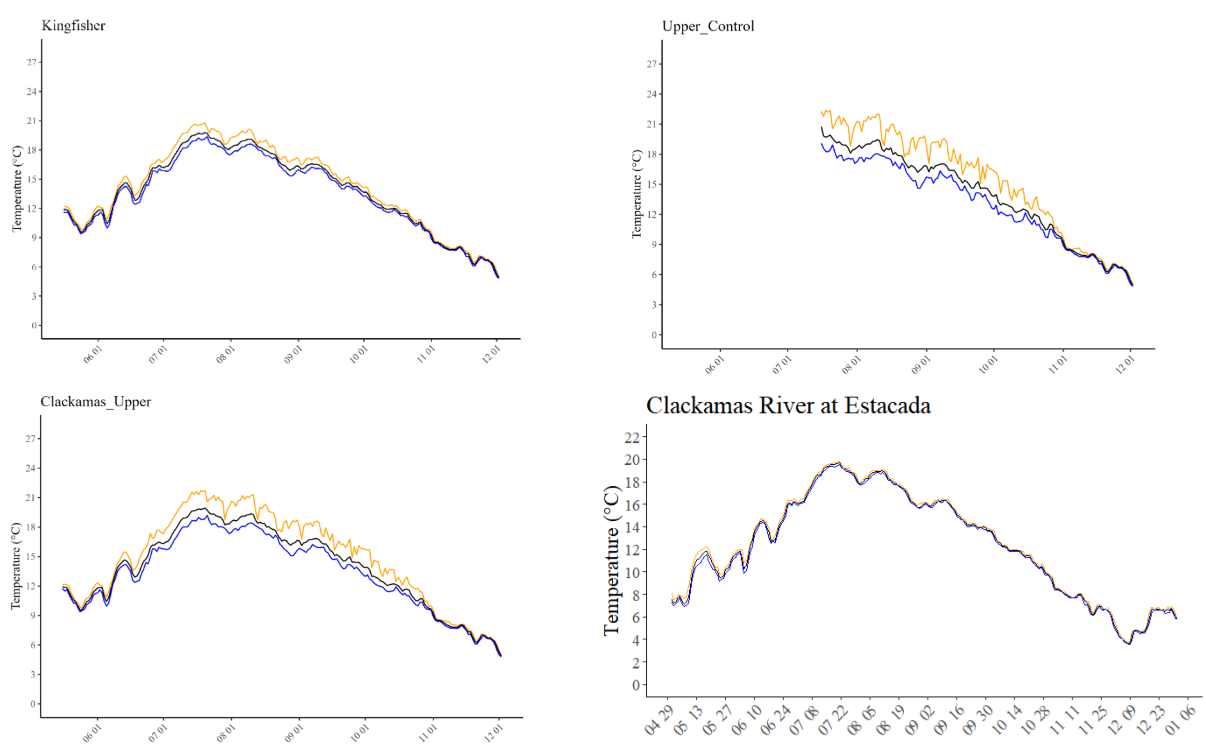


*Figure 25. Line graphs display daily (low (blue), average (black), and high (yellow)) temperature trends for the Kingfisher, Upper Control, Clackamas Upper, and Clackamas River at Estacada temperature monitoring sites.*

## Eagle Creek and Middle control

The temperature monitoring data from the Eagle Creek restoration site, the Middle Control site, and the Clackamas Middle site reveal consistent seasonal trends, with peaks in summer and cooling in the fall (Figure 26). Eagle Creek shows slightly lower peak summer temperatures compared to the nearby Middle Control, indicating potential cooling benefits from restoration efforts, although both sites follow a similar trend. Clackamas Middle, a mainstem site located directly upstream of both, exhibits slightly higher overall summer temperatures. Compared to all three, the Clackamas River at Estacada monitor, which serves as a baseline reference, demonstrates the coolest and most stable temperature profile. Collectively, these patterns imply that restoration at Eagle Creek may be contributing to localized thermal improvements.

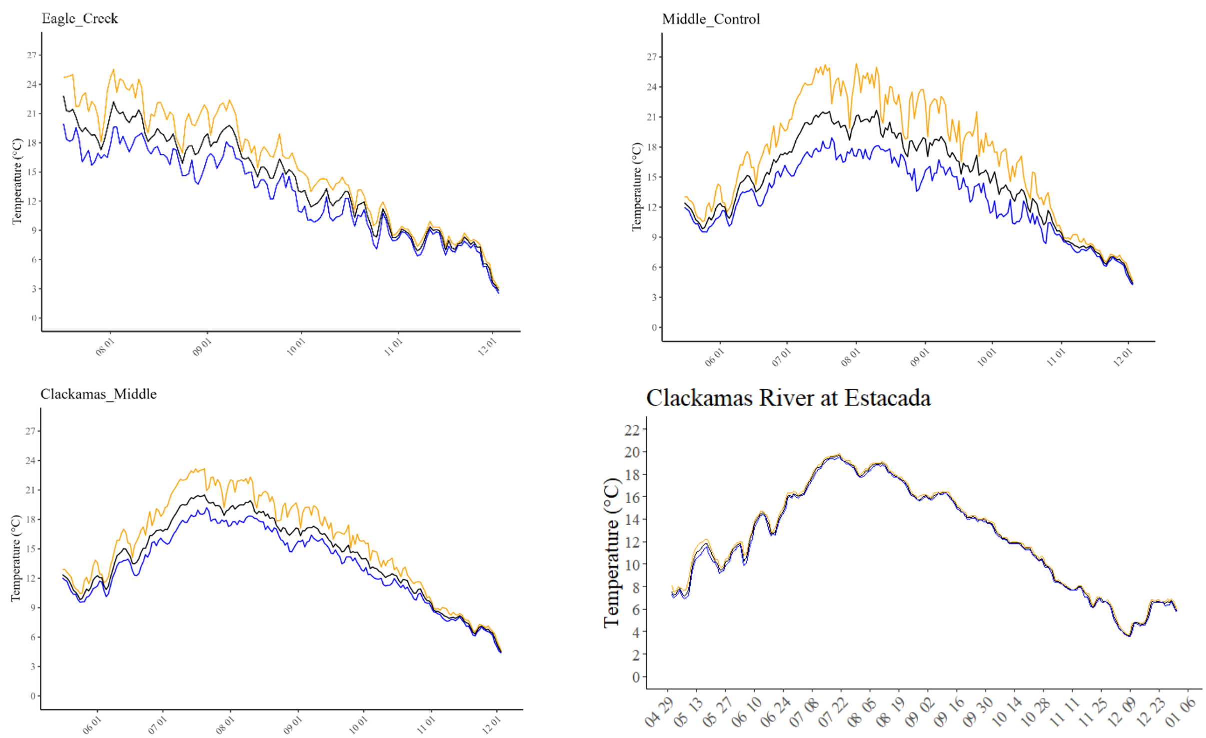


*Figure 26. Line graphs display daily (low (blue), average (black), and high (yellow)) temperature trends for the Eagle Creek, Middle Control, Clackamas Middle, and Clackamas River at Estacada temperature monitoring sites.*

## Riverbend and Lower Control

The temperature data from the four monitoring sites reveal clear seasonal patterns, showing peak temperatures in summer and cooling into winter (Figure 27). The Riverbend restoration site consistently exhibits very similar peak temperatures to those of the nearby Lower Control site. Both sites closely track with the Clackamas Lower site, located on the mainstem channel between the Lower Control and Riverbend sites, although Clackamas Lower generally shows slightly higher temperatures. In contrast, the Clackamas River at Estacada temperature monitoring site, located further upstream, which serves as a baseline reference, displays the coolest and most stable temperature regime. Collectively, these patterns highlight how temperatures are comparable, and any cooling effect from restoration at Riverbend is subtle or not clearly distinguishable from the Control and how temperatures compare across the river network.

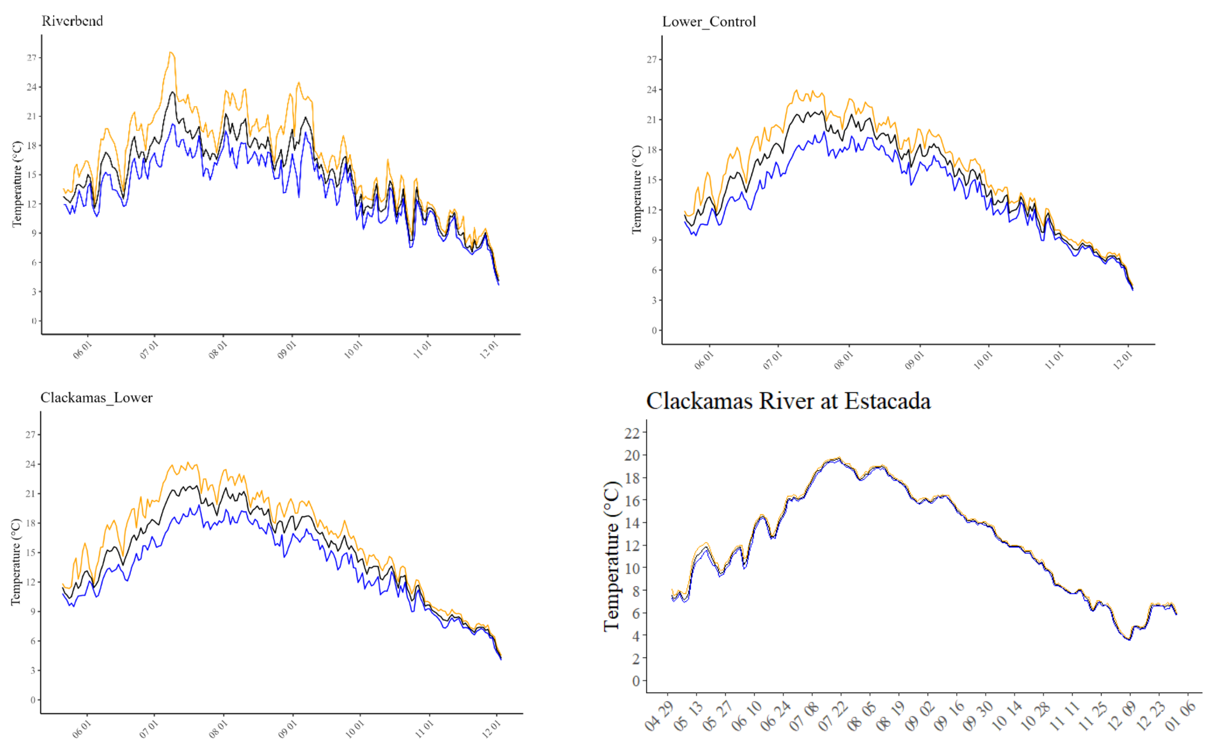


*Figure 27. Line graphs display daily (low (blue), average (black), and high (yellow)) temperature trends between the Riverbend, Lower Control, Clackamas Lower, and Clackamas River at Estacada temperature monitoring sites.*

## Wood Methods Comparison

We compared methods used to describe wood volume ($m^3$). Individual wood pieces were measured at all sites within each habitat unit, where both a ground survey and UAS imagery were captured. To stabilize variance and make data more normally distributed, we used a Box-Cox transformation. We then compared wood volume results from the ground surveys and UAS imagery across habitat units using a simple linear regression (Table 47).

*Table 47. Results of ground surveys and UAS survey comparisons for wood volume ($m^3$) and the number of key pieces across all UAS sites, at the Unit scale and the Reach scale (per 100m of primary channel).*

| Habitat Metrics | Residual DF | F-statistic | P-value | Adjusted $R^2$ |
|---|---|---|---|---|
| Wood Volume Unit Scale | 160 | 82.58 | 3.709 | 0.3363 |
| Wood Volume Reach Scale (wood per 100m of primary channel). | 9 | 307.8 | <0.001 | 0.9684 |

The modeled results at the unit scale suggest that the UAS imagery has challenges describing wood volume across different unit types. While there is a positive trend, using UAS imagery to describe wood volume can be hindered by factors such as canopy closure, channel margins, varying wood volume levels, and the complexity related to the size and orientation of wood structures (Figure 28).

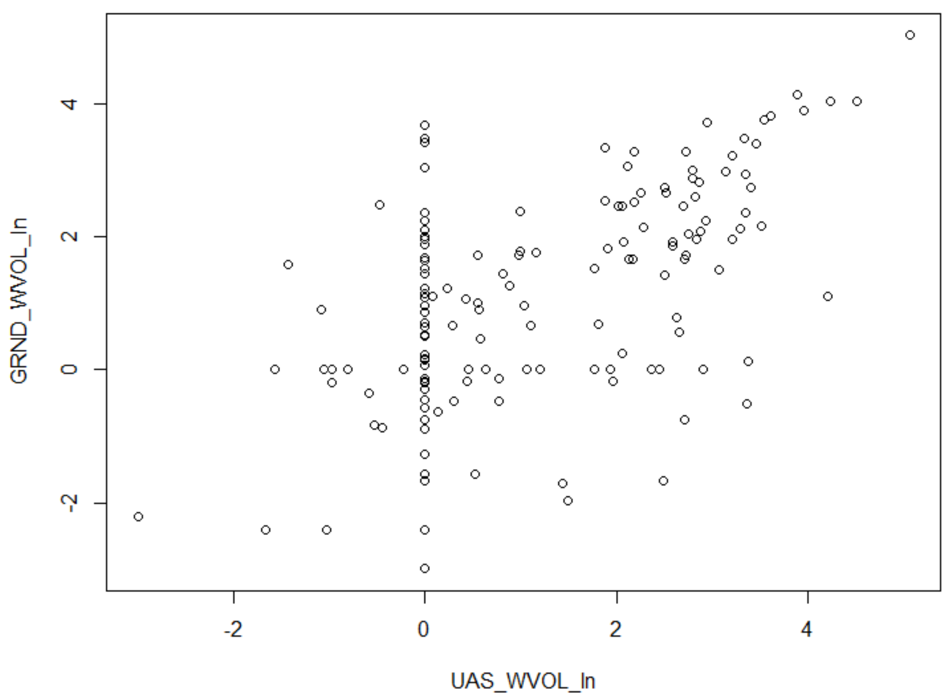


*Figure 28. Scatterplot results of a log-transformed linear regression between ground survey and aerial imagery for large wood volume ($m^3$) and the number of key pieces at the Unit scale.*

The modeled results at the Reach Scale suggest that the UAS imagery correlates with the ground-based measurements, suggesting that UAS can serve as an appropriate tool for estimating wood volume, channel margins, varying wood volume levels, and the complexity related to the size and orientation of wood structures (Figure 29).

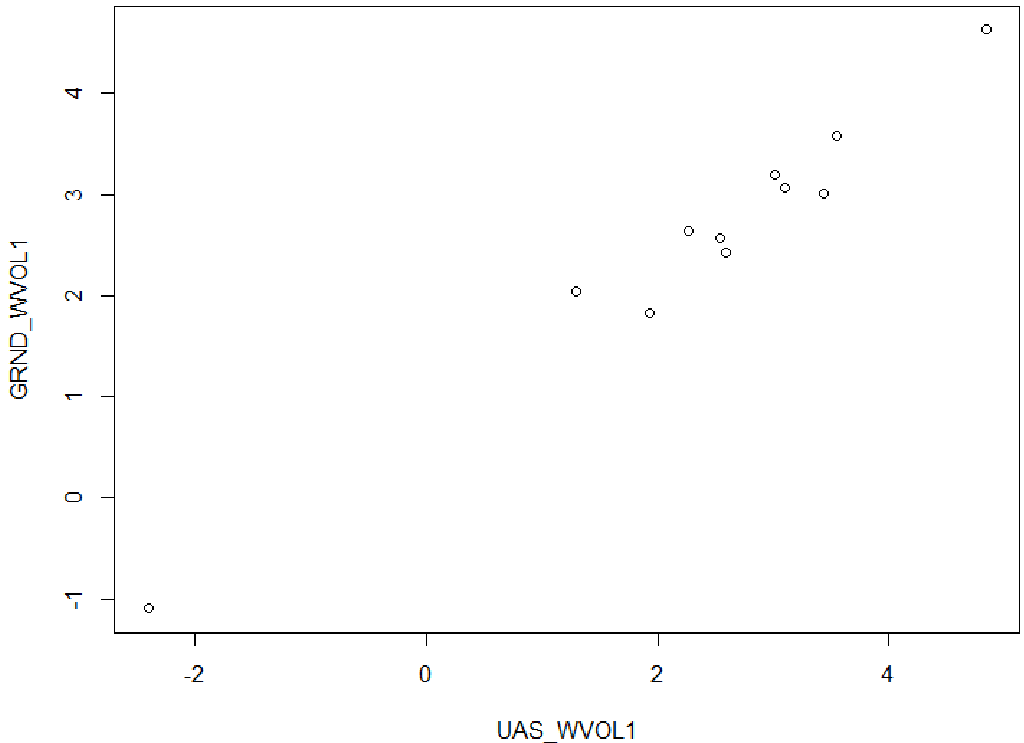


*Figure 29. Scatterplot results of a log-transformed linear regression between ground survey and aerial imagery for large wood volume (m³) and the number of key pieces at the Reach scale (per 100m of primary channel).*

## DISCUSSION

### Barton Natural Area

The restoration efforts at Barton Natural Area between 2023 and 2024 resulted in notable changes to stream habitat characteristics. While the primary and secondary channel areas slightly decreased, the percentage of pool habitat increased, suggesting improvements in habitat complexity and potential fish refuge. The significant rise in large wood volume and the increase in key wood pieces indicate enhanced structural habitat, which benefits salmonid species by providing cover and improving hydraulic diversity. However, a decline in residual pool depth suggests potential sediment accumulation or channel adjustments post-restoration. Substrate composition shifted slightly, with an increase in fine sediments and gravel, while the percentage of cobble and boulder decreased, reflecting changes in sediment transport dynamics. These habitat modifications align with the goals of increasing fish habitat complexity and floodplain connectivity, as seen by observed improvements in the habitat ratings for Chinook salmon, coho salmon, and steelhead. Continued monitoring will be essential to assess long-term trends and the success of the restoration enhancements.

### Holcomb Creek

The restoration efforts at Holcomb Creek between 2023 and 2024 led to several notable changes in habitat characteristics. While the primary channel area decreased, the secondary channel area expanded slightly, suggesting improved floodplain connectivity and habitat complexity. However, the percentage of pool habitat declined, possibly due to changes in stream morphology or flow distribution following restoration. Notably, a large beaver pool was removed and reconfigured during restoration efforts, and several BDA (beaver dam analog) structures were added, indicating that the pool habitat will likely improve as beavers return to the system. A significant increase in large wood volume emphasizes the effectiveness of wood placements in enhancing habitat structure, although only one key piece of wood was measured. The substrate composition shifted, with a reduction in fine sediments and gravel, and increases in the percentages of cobble, boulder, and bedrock, due to the addition of these substrates during restoration. The observation of Pacific lamprey constructing redds and the presence of coho salmon and redside shiners during snorkel surveys indicate that the habitat continues to support a diverse array of aquatic species. Despite the mixed changes in habitat rating, the increase in structural complexity and reduction in fine sediments demonstrate progress toward improving stream health.

### Johnson “J” Creek

The restoration efforts at Johnson Creek, conducted between 2023 and 2024, resulted in substantial changes to the channel structure and habitat composition. The most notable improvement was the significant expansion of the primary and secondary channel areas, which more than doubled following restoration, enhancing overall connectivity and the available aquatic habitat. Although the percentage of pool habitat decreased, this change likely reflects a more diverse channel morphology, with increased riffle and glide areas contributing to habitat complexity. The total volume of large wood increased, but the number of key wood pieces decreased. A positive shift in bedload composition was observed, with a marked reduction in fine sediments and an increase in gravel, cobble, and boulders, which can provide better spawning habitat and improved substrate stability (Reiser et al. 1979). Notably, the restoration efforts resulted in six pool units retaining water throughout the summer, whereas the entire channel had previously gone dry, marking a significant improvement. The limited presence of fish, with only mosquitofish observed during snorkel surveys, indicates that further monitoring is necessary to assess the long-term benefits of restoration for salmonid species.

### Kingfisher

The restoration of the Kingfisher Side Channel from 2021 to 2024 resulted in significant habitat modifications, particularly in substrate composition and wood volume. The reduction in fine sediment and the increase in gravel and cobble percentages indicate improved substrate stability, which benefits fish spawning and overall aquatic habitat quality. The addition of large wood structures enhanced channel complexity, with an increase in wood volume and the number of key wooden pieces. While the percentage of pool habitat decreased, this may reflect a more balanced distribution of habitat types, creating a mix of pools and fast-water units. Following restoration, the year-round connectivity of the channel marks a significant improvement, ensuring a continuous flow and habitat availability for fish species. The presence of coho salmon, dace, northern pike minnow, and mosquitofish during the snorkel survey suggests some recolonization of the restored habitat; further monitoring will be necessary to assess the long-term benefits for salmonid populations. Despite some observed improvements, the residual pool depth decreased slightly, and the off-channel area was lost, indicating potential trade-offs in the restoration design. Overall, the Kingfisher Side Channel restoration has resulted in increased structural complexity and improved habitat quality; ongoing evaluations are necessary to determine its full impact.

### Eagle Creek Complex

From 2020 to 2024, the restoration of the Eagle Creek Complex led to notable improvements in stream morphology and habitat quality**.** Enhancements included improving channel connectivity, increasing wood volume, and improving substrate composition, all of which likely expanded winter rearing habitat for juvenile coho salmon (Nickelson et al. 1992). Primary and secondary channel areas grew significantly. However, seasonal flow variations resulted in the drying of secondary channels during summer.

The addition of large wood structures added habitat complexity and boosted total wood volume, despite a slight decline in the number of key pieces. While the percentage of pool habitat decreased, increases in residual pool and riffle depths suggest improved habitat conditions for salmonids. Substrate composition shifted toward more gravel and cobble, enhancing spawning and rearing environments.

Initially, changes in flow routing and summer drying led to lower habitat ratings for Chinook, steelhead, and coho salmon. By 2024, the ratings improved, indicating that restoration benefits were starting to provide benefits. Despite these gains, the site remains heavily influenced by seasonal flows. Much of the complex dries out in summer, underscoring the need for continued monitoring to assess long-term habitat stability and suitability for salmonids across life stages.

A decline in observed habitat quality and salmonid presence during summer months may reflect high temperatures and reduced water availability, especially due to the loss of summer pools and dry secondary channels compared to pre-restoration conditions.

### Riverbend

The restoration efforts at Riverbend from 2021 to 2024 resulted in notable changes in channel morphology, habitat complexity, and connectivity, although some challenges remain. The expansion of the primary channel improved overall channel capacity while off-channel and secondary habitat connectivity increased significantly. The introduction of large wood structures and an apex jam contributed to an increase in residual pool depth and wood volume, improving habitat complexity and cover for aquatic species. However, despite these structural improvements, summer conditions remain harsh, with Sieben Creek, the tributary that flows into Riverbend, and most of the primary channel drying completely, limiting available summer refuge. This seasonal drying, an increase in fine sediment, and a decrease in gravel percentage may explain why habitat quality ratings for salmonid species did not improve post-restoration. While the enhancements increased winter habitat availability and complexity, the lack of persistent summer flow suggests that future efforts may need to focus on improving year-round water retention to support fish populations during critical low-flow periods.

### Control Channels

The analysis of control sites (Upper, Middle, and Lower control channels) over the years (2020–2024) reveals minimal changes in habitat metrics over time but significant differences between sites. Although no statistically significant trends emerged across years in key metrics such as pool habitat, wood volume, and substrate composition, variations in primary and secondary channel areas, off-channel areas, and depth-related metrics indicate site-specific differences. The Upper Control site exhibited a gradual increase in primary channel area, likely influenced by changes in river discharge, while the Middle Control site remained stable across all measured parameters. In contrast, the Lower Control site demonstrated greater variability, particularly in the secondary channel area and key wood pieces, which fluctuated due to high-flow events and downstream wood accumulation. These findings suggest that while overall habitat conditions at control sites have remained relatively stable over time, site-specific factors, including hydrology, temperature influences, and natural wood recruitment, contribute to variability in habitat complexity and availability.

### Austin Hot Springs

The 2024 pre-restoration survey of Austin Hot Springs identified a confined channel with limited lateral movement and poor to fair salmonid habitat. The site exhibited a relatively low number of pool habitats and moderate substrate diversity, with cobble and gravel as the predominant substrate types. Although large wood volume was present, it was sparse, with only three key pieces recorded. A snorkel survey documented the presence of coho salmon, Chinook salmon, steelhead, and cutthroat trout. Restoration efforts in summer 2024 aimed to enhance habitat complexity and fish suitability. A comparative post-restoration assessment is planned for 2025 to evaluate changes in habitat quality, wood volume, and salmonid use.

### Temperature Monitoring

Across all monitored sites, temperature data revealed consistent seasonal trends, with peak values in summer and cooling through fall. At each of the three restoration sites—Riverbend, Eagle Creek, and Kingfisher—temperatures were slightly lower than at their corresponding control sites, suggesting localized cooling benefits potentially from restoration efforts. These differences were most evident during peak summer months. Adjacent mainstem temperature monitor sites generally exhibited higher temperatures than the restoration and control sites. The Clackamas River at Estacada monitoring site, located upstream of all other sites, consistently recorded the coolest and most stable temperatures. Overall, the results indicate that restoration may contribute to localized thermal improvements, though effects vary by site and broader watershed dynamics play an important role.

### Wood Methods Comparison

Our findings highlight both the potential and the limitations of using UAS imagery to estimate wood volume in complex riparian environments. While a positive relationship was observed between UAS and ground-based measurements, particularly at the reach scale, challenges remain at individual habitat unit scales. Variations in canopy closure, wood orientation, and unit complexity can reduce the accuracy of UAS volume estimates at the habitat unit level. Moving forward, we plan to integrate a new LiDAR-equipped drone system into our workflow. This advanced technology will enable us to capture and produce high-resolution, three-dimensional data capable of penetrating dense canopy cover and improving our ability to quantify wood volume, structure, and surface area with greater accuracy.

## Conclusion

This report presents findings from habitat surveys and fish assemblage assessments conducted by the Oregon Department of Fish and Wildlife (ODFW) at multiple sites along the Clackamas River and its tributaries. The study included pre-restoration, post-restoration, and control sites to evaluate the effectiveness of recent habitat enhancement efforts. Surveys were conducted using a combination of unoccupied aerial systems (UAS), physical habitat ground surveys, and snorkel surveys to assess both seasonal variations and biological responses to restoration activities.

In 2024, ODFW surveyed eleven sites, including one pre-restoration site: Austin Hot Springs. Three one-year post-restoration sites, Barton Natural Area, Johnson “J” Creek, and Holcomb Creek. Following the 2023 report, we decided to incorporate three multi-year post-restoration sites into our annual survey rotation, as well as temperature monitoring for a more robust analysis. The additional data collected from Kingfisher, Eagle Creek, Riverbend, and the four control sites will aid in addressing impact changes throughout the lower Clackamas River once the FIP Project concludes in 2026. Restoration activities were completed at Barton Natural Area, Holcomb Creek, and Johnson “J” Creek in 2023, allowing for a one-year post-restoration evaluation of habitat changes and biological responses. Additionally, restoration work took place at Austin Hot Springs in the summer of 2024, with follow-up monitoring planned for 2025 to assess its effectiveness. The planned enhancements at Landslide Toe have been postponed, and comparative analyses will be conducted once the treatments are implemented.

The results presented in this report offer insights into the early effects of restoration efforts on stream morphology, habitat complexity, and fish usage. By comparing pre- and post-restoration conditions, we aim to assess the effectiveness of habitat enhancements and inform future restoration strategies. The discussion evaluates the observed trends and highlights key findings.

One year after restoration treatment, habitat assessments across the Barton Natural Area, Holcomb Creek, and Johnson “J” Creek sites revealed no statistically significant differences in most habitat attributes. Despite this, slight variations were observed among the sites, suggesting early indicators of positive response. Notably, there was a measurable increase in overall large wood volume and a shift in substrate composition, with higher proportions of gravel, cobble, and boulder substrate features associated with improved habitat complexity.

Positive trends were also evident at the Kingfisher Side Channel, Eagle Creek Complex, and Riverbend sites, where post-treatment surveys showed improvements in substrate composition, habitat condition ratings, and the volume of large wood. The placement of large wood strategically anchored within active channel margins is expected to provide long-term structural benefits.

These preliminary outcomes support the effectiveness of the restoration strategies implemented. While significant changes across all metrics may not yet be detectable, the observed slight differences and site-specific improvements point to emerging habitat enhancements. As the final year of post-restoration monitoring approaches, it is anticipated that cumulative wood recruitment and further habitat development will provide clearer evidence of ecological gains.

While positive outcomes have been noted and habitat rates are improving, much of the available habitat remains largely unoccupied by salmonids during summer snorkel surveys, despite the presence of native species across all sites. Summer rearing is likely limited by stream temperatures downstream of River Mill Dam; however, restoration activities have enhanced overwinter rearing at restoration sites. The Eagle Creek Complex, Holcomb Creek, and Austin Hot Springs recorded the most salmonid observations during summer snorkel surveys, likely due to the protected deep pools, and several disconnected side channel pools that are influenced by hyporheic flow in Eagle Creek, and the location of Austin Hot Springs in the upper Clackamas River basin, which maintains colder water temperatures, providing refuge during the warm summer months.

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